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SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING

INVESTIGATING DETERMINANTS OF LEAN CONSTRUCTION IMPLEMENTATION IN BUILDING CONSTRUCTION PROJECTS: THE CASE OF SELECTED CONSTRUCTION COMPANIES IN ADDIS ABABA

By

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A Thesis Submitted to the School of Graduate Studies of Addis Ababa University-Addis Ababa Institute of Technology in Partial Fulfillment of the Requirements for Master of Civil Engineering Degree in Construction Technology and Management

ADVISOR: GIRMAY KAHSSAY ABAY (PhD)

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Addis Ababa, Ethiopia

Declaration

Declaration

I hereby declare that the research titled "Investigating determinants of lean construction Implementation in building construction Project: The Case of selected construction companies in Addis Ababa" is my own original work and has not been submitted for any degree at any University or any other institution.

GASHAW KIBRU KIDANIE		23-04-2025
Name of Students	**Signatures**	**Date**

Endorsement

In my capacity as the research advisor, I hereby attest that I have read and assessed the thesis paper, "Investigating determinants of Lean Construction Implementation in Building Construction Projects: The Case of Selected Construction Companies in Addis Ababa," which was written under my supervision by Gashaw Kibru Kidanie. I recommend accepting it as a partial fulfillment of the prerequisites for the Master of Civil Engineering degree in Construction Technology and Management.

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Approval Sheet

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Acronyms

BIM	Building Information Modeling
JIT	Just In Time
LC	Lean Construction
LPs	Lean Practices
LCI	Lean Construction Institute

Abstract

Lean Construction involves applying lean manufacturing principles, or lean thinking, to the construction industry with core concept of delivering the right things to the right place at the right time, in the right quantity, while minimizing waste and remaining adaptable to change. However, In Addis Ababa, lean implementation is still in its early stages, primarily relying on push planning systems and so far there is very few or no revealed study has been observed with regards of LC challenges. Thus, the main purpose of this study was to investigate the critical factors influencing the implementation of lean construction (LC) in building projects, focusing on four independent variables: Project Complexity, Management Support, Training and Education, and Cultural Attitudes. Convenience sampling was used to selecting a sample of 170 respondents from four selected construction companies in Addis Ababa and a structured questionnaire with a response rate of 95% was used to collect 160 valid data points. Descriptive research designs as well as a quantitative research approach were used to conduct the study. The Statistical Process for Social Sciences (SPSS version 27) was used to conduct statistical analyses. Utilizing regression analysis, the study reveals that all four variables exhibit significant positive associations with lean construction implementation, with correlation coefficients ranging from 0.659 to 0.719. Notably, Training and Education demonstrate the strongest relationship (0.719), followed by Management Support (0.705), Cultural Attitudes (0.684), and Project Complexity (0.659). The model fitness analysis indicates an R^2 *value of 0.597, suggesting that approximately 59.7% of the variance in lean construction implementation is explained by these factors. However, 40.3% of the variance remains unexplained, indicating potential influences from other unexamined variables. The significance of the regression model, evidenced by an ANOVA significance value of 0.00, confirms its effectiveness in predicting the barriers to lean construction implementation. Standardized coefficients further reveal that Training and Education (Beta = 0.250) is the most influential factor, followed by Management Support (Beta = 0.236), Cultural Attitudes (Beta = 0.229), and Project Complexity (Beta = 0.181). These findings highlight the necessity of knowledge, skills, and management commitment in overcoming barriers to lean practices. The study emphasizes that a lack of training and awareness can hinder the effective application of lean methodologies, as noted in prior research. Management support emerged as a crucial element, with top management's commitment being vital for fostering a lean culture. Cultural attitudes were identified as barriers, wherein personal preferences and trust issues between management and employees can impede lean implementation. Additionally, the complexities associated with construction projects, including stakeholder interdependencies, pose significant challenges. In conclusion, the study identifies Training and Education, Management Support, Cultural Attitudes, and Project Complexity as key drivers in the successful adoption of lean construction. Recommendations for construction companies include investing in training programs, enhancing management support, fostering positive cultural attitudes, and effectively managing project complexities. By addressing these factors, construction firms can improve project efficiency, reduce waste, and ultimately enhance profitability and project delivery outcomes.*

Key words: *Building projects, Lean construction, Project Complexity, Management support, Training & Education, Cultural Attitudes, Addis Ababa*

CHAPTER ONE: INTRODUCTION

1.1 Background of Study

Over the past few decades, the research community has been actively investigating lean construction. As a result, some research themes can be emphasized in the areas of lean design and planning, waste identification and elimination, lean construction education, and the integration of lean construction with Building Information Modeling (BIM) and sustainability (Evans et al. 2017). It also includes the factors that enable and/or challenge the adoption and application of lean construction (Khaba et al. 2017), as well as the consequences of its application (Shahbaz et al. 2019). From the above themes of LC, application barriers and enablers fall within the scopes of this study.

The research community has given the topic of examining the barriers to adopting and implementing lean construction a great deal of attention. These studies have been carried out in different parts of the world. For example, research done in 2012 in the USA and Hong Kong revealed that the adoption and application of lean construction is hampered by a lack of sustainable practices, a lack of effective communication amongst all project participants, the size of the construction project, and a lack of knowledge and comprehension of LC (Koranda et. al., 2012).

An additional study conducted by Khaba et. al., (2017), insufficient government support (providing the necessary policies, codes, and regulations), a lack of performance measurement systems, a lack of customer focus and understanding, project subcontracting, financial constraints, and cultural differences are just a few of the more than ten barriers to implementing lean construction that were identified. Additionally, the research conducted by Bajjou et. al., (2018) led to the identification of three significant obstacles: financial limitations, managerial and employee incompetence, and a lack of awareness.

Further studies were carried out between 2019 and 2021, so as to explore key barriers, such as, resistance of management and staff to change, lack of transparency and stakeholder involvement, lack of quality planning, implementation costs and time, limited use of off-site construction and prefabrication, and traditional design and implementation methods (Innella et al., 2019; Sweis et. al., 2021; Huaman-Orosco et, al., 2021). In addition, the research community has made considerable efforts to identify factors that facilitate or enable the adoption and implementation of lean construction practices and similar studies addressing barriers and factors facilitating the implementation of LC have been carried out in a number of countries. For example, the study by Shahbaz et. al., (2019), found that lean learning, training and research, as well as continuous improvements in process and product development and cooperative working relations between project participants, significantly facilitate lean construction.

Moreover, the research conducted by Yahya et. al., (2017) found that knowledge creation and management, the development of LC-based performance measurement frameworks and the promotion of a culture of teamwork in construction projects play a very important role in enabling lean construction to be implemented. This was followed by further studies carried out in the US, Brazil and the United Kingdom in 2017, which identified enabling factors such as the development of a lean culture through support for lean education, training and research, investor and client requirements and bottom-up strategies (Zanotti et. al., 2017). This trend has continued in the years 2018-2021 to come with studies carried out in a number of regions, including China, India, Norway, South Africa, Saudi Arabia, New Zealand, Brazil, Turkey and Iran. These research efforts have revealed the importance of enablers such as the support and commitment of senior management, the building of trust, the production of pullout, cooperation practices, the promotion of teamwork culture in construction projects, adequate human resources and the support of government and regulatory authorities (Karaniawala et. al., 2018; Maradzano et. al., 2018).

Therefore, it can be concluded that the literature analysis shows a clear research gap in the Ethiopian context with regard to a comprehensive view of the barriers and enablers to the adoption and application of lean construction. In this respect, the study aims to address the determinants of implementation of lean construction in building construction projects: the case of selected companies in Addis Ababa, with particular emphasis on variables related to project complexity, training and education, managerial support and cultural attitudes.

1.2 Statement of the Problem

Lean construction involves the collective efforts of everyone in an organization to identify waste and make incremental improvements daily and aligning towards common goals. According to Salvatierra et. al., (2015), successfully implementing lean principles long-term requires a shared understanding of these principles, waste, and customer value among all members. A supportive culture fosters social interactions among team members, enabling them to adapt lean philosophy to project complexities and technologies, which facilitates continuous learning through iterative processes. However, many organizations begin by applying only some lean tools, leading to the misconception that they are embracing lean without grasping its underlying philosophy (Soren, 2014). The complexities and large number of participants in construction projects can hinder lean implementation, often resulting in a return to traditional methods due to perceived resource, labor, and time burdens (Okere, 2017).

Common barriers to lean implementation include insufficient training, lack of top management support, inadequate long-term planning, and resistance to change (Alarcón et. al., 2002). Full backing from top management is crucial, and information must be accessible at all organizational levels. Salvatierra et al. (2015) also note that short-term lean implementation in projects can create additional challenges. Literature indicates that barriers relate to people, business practices, and education, with limited research on how company size and sector affect lean implementation. Understanding these factors can help engineers make informed decisions about integrating lifelong learning in their projects.

In Ethiopia, construction professionals exhibit some awareness of Lean Construction but have limited knowledge of related concepts like the last planner system and value stream mapping. Their understanding of prefabrication and just-in-time practices is comparatively better. While Lean Construction is not yet widely practiced in Ethiopia, awareness exists among professionals (Ayalew et. al., 2016). In Addis Ababa, lean implementation is still in its early stages, primarily relying on push planning systems. Zenawi et. al. (2022), report that construction management processes utilize critical path methods and master schedules. To enhance performance, adopting systems like the last planner system is recommended (Zenawi et. al., 2022).

Furthermore, research focusing on lean implementation in Jima city (Wondimagegn, 2021) indicates a scarcity of standard procedures for key lean concepts, highlighting the need for further investigation. Additionally, Tsion (2020) explored the implications of lean construction on labor productivity using value stream mapping, revealing a high incidence of non-value-adding activities, underscoring the necessity for lean techniques.

However, so far there is very few or no revealed study has been observed with regards to challenges in LC implementation in Addis Ababa. Thus, this study aims to identify the determinants of lean construction implementation in selected building projects in Addis Ababa, focusing on project complexity, training and education, management support, and cultural attitudes. These four independent variables have been selected because they are the five top most identified and studied barriers globally.

1.3 Research Questions

1. What are the determinants of LC implementation in building construction projects in selected construction companies in Addis Ababa?
2. What impact do LC implementation determinants and principles have on the cost of building construction in selected construction companies in Addis Ababa?
3. What actionable strategies can be developed to overcome the challenges associated with the determinants of LC implementation in selected construction companies in Addis Ababa?

1.4 Objectives of the Study

1.4.1 General Objectives

To investigate determinants of lean construction implementation in building construction projects: the case of selected construction companies in Addis Ababa.

1.4.2 Specific Objectives

- To evaluate determinants of LC implementation in building construction projects: the case of selected construction companies in Addis Ababa.
- To assess the effects of LC implementation determinants and LC principles on the cost of building construction, the case of selected construction companies in Addis Ababa.
- To develop actionable strategies for overcoming the challenges associated with determinants of LC implementation, the case of selected construction companies in Addis Ababa.

1.5 Significance of the Study

The aim of this study is to highlight the factors, which building construction societies should be aware of and consider in terms of their effectiveness and efficiency in the execution of construction projects and in improving their output. By understanding these factors, construction companies can implement more strategic and efficient management practices, which in turn can improve their overall productivity and performance. Empirically, the results of this research provide valuable insights for the construction companies in order to improve their procedures. The aim of this study was to identify the main factors influencing the lean construction implementation in building construction projects and, how these factors interact with the waste minimization process for building construction projects. Therefore, consideration of minimizing waste levels in construction projects is very useful and has a major impact on the profitability of the company. Construction companies can significantly reduce construction costs and increase their profit by eliminating construction waste.

1.6 Scope of the Study

This study mainly focuses on evaluation of lean construction implementation specifically in building construction projects located in Addis Ababa. The scope encompasses the aspects related to lean construction implementation determinant factors, such as project complexity, managements supports, training and education, and cultural attitudes, with a particular emphasis on four selected construction companies operating in Addis Ababa city. The study is limited to Addis Ababa, the capital city of Ethiopia, due to its significance as a hub of construction activities and urban development within the country. The study specifically targets the building construction sector within Addis Ababa, including residential, commercial, and institutional building projects. It does not encompass other construction sectors such as infrastructure, heavy civil engineering, or industrial construction.

1.7 Organization of the Thesis

This research is organized into five chapters. Chapters 1 introduces the entire thesis, and it covers the background of the study, statement of the research problem, the objectives of the study, the significance of the study and scope of the study. Chapter 2 is devoted to presenting a review of the literature related to conceptual issues. Chapter 3 covers the research design and methods, which will be employed and the method used to collect data for the research. Chapter 4 covers analysis of the data gathered and provided a solid interpretation to the data. The final chapter assesses the findings of this study, drew conclusions and important recommendations.

CHAPTER TWO
2. LITERATURE REVIEW

2.1. Definition of Lean Construction

The principles of Lean Construction encompasses the methods, strategies, and tools utilized to achieve the goals of Lean Construction (Ong and Sui Pheng, 2021). Lean Construction adopts Lean Production principles to enhance productivity and effectiveness by reducing waste in construction activities (Ogunbiyi, 2014). The principles align with sustainability objectives in two significant ways: focusing on waste reduction and emphasizing 'value,' which is beneficial for clients pursuing business, environmental, and social excellence simultaneously (Barboza and Forgues, 2012). According to Lean Construction principles, only conversion activities add value and should be optimized, whereas non-value-adding flow activities should be minimized or eliminated (Vimal Kumar and Ramaswamy, 2016).

2.2. Theoretical Background of Lean Construction

Lean Construction, inspired by Lean production theory, originated within the Toyota Production System (TPS) developed by Ohno in the 1980s. It integrates operational research and functional development within design and construction, applying lean manufacturing principles throughout the entire process (Harsha et. al., 2013). The primary focus of Lean Construction is on streamlining processes by eliminating non-value-adding activities that consume time, resources, and/or space. It emphasizes enhancing processes by reducing the duration of each activity, forming a foundation for project management principles (Nwaki et. al., 2021).

Adopted in the construction industry as a modern project management approach, Lean philosophy aims to eliminate waste and create value for customers (Salem, 2005). Originating from Lean manufacturing principles, Lean Construction tools like the Last Planner System, Just in Time, Total Quality Management, and Continuous Improvement have gained significant traction in developing countries (Jarkiholi et. al., 2020).

Lean Construction involves applying lean manufacturing principles, or lean thinking, to the construction industry (Nwaki et. al., 2021). The core of the lean concept is delivering the right things to the right place at the right time, in the right quantity, while minimizing waste and remaining adaptable to change. It emphasizes reducing waste, enhancing customer value, and continuous improvement. According to (Nwaki et. al., 2021), Lean Construction aims to achieve customer satisfaction by using fewer materials, less money, and fewer resources. Its primary objective is to minimize all non-value-adding activities related to resources and time in construction projects (Salem, 2005). Overall, Lean Construction has emerged as an effective method for designing construction systems, reducing all forms of waste, and maximizing customer value. It benefits the customer by producing fewer defects and benefits contractors by using fewer resources and reducing environmental impact due to decreased waste.

2.3. Lean Construction Usable Tools in Construction Industry

The effectiveness of lean construction tools is assessed using standardized lean implementation metrics and performance criteria (Parfenova et. al., 2020). Tools like the Last Planner System, Just in Time (JIT), Total Quality Management (TQM), and Continuous Improvement have garnered significant attention, especially in developing nations (Meng, 2019). According to Issa (2013) several lean construction tools can be applied to construction projects, including:

- 5S Methodology: A workplace organization and visual management system focused on Sort, Set in Order, Shine, Standardize, and Sustain.
- Just-In-Time (JIT) Delivery: Coordinating material deliveries to arrive exactly when needed on the construction site, minimizing inventory.
- Last Planner System: A collaborative planning process that engages all stakeholders to make reliable commitments and reduce project uncertainty.
- Pull Planning: A scheduling technique that starts with the desired end-output/outcome and works backward to determine the necessary precursor activities.
- Value Stream Mapping: A visual tool that maps the flow of materials and information to identify waste and opportunities for improvement.

- 7S Workplace Organization: An extension of 5S that adds two additional steps - Safety and Sustainability.
- A3 Problem Solving: A structured problem-solving approach using a standardized one-page report format.
- Total Productive Maintenance (TPM): A system for optimizing the effectiveness of manufacturing equipment.

Furthermore, lean design tools such as Target Value Design (TVD), Set-Based Design (SBD), Building Information Modeling (BIM), Choosing by Advantage (CBA), and the Last Planner System (LPS) are also used. However, there is currently no evaluation tool that assesses the level of use of specific practices in a project (Herrera et. al., 2019). The implementation of these lean tools and techniques has significantly reduced waste and improved performance in construction projects (Nwaki et. al., 2021).

2.4. Barriers to Implement Lean Construction

The implementation of lean construction faces a number of challenges, which were categorized according to a large review of the international literature on lean practice. For example, organizations implementing lean in their projects face difficulties in adopting the philosophy of their staff, processes and management. In the US, for example, there are problems with low commitment from senior management, low awareness of lean practices and poor communication between teams on information sharing (Demirkesen et. al., 2019). The UK, on the other hand, faces obstacles in the form of a lack of knowledge of lean by professionals, resistance to change and difficulties in adopting a lean culture (Sarhan et. al., 2012).

However, the construction sector has projects, which are temporary and do not justify the long-term training and research of staff (Salem et. al., 2006). Therefore, organizations have started to use lean tools in specific projects (Okere, 2017); some have succeeded, while others have failed to deliver the expected results and are reverting to traditional management systems (Okere, 2017). Ballard et. al., (2007) propose to start implementation by motivating project leaders, training all project members, introducing tools to build habits, culture and continuous improvement, and then move to the lean philosophy.

Additionally, Salvatierra et. al., (2015), suggested that a balance should be in place between instruments, culture and philosophy in order to maintain good lean practices in the long term. In Colombia, there are barriers such as a perception of insecurity for positive results, transparency of information between teams and national legislation that does not allow flexibility in lean projects (Castiblanco et. al., 2019).

2.5. Overview of Barriers to Implementing Lean Construction

The lack of a long-term philosophy, workers' resistance to change, and organizational, cultural, and attitude barriers to Lean implementation in the construction context were among the factors highlighted in a review of the current literature (Shang et. al., 2014). An investigation by Albliwi et. al., (2014) discovered that the main barriers to implementing Lean methods were the inability to provide people with meaningful learning experiences. If there are consistent efforts to engage people in meaningful learning experiences, then using Lean methods will be popular (Albliwi et. al., 2014). They add that the other difficulties facing this new idea in the construction sector are a lack of agreement on how to interpret Lean and a shortage of academics to closely collaborate with industry practitioners on implementing Lean concepts.

Wodlaski et. al., (2011) identified seven barriers that stand in the way of Lean construction in public settings, such as transportation and infrastructure projects. These included lack of resources, risk management, insurance, legislative concerns, apprehension about change, incompatibilities with conventional state transportation authorities (STAs) and procedures, and an uncertainTY. Wodalski et. al., (2011) used case studies, such as the Albanian Motorway Project, Jubail Industrial City, and Bechtel's case studies, that showed how Lean techniques were successfully applied in the infrastructure sector.

In Shang et. al., (2014) twenty-two barriers to Lean construction in China were surveyed and divided into six categories: partner and people, managerial and organizational, lack of commitment and support, cultural and philosophical, government-related, and procurementrelated. The top five barriers identified by Shang et. al., (2014) were inadequate management skills, multi-layer subcontracting, a lack of Lean culture within the company, a lack of long-term thinking, and a lack of top-level management support. The study concentrated on the Chinese market rather than the US market, even though it gave a broad overview of the main barriers to applying Lean in the construction sector projects involving transportation.

Jadhav et. al., (2013) evaluated the application of Lean and identified 24 Lean barriers. The top five barriers to prevalence of LC, according to them were lack of resources to invest, the need for large investments, or financial constraints; lack of senior management commitment and involvement; worker or employee attitude, cultural differences; and lack of strong leadership. Abolhassani et. al., (2016) listed the following as the main barriers to putting Lean principles into practice: a lack of management commitment, an unsuitable culture, unsustainability, high investment costs, and Lean past failures. One of the five pillars of Lean, continuous improvement, or Kaizen, encounters three barriers: technological, cultural, and technical (Protzman et. al., 2016). Middle managers failed to implement Lean principles at the project level because; they did not have the support of the company's executive body (Protzman et. al., 2016).

Rodewohl (2014) categorized the barriers to Lean implementation as structural and cultural in their case-study report on the application of Lean construction principles in transportation and infrastructure projects in Norway. According to Rodewhol (2014), the biggest barriers were lack of knowledge about the core principles and ideas of Lean, which was followed by a lack of management support and challenges with the paradigm shift toward Lean thinking. Oladiran (2008) thought it was likely that one or more of the seven categories would contain the barriers to applying Lean in the Nigerian construction sector. According to him, it is possible that those working in the construction industry lacked the necessary abilities or knowledge, or they might have been motivated by selfishness, resistance to change, or even the presumption of needless authority by architects. Additionally, barriers like financial and logistical, government corruption and bureaucracy, and lack of support from upper management are hindering the implementation of LC (Oladiran, 2008).

Lack of group work culture, shared vision, and consensus are found to be the least problematic barriers to the implementation of Lean in the Libyan construction industry, while inadequate knowledge and skills were found to be the biggest barriers (Omran et. al., 2009; Alinaitwe, 2015). Effective resource management in large construction companies is adversely affected by the inability to measure team performance (Omran et. al. (2015). According to Omran et. al.,(2015) the top three barriers to Lean construction in the Libyan construction industry were inadequate knowledge and skills, a lack of organizational culture that supported teamwork, and the inability to measure team performance and progress. The team's inability to maintain alignment with other teams and lack of group culture came in sixth and seventh places, respectively.

However, Alinaitwe (2009) discovered that the top three other barriers were the inability to deliver inputs on time, the lack of communication and transportation infrastructure, and the inability of teams to stay in sync with one another; the lack of management leadership was far lower on the list of barriers that were prioritized. On the other hand, Lean Construction in the U.K. construction sector was distinct. Cultural and attitudinal barriers were found to be the most common, followed by implementation costs and lack of Lean expertise (Bashir et. al., 2015; Sarhan et. al., 2013).

2.6. Global Barriers to LC Implementation

For over two decades, Lean Construction has been adopted across more than 48 countries, with a significant body of literature documenting its evolution—over 1,382 research papers have been published on the subject (Engebø et. al., 2017). This extensive research reflects Lean Construction's growing influence in the construction sector and highlights its potential to improve efficiency and reduce waste. While the majority of these publications originate from the United States and Europe, the methodology has gained traction in countries such as Brazil, Chile, and Peru, indicating a broader acceptance and application of Lean principles in diverse cultural and economic contexts.

Despite its widespread adoption, many organizations report difficulties in fully realizing the benefits of the Lean philosophy. According to Okere (2017), these challenges stem from various barriers that impede effective implementation. Researchers have identified 110 barriers to Lean Construction implementation globally, categorizing them into three primary groups (Okere, 2017):

People (29 percent): This category encompasses issues related to education, management, operations, and organizational culture. A foundational lack of understanding of Lean principles among workers can lead to resistance and hinder collaboration. Moreover, inadequate leadership training can prevent managers from effectively guiding teams through the transition to Lean methodologies.

Production Process (20 percent): This category focuses on aspects such as customer identification, management, planning, and control. Effective Lean implementation requires a clear understanding of customer needs and expectations, which are often overlooked. Without this focus, organizations may struggle to align their processes with Lean principles, resulting in inefficiencies.

Production Management and Logistics Processes (51 percent): This category represents the largest proportion of barriers and includes governance issues, lack of long-term business philosophy, and deficiencies in processes and systems. Effective governance is critical for fostering an environment conducive to Lean practices, and without a commitment to long-term improvement, organizations may revert to traditional methods.

In the United States, research conducted by Demirkesen et. al., (2019) identified people-related factors as the primary barriers to Lean Construction, particularly concerning educational shortcomings and leadership training. The lack of standardized knowledge further complicates learning for newcomers to Lean, leading to disagreements among experts regarding its core concepts. This fragmentation can create confusion and inconsistency in implementation efforts, thereby inhibiting progress.

Colombia faces unique challenges, including resistance to change, high costs associated with implementation, and issues related to information transparency (Alarcón et. al., 2017). The fear of change can create a significant barrier, as employees may be reluctant to adopt new practices that disrupt established routines. Additionally, when implementation costs are perceived as exorbitant, organizations may hesitate to invest in Lean initiatives, limiting their potential for improvement.

In Chile, the implementation of Lean Construction is often delayed due to a lack of support from top-level management and insufficient vertical communication, which prevents critical information from reaching all levels of the organization (Engebø et. al., 2017). This lack of support can lead to disengagement among employees, who may feel that Lean initiatives are not prioritized by leadership, thus diminishing their motivation to engage in the process.

Moreover, short-term thinking prevalent in many organizations can hinder the resolution of underlying problems, creating cycles of recurring issues (Salvatierra et. al., 2015). When organizations focus on immediate results rather than long-term solutions, they may fail to address the root causes of inefficiencies, leading to ongoing challenges that compromise project outcomes.

In Peru, the primary barriers include the absence of state regulations that would facilitate institutional participation in Lean initiatives, a lack of collaboration between industry and academia, and the perceived high costs of implementation (Huaman et. al., 2021). These factors can strangle innovation and limit the sharing of best practices, which are essential for successful Lean adoption. Additionally, there is significant opposition to change, as organizations may be entrenched in traditional practices that resist new methodologies (Medina, 2014).

The cumulative impact of these barriers is significant, as they affect customer satisfaction, lead to cost overruns, necessitate rework, and may result in project stoppages. Issues that begin in the design phase often carry over into the construction stage, leading to limited improvements and overall project inefficiencies (Gutiérrez, 2020). As organizations grapple with these challenges, the need for a comprehensive approach to Lean implementation becomes increasingly evident, emphasizing the importance of education, leadership support, and collaborative efforts between stakeholders to overcome the barriers hindering progress.

2.7. Key Barriers to LC Implementation Selected for This Study and Their Rationale

The implementation of lean construction within the construction industry necessitates a thorough identification and analysis of the most influential barriers that impede progress. This study focuses on four pivotal factors: training and education, management support, cultural attitudes, and project complexity. These factors have emerged as significant influences based on extensive research conducted by various scholars, for instance, Omran et al. (2009); Shang et al. (2014); Protzman et al. (2016); Sarhan et al., (2012); Demirkesen et al. (2019) and they establishing them as critical elements for understanding the dynamics of lean construction.

Training & education serve as foundational components for the successful adoption of lean practices. Research by Omran et al. (2009) emphasizes that inadequate knowledge and skills represent major barriers to effective implementation. For construction professionals to fully embrace lean methodologies, they must possess a comprehensive understanding of the underlying principles and techniques. This study prioritizes training and education as a critical factor, as equipping personnel with the necessary skills fosters a competent workforce, ultimately leading to improved project outcomes and enhanced operational efficiency.

Management support is another vital factor significantly impacting lean construction. According to Shang et al. (2014), a lack of top-level management support can severely hinder the adoption of lean practices. Without commitment from senior leadership, initiatives aimed at implementing lean principles are likely to falter. Protzman et al. (2016) further illustrate that middle managers often struggle to apply lean methods without the backing of executive bodies. This study emphasizes the importance of management support as essential for cultivating an organizational culture that embraces lean thinking, thereby making it a core focus of our investigation.

Cultural attitudes within an organization also play a significant role in the successful implementation of lean construction. Studies conducted in regions such as the UK and the US reveal resistance to change and a lack of a supportive lean culture among professionals (Sarhan et al., 2012). By concentrating on cultural attitudes, this study aims to address the underlying beliefs and behaviors that can either facilitate or obstruct the transition to lean practices. Cultivating a positive organizational culture that encourages innovation and openness to change is fundamental for the successful adoption of lean principles.

Furthermore, project complexity is a critical factor influencing lean construction implementation. As construction projects become increasingly intricate, the challenges associated with coordination, resource management, and effective communication escalates significantly. These complexities often lead to miscommunication and difficulties in team coordination, exacerbating the issues as stated by Demirkesen et al. (2019). The complexities highlighted in various studies can result in misunderstandings and inefficiencies, further complicating the adoption of lean practices. This study considers project complexity vital, as understanding and managing these complexities are crucial for the successful integration of lean methodologies into construction projects.

In conclusion, training & education, management support, cultural attitudes, and project complexity have been selected as the top factors for this study due to their impactful roles in lean construction implementation as stated and investigated by different scholars. By addressing these barriers in a holistic manner, we can pave the way for overcoming the challenges faced by the industry, ultimately leading to more efficient and effective construction practices.

2.8. Breakdown of Barriers Found in the Literature

2.8.1. Training and Education

Inadequate knowledge and skills have been identified as significant factors adversely affecting worker productivity within various industries, particularly in construction (Omran et. al., 2015). This issue is multifaceted, affecting not only individual performance but also broader organizational effectiveness. The lack of essential knowledge and skills can lead to inefficiencies and errors, which ultimately diminishes overall productivity levels.

Alinaitwe (2009) argued that this deficiency in knowledge and skills is particularly detrimental to teamwork and concurrent engineering, both of which are crucial components of Lean construction. Lean construction emphasizes collaboration and efficiency, requiring that team members possess a shared understanding of processes and practices. When workers are ill equipped with the necessary knowledge, their ability to collaborate effectively becomes compromised, leading to misunderstandings and miscommunication. This breakdown in teamwork can further result in delays and increased costs, undermining the principles of Lean construction.

Additionally, insufficient knowledge concerning implementation practices can precipitate technical challenges throughout the construction supply chain. Such challenges create uncertainty in workflow reliability, which is critical for maintaining smooth operations. The Just-In-Time (JIT) approach, a core principle of Lean construction, relies on precise timing and coordination of materials and tasks to minimize waste. If workers lack the knowledge to effectively implement JIT practices, the entire supply chain can become unstable, leading to delays and increased costs. Alinaitwe (2009) highlights how this uncertainty can severely hinder an organization's capacity to operate efficiently, ultimately affecting project outcomes.

Moreover, the lack of knowledge extends to the implementation of Lean Six Sigma, another fundamental concept of Lean construction aimed at improving processes through data-driven decision-making and quality management. According to Albliwi et. al., (2014), without a solid understanding of Lean Six Sigma methodologies, organizations may struggle to achieve the intended improvements in quality and efficiency. This gap in knowledge can prevent teams from effectively identifying and addressing inefficiencies, further perpetuating the cycle of underperformance.

Beyond the insufficiencies observed at the worker level, organizational leaders and managers also exhibit significant gaps in their knowledge and competencies. These leadership shortcomings exacerbate the challenges faced in implementing Lean principles. Issues such as inadequate pre-planning, limited experience in change management, and poor candidate selection for training and Lean certification programs contribute to a lack of preparedness for Lean implementation (Shang et. al., 2014; Alinaitwe, 2009).

In particular, inadequate pre-planning can lead to misaligned goals and expectations, creating confusion among team members regarding their roles and responsibilities. Limited experience in change management can hinder leaders' ability to guide their teams through the complexities of adopting new methodologies, leading to resistance and frustration among employees. Furthermore, poor selection of candidates for training and Lean certification programs means that the individuals who are meant to champion and facilitate Lean practices may not possess the requisite skills or knowledge, thereby undermining the initiative's success (Halling et. al., 2013).

The failure to accurately estimate implementation costs can also present a significant barrier, as organizations may find themselves unprepared for the financial implications of rolling out Lean initiatives. Insufficient project team skills further compound these issues, as teams may lack the necessary expertise to effectively collaborate and execute Lean strategies.

Additionally, insufficient training for workers and lack of understanding of Lean concepts are significant barriers within the knowledge and skills category. Without adequate training, employees may struggle to grasp the principles underlying Lean construction and may be ill prepared to apply these concepts in practice. This lack of foundational knowledge can lead to resistance to change, as employees may be unsure of how Lean practices will affect their work or the organization as a whole (Albliwi et. al., 2014).

The interplay of inadequate knowledge and skills at both the worker and managerial levels creates a complex landscape that obstructs the implementation of Lean principles in organizations. Addressing these deficiencies is crucial for fostering a culture of continuous improvement and enhancing overall productivity within the construction industry and beyond. Organizations must prioritize comprehensive training and development programs, as well as effective leadership strategies, to ensure that all team members are equipped with the knowledge and skills necessary to succeed in a Lean environment.

2.8.2. Management Support

The prioritization of lack of commitment and support varies significantly across the current literature, reflecting the complexity of organizational dynamics and the implementation of Lean principles. This inconsistency suggests that the context and culture of different industries and regions play a crucial role in shaping perceptions of what constitutes the most pressing barriers to change.

Several studies underscore that insufficient commitment and support from management is a critical obstacle to effectively implementing Lean principles within organizations. For example, Shang et. al., (2014) conducted research in China's construction sector and highlighted the absence of a long-term philosophy as the foremost barrier to Lean implementation. These findings emphasize that without a sustained commitment to Lean thinking from leadership, organizations may struggle to adopt the principles necessary for optimizing processes and enhancing efficiency.

In the context of Libya, Omran et. al., (2015) further corroborated the importance of management support by ranking the lack of support, organizational culture, and commitment from, top management as the second, most significant barrier among seven identified challenges within the construction industry. This indicates a recognition that not only does management commitment matter, but also does the overall organizational culture, which can either facilitate or hinder the adoption of Lean principles.

Similarly, research conducted in the U.K. construction industry by Sarhan et. al., (2013) reached a comparable conclusion, placing lack of commitment from upper management as the second most significant barrier out of ten identified obstacles. This consistency across different geographical contexts reinforces the idea that strong leadership commitment is essential for fostering an environment conducive to Lean implementation.

Conversely, other studies present a different perspective. For instance, research in the Ugandan construction industry by Alinaitwe (2009) ranked the lack of leadership in management at the bottom of the prioritization list of barriers. This divergence suggests that in some contexts, other factors may be, viewed as more critical impediments to progress highlighting the need for a nuanced understanding of local conditions and challenges.

Furthermore, some studies opted not to prioritize barriers at all, indicating that the complexity of organizational change might not lend itself to straightforward categorization. This lack of prioritization can stem from varying methodologies or differing focuses within research, suggesting that a more holistic approach may be necessary to fully, understand the barriers organizations face.

Additionally, Bashir et. al., (2015) found that the lack of long-term forecasting and investment, which can be, interpreted as a proxy for insufficient management commitment and support, was ranked eighth out of eleven barriers. This finding highlights that while management support is crucial, its absence may not always be the foremost concern compared to other operational deficiencies or strategic misalignments that organizations face.

The literature presents a complex landscape regarding the prioritization of lack of commitment and support as a barrier to Lean implementation. The variance in findings across different studies underscores the importance of context, organizational culture, and the specific challenges faced by industries. Understanding these dynamics is essential for developing effective strategies to enhance management commitment and support, ultimately facilitating the successful implementation of Lean principles.

2.8.3. Cultural Attitudes

The literature highlights a pervasive resistance to change within organizations, a phenomenon documented by researchers such as Shang et al., (2014) and Abolhassani et al., (2016). This resistance is not merely a surface-level issue; rather, it is deeply rooted in the organizational culture and employee attitudes. As a result, they classified resistance to change as a significant cultural and attitudinal barrier that impedes progress and innovation.

Interestingly, various findings suggest that resistance from employees is cited more frequently than that from management. This discrepancy raises important questions about the dynamics of organizational change and the factors influencing employee attitudes. Among the primary contributors to this resistance are personal preferences, which often reflect individual values and experiences that may conflict with proposed changes. Additionally, the absence of cooperation and mutual trust between management and employees exacerbates this issue. When employees feel disconnected from leadership or perceive a lack of support and understanding from their managers, their willingness to embrace change diminishes significantly.

These cultural and attitudinal barriers are particularly evident in the implementation of Lean principles within the construction industry, as noted by Abolhassani et al., (2016). Lean methodologies require a fundamental shift in how work was approached, emphasizing efficiency, collaboration, and continuous improvement. However, when employees resist these changes due to entrenched personal preferences or a lack of confidence in management, the successful adoption of Lean principles becomes increasingly challenging. Thus, addressing these cultural and attitudinal barriers is crucial for fostering an environment conducive to change and enhancing the overall effectiveness of Lean implementation.

2.8.4. Technical Barriers

Bashir et al., (2015) and Albliwi et al., (2014) identified a critical barrier to Lean implementation in the U.K. construction industry: a lack of understanding regarding how to initiate the Lean process. This barrier highlights a significant challenge faced by organizations attempting to adopt Lean methodologies. Many stakeholders within the construction sector may be aware of Lean principles conceptually, but they often struggle with the practicalities of getting started. This gap in understanding can lead to hesitation and reluctance to engage with Lean practices, ultimately stalling progress and impeding successful implementation.

The Challenge of Getting Started

The initial phase of Lean implementation is crucial, as it sets the tone for the entire process. Organizations need a clear strategy that outlines the steps involved in adopting Lean practices. However, without adequate knowledge or guidance, stakeholders may feel overwhelmed by the complexities associated with Lean, leading to confusion and inaction. This lack of clarity can result from several factors:

Insufficient Training: Many organizations fail to provide comprehensive training for employees at all levels, which is vital for fostering understanding and buy-in. When workers are not adequately trained in Lean principles and tools, they may be unsure of how to apply them effectively.

Poor Communication: Effective communication is essential during the initial stages of Lean implementation. If management does not clearly articulate the goals, processes, and benefits of Lean, employees may remain uninformed or skeptical about the changes, leading to resistance.

Absence of Leadership Commitment: For Lean initiatives to succeed, strong support and commitment from leadership are necessary. When leaders lack a clear vision or understanding of Lean, it can create uncertainty among employees regarding the organization's direction and priorities.

Technical Barriers to Implementation

In addition to the foundational barrier of understanding how to get started, Bashir et al., (2015) and Rahbek et al., (2011) highlighted other technical barriers that hinder Lean implementation. One significant barrier identified was the slow pace of change within organizations, which was noted in both the U.K. construction industry and Denmark's public sector. This slow pace can be attributed to several interrelated factors:

Organizational Culture: Many organizations have established cultures that resist change, preferring to maintain the status quo. This resistance can manifest as reluctance to adopt new practices or skepticism about the benefits of Lean methodologies. When employees are accustomed to traditional ways of working, the prospect of change can be daunting, leading to inertia.

Complexity of Construction Projects: The construction industry is often characterized by complex projects with numerous stakeholders and interdependencies. This complexity can make it difficult to implement Lean principles uniformly across all aspects of a project, leading to fragmented efforts and slow progress.

Bureaucratic Processes: In public sector organizations, bureaucratic processes can further slow the pace of change. Rigorous regulatory requirements and lengthy approval processes can delay the implementation of Lean initiatives, hindering the ability to respond quickly to emerging challenges.

Resource Constraints: Implementing Lean practices often requires investment in training, tools, and technologies. In environments where resources are limited, organizations may struggle to allocate the necessary funds or personnel to support Lean initiatives. This lack of investment can stifle momentum and limit the effectiveness of implementation efforts.

2.9. Implications for Lean Implementation

The barriers identified by Bashir et. al., (2015) and Albliwi et al., (2014) have significant implications for organizations seeking to implement Lean in the construction industry. Addressing these barriers requires a multifaceted approach:

Enhanced Training Programs: Organizations should prioritize comprehensive training programs that equip employees with the knowledge and skills needed to understand and apply Lean principles effectively. This training should be tailored to different roles within the organization to ensure relevance and engagement.

Clear Communication Strategies: Management must develop clear communication strategies that articulate the goals and benefits of Lean implementation. Regular updates, workshops, and feedback sessions can help to foster a culture of transparency and collaboration.

Leadership Engagement: Strong commitment from leadership is essential for driving Lean initiatives forward. Leaders should actively participate in training and implementation efforts, demonstrating their support and commitment to the Lean philosophy.

Cultural Change Initiatives: Organizations may need to undertake cultural change initiatives that promote a mindset of continuous improvement and adaptability. Encouraging employee participation in decision-making processes and recognizing contributions can help to foster a more agile and receptive organizational culture.

Incremental Change: Given the complexities of construction projects and the slow pace of change, organizations may benefit from adopting an incremental approach to Lean implementation. By starting with small pilot projects, organizations can build momentum and demonstrate the value of Lean practices before scaling up to broader initiatives.

The barriers to Lean implementation identified by Bashir et. al., (2015) and Albliwi et. al., (2014) underscore the importance of addressing both foundational knowledge gaps and technical challenges. By adopting a strategic approach that encompasses training, communication, leadership commitment, and cultural change, organizations can enhance their capacity to implement Lean methodologies effectively, ultimately leading to improved efficiency and value creation within the construction industry.

2.10. Empirical Review of Previous Researches Papers

Tsion Assefa Zewde (2020) conducted a study aimed at assessing the level of Non-Value-Adding Activities (NVAA) and identifying their underlying causes through value stream mapping (VSM). The research seeks to improve labor productivity by applying Lean concepts and principles, integrating VSM with discrete event simulation (DES). Two case studies—slab rebar and HCB operations—were chosen, with data collected by observing the time taken for each sub-process and interviewing the personnel involved in the project. The VSM developed was utilized to analyze and quantify the NVAA within the operations and to suggest appropriate Lean concepts and principles. Following this, detailed DES models were created to represent the current state maps and to explore various optimization scenarios. The findings indicated that NVAA comprised 99.96% and 99.7% of the slab rebar and HCB operations, respectively.

Wondimagegn Gebeyehu Ganebo (2021) conducted a study to evaluate Lean Construction practices in building projects within Jimma City, employing a descriptive research approach. The findings revealed that Lean Construction practices in Jimma City include regular performance assessments of site workers, a focus on identifying client needs, prioritizing projects that require immediate attention, strict criteria for subcontractor selection, and involving project participants in schedule creation based on their RII values become highly implemented. Additionally, the study found that 50% of respondents had an average level of awareness regarding Lean Construction practices, while 46% indicated that the implementation of these practices in building projects was effective.

Susmy Michael and Sahimol Eldhose (2016) discuss that defects are prevalent in the construction of multi-storied buildings, emphasizing the need to identify these defects to improve quality in construction projects. The paper outlines effective methods for enhancing quality in construction processes and operations using the Six Sigma principle. It identifies several factors affecting construction quality, including scheduling delays, poor material quality, inadequate machinery, insufficient labor training, and lack of safety measures. The Sigma level for multi-storied residential buildings is calculated, revealing a success rate of 85-90% for construction activities. This indicates that to achieve a higher Sigma level, it is essential to reduce defects across all tasks involved.

Francisco Ribes Garcia (2014) explains that Six Sigma is a methodology primarily aimed at enhancing quality and time management in projects. The Six Sigma framework improves time, quality, and value management within these projects. In the construction industry, each building serves as a model for the IT sector, indicating that improvements in uptime and quality can be complex. This study aims to demonstrate that Six Sigma can effectively enhance time and quality management in building construction. According to Six Sigma principles, the objective is to identify defects in various areas. This approach helps reduce defects, minimize accidents, and decrease financial waste by focusing on quality management. The analysis concludes that Six Sigma can optimize and enhance both general and specific project timelines and quality.

Muharrem Firat Yilmaz (2014) Six Sigma offers significant advantages for improving methods essential for enhancing performance. Implementing Six Sigma principles does not require more time than traditional project timelines, unlike other process and quality improvement techniques. It provides both qualitative and quantitative approaches along with tools for process enhancement, allowing for performance measurement and subsequent improvement. The paper concludes that the methodology of Six Sigma can effectively boost both quality and quantity while also controlling the technical and financial success of projects. The researcher also notes that Six Sigma establishes a robust system for continuous data collection and operational techniques for measuring performance and processes. Integrating the Six Sigma framework with existing project management practices enhances the efficiency of both site and office departments.

Sunil V. Desale and Dr. S. V. Deodhar (2013) to achieve growth in the construction industry, ongoing efforts are essential. Such growth opportunities can be enhanced by adopting various management principles and tools from Lean and Six Sigma to minimize or eliminate waste. Delays are prevalent in construction, leading to high costs associated with quality. With increasing competition from both national and international construction companies, there is a growing need to implement Lean concepts. This paper highlights critical challenges faced by construction firms and examines the impact of Lean and Six Sigma methodologies within the Indian construction sector. While Lean Construction and Six Sigma principles have been successfully adopted in various countries, they have yet to be fully utilized in the construction industry. This paper focuses on the emerging concept of Lean Construction, which is grounded in fundamental management principles.

Mehmet Tolga Taner (2013), this paper highlights the significance of key success factors for successfully implementing six sigma in construction companies. The active participation and commitment of senior managers, along with quality initiatives involving suppliers and customers, are identified as crucial factors for success. Leadership and commitment from top management, along with cooperation from middle management, are also recognized as critical success factors for the effective initiation of Six Sigma. Additionally, a lack of knowledge about the implementation process is found to hinder its adoption. High levels of waste and excessive costs are identified as detrimental to the performance of construction firms. Six Sigma proves to be particularly beneficial for products with low defect rates and waste, leading to reduced costs and increased customer satisfaction.

2.11. Conceptual Framework

Based on relevant research on lean construction implementation factors that are considered as barriers as well as enablers (if they exercised properly), four factor were identified. These factors and their relationship to lean construction implementation have been discussed in the previously mentioned sections of this chapter. The four elements are project complexity, management support, training and education, and the cultural attitudes. Based on the above discussion the below conceptual frameworks developed and presented as follows.

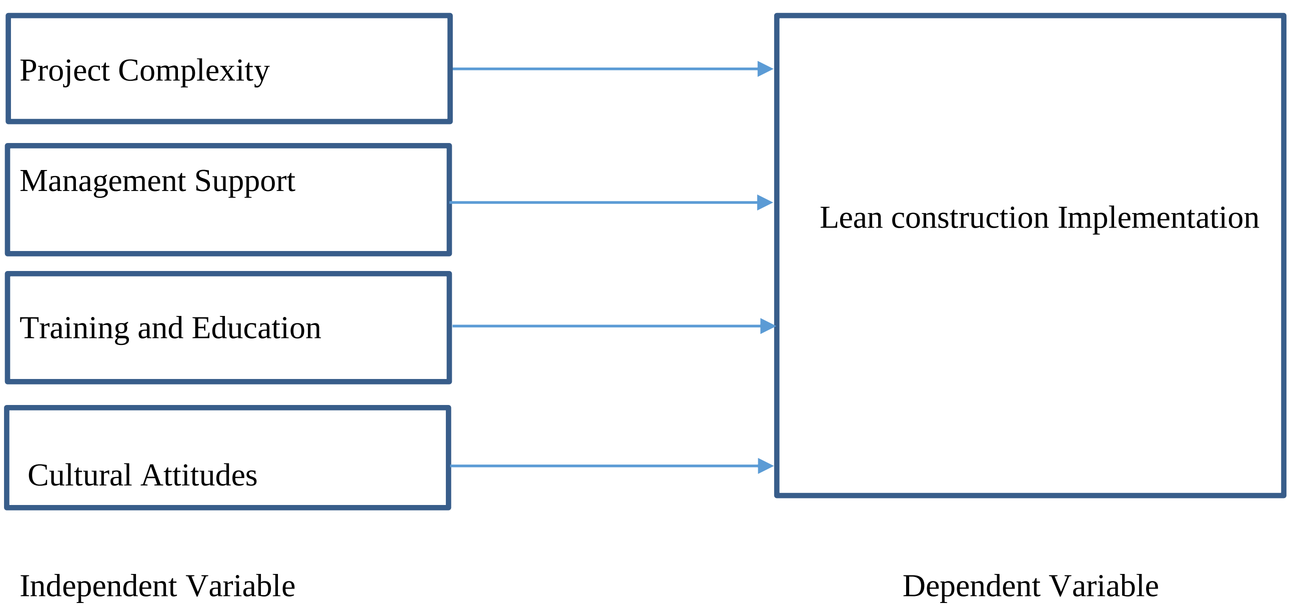


Figure 2.1: Conceptual Framework of Independent and Dependent variable relationship
Source: Researcher own developments based on the Literature Reviewed, 2024

HYPOTHESIS:

Hypothesis 1: Project Complexity has significantt effects on lean construction implementation.

Hypothesis 2: Management Support has significantt effects on lean construction implementation.

Hypothesis 3: Training and eeducation have significantt effects on lean construction implementation.

Hypothesis 4: Cultural Attitudes have significantt effects on lean construction implementation.

CHAPTER THREE

3. Research Design, Method and Methodology

3.1. Research Area

The research has been, conducted in Addis Ababa City, the capital of Ethiopia. Addis Ababa is chosen due to its rapid urbanization and significant number of ongoing construction projects, making it a suitable place for assessing Lean Construction practices. Addis Ababa, home to over 5 million residents, has become a hub of construction activity, hosting around 1,200 registered construction companies (Central Statistics Agency data, 2021). These companies range from small-scale contractors to large multinational firms, reflecting a diverse and competitive industry landscape. This dynamic environment makes Addis Ababa an ideal place to do case studies for assessing the implementation of Lean Construction procedure and their influence on project efficiency and quality amidst the city's burgeoning infrastructure development.

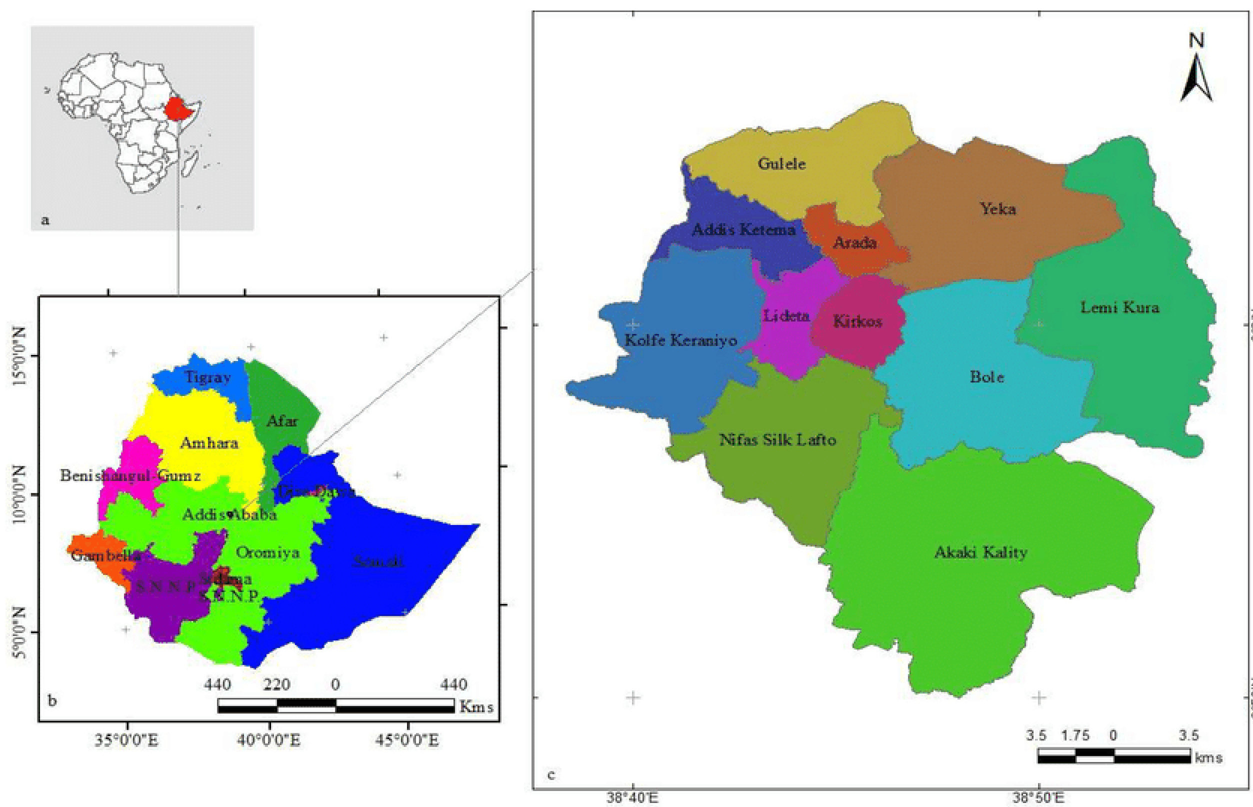


Figure 3. 1 Map of Addis Ababa, with Sub-Cities. Source: Ethio-GIS (2022)

3.2. Research Approach

The study adopts a quantitative research method to provide a comprehensive understanding of Lean Construction (LC) practices in Addis Ababa. This approach is selected for its ability to enhance the validity and reliability of the research findings, allowing for robust data collection and analysis.

Selection Criteria for Construction Companies

To ensure the relevance and capability of the selected construction companies, the following criteria have been established:

Currently Have Slight LC Experience:

Each of the selected companies has some level of experience with Lean Construction practices, especially on bar scheduling optimization and 5S methods. This criterion is vital because it ensures that the companies are not starting from scratch; they possess foundational knowledge that can be built upon. This experience allows for a more nuanced understanding of how LC principles can be effectively integrated into their operations, facilitating a smoother transition and implementation of advanced methodologies.

Currently Active and Operational:

All four companies Ayat Real Estate and Construction Plc, Jambo Real estate and Construction Plc, Flintstones Homes and Gift Real Estate and Construction Plc are actively engaged in ongoing construction projects. Their operational status is crucial for the study, as it demonstrates their relevance in the industry. This active engagement provides the researchers with real-time insights into the challenges and successes these companies face while implementing LC practices, making the findings more applicable and timely.

Private and Locally Owned Companies:

The selected companies are privately owned and operated within Ethiopia. This local ownership ensures that they have a deep understanding of the market dynamics, regulatory landscape, and client needs specific to Addis Ababa. Such insights are essential for the effective execution of construction projects, as they can tailor their LC practices to better suit local conditions and expectations, thereby enhancing project success rates.

Corporate Form of Business Organization:

Each company operates as a corporate entity, which typically entails a structured organizational hierarchy, formalized processes, and established corporate governance practices. This corporate structure often correlates with higher reliability and professionalism, particularly in managing large-scale projects. The presence of defined roles and responsibilities within these companies can facilitate more effective communication and decision-making processes, which are critical when implementing Lean methodologies.

Vast Number of Projects:

Ayat, Jambo, Gift, and Flintstone Homes boast a substantial portfolio of completed and ongoing projects. This extensive experience not only demonstrates their capability but also allows them to draw valuable insights and proven methodologies from their past work. The breadth of their project experience increases the likelihood of successful outcomes when adopting new practices, as they can leverage lessons learned from previous challenges and successes.

Years of Experience:

Each of the selected companies has over 20 years of experience in the construction industry. This long standing presence indicates a track record of sustained performance and resilience in overcoming various industry challenges. Their experience positions them to adapt effectively to evolving market demands and to implement LC practices that can lead to increased efficiency, reduced waste, and enhanced project delivery times.

By selecting companies that meet these criteria, the study aims to gather rich, relevant data that can contribute to a deeper understanding of Lean Construction practices in the context of Addis Ababa's building construction projects. This focused approach will help to identify both the benefits and challenges associated with LC implementation, ultimately providing actionable insights for practitioners in the field.

3.3. Study Companies Background and Profiles

Gift Real Estate and Gift Construction plc

Background: Gift has been a key player in the construction and real estate sectors for over 25 years. The company has diversified its operations to include trading in various building materials and services.

Profile:

- Years of Experience: 25+ years
- Number of Employees: Approximately 250, out of which 95 are in construction and real estate developments
- Projects: Gift has successfully completed numerous residential and commercial projects, including luxury apartments, office buildings, and shopping centers.

Ayat Real Estate

Background: Ayat real Estate has been operating in the construction and real estate market for over 25 years, Ayat specializes in real estate development and construction. It has built a strong reputation for delivering high-quality residential and commercial properties.

Profile:

- Years of Experience: 25+ years
- Number of Employees: Around 250, out of which 95 are in construction and real estate developments
- Projects: Notable projects include large residential complexes, mixed-use developments, and commercial buildings.

Jambo Construction Plc and Jambo Real Estate Plc

Background: Jambo has been operating in the construction and real estate market for over 20 years. The company has expanded its services to include trading in construction materials and supplies.

Profile:

- Years of Experience: 20+ years
- Number of Employees: Approximately 150, out of which 55 are in construction and real estate developments
- Projects: Jambo has worked on various projects, including hotels, residential developments, and infrastructure projects.

Flintstone Homes

Background: Flintstone Share Company has been involved in the construction and real estate sector for over 20 years. The company also engages in trading construction materials, contributing to local building projects.

Profile:

- Years of Experience: 20+ years
- Number of Employees: About 125, out of which 50 are in construction and real estate developments
- Projects: The Company has completed several residential and commercial projects, focusing on innovative building solutions.

3.4. Research Design

The research design for investigating determinants of Lean Construction project practices in Addis Ababa was descriptive and explanatory, aligning with the complexities of the construction industry in the city. This approach is supported by literature emphasizing the determinants of Lean

Construction principles, techniques, and implementation in diverse contexts (Ssali et. al., 2016). Data collection methods include documents review and questionnaire surveys, supported by site observations to supplement the data collection process.

The research strategies employed were quantitative (Likert scale) and case study. The quantitative approach was utilized to gather factual data and study relationships between facts, theories, and previous research findings. This approach will involve statistical analysis of survey responses, providing quantitative insights into the adoption and influence of Lean Construction procedures located in Addis Ababa's building construction. Furthermore, the study deployed case study using 5S Methods for the purpose of triangulation, since the document analysis have been carried out from articles, published journals and other scholarly works as secondary source of data.

5S Methods background

The 5s methodology, which originates in Japan, aims to enhance the efficiency of shared workspaces by integrating routine tasks like cleaning, sorting, and rearranging the workspace and its surroundings. It was first created to improve housekeeping. However, these days, it's used to maintain a better workplace. It consists of five steps that must be followed in order. It offers a fundamental framework for any organization's lean imitation program for ongoing development.

The Below listed Japanese terms collectively are called 5S.

1st S – Seiri – Meaning **"Sort"**

2nd S – Seiton – Meaning **"Set In Order"**

3rd S – Seiso – Meaning **"Shine"**

4th S – Seiketsu – Meaning **"Standardize"**

5th S – Shitsukae – Meaning **"Sustain"**

5S is not a system or program that can be started and completed. It is continuous improvement process that provides a never ending methodology to continuously improve your operation. It has proven to work in any business, every sector, all industries, in any country and has been instrumental in changing the culture of organizations.

3.5. Study Variables

❖ Dependent Variable

- Lean construction implementations

The dependent variable in this research paper is the implementation of Lean Construction, which includes a collection of principles and techniques designed to maximize value while minimizing waste in construction projects. The successful implementation of Lean Construction practices hinges on a variety of determinants that influence how effectively these principles can be integrated into building projects. Understanding these factors is crucial for optimizing value and minimizing waste throughout the construction process.

❖ Independent Variables

- Project Complexity

Project complexity in building construction is influenced by several factors, including stakeholder diversity, interdependencies among tasks, and technical challenges. Multiple stakeholders, such as homeowners, architects, and contractors, have varying expectations that complicate decision-making and can lead to delays and increased costs, making lean implementation difficult. The interrelated nature of construction tasks means that delays in one area can impact the entire project, complicating scheduling and resource allocation. Additionally, unique architectural designs and specialized materials present technical challenges that require careful planning to ensure compliance with building codes. While lean methods aim to streamline processes and reduce waste, the inherent complexity of residential projects can hinder their effective application.

- Management Support

Management support is essential for successfully implementing Lean Construction practices in building construction projects. This support manifests through effective budget allocation for Lean initiatives, such as funding software that enhances project tracking and communication. Active participation in training sessions by management emphasizes the importance of Lean principles, empowering project managers to advocate for these methods within their teams. Additionally, fostering open communication about Lean objectives creates an environment where employees feel comfortable discussing challenges and proposing improvements, ultimately leading to higher engagement and more effective implementation of Lean practices.

- Training and Education

Training and education are vital for equipping the workforce with the necessary knowledge and skills for effective Lean Construction implementation. Comprehensive training programs focused on Lean methodologies enable workers to understand and apply concepts such as 5S method, which helps identify waste and improve workflows in building construction projects. Continuous learning through regular professional development ensures employees stay updated on the latest Lean practices, fostering engagement and better project outcomes. Moreover, empowering the workforce by educating them on Lean principles encourages employees to take ownership of their roles, leading to the identification of inefficiencies and the proposal of innovative solutions that enhance project success.

- Cultural Attitudes

Cultural attitudes within an organization significantly influence the acceptance and effectiveness of Lean Construction practices. Resistance to change often arises from skepticism towards new methodologies and a preference for traditional practices, which can hinder implementation and reduce the effectiveness of Lean initiatives. Employees may also fear the unknown; apprehensive about how new practices might impact their job security and roles, leading to reluctance in embracing change. To address these challenges, promoting a culture that values continuous improvement and open-mindedness is essential; encouraging team members to share their experiences and successes with Lean practices can alleviate fears and foster a supportive environment. Recognizing and celebrating achievements from Lean initiatives further reinforces positive attitudes towards change, facilitating a smoother adoption of new methodologies.

3.6. Study Population

The intended participants of this research were limited to Building Construction Projects in Addis Ababa; four selected building construction companies, Ayat, Jambo, Gift and Flintstones homes.

3.6.1. Sample Size and Sampling Procedure

In order to guarantee the accuracy and economy of the research findings, sampling was introduced. The four chosen building construction businesses' workings on building construction projects in Addis Ababa were the study's respondents.

The sampling method for this study was a non-probability sampling methods. The sampling technique employed was purposive sampling. Purposively picked engineers and professionals other than clerical employee of Ayat, Gift, Jambo and Flintstone were those that are actively working on building construction projects in Addis Ababa.

The sample size for this study was determined based on the objectives and feasibility of data collection. 170 questionnaires were distributed to the respondents in the study and 160 questionnaires were returned that is 95% of return rates, which is acceptable, comprising from each 50 respondents were considered and distributed to Ayat Real Estate and Gift Real Estate, while from each 35 respondents were considered and distributed to Jambo Real Estate and Flintstone homes. The selection of respondents was based on their involvement in ongoing building construction projects in Addis Ababa. Overall, the sampling procedure aims to select a representative sample based on the above listed criteria, which encompass Slight LC experience, Currently Active and Operational, Private and Locally Owned, Corporate Form of Business Organization, Vast Number of Projects, Years of Experience in building construction projects in Addis Ababa, allowing for comprehensive data collection and analysis to address the research objectives effectively.

3.6.2. Sample Size Determination

To prevent distortion of the output, the sample that needs to be taken needs to be manageable. Consequently, in order to reduce the risk of the aforementioned, the proper formula must be used. As a result, Yamane's (1967) formula, which offers a simplified technique to compute the sample size, was employed by the study to establish the sample size. This calculation is predicated on a desired precision level of 5% and a desired confidence level of 95%.

$$n = \frac{N}{1+N(e^2)}$$

n = Sample size

N = Target audience = 295 in Ayat, Gift, Jambo and Flintstone homes working in Addis Ababa

e = an error = 5%

Then

$n = \frac{295}{1+295(0.05^2)}$, n = 169.78 ≈ 170, Engineering professional and non-clerical workers, to make proportional for each

Therefore, the study has taken 170 samples in the study area; out of it, 160 were returned.

3.7. Sources of Data

This research paper utilized primary and secondary sources of data. Observations, case study and structured questionnaires were all used to gather primary data. Books, journals, research reports, and other published and unpublished sources were the sources from which secondary data were gathered and analyzed.

3.8. Method of Data Collection

In this study, quantitative methods were utilized to analyze data systematically. Data collection was conducted through structured questionnaires employing Likert scales, designed to measure the attitudes and perceptions of respondents regarding various aspects of building construction practices. The target population for this research consisted of engineering professionals actively engaged in construction projects within four selected building companies in Addis Ababa. Questionnaires were strategically distributed across different project sites throughout the city to ensure a diverse sample and comprehensive insights.

In addition to the questionnaires, case study data collection sheets were employed to focus on specific construction activities, namely Hollow Concrete Block (HCB) and plastering works. These sheets were used to document the implementation of Lean methodologies, particularly the 5S system, which emphasizes organization and efficiency in the workplace. By combining questionnaire responses with detailed case study analyses, the study aimed to provide a robust quantitative framework for evaluating the effectiveness of Lean Construction practices in the targeted projects, facilitating a deeper understanding of their impact on productivity and cost within the building construction projects of the selected companies.

3.9. Data Analysis

Data collected through the structured questionnaires were systematically organized, tabulated, analyzed, and interpreted using appropriate statistical methods, specifically employing SPSS-27 software. This statistical tool facilitated a comprehensive analysis of the data, allowing for the application of various statistical techniques to derive meaningful insights. The results of the analysis were effectively displayed through tables, graphs, and charts, complemented by basic percentages, which enhanced the clarity of the findings and supported further interpretation.

In addition to the quantitative analysis, a case study was conducted to assess the cost implications of implementing the 5S methods derived from Lean Construction (LC) principles. This case study involved a comparative analysis between the costs associated with 5S implementation and those of conventional construction methods utilized in the selected projects. The results of this case study were meticulously tabulated and presented in both percentage and numerical formats, providing a clear and concise comparison of the cost efficiencies of the two methodologies.

Furthermore, a document analysis was conducted to include insights from relevant articles, published journals, and other scholarly works. This secondary data collection served a triangulation purpose, enriching the study by providing additional context and corroborating evidence to support the primary findings. By integrating qualitative insights from secondary sources with the quantitative data from the questionnaires and the case study, the research achieved a more comprehensive understanding of the impact of the determinants on Lean Construction practices. This multifaceted approach underlines the importance of employing diverse methodologies to enhance the reliability and validity of research outcomes in the construction industry.

3.10. Model and Variable Specification

For analyzing the dependent and independent variables in the study, multiple linear regression models were employed. The model can be expressed as follows:

$$Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e$$

Where:

e = the error term

a = Coefficient of intercept (Constant)

$\beta_1 \ldots \beta_4$ = the regression coefficients representing the change in Y relative to a one-unit change in $X_1 \ldots X_4$, respectively.

Y=dependent variable (Lean construction implementation)

X_1 = Project Complexity

X_2 = Management Support

X_3 = Training and Education

X_4 = Cultural Attitudes

3.11. Reliability and Validity

3.11.1. Reliability

Reliability refers to a measure of the degree to which research instruments yield consistent results (Tavakol and Dennick, 2011). In this study, reliability was ascertained by pre-testing the questionnaire with a selected sample of employees from the concerned company. Recommenndation of different scholars regarding the acceptable Cronbach's alpha is 0.70 and above, thus in this study also the same limit is considered (and satisfied) for the questionnaire survey reliability which output from SPSS Version 27.0 is shown in Table 3.1.

Table 3.1 Reliability Test result of Cronbach's Alpha

	Reliability Statistics	
Variables	Cronbach's Alpha	N of Items
Project Complexity	0.766	6
Management Support	0.766	6
Training & Education	0.770	5
Cultural Attitudes	0.781	6
Lean Construction Implementation	0.778	6
Overall Items	0.958	29

Source: Own Survey, (2024)

3.11.2. Validity

The accuracy of data collected largely depended on the data collection instruments in terms of validity. Validity as noted by Robinson (2002) is the degree to which result obtained from the analysis of the data actually represents the phenomenon under study. Validity was ascertained by having all the objective questions included in the questionnaire.

3.12. Ethical Considerations

The researcher ensured that all ethical guidelines and principles are strictly adhered to throughout the study. Participants in the research project were given comprehensive information about the objective and procedure of the study. Before involvement in the research, informed consent was obtained from all participants. Only those individuals and organizations who voluntarily agree to participate were approached. To maintain the integrity of the research findings, the researcher was upholding a commitment to honesty and transparency. Data were accurately collected and reported without any manipulation or distortion to support predetermined conclusions. Additionally, measures were taken to safeguard the privacy and confidentiality of participants' information. Throughout the research process, every effort was made to ensure that participants are not subjected to any physical or psychological harm.

CHAPTER FOUR

4. Findings Presentation, Discussions and Interpretation

This section presents the findings and discussion derived from a comprehensive study assessing Lean Construction Practices in specific building construction projects within Addis Ababa City. The study incorporated perspectives from contractors and consultants involved in various projects, guided by the research objectives and scope. Data collection utilized structured questionnaires, case study data sheet and site observation to evaluate determinant factors of LC implementation, across the case building construction projects in Addis Ababa City.

4.1. Personal and Organizational Profile of Respondent

4.1.1. Four Selected Construction Companies for this Study

Table 4. 1 Four Selected Construction Companies

Selected Companies in Addis Ababa	No. Questionnaires distributed Respondents	Each Companies shares out of 170 in %	No. Questionnaires Returned	Returned Rate out of each share in %	Variance
AYAT Real Estate	50	29.4	48	28.24	1.18
GIFT Real estate and Gift construction plc	50	29.4	50	29.41	0.00
JAMBO construction plc and Jambo real-estate plc	35	20.6	32	18.82	1.76
FLINTSTONE Homes	35	20.6	30	17.65	2.94
Total	170	100.0	160	94.12	5.88

Source: Own Survey, (2024)

Table 4.1 presents data on the selection of four building construction companies in Addis Ababa: Ayat, Gift, Jambo and Flintstone Homes. Ayat and Gift has an equal distribution of 50 employees, while Jambo and Flintstone have an equal distribution of 40 employees. The total across all four building construction companies are 170 respondents as cumulative participants. Ayat and Gift each accounts for 29.4 % of the total participants, while Jambo and Flintstone each accounts for 20.6 %.

4.1.2. Respondent Background Data Presentation

This section aims to provide comprehensive details about the survey respondents, encompassing their level of Education, their current position in the company, their experience and exposure of the individuals involved in this study.

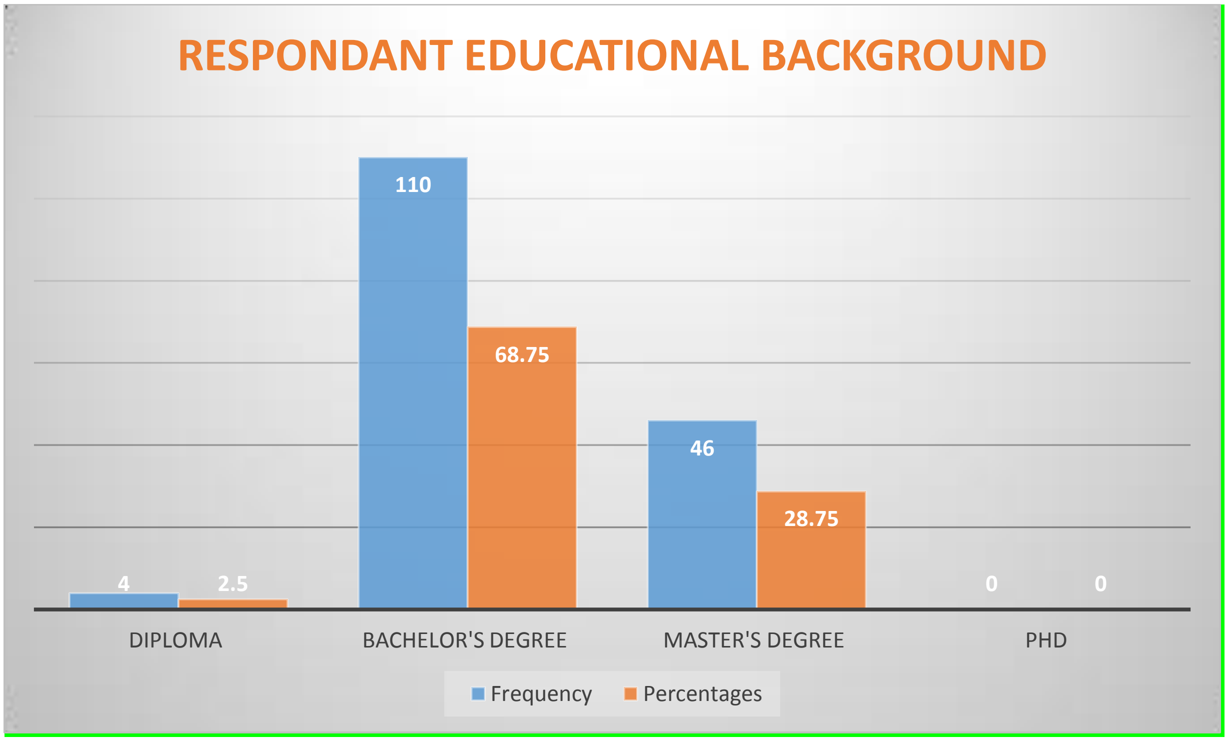
4.1.2.1. Respondent's Level of Education

Tigure 4.1 shows the educational levels of the respondents. Among the 160 participants, 46 (28.75%) hold a Master's degree, 110 (68.75%) have a BSc. degree, and 4 (2.5 %) possess a Diploma. The valid percentages align with the overall percentages since there are no missing data. The cumulative percentages indicate that by adding the PhD holders, the cumulative percent reaches 100%, showing that the majority of the respondents have a BSc. degree, followed by those with a Master's degree. This shows that the respondents' education level strongly supports to identify the Lean Construction implementation challenges that hinders not to implements on Building Construction Projects based on this study's objectives.

Table 4.2 Respondents Educational Background

Respondent Educational Background	Frequency	Percentages
Diploma	4	2.5
Bachelor's Degree	110	68.75
Master's Degree	46	28.75
PhD	0	0
Total Respondents	**160**	**100**

Source: Own Survey, (2024)



Source: Own Survey, (2024)

Figure 4. 1: Respondent's Level of Education

4.1.2.2. Respondents Current Job Position in the Companies

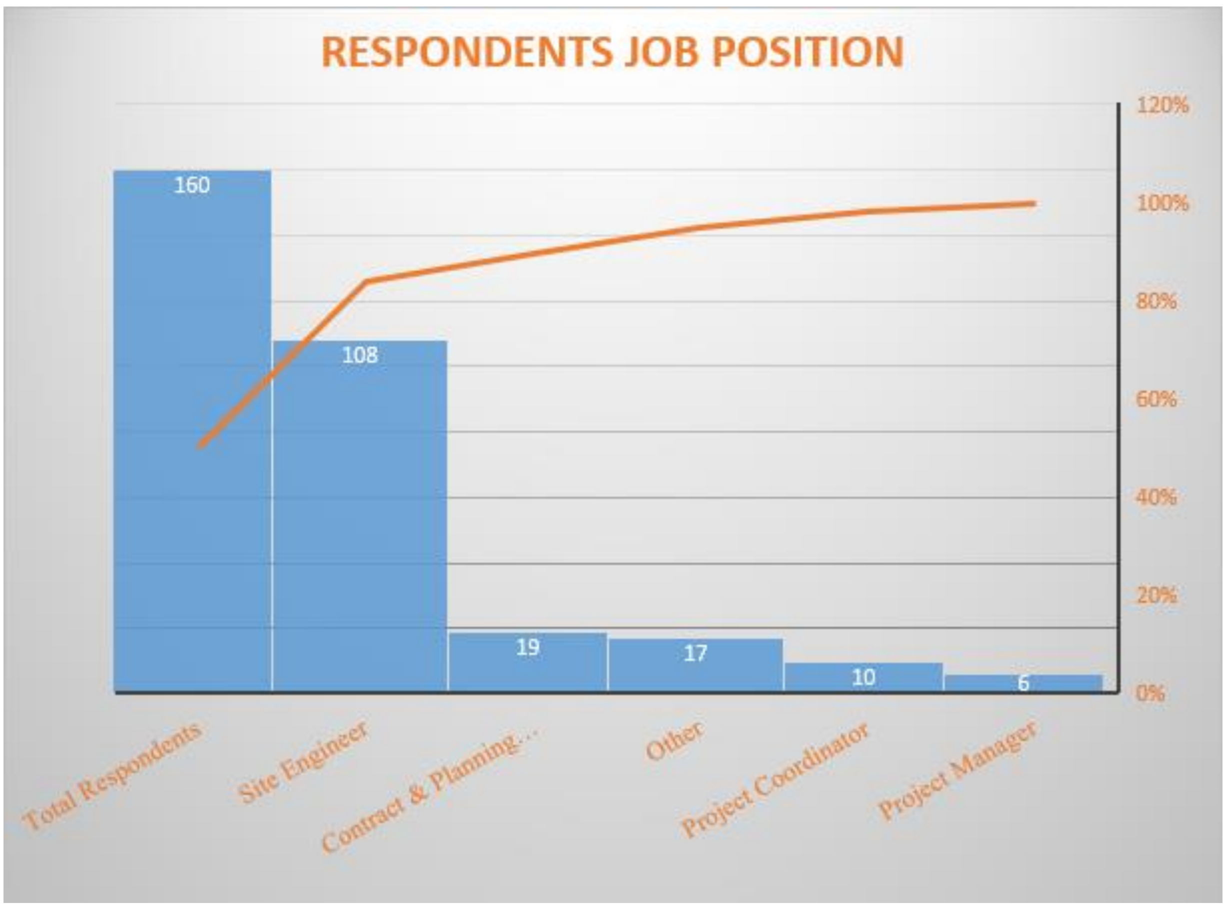
Figure 4.2 outlines the positions held by respondents, revealing a diverse range of roles within the companies. The majority of respondents, 108 individuals (65.56%), are Site Engineers, indicating that most insights on Lean Construction Practices come from those directly involved in technical and operational aspects of projects. Resident Engineers constitute 13.3% (12 respondents), providing perspectives from on-site supervisory roles. Project Managers make up 10% (9 respondents), offering strategic and management viewpoints crucial for understanding the implementation of Lean practices. Contract Administration personnel, representing 6.7% (6 respondents), contribute insights into the legal and contractual aspects of construction projects. Finally, 4.4% (4 respondents) fall into the 'others' category, adding a diverse range of expertise.

This varied representation helps comprehensively assess Lean Construction Practices on building projects, aligning with the study's objectives.

Table 4. 3 Respondents Job Positions

Respondent Job Position in the Company	Frequency	Percentages
Project Manager	6	3.75
Project Coordinator	10	6.25
Contract & Planning Engineer	19	11.875
Site Engineer	108	67.5
Other	17	10.625
Total Respondents	**160**	**100**

Source: Own Survey, (2024)



Source: Own Survey, (2024)

Figure 4.2: Respondents Current Job Position in the Companies

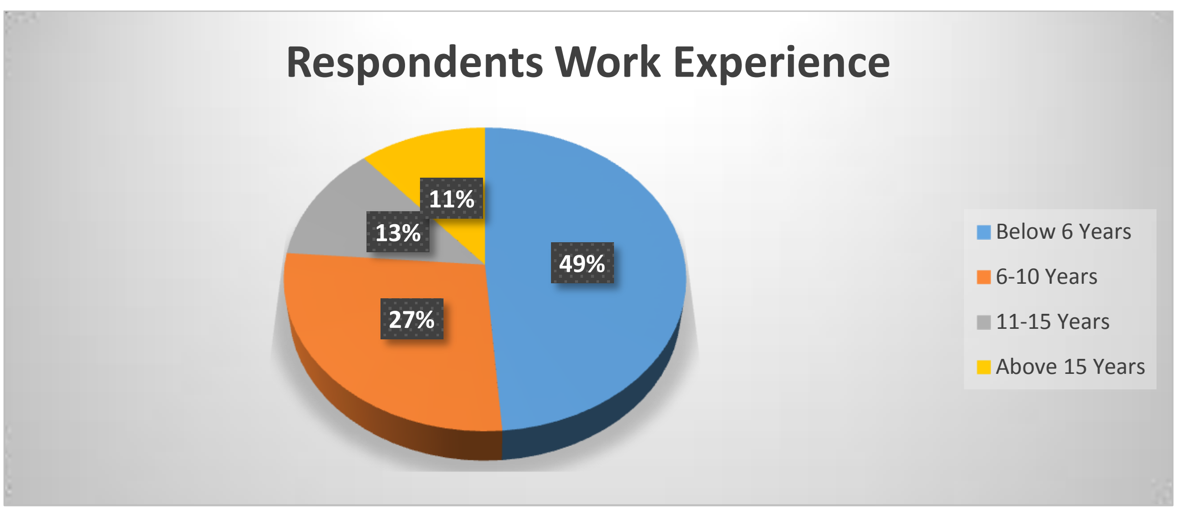
4.1.2.3. Respondent Work Experience

The table shows the distribution of respondents' service years, indicating their experience levels in implementing Lean Construction Practices on building projects. Nearly half (49%) have less than 6 years of experience, suggesting that a significant portion of the workforce is relatively new and may require additional training and support to fully adopt Lean methodologies. Those with 6-10 years of experience make up 27%, indicating a moderate level of practical exposure. More seasoned professionals with 11-15 years, (12.6%) and above 15 years (11.35%) of experience are fewer, highlighting a potential gap in experienced leadership to drive lean practices.

Table 4.4 Respondent's work experience in the companies

Respondent's work experience	Frequency	Percent
Below 6 Years	78	49
6-10 Years	44	27.15
11-15 Years	20	12.6
Above 15 Years	18	11.35
Total	**160**	**100**

Source: Own Survey, (2024)



Source: Own Survey, (2024)

Figure 4.3: Respondents work experience in the Companies

4.2. Determinants of LC Implementation in Study Companies' Building Projects

4.2.1. Descriptive Analysis of Determinants of LC Implementation

A basic statistical technique for summarizing and describing the key features of a data set is descriptive analysis. A clear picture of the data is presented through a variety of metrics and visualizations, making it easier to understand and communicate the results. In our case, this is especially true when using mean and standard deviation. Before conducting more complex inferential analysis, this type of analysis is often the initial phase of data exploration. Descriptive analysis is important because it can give stakeholders a comprehensive picture of the data and enable them to make smart decisions. Analysts can identify patterns, trends, and anomalies that may require further research by understanding the fundamentals of a data set. In summary, descriptive analysis is an essential data analysis tool that creates the foundation for deeper insights. Effective data aggregation and visualization enables researchers and decision makers to understand complex information quickly and accurately.

4.2.1.1. Descriptive Analysis for Project Complexity

Table 4.5 Project Complexity Data Analysis

Descriptive Statistics			
Indicators	N	Mean	SD
The overall complexity of this project negatively affects lean construction implementation.	160	4.49	0.502
The involvement of many different stakeholders complicates lean construction implementation.	160	4.42	0.640
The involvement of multiple disciplines affects the success of lean construction implementation.	160	4.33	0.814
Unforeseen circumstances frequently hinder lean construction implementation.	160	4.49	0.502
Frequent changes in project design disrupt lean construction implementation.	160	4.54	0.500
Complexity significantly affects project timelines in relation to lean construction implementation.	160	4.49	0.502
Valid N (listwise)	160		

Source: Own Survey, (2024)

Table 4.5 shows an overview of the average values of the individual elements in the "project complexity" area. From the above it can be deduced that an agreement exists for most article registries. Therefore, we can conclude that project complexity, as one of the factors of lean construction implementation in building construction projects, plays a crucial role in its implementation. Project complexity in building construction refers to the intricacies associated with various dimensions, including the number of stakeholders, interdependencies, and the technical challenges involved. According to Geraldi et. al., (2011), complexity can be categorized into structural, temporal, and procedural dimensions.

4.2.1.2. Descriptive Analysis for Management Support

Table 4.6 Management Support Data Analysis

Descriptive Statistics			
Indicators	N	Mean	Std. Deviation
There is no dedicated budget for lean initiatives, which undermines effective implementation.	160	4.49	0.502
Management is not committed to continuous improvement, which detracts from lean construction implementation.	160	4.42	0.640
Upper management is lack support practice of lean initiatives, which negatively affects implementation.	160	4.33	0.814
Top management considered lean construction implementation is very expensive	160	4.49	0.502
Management conceives the lean construction implementation is too technical to implements.	160	4.54	0.500
Management seldom communicates about lean objectives, hindering implementation efforts.	160	4.49	0.502
Valid N (listwise)	160		

Source: Own Survey, (2024)

Using the statistics from Table 4.6, the researcher can conclude from the mean values that all of the items listed under the management support indicators met with agreement. Therefore, we can say that management supports as a factor of lean construction implementation in building construction companies has a great influence on the sector involved, so they should work on it to increase their company acceptance. Therefore, any company searching in the industry should pay special attention to the intended factor as it plays a very important role in the companies' efficiency and effectiveness. Shang et. al., (2014) stated this on his surveyed 22 barriers to implementing Lean in construction in China, out of them the top five barriers found by Shang et. al., (2014) were lack of long-term philosophy, absence of a Lean culture in the organization, multi-layer subcontracting, insufficient management skills and lack of support from top management. In addition, lack of top management commitment was ranked second of the 10 barriers found to implementing Lean Construction in the U.K construction industry (Sarhan et. al., 2013).

4.2.1.3. Descriptive Analysis for Training and Education

Table 4.7 Training and Education Data Analysis

Descriptive Statistics			
Indicators	N	Mean	Std. Deviation
I have no received formal training in lean construction principles, which aids implementation.	160	4.49	0.502
My organization does not conducts training sessions on lean methodologies that support effective implementation.	160	4.42	0.640
I do not feel adequately trained to implement lean practices in my work.	160	4.33	0.814
There is no ongoing training is provided for new team members that facilitating their lean construction implementation.	160	4.49	0.502
I would like more training on lean methodologies to enhance my implementation skills.	160	4.49	0.502
Valid N (listwise)	160		

Source: Own Survey, (2024)

Table 4.7 shows a picture of the mean values of the individual items under training and education. From the above, it can be said that there is an agreement for most item registries. Therefore, we can conclude that training and education, as one of the factors of the lean construction implementation. Alinaitwe (2009) believed that lack of knowledge and skills was a barrier to teamwork and concurrent engineering, both of which were considered key concepts of Lean construction. Lack of knowledge of implementation could also pose technical issues to the construction supply chain by creating uncertainty of workflow reliability, which will subsequently affect the application of the LC. Albliwi et. al., (2014) also found that failure to engage people in meaningful learning experiences was the primary barrier to implementation of Lean methods. Practicing Lean methods will be in vogue if the experiences are equipped with sustained efforts to engage people in meaningful learning experiences (Albliwi et al., 2014).

4.2.1.4. Descriptive Analysis for Cultural Attitudes

Table 4.8 Cultural Attitudes Data Analysis

Descriptive Statistics			
Indicators	N	Mean	Std. Deviation
There is no established process for implementing employee suggestions, which hinders lean construction.	160	4.42	0.640
Team members rarely express concerns about current practices, which can negatively affect lean construction implementation.	160	4.33	0.814
The organizational culture is resistant to change, obstructing lean construction implementation.	160	4.49	0.502
My organization is not open to adopting new practices that enhance lean construction implementation.	160	4.54	0.500
Team members feel discouraged from suggesting improvements that would support lean construction implementation.	160	4.49	0.502
Lean principles are seldom discussed in team meetings, undermining their importance for implementation.	160	4.42	0.640
Valid N (listwise)	160		

Source: Own Survey, (2024)

From the data of Table 4.8 the researcher can conclude from the mean figures that all of the items put up under cultural attitudes attracted an agreement. Therefore, we can say the cultural attitudes as a factor of building construction projects LC implementation for construction companies. Personal preferences and lack of cooperation and mutual trust between management and employees were among the cultural and attitudinal barriers to implementing Lean principles in building construction (Abolhassani et. al., 2016).

4.2.1.5. Descriptive Analysis for Lean Construction Implementation

Table 4.9 Lean Construction Implementation Data Analysis

Descriptive Statistics			
Indicators	N	Mean	Std. Deviation
Material waste is a significant issue in our construction projects, which requires LC implementation.	160	4.33	.814
I believe that reducing material waste is essential for successful lean construction implementation.	160	4.49	.502
I believe that implementing lean construction practices helps to significantly reduce waste on projects.	160	4.54	.500
I feel that better planning could significantly reduce material waste on our projects, as LC do.	160	4.49	.502
Time waste is a prevalent issue in our construction projects that require LC implementations.	160	4.39	.709
I believe that better communication could reduce waste on our teams, which can be achieved through implementing LC.	160	4.49	.502
Valid N (listwise)	160		

Source: Own Survey, (2024)

Similarly like other variables, the lean construction implementation also has high agreement with above 4.0 mean values. Therefore, if any company wants to invest in LC implementation it is the first step to deal with the above mentioned variable and can be a stepping stone for other factors that are not taken into account in this study. This is evident from the table above, which shows that respondents indicated that building construction companies' factors have the highest mean value and very good standard deviation. Therefore, the selected factors are crucial for the building construction companies to maximize their return on investment by achieving the best competitiveness from its investment.

4.2.2. Inferential Analysis of Determinants of LC Implementation

A statistical technique called inferential analysis is used to make inferences about a population from a sample of data. It includes methods such as regression analysis, correlation and hypothesis testing. The main goal is to make conclusions or inferring about a broader population, allowing researchers to assess correlations and test hypotheses while accounting for data variability and uncertainty.

4.2.2.1. Correlation Analysis of Determinants of LC Implementation

According to Field (2005), a correlation coefficient is a very useful way to summarize the relationship between two variables into a single number ranging from -1 to +1. To examine the relationships between the variables in this study, correlation analysis was performed for each variable using the Pearson correlation coefficient (r). Field's (2005) guidelines were used to interpret the strength of relationships between variables, primarily because they were simple. According to its classification, the correlation efficiency (r) is weak between 0.1 and 0.30, moderate between 0.3 and 0.50, and strong > 0.5. Regarding the correlation between the variables, Table 4.10 makes it clear that this is the case for each Variables the case is significantly correlated at a significant level of $p<0.01$ when numbers with the symbol (**) are included. The relationship between the four aspects of independent variable and lean construction implementation has shown in Table 4.10 below

Table 4.10 Correlation Data Analysis for all variables

Correlations						
		Project Complexity-1	Management Support-2	Training and Education-3	Cultural Attitudes-4	Lean Construction Implementation-5
1. Project Complexity	Pearson Correlation	1	0.762**	0.704**	0.843**	0.659**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	160	160	160	160	160
2. Management Support	Pearson Correlation	0.762**	1	0.631**	0.515**	0.705**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	160	160	160	160	160
3. Training and Education	Pearson Correlation	0.704**	0.631**	1	0.586**	0.719**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	160	160	160	160	160
4. Cultural Attitudes	Pearson Correlation	0.843**	0.515**	0.586**	1	0.684**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	160	160	160	160	160
5. Lean Construction Implementation	Pearson Correlation	0.659**	0.705**	0.719**	0.684**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	160	160	160	160	160
**. Correlation is significant at the 0.01 level (2-tailed).						

Source: Own Survey, (2024)

According to Table 4.10, all four independent variable(Project Complexity, Management Support, Training and Education and Cultural Attitudes in this case) had a positive association with lean construction implementation ranging from 0.659 to 0.719, and all coefficients were significant at the p<0.01 level. Furthermore, the table shows that the strongest positive relationship is with training and education 0.719, followed by management support, which stand second with the value of 0.705. Cultural attitudes and project complexity had the third and fourth positive relationships, with correlation coefficients of 0.684 and 0.659, respectively.

4.2.2.2. Assumption Test for Regression Analysis

4.2.2.2.1. Normality Distribution Assumption Test

According to Matt N, Carlos A and Deson K (2013), the distribution of errors (or conversely the conditional distribution of the response variable) for any given combination of values on the predictor variables is formally subject to this assumption. By examining the degree of skewness and kurtosis, one can determine whether a distribution is normal. The values for asymmetry and kurtosis between -2 and +2 are considered acceptable in order to prove normal univariate distribution (George & Mallery, 2010).

Table 4.11 Normality test using Skewness and Kurtosis

Descriptive Statistics					
	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Project Complexity	160	-0.387	0.192	0.340	0.381
Management Support	160	-0.246	0.192	-0.380	0.381
Training and Education	160	-0.350	0.192	-0.256	0.381
Cultural Attitudes	160	-0.978	0.192	0.855	0.381
Lean Construction Implementation	160	0.173	0.192	-0.914	0.381
Valid N (listwise)	160				

Source: Own Survey, (2024)

We concluded that the data were normally distributed, because, as Table 4.11 shows, the skewness and kurtosis of the four independent variables, (Project Complexity, Management Support, Training and Education and Cultural Attitudes) compared to the predicted Lean Construction Implementation were within an acceptable range of ±1. Therefore, we can conclude that there is healthy or positive distribution of the factor, which has collected from the respondent that can be, concluded it is under normal distribution of scaling. Hence, any improvements in practice toward the accomplishment of the intended factor are, positively contributed in enhancing the implementation of Lean construction in building construction projects of the companies.

4.2.2.2.2. Multi-Collinearity Assumption Test

To determine whether the data set has a multi-collinearity problem or whether the explanatory variables in the model have a linear dependence, collinearity diagnostics were performed. To verify this, the study uses the Variance Inflation Factor (VIF), which determines how strongly correlations between independent variables influence the accuracy of regression estimates. The Variance Inflation Factor (VIF) should ideally be close to one and no more than ten. Using Formula $1-R^2$ for each variable, tolerance is a measure of the proportion of variability in the specified independent variable that cannot be accounted for by the other independent variables in the model. A very small value (less than 0.10) indicates the possibility of multi-collinearity because it has high multiple correlations with other variables. However, all variance inflation factors are below 10 as shown in the table, indicating that multi-collinearity is not a problem.

Table 4.12 Collinearity Test

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Project Complexity	0.135	5.418
	Management Support	0.345	2.896
	Training and Education	0.482	2.076
	Cultural Attitudes	0.249	4.014
a. Dependent Variable: Lean Construction Implementation			

Source: Own Survey, (2024)

4.2.2.2.3. Linearity Assumption Test

The linearity of the relationship between the dependent variable (lean construction implementation) and the independent variables (Project Complexity, Management Support, Training and Education and Cultural Attitudes) is essential because regression analysis is based on the idea of correlation.

Residual plots make it easier to examine linearity. Since the points in a normal PP chart lie on a straight line, the PP chart in Figure 4.4 illustrates the linear relationship between the independent variable and dependent variables as follow.

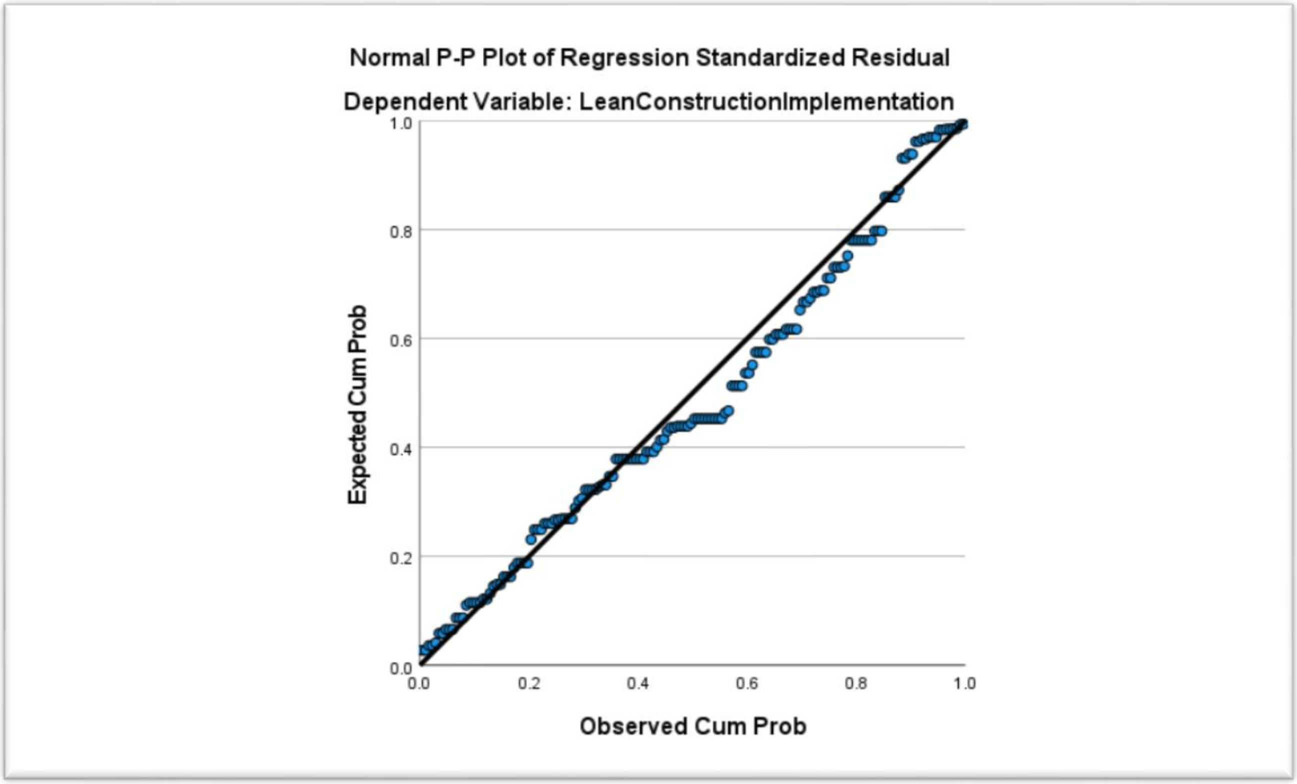


Figure 4.4 Linear Normality P-P plot test result
Source: Own Survey, (2024)

Figure 4.4 displays the normal probability plot of the standardized residuals. It shows that there is no noticeable deviation from the normality assumption, as the representation roughly resembles a diagonal straight line. This suggests that the assumption that the errors are normally distributed is correct and linear.

4.2.2.2.4. Homoscedasticity Assumption Test

The assumptions of pairs of variables having equal variances, to identify violations of this assumption, simple statistical tests or residual plots can be used. Figure 4.5 shows the plot of the standardized residuals versus the standardized fitted values. We can see that the distribution of residuals is constant throughout the graph i.e. no systematic patterns can be found. Heteroscedastic problems do not exist, as this non-systematic random pattern shows.

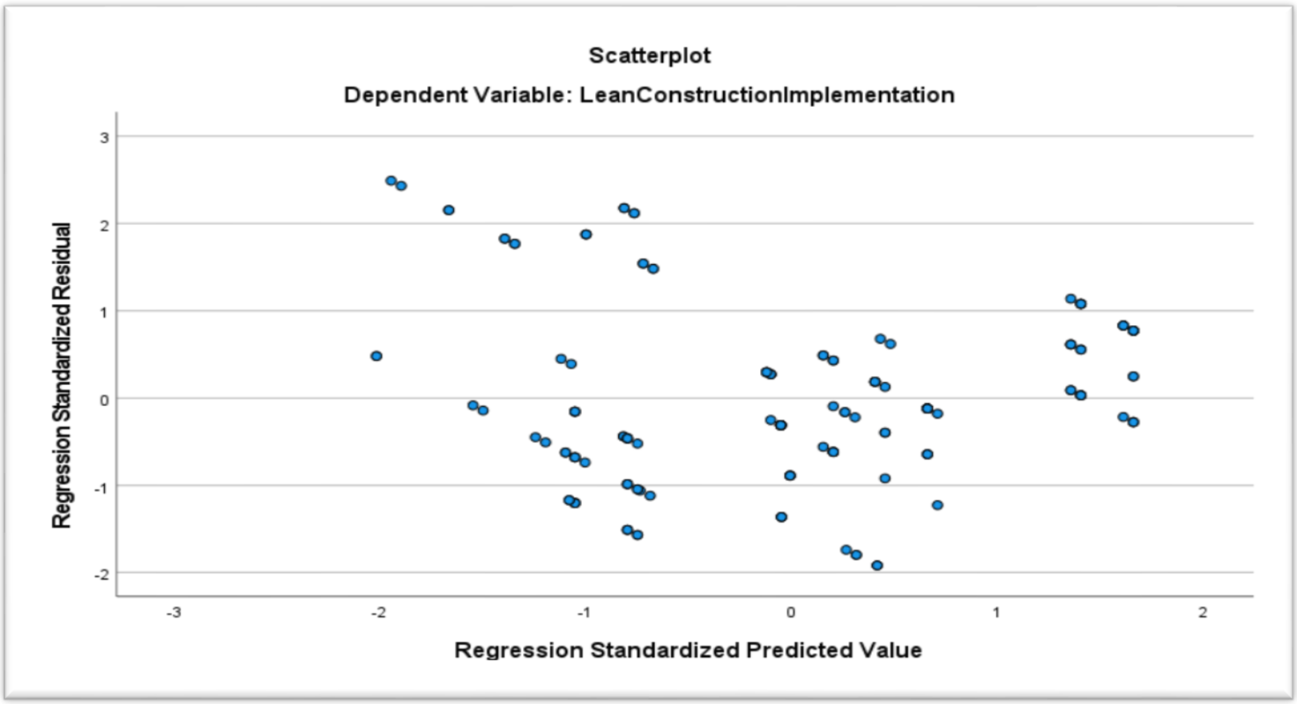


Figure 4.5 Scatterplot test result

Source: Own Survey, (2024)

The researcher is therefore in a good position to conduct regression analysis. For this reason, the regression analysis of the study was carried out and the results were found to be consistent with those of other analyses.

4.2.2.3. Regression Analysis of Determinants of LC Implementation

4.2.2.3.1. Regression Analysis Presentation

Table 4.13 Model Summary interpretation and inference

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.773[a]	0.597	0.587	0.19100
a. Predictors: (Constant), Cultural Attitudes, Management Support, Training and Education, Project Complexity				

Source: Own Survey, (2024)

The model summary table above contains the results of the model fitness analysis. The regression model represents how much of the variance in the measure of the dependent variable (lean construction implementation) is explained by the independent variable (Project Complexity, Management Support, Training and Education and Cultural Attitudes). The value of R^2 in the model summary table is 0.597, which means that about 59.7% of the variation in challenges or barriers is reflected in the variation in lean construction implementations. However, the remaining, approximately 40.3% are unexplained fluctuations that are due to the non-inclusion of other relevant variable in this study.

Table 4.14 ANOVA Interpretation and inference

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.393	4	2.098	57.519	0.000[b]
	Residual	5.654	155	0.036		
	Total	14.048	159			
a. Dependent Variable: Lean Construction Implementation						
b. Predictors: (Constant), Cultural Attitudes, Management Support, Training and Education, Project Complexity						

Source: Own Survey, (2024)

As we can see from the above ANOVA table, the significance value is 0.00, which is less than the 5% significance level, and the residual value and F value are small, that dictate the entire regression model is important. Therefore, the result of the study indicated that the regression model significantly predicts the challenges or barriers of the lean construction implementation in the study area.

Table 4.15 Summary of Coefficients Interpretation and inference

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.738	0.205		8.483	0.000
	Project Complexity	0.122	0.093	0.181	1.303	0.014
	Management Support	0.174	0.064	0.236	2.716	0.007
	Training and Education	0.215	0.063	0.250	3.399	0.001
	Cultural Attitudes	0.112	0.050	0.229	2.239	0.008

a. Dependent Variable: Lean Construction Implementation

Source: Own Survey, (2024)

The table above shows the coefficients of a regression analysis that evaluates the relationship between the lean construction implementation (dependent variable) and four independent variables: Project Complexity(X1), Management Support(X2), Training and Education(X3) and Cultural Attitudes(X4). All independent variables have a significant impact on lean construction implementation, as indicated by their p-values (Sig. = .000). The standardized coefficients (beta) show the relative strength of each predictor. Training and Education(X3) has the strongest influence (Beta = .250), and the Management Support(X2) stand second with their value of (Beta = .236). Furthermore, Cultural Attitudes(X4) (Beta = .229) and Project Complexity(X1) (Beta = .181) stands third and fourth respectively.

4.2.2.4. Hypothesis test of Determinates of LC Implementation

Table 4.16 Hypothesis Test

Hypothesis Ranks order	Description	Beta Result
H3	Training and Education has a positive and significant effect on buying decision of mobile phone	0.250
H2	Management Support has a positive and significant effect on buying decision of mobile phone	0.236
H4	Cultural Attitudes has a positive and significant effect on buying decision of mobile phone	0.229
H1	Project Complexity has a positive and significant effect on buying decision of mobile phone	0.181

Source: Own Survey, (2024)

4.3. Effects of LC Implementation and Determinants on Building Construction Project Costs in Addis Ababa Selected Construction Companies

4.3.1. Case Study Using 5'S Methods

4.3.1.1. Steps and Procedures of 5S Implementation

1. **SEIRI (SORT OUT)**

Seiri is the initial step, focusing on sorting out unnecessary items from the workspace. This process is vital for creating an efficient working environment by ensuring that only essential tools and materials are present.

On-Site Practices:

The team conducted a Seiri exercise by categorizing tools and materials. They removed unused scaffolding and excess materials, which minimized search time and improved efficiency, ultimately reducing project delays and material wastage, thereby reduce cost of the construction projects as follows:

- **Dispose of Unnecessary Items:** Team members identify and properly discard items that do not belong in the work area, reducing clutter.
- **Eliminate Obstacles:** By clearing out unnecessary items, the workspace becomes more navigable, facilitating smoother operations.
- **Minimize Disturbances:** A decluttered environment reduces distractions, allowing workers to concentrate on their tasks.

2. **SEITON (SET IN ORDER)**

Seiton involves organizing the remaining items efficiently. This step ensures that every tool and material has a designated place, facilitating easy access and use.

On-Site Practices:

Tools and materials were organized using labeled storage bins and wall-mounted racks. This arrangement made it easy for workers to locate and return tools; reducing time spent searching and preventing the loss of materials, which can lead to waste. Thus, the following steps were undertaken.

- **Arrange Tools for Accessibility:** Tools and materials are placed based on their frequency of use, ensuring quick access.
- **Ergonomic Arrangement:** Tools are positioned to minimize physical strain, enhancing worker safety and efficiency.
- **Implement a First-Come-First-Served Basis:** This approach helps manage resources effectively, particularly during collaborative tasks.

3. SEISO (SHINE)

Seiso emphasizes thorough cleaning of the workspace, tools, and equipment, ensuring everything is maintained in a "nearly new" condition. This step is crucial for safety and operational quality.

On-Site Practices:

During the construction, a routine cleaning schedule was implemented. Workers cleaned the site at the end of each day, which not only improved safety but also allowed for quick identification of any equipment issues, thereby preventing costly downtime and material losses. The procedure was followed as below;

- **Comprehensive Cleaning:** Regular cleaning efforts help identify wear and tear or potential hazards.
- **Inspection during Cleaning:** Cleaning sessions serve as inspections, allowing teams to spot issues before they escalate.
- **Promote a Safe Environment:** A clean workspace reduces hazards and enhances overall employee morale.

4. **SEIKETSU (STANDARDIZE)**

Seiketsu ensures that the practices established in the first three steps become standardized across the organization. This involves creating uniform procedures and maintaining high standards.

On-Site Practices:

A close follow up were done to standardize the 5S practices across different teams. Regular training ensured that every worker understood the importance of these standards, leading to more efficient operations and less material waste due to standardized handling and storage procedures.

- **Document Best Practices:** Outlined standardized processes.
- **Regular Training:** Conducted training sessions to reinforce the importance of adhering to established standards.
- **Consistency in Orderliness:** Ensure that all team members are following the same organizational principles.

5. **SHITSUKE (SUSTAIN)**

Shitsuke focuses on sustaining the improvements achieved through the 5S process. It emphasizes the need for continuous discipline and adherence to standards.

On-Site Practices:

Continuous audits were implemented to assess adherence to 5S practices. These practice sustained focus on 5S contributed to significant reductions in material waste, as teams were better equipped to manage resources efficiently.

- **Instill a Culture of 5S:** Encourage all employees to take ownership of maintaining organizational practices autonomously.
- **Regular Audits:** Conduct audits to ensure compliance with 5S practices and identify areas for further improvement.
- **Ongoing Training and Engagement:** Provide regular training sessions to refresh knowledge and commitment to 5S principles.

4.3.1.2. Reducing Material Wastage through 5S

The implementation of the 5S methodology directly contributes to reducing material wastage in our case building construction projects. By sorting and organizing tools and materials, teams minimize the likelihood of losing or misplacing items, which often leads to unnecessary purchases. Additionally, a clean and well-organized workspace facilitates better inventory management, allowing teams to track materials more effectively and reduce excess inventory.

Regular cleaning and maintenance ensure that equipment remains in good working condition, preventing costly repairs and downtime that can lead to project delays and material waste. Standardizing practices also means that everyone on the team is aware of how to use and store materials properly, further minimizing waste.

In conclusion, the 5S methodology serves as a powerful framework for enhancing efficiency and reducing material wastage in construction projects. By systematically implementing each step, organizations can foster a culture of continuous improvement, leading to better operational performance and resource management.

4.3.2. Case Study Project Background

The 5'S methodology was applied on actual construction site of a residential building. The activities were HCB Work and plastering work. The data were collected for 16 days within 8 weeks period, which is organized 8 days for HCB work and 8 days for plastering works. The cases mostly focused on waste with its cost implication on the project for HCB and Plastering works.

- Residential Building (2B+G+14)
- Total Area = 836 sq. m
- Built-up Area = 792sq. m
- HCB Work = 2250 m^2 for 2^{nd} Floor to 6^{th} Floor
- Plastering work = 2500 m^2 for 2^{nd} Floor to 6^{th} Floor

- **Assumption taken for Area of 1 m^2 coverage**
  - HCB work
    - Cement =7 kg
    - Sand = 0.036 m3
    - HCB = 13 Pcs
  - Plastering Work
    - Cement =6.5 kg
    - Sand = 0.026 m^3

4.3.2.1. Case Study Task 1-HCB Works

4.3.2.1.1. HCB Work Quantity

In the following table the quantity of cement, HCB, and sand are given for estimated, conventional and 5'S methodology

Table 4.17 Material Utilized Quantity Data

Material	Design Estimated	Conventional Work Practice	5'S Method
Cement(in Bag)	158	166	160
HCB (in Pcs)	29,250	30,713	29,835
Sand(in m3)	80.87	86.53	82.08

Total Quantity Covered 2250 Sq.m from 2nd floor to 6th floor

Source: Own Survey,(2024)

4.3.2.1.2. Percentage wastage in HCB Work

The following table shows the percentage wastage of cement, sand, and brick for conventional and 5'S methodology.

Table 4.18 Percentage wastage in HCB Work

Material	Conventional Work Practice	5'S Method
Cement	5%	1.3%
HCB	5%	2.0%
Sand	7%	1.5%

Source: Own Survey,(2024)

4.3.2.1.3. Cost Comparison for HCB Work

Following table shows cost comparison between estimated, conventional and 5'S methodology.

Table 4.19 Cost Comparison for HCB Work

Material	Estimated	Conventional Work Practice	5'S Method
Cement(in Birr)	158,000.00	166,000.00	160,000.00
HCB (in Birr)	1,170,000.00	1,228,520.00	1,193,400.00
Sand(in Birr)	254,740.50	272,569.50	258,552.00
Total	1,582,740.50	1,667,089.50	1,611,952.00

1 Bag Cement= 1000 Birr, 1 Class B HCB = 40 Birr, 1 M3 Sand = 3150 Birr

Source: Own Survey,(2024)

4.3.2.2. Case Study Task 2- Plastering Work

4.3.2.2.1. Plastering Work Quantity

In the following table the quantity of cement, and sand are given for estimated, conventional and 5'S methodology.

Table 4.20 Plastering Work Quantity

Material	Estimated	Conventional Work Practice	5'S Method
Cement (in Bag)	163	181	170
Sand (in M3)	65.52	72.07	68.6

Source: Own Survey,(2024)

4.3.2.2.2. Percentage Wastage in Plastering Work

The following table shows the percentage wastage of cement and sand for conventional and 5'S methodology.

Table 4.21 Percentage wastage in plastering work

Material	Conventional Work Practice	5'S Method
Cement	11 %	4.3 %
Sand	10 %	4.57 %

Source: Own Survey,(2024)

4.3.2.2.3. Cost Comparison for Plastering Work

Following table shows cost comparison between estimated, conventional and 5'S methodology.

Table 4.22 Cost comparison for plastering work

Material	Estimated	Conventional Work Practice	5'S Method
Cement in Birr	163,000	181,000	170,000
Sand in Birr	206,388	227,021	216,090
Total	369,388	408,021	386,090

1 Bag Cement= 1000 Birr, 1 M3 Sand = 3150 Birr

Source: Own Survey, (2024)

4.3.2.3. Total Cost Difference for Both Tasks

From 2nd to 6th floor Residential Building work only for HCB work and Plastering work

All values from Table 4.19 and Table 4.22

- **Conventional Work Practice Total Cost Sum** = HCB total +Plastering total

  = Br 1,667,089.50 + Br 408,021

  = Br 2, 075,110.5
- **5S Method Total Cost Sum** = HCB total +Plastering total

  = Br 1,611,952.00 + Br 386,090

  = Br 1, 998,042
- **Total Cost Variation** = Conventional Total Sum -5S Method Total Sum

  = Br 2,075,110.5- Br 1,998,042

  = Br 77,068.5

So for 2B+G+14 Building

=77,068.5*3

= Br 231,205.5

4.3.3. Interpretation of Results

4.3.3.1. Wastage Reduction

4.3.3.1.1. HCB Work (Hollow Concrete Block):

- **Sand**: Reduced from 5% to 1.3%
- **HCB**: Reduced from 5% to 2%
- **Cement**: Reduced from 7% to 1.5%

The significant reduction in wastage for HCB work indicates that the application of 5S has led to a more efficient use of materials. For instance, the decrease in sand wastage from 5% to 1.3% suggests improved handling and placement techniques, as well as better planning in terms of quantity needed. Reducing cement waste from 7% to 1.5% reflects enhanced mixing and application methods, likely tied to standardized processes established during the 5S implementation.

4.3.3.1.2. Plastering Work:

- **Sand**: Reduced from 11% to 4.3%
- **Cement**: Reduced from 10% to 4.57%

Similar to HCB work, plastering also saw substantial decreases in material wastage. The reduction in sand wastage by nearly 6.7% and cement reduction by over 5% highlights improved application techniques and better training for workers. This indicates a strong grasp of the plastering process, which can be attributed to the "Set in Order" and "Standardize" phases of 5S.

4.3.4. Cost Implications

- **Total Cost Reduction**: The total cost for HCB work and plastering was reduced by Br 77,068.50 for the construction of the 2nd to 6th floors of the building. This figure illustrates not only the financial benefits of reducing material wastage but also the overall improvement in project efficiency.
- **Projected Savings for Larger Projects**: For a more extensive project, such as a 2B+G+ 14 residences building, the projected cost reduction for these two activities amounts to Br

231,205.50. The savings on larger projects can be significant, emphasizing the importance of implementing efficient practices across all phases of construction.

4.3.5. Determinants of LC Implementation Complemented with 5S Methods

4.3.5.1. Benefits of 5S Methods on Project Complexity

The building construction case project has unique architectural features, such as curved walls and varying ceiling heights, increasing the complexity of both HCB and plastering work. Therefore, the 5S methodology helps streamline processes in this complex environment by ensuring that materials and tools are organized, reducing the time spent searching for items and minimizing errors during installation.

4.3.5.2. Committed Management Support as Enablers for 5S Methods Practice

The project manager regularly holds meetings to emphasize the importance of the 5S methodology and allocates resources for implementing it effectively. Thus, with this strong management support, workers are motivated to adhere to 5S practices in both HCB and plastering activities. For instance, management was provided labeled storage for tools used in plastering, ensuring quick access and minimizing downtime.

4.3.5.3. Continues Training and Education as Enablers for 5S Methods Practice

Before starting the project, the contractor conducts training sessions on the 5S methodology for all workers involved in HCB and plastering tasks. This training equips workers with practical skills to identify waste. For instance, workers learn to implement sorting (Seiri) and organization (Seiton) in their daily tasks, leading to more efficient plastering processes and reduced material waste from HCB installations.

4.3.5.4. Properly Managed Cultural Attitudes as Enablers for 5S Methods Practice

The project team fosters a culture of teamwork and continuous improvement, encouraging workers to share ideas on reducing waste. Thus, we observed, that when team members feel valued and engaged in the process, they are more likely to embrace the 5S methodology. For instance, during daily briefings, workers were suggesting improvements in the placement of HCB materials to minimize movement and enhance efficiency.

4.4. Discussion and Interpretation

The aim of this study was to identify the challenges or barriers to implementing Lean Construction (LC) in building projects, focusing on four specific construction companies. The research identified four key factors: Project Complexity, Management Support, Training and Education, and Cultural Attitudes, all of which significantly affected LC implementation, aligning with the study's objectives.

Among these factors, Training and Education emerged as the most critical for successful LC implementation, as shown by its highest beta and significance values. This indicates that knowledge, awareness, skills, and experience play a crucial role in LC implementation within building projects. For instance, Alinaitwe (2009) argued that a lack of knowledge and skills hindered teamwork and concurrent engineering, both vital concepts in Lean construction. Insufficient knowledge regarding implementation can lead to technical challenges in the construction supply chain, causing uncertainty in workflow reliability and affecting LC application. Albliwi et. al., (2014) also noted that failing to engage individuals in meaningful learning experiences was a primary barrier to Lean method implementation. They suggested that practicing Lean would be more successful if efforts were sustained to engage people in meaningful learning. Furthermore, they pointed out that differing interpretations of Lean and a lack of collaboration between academics and industry practitioners represent additional challenges to this emerging concept in the construction sector.

The second most influential factor was Management Support. The study found a positive correlation between management support and LC implementation, as indicated by the beta and significance values. Since management plays a decisive role in organizations, their strong commitment and follow-up are essential for successfully implementing LC. A lack of management support can render implementation impossible. Shang et. al., (2014) identified this in their survey of 22 barriers to Lean implementation in construction in China, highlighting that the top five barriers included a lack of long-term philosophy, absence of a Lean culture, multi-layer subcontracting, insufficient management skills, and lack of support from upper management. Similarly, Sarhan et. al., (2013) ranked the lack of top management commitment as the second most significant barrier to Lean Construction in the UK construction industry.

Cultural Attitudes and Project Complexity also emerged as influential factors affecting LC implementation, representing challenges in building construction projects. Barriers related to cultural attitudes included personal preferences, a lack of cooperation, and insufficient mutual trust between management and employees (Abolhassani et. al., 2016). Project Complexity refers to the various intricacies involved, such as the number of stakeholders, interdependencies, and technical challenges. Geraldi et. al., (2011) categorized complexity into structural, temporal, and procedural dimensions.

The analysis effectively addressed the research objectives, demonstrating that Training and Education, Management Support, Cultural Attitudes, and Project Complexity significantly influence LC implementation and promote long-term adoption in building construction projects.

To leverage these insights, construction companies should prioritize understanding these factors and commit to ongoing adaptability. This focus will enhance project efficiency and effectiveness, ultimately increasing profitability by minimizing waste and reducing costs. Additionally, LC can improve project delivery through better planning practices and rigorous follow-up.

Furthermore, the application of the 5S methodology on HCB works and plastering work has yielded impressive results in terms of material wastage reduction and cost savings. This case study not only highlights the effectiveness of 5S in a construction setting but also reinforces the methodology's potential for broader application across various types of projects. By embracing such systematic approaches, construction companies can enhance efficiency, promote sustainability, and improve overall project outcomes.

4.5. Actionable Strategies for Overcoming the Challenges Associated with Determinants of Implementation of LC

Based on the findings of this study, several detailed recommendations are proposed for building construction companies aiming to enhance the implementation of lean construction (LC) practices. These recommendations target the key factors identified in the analysis: Training and Education, Management Support, Cultural Attitudes, and Project Complexity.

4.5.1. Suggested Strategies Based on the Finding and Analysis

- **Enhance Training and Education Programs**
  - Develop Comprehensive Training Modules:

Companies should create and implement structured training programs that cover the principles and practices of lean construction. Training should focus not only on theoretical knowledge but also on practical applications, fostering skills that enable employees to effectively contribute to lean initiatives.

  - Engage in Continuous Learning:

Establish a culture of continuous improvement through regular workshops and refresher courses. Encourage employees to engage in meaningful learning experiences that promote collaboration and knowledge sharing. This aligns with the findings of Albliwi et al. (2014), emphasizing the importance of engaging people in practical learning scenarios.

  - Customize Training to Address Specific Needs:

Tailor training content to address the unique challenges and contexts of each project or company. This may involve assessing current skill levels and knowledge gaps to provide targeted training that enhances capability and confidence in implementing lean methods.

- **Strengthen Management Support**
  - Foster a Lean Culture:

Management should actively promote a culture that values lean principles. This includes integrating lean thinking into the organizational mission and values, ensuring that all employees understand the benefits of lean construction.

  - Commitment to Resource Allocation:

Top management must demonstrate commitment by allocating necessary resources both financial and human to support lean initiatives. This includes hiring or training individuals specifically tasked with overseeing lean implementation.

- Establish Clear Communication Channels:

Create open lines of communication between management and employees to facilitate feedback and suggestions regarding lean practices. Regular updates and discussions about lean goals can help maintain focus and morale among team members.

- **Cultivate Positive Cultural Attitudes**
  - Build Trust and Collaboration

Encourage a culture of trust and mutual respect between management and employees. This can be achieved through team-building activities, open forums for discussion, and recognition of collaborative efforts in lean initiatives.

- Address Personal Preferences:

Recognize and address individual preferences and concerns regarding changes in processes. Involve employees in decision-making processes related to lean implementation to enhance their buy-in and reduce resistance to change.

- Promote Shared Values:

Develop and communicate a shared vision for lean construction that underscores the benefits for all stakeholders. Emphasizing how lean practices lead to improved project outcomes can foster a collective commitment to the transition.

- **Manage Project Complexity**
  - Implement Robust Project Management Techniques:

Utilize advanced project management methodologies to effectively address the complexities inherent in construction projects.

- Conduct Complexity Assessments:

Before project initiation, conduct thorough assessments to identify potential complexities and challenges. This proactive approach allows for the development of tailored strategies to mitigate risks associated with project intricacies.

- Enhance Stakeholder Engagement:

Facilitate regular meetings and workshops with all stakeholders to ensure alignment and understanding of project goals and lean practices. Engaging stakeholders early and often can increase cooperation and reduce potential conflicts.

- **Monitor and Evaluate Lean Implementation**
  - Establish Key Performance Indicators (KPIs):

Develop KPIs to measure the effectiveness of lean initiatives. Regularly review these indicators to assess progress and identify areas for improvement.

- Encourage Feedback Loops:

Implement mechanisms for continuous feedback from employees regarding the lean processes. This feedback should be used to refine training programs, management strategies, and cultural initiatives to ensure that they remain relevant and effective.

- Adapt to Changing Conditions:

Stay responsive to changing project conditions and feedback from the workforce. Flexibility in approaches allows organizations to adapt lean methods to their unique contexts and challenges.

4.5.2. Summary of Actionable Strategies

Key Strategies-1: Enhance Training and Education Programs

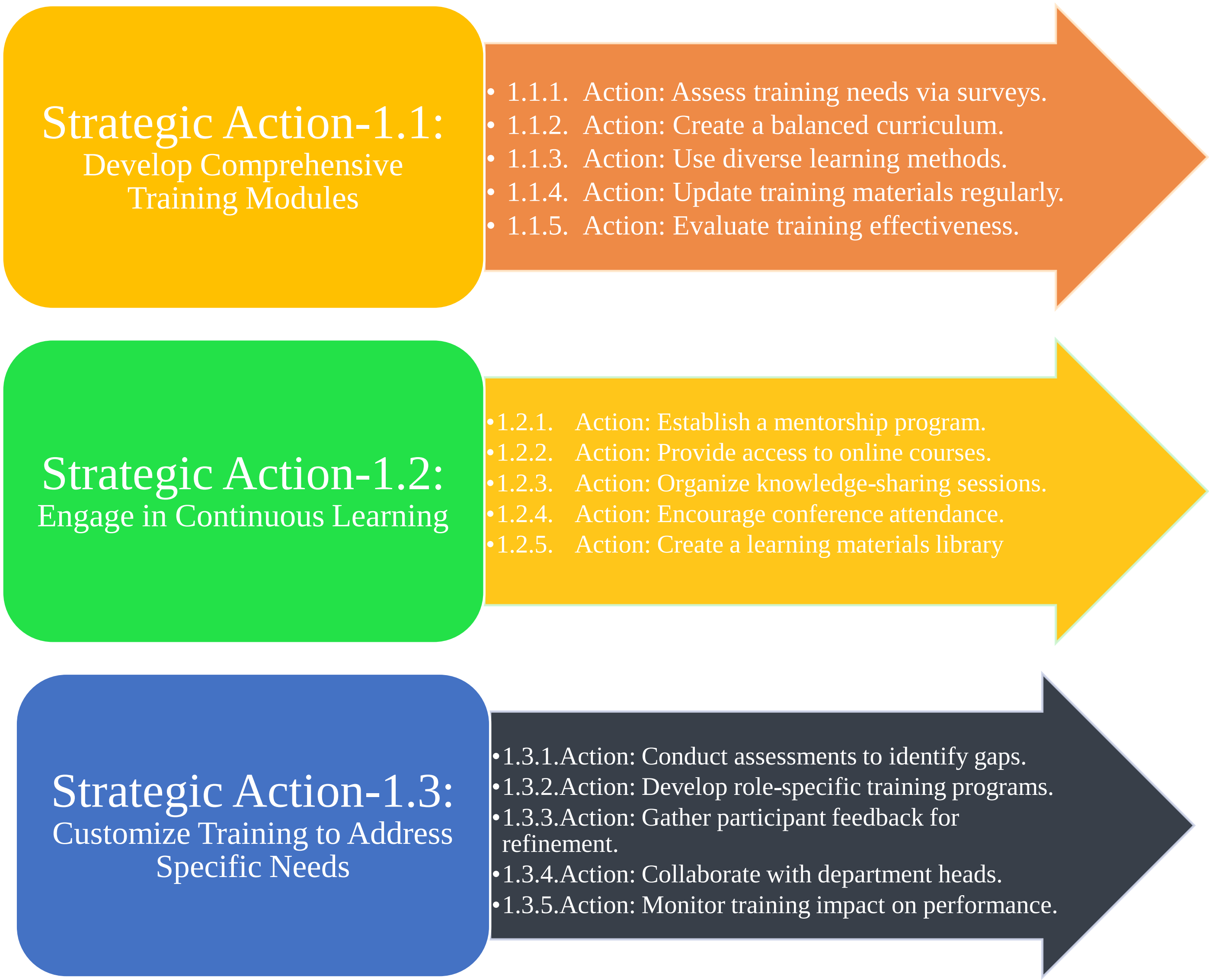


Figure 4.6 Enhance Training and Education Programs

Key Strategies-2: Strengthen Management Support

Figure 4.7 Strengthen Management Support

Key Strategies-3: Cultivate Positive Cultural Attitudes

Figure 4.8 Cultivate Positive Cultural Attitudes

Key Strategies-4: Manage Project Complexity

Figure 4.9 Manage Project Complexity

Key Strategies-5: Monitor and Evaluate Lean Implementation

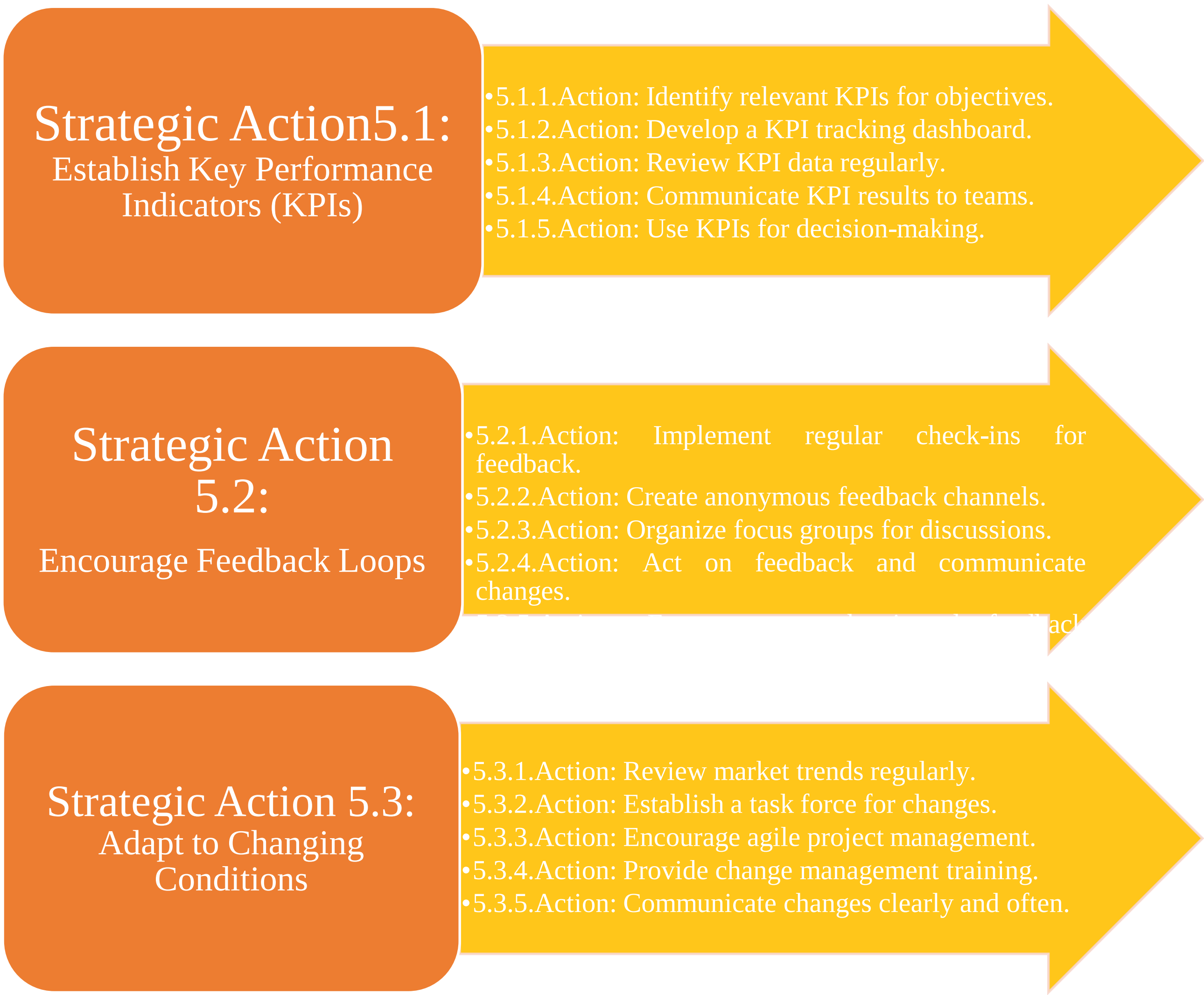


Figure 4.10 Monitor and Evaluate Lean Implementation

By focusing on these recommendations, building construction companies can significantly enhance their lean construction implementation efforts. Emphasizing training and education, strengthening management support, cultivating a positive organizational culture, effectively managing project complexity and continuously monitoring progress will lead to improved project efficiency, reduced waste, and increased profitability. Ultimately, these strategies will foster a more sustainable and effective application of lean principles, contributing to the long-term success of construction projects.

CHAPTER FIVE

5. Summary, Conclusion and Recommendation

This chapter provides the summary of the findings of the study, conclusions drawn from findings and recommendations based on the findings. A conclusion drawn was, deduced from analysis and objectives set for the research. The area for further research was, also suggested in this chapter.

5.1. Summary

The study undertook an in-depth analysis of the factors influencing the implementation of lean construction (LC) in building projects, focusing on four independent variables: Project Complexity, Management Support, Training and Education, and Cultural Attitudes. The primary objective was to identify how these variables serve as challenges or barriers to the successful application of lean construction principles in selected construction companies.

❖ **Key Findings**

- **Positive Associations with Lean Construction:**

  The analysis revealed that all four independent variables exhibited significant positive associations with lean construction implementation, with correlation coefficients ranging from 0.659 to 0.719. Notably, Training and Education had the strongest positive relationship (0.719), followed by Management Support (0.705). Cultural Attitudes (0.684) and Project Complexity (0.659) also demonstrated positive correlations, indicating that each factor plays a crucial role in facilitating lean practices.

- **Model Fit and Variance Explanation:**

  The regression model analysis provided an R^2 value of 0.597, suggesting that approximately 59.7% of the variance in challenges or barriers to lean construction implementation can be explained by these independent variables. The remaining 40.3% of unexplained variance indicates that other relevant factors may influence lean construction practices, which were not included in this study.

- **Statistical Significance:**

  ANOVA results indicated a significance value of 0.00, affirming that the regression model significantly predicts the challenges associated with lean construction implementation. This reinforces the validity of the model in understanding the dynamics at play in lean construction settings.

- **Standardized Coefficients:**

  The regression analysis yielded standardized coefficients (beta) that highlighted the relative strength of each predictor:

  - Training and Education: Beta = 0.250 (strongest influence)
  - Management Support: Beta = 0.236 (second strongest)
  - Cultural Attitudes: Beta = 0.229
  - Project Complexity: Beta = 0.181

These coefficients illustrate the hierarchy of influence among the factors, with Training and Education emerging as the most critical element for successful lean construction adoption.

❖ **Implications of Findings**

1. **Training and Education:**

   The study emphasized that enhancing knowledge, skills, and awareness through effective training programs is vital for overcoming barriers to lean implementation. Previous research highlighted that inadequate knowledge and skills significantly hinder teamwork and concurrent engineering key components of lean construction. Engaging in meaningful learning experiences is essential for fostering a culture of continuous improvement.

2. **Management Support:**

   The findings underscored the importance of strong management commitment to lean initiatives. Without adequate support from top management, the implementation of lean practices is likely to falter. Historical barriers identified in previous studies, such as lack of long-term philosophy and insufficient management skills, further highlight the need for decisive leadership in promoting lean culture.

3. Cultural Attitudes:

Cultural factors, including personal preferences and the level of cooperation between management and employees, were identified as significant barriers to implementing lean principles. A collaborative and trust-based culture is essential for the effective adoption of lean methodologies.

4. Project Complexity:

The study acknowledged that project complexity poses unique challenges to lean construction. Factors such as the number of stakeholders, interdependencies, and technical challenges can complicate lean implementation. Understanding and managing these complexities is crucial for the successful application of lean principles in construction projects.

5.2. Conclusion

The findings from this study provide compelling evidence regarding the critical factors influencing the successful implementation of lean construction (LC) practices in the building construction industry. Analyzing, the relationships between four independent variables: Project Complexity, Management Support, Training and Education, and Cultural Attitudes revealed significant positive associations with lean construction implementation. The correlation coefficients ranged from 0.659 to 0.719, indicating robust relationships, with Training and Education identified as the most influential factor.

Key Insights

- **Training and Education:** With a coefficient of 0.719 and a standardized beta of 0.250, Training and Education emerged as the foremost determinant of lean construction success. This underscores the necessity for a well-informed workforce equipped with the right skills and knowledge. The study corroborates existing literature that highlights knowledge gaps as barriers to lean implementation. Specifically, a lack of understanding can lead to inefficiencies and misinterpretations of lean principles, which can adversely affect workflow reliability and overall project outcomes.

- **Management Support:** Following closely, Management Support (Beta = 0.236) is pivotal in ensuring that lean initiatives are successfully integrated into organizational practices. The findings illustrate that strong commitment from top management is essential for fostering a culture that embraces lean methodologies. Without adequate support and follow-up from management, the chances of successful implementation diminish significantly. Historical barriers identified in previous studies, such as insufficient management skills and lack of long-term philosophy, further accentuate the importance of this factor.
- **Cultural Attitudes:** Cultural Attitudes also play a significant role, with a beta value of 0.229. The study reveals that personal preferences, lack of trust, and cooperation between management and employees can hinder the adoption of lean principles. These points to the need for organizations to cultivate a supportive culture that promotes collaboration and open communication, which are vital for successful lean implementation.
- **Project Complexity:** Lastly, Project Complexity, with a beta of 0.181, represents the inherent challenges associated with multifaceted construction projects. The intricacies of managing various stakeholders and technical dependencies can complicate lean initiatives. Understanding and addressing these complexities is crucial for the effective application of lean practices.

Overall Model Efficacy

The regression model indicated that approximately 59.7% of the variance in lean construction implementation could be, explained by these four factors, highlighting the importance of these variables in shaping outcomes. The model's statistical significance, evidenced by an ANOVA p-value of 0.00, reinforces its reliability in predicting the challenges and barriers to lean implementation. However, it is essential to acknowledge that nearly 40.3% of the variance remains unexplained, suggesting that other influential factors may exist beyond the scope of this study.

Implications for Practice

The implications of these findings are substantial for construction firms aiming to enhance their lean construction strategies. Organizations must prioritize investments in training programs to elevate workforce competencies. Additionally, fostering a strong management commitment and a supportive cultural environment will be integral for overcoming barriers and achieving sustained success in lean initiatives.

To ensure effective project delivery, companies should adopt a holistic approach that integrates these findings into their operational frameworks. By doing so, they can not only minimize waste and reduce costs but also enhance overall project efficiency and effectiveness. In summary, the study affirms that addressing the identified factors is crucial for the successful adoption of lean construction practices, ultimately leading to improved profitability and project outcomes in the competitive construction landscape.

5.3. Recommendation

Based on the study's findings, recommendations for enhancing Lean Construction (LC) practices in building construction companies are organized into four key areas.

- ❖ First, Training and Education should prioritize the development of comprehensive training modules that thoroughly cover the principles and practices of lean construction. This includes not only theoretical knowledge but also practical applications that equip employees with the skills necessary to contribute effectively to lean initiatives. Additionally, fostering a culture of continuous learning through regular workshops and refresher courses is essential. Tailoring training content to address the specific needs and challenges of each project will further enhance employee capability and confidence in implementing lean methods.
- ❖ Second, Management Support is crucial for successful LC implementation. Management should actively promote a culture that values lean principles, integrating these concepts into the organization’s mission and values. Committing adequate resources—both financial and human—is vital to support lean initiatives. Furthermore, establishing clear communication channels

between management and employees will facilitate feedback and suggestions, helping to maintain focus and morale around lean goals.

- Third, Cultural Attitudes within the organization must be nurtured. Building a culture of trust and collaboration between management and employees can be achieved through team-building activities and open forums for discussion. Recognizing individual preferences and involving employees in decision-making processes related to lean implementation will enhance buy-in and reduce resistance to change. Promoting shared values and a collective vision for lean construction will unite stakeholders in their commitment to achieving improved project outcomes.

- Lastly, effective Project Complexity Management is essential to navigate the inherent challenges in construction projects. Companies should implement robust project management techniques that address these complexities while conducting thorough complexity assessments before project initiation. This proactive approach allows for the identification of potential challenges and the development of tailored strategies to mitigate risks. Enhancing stakeholder engagement through regular meetings and workshops ensures alignment and understanding of project goals and lean practices, fostering cooperation and reducing potential conflicts.

By focusing on these areas Training and Education, Management Support, Cultural Attitudes, and Project Complexity Management building construction companies can significantly improve their efficiency, reduce waste, and ensure the successful implementation of lean principles, ultimately contributing to the long-term success of their projects.

5.4. Limitations and Suggestion for Future Research

In any research study, it is crucial to acknowledge the limitations that may affect the interpretation of the findings. Understanding these limitations helps contextualize the results and offer insights into areas that require further exploration. This section outlines the key limitations encountered in the current study, primarily focused on the factors influencing lean construction implementation in building construction projects for the case of four selected construction companies in Addis Ababa. Additionally, based on these limitations, suggestions for future research are proposed. These suggestions aim to broaden the scope of inquiry, enhance methodological rigor, and provide deeper insights into LC implementation in building construction projects. As a result, the study highlighted limitations, which necessitates exercising caution when interpreting the study's findings as follows.

- **Sample Size and Demographics:** The study focused primarily on employees of Ayat, Gift, Jambo and Flintstones construction companies in Addis Ababa, which may not represent the broader base. The limited demographic diversity could affect the generalizability of the findings.
- **Exclusion of Other Factors:** While the study identified four key factors (project complexity, management support, training and education and cultural attitudes) as independent variables in this study as influencing LC implementations for building construction companies, other factors were not explored.

❖ Suggestions for Future Research

- **Exploration of Additional Factors:** Investigate other potential factors influencing LC implementation. A comprehensive approach will enhance understanding of the concepts dynamics.
- Additionally, expanding the study to include a larger and more diverse sample of construction companies across various regions would enhance the generalizability of the findings.

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Appendix-I: Survey Questionnaire

This questionnaire designed and attached to this letter is to study the title “Investigating Determinants of Lean Construction Implementation in Building Construction Projects: A Case of Selected Construction Companies in Addis Ababa.” as part of Partial Fulfillment of the Requirement for the Degree of Masters of Civil Engineering in Construction Technology and Management at Addis Ababa University-AAIT Campus. The information obtained will be used for academic purposes only; all information and feedback will be kept strictly confidential. Your invaluable response will significantly contribute to the success of my study. Therefore, I am kindly requesting you to respond to each question.

Thank you

Name: **GASHAW KIBRU KIDANIE** **Email Address:** **gashawkibru1985@gmail.com**

Addis Ababa, (Ethiopia)

Part I: Personal and organizational profile of respondent

Please choose the appropriate choice by putting (√)

1. Organization Name: ______________________________

2. What is your education level?

☐ Diploma ☐ Bachelor's Degree ☐ Master's Degree ☐ PhD

3. How many years have you worked with this construction company?

□ 0-5 □ 5-10 □ 10-15 □ More than 15

4. What is your position in the Company?

□ Project Manager □ Project Coordinator □ Contract and Planning Engineer

□ Site engineer □ others

Part II: Independent Variables Indicators Questions that can assess the intended constraint variables. Please choose the appropriate choice by putting (√). The level of agreement is represented by 1 = Strongly Disagree, 2 = Disagree, 3 = Average 4 = Agree, 5 = Strongly Agree

1. Project Complexity Constraints

No.	Indicators		2	3	4	5
1	The overall complexity of this project negatively affects lean construction implementation.					
2	The involvement of many different stakeholders complicates lean construction implementation.					
3	The involvement of multiple disciplines affects the success of lean construction implementation.					
4	Unforeseen circumstances frequently hinder lean construction implementation.					
5	Frequent changes in project design disrupt lean construction implementation.					
6	Complexity significantly affects project timelines in relation to lean construction implementation.					

2. Management Support Constraints

No.	Indicators	1	2	3	4	5
1	There is no dedicated budget for lean initiatives, which undermines effective implementation.					
2	Management is not committed to continuous improvement, which detracts from lean construction implementation.					
3	Upper management lack support for practice of lean initiatives, which negatively affects implementation.					
4	Top management considered lean construction implementation is very expensive.					
5	Management conceives the lean construction implementation is too technical to implement.					
6	Management seldom communicates about lean objectives, hindering implementation efforts.					

3. Training and Education Constraints

No.	Indicators	1	2	3	4	5
1	I have not received formal training in lean construction principles, which would have aided implementation.					
2	My organization does not conduct training sessions on lean methodologies that support effective implementation.					
3	I do not feel adequately trained to implement lean practices in my work.					
4	There is no ongoing training provided for new team members to facilitate their lean construction implementation.					
5	I would like more training on lean methodologies to enhance my implementation skills.					

4. Cultural Attitude Constraints

No.	Indicators	1	2	3	4	5
1	There is no established process for implementing employee suggestions, which hinders lean construction.					
2	Team members rarely express concerns about current practices, which can negatively affect lean construction implementation.					
3	The organizational culture is resistant to change, obstructing lean construction implementation.					
4	My organization is not open to adopting new practices that enhance lean construction implementation.					
5	Team members feel discouraged from suggesting improvements that would support lean construction implementation.					
6	Lean principles are seldom discussed in team meetings, undermining their importance for implementation.					

Part III: Dependent Variables Indicator Questions that can Help Assess the Intended Constraints

1. Lean Construction Implementation Drivers

No.	Indicators	1	2	3	4	5
1	Material waste is a significant issue in our construction projects, which requires LC implementation.					
2	I believe that reducing material waste is essential for successful lean construction implementation.					
3	I believe that implementing lean construction practices helps to significantly reduce waste on projects.					
4	I feel that better planning could significantly reduce material waste on our projects, as LC do.					
5	Time waste is a prevalent issue in our construction projects that require LC implementations.					
6	I believe that better communication could reduce waste on our teams, which can be achieved through implementing LC.					

Appendix II: Data Collection Tool Excel Sheet for Case Study

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date		Period		
Location	Ayat Tsebel around Mekedonia		Building Types	2B+G+14 RESIDENT BUILDING
Activity Location				
Estimated Area to be Covered for the date in m2				
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement in bags				
Sand in m3				
HCB in pcs				
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in bags				
Sand in m3				
HCB in pcs				
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in bags				
Sand in m3				
HCB in pcs				

5S Method Data Collection Sheet for Plastering Works				
Task Types:	Plastering Work	Observer:	GASHAW KIBRU	
Date		Period		
Location	Ayat Tsebel around Mekedonia		Building Types	2B+G+14 RESIDENT BUILDING
Activity Location				
Estimated Area to be Covered for the date in m2				
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement in bags				
Sand in m3				
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in bags				
Sand in m3				
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in bags				
Sand in m3				

Appendix III: Row Data for Case Study Analysis Using 5S Method

1. HCB WORK ROW DATA COLLECTED

HCB Data Collection Schedules			
Date	Observed Week	Days Observed	HCB Quantity Executed in M2
Tuesday 9/7/2024	Week 1	Day 1	270
Thursday11/07/24	Week 1	Day 2	270
Tuesday 23/07/2024	Week 3	Day 5	270
Thursday 25/07/2024	Week 3	Day 6	276
Tuesday 6/08/2024	Week 5	Day 9	284
Thursday 8/08/2024	Week 5	Day 10	290
Tuesday 20/08/2024	Week 7	Day 13	290
Thusrday 22/08/2024	Week 7	Day 14	300
			2250

5S Method Data Collection Sheet for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Tuesday 9/07/2024	Period	Week 1, Day 1	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	2nd Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		270		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	18.9	Bags	Site Physical Observation from design	
Sand	9.72	M^3	Site Physical Observation from design	
HCB	3510	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	19.845		19.1457	
Sand in m3	10.4004		9.8658	
HCB in Pcs	3685.5		3580.2	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-0.945		-0.2457	
Sand in m3	-0.6804		-0.1458	
HCB in Pcs	-175.5		-70.2	

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Tuesday 11/07/2024	Period	Week 1, Day 2	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	2nd and 3rd Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		270		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	18.9	Bags	Site Physical Observation from design	
Sand	9.72	m^3	Site Physical Observation from design	
HCB	3510	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	19.845		19.1457	
Sand in m3	10.4004		9.8658	
HCB in Pcs	3685.5		3580.2	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-0.945		-0.2457	
Sand in m3	-0.6804		-0.1458	
HCB in Pcs	-175.5		-70.2	

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Tuesday 23/07/2024	Period	Week 3, Day 5	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	3rd Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		270		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	18.9	Bags	Site Physical Observation from design	
Sand	9.72	m^3	Site Physical Observation from design	
HCB	3510	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	19.845		19.1457	
Sand in m3	10.4004		9.8658	
HCB in Pcs	3685.5		3580.2	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-0.945		-0.2457	
Sand in m3	-0.6804		-0.1458	
HCB in Pcs	-175.5		-70.2	

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Thursday 25/07/2024	Period	Week 3, Day 6	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	3rd and 4th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		276		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	19.32	Bags	Site Physical Observation from design	
Sand	9.936	m^3	Site Physical Observation from design	
HCB	3588	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	20.286		19.57116	
Sand in m3	10.63152		10.08504	
HCB in Pcs	3767.4		3659.76	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-0.966		-0.25116	
Sand in m3	-0.69552		-0.14904	
HCB in Pcs	-179.4		-71.76	

5S Method Data Collection sheets for HCB Works					
Task Types:	HCB Work		Observer:	GASHAW KIBRU	
Date	Tuesday 6/08/2024		Period	Week 5, Day 9	
Location	Ayat Tsebel around Mekedonia			Building Types	
Activity Location	4th Floor			2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2			284		
Input (Design Estimation)	Design Estimated Quantity		Unit	Data Source	Remarks
Cement	19.88		Bags	Site Physical Observation from design	
Sand	10.224		m^3	Site Physical Observation from design	
HCB	3692		Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice			Actual Utilized for 5S Methods	Remarks
Cement in Bag	20.874			20.13844	
Sand in m3	10.93968			10.37736	
HCB in Pcs	3876.6			3765.84	
Waste	Actual Waste for Conventional Work Practice			Actual Waste for 5S Methods	Remarks
Cement in Bags	-0.994			-0.25844	
Sand in m3	-0.71568			-0.15336	
HCB in Pcs	-184.6			-73.84	

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Thursday 8/08/2024	Period	Week 5, Day 10	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	4th and 5th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		290		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	20.3	Bags	Site Physical Observation from design	
Sand	10.44	m^3	Site Physical Observation from design	
HCB	3770	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	21.315		20.5639	
Sand in m3	11.1708		10.5966	
HCB in Pcs	3958.5		3845.4	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-1.015		-0.2639	
Sand in m3	-0.7308		-0.1566	
HCB in Pcs	-188.5		-75.4	

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Tuesday 20/08/2024	Period	Week 7, Day 13	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	5th and 6th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		290		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	20.3	Bags	Site Physical Observation from design	
Sand	10.44	m^3	Site Physical Observation from design	
HCB	3770	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	21.315		20.5639	
Sand in m3	11.1708		10.5966	
HCB in Pcs	3958.5		3845.4	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-1.015		-0.2639	
Sand in m3	-0.7308		-0.1566	
HCB in Pcs	-188.5		-75.4	

5S Method Data Collection sheets for HCB Works				
Task Types:	HCB Work	Observer:	GASHAW KIBRU	
Date	Tuesday 9/07/2024	Period	Week 1, Day 1	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	6th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		300		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	21	Bags	Site Physical Observation from design	
Sand	10.8	m^3	Site Physical Observation from design	
HCB	3900	Pcs	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in Bag	22.05		21.273	
Sand in m3	11.556		10.962	
HCB in Pcs	4095		3978	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in Bags	-1.05		-0.273	
Sand in m3	-0.756		-0.162	
HCB in Pcs	-195		-78	

2. PLASTERING WORK ROW DATA COLLECTED

Plastering Data Collection Schedules			
Date	Observed Week	Days Observed	HCB Qty Executed in m^2
Tuesday 16/07/2024	Week 2	Day 3	270
Thursday 18/07/2024	Week 2	Day 4	284
Tuesday 30/07/2024	Week 4	Day 7	308
Thursday 1/08/2024	Week 4	Day 8	320
Tuesday 13/08/2024	Week 6	Day 11	324
Thursday 15/08/2024	Week 6	Day 12	328
Tuesday 27/08/2024	Week 8	Day 15	330
Thursday 29/08/2024	Week 8	Day 16	336
			2500

5S Method Data Collection sheets for Plastering Works					
Task Types:	Plastering Work		Observer:	GASHAW KIBRU	
Date	Tuesday 16/07/2024		Period	Week 2, Day 3	
Location	Ayat Tsebel around Mekedonia			Building Types	
Activity Location	2nd Floor			2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		270			
Input (Design Estimation)	Design Estimated Quantity	Unit		Data Source	Remarks
Cement	17.55	Bags		Site Physical Observation from design	
Sand	7.02	m^3		Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice			Actual Utilized for 5S Methods	Remarks
Cement in bags	19.4805			18.30465	
Sand in m3	7.722			7.340814	
Waste	Actual Waste for Conventional Work Practice			Actual Waste for 5S Methods	Remarks
Cement in bags	-1.9305			-0.75465	
Sand in m3	-0.702			-0.320814	

5S Method Data Collection sheets for Plastering Works				
Task Types:	Plastering Work	Observer:	GASHAW KIBRU	
Date	Thursday 18/07/2024	Period	Week 2, Day 4	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	2nd and 3rd Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		284		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	18.46	Bags	Site Physical Observation from design	
Sand	7.384	m^3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in bags	20.4906		19.25378	
Sand in m3	8.1224		7.7214488	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in bags	-2.0306		-0.79378	
Sand in m3	-0.7384		-0.3374488	

5S Method Data Collection sheets for Plastering Works					
Task Types:	Plastering Work		Observer:	GASHAW KIBRU	
Date	Tuesday 30/07/2024		Period	Week 4, Day 7	
Location	Ayat Tsebel around Mekedonia			Building Types	
Activity Location	3rd Floor			2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2			308		
Input (Design Estimation)	Design Estimated Quantity		Unit	Data Source	Remarks
Cement	20.02		Bags	Site Physical Observation from design	
Sand	8.008		M3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice			Actual Utilized for 5S Methods	Remarks
Cement in bags	22.2222			20.88086	
Sand in m3	8.8088			8.3739656	
Waste	Actual Waste for Conventional Work Practice			Actual Waste for 5S Methods	Remarks
Cement in bags	-2.2022			-0.86086	
Sand in m3	-0.8008			-0.3659656	

5S Method Data Collection sheets for Plastering Works				
Task Types:	Plastering Work	Observer:	GASHAW KIBRU	
Date	Thursday 01/08/2024	Period	Week 4, Day 8	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	4th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		320		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	20.8	Bags	Site Physical Observation from design	
Sand	8.32	M3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in bags	23.088		21.6944	
Sand in m3	9.152		8.700224	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in bags	-2.288		-0.8944	
Sand in m3	-0.832		-0.380224	

5S Method Data Collection sheets for Plastering Works					
Task Types:	Plastering Work		Observer:	GASHAW KIBRU	
Date	Tuesday 13/08/2024		Period	Week 6, Day 11	
Location	Ayat Tsebel around Mekedonia			Building Types	
Activity Location	4th and 5th Floor			2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2			324		
Input (Design Estimation)	Design Estimated Quantity		Unit	Data Source	Remarks
Cement	21.06		Bags	Site Physical Observation from design	
Sand	8.424		M3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice			Actual Utilized for 5S Methods	Remarks
Cement in bags	23.3766			21.96558	
Sand in m3	9.2664			8.8089768	
Waste	Actual Waste for Conventional Work Practice			Actual Waste for 5S Methods	Remarks
Cement in bags	-2.3166			-0.90558	
Sand in m3	-0.8424			-0.3849768	

5S Method Data Collection sheets for Plastering Works				
Task Types:	Plastering Work	Observer:	GASHAW KIBRU	
Date	Thursday 15/08/2024	Period	Week 6, Day 12	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	5th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		328		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	21.32	Bags	Site Physical Observation from design	
Sand	8.528	m^3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in bags	23.6652		22.23676	
Sand in m3	9.3808		8.9177296	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in bags	-2.3452		-0.91676	
Sand in m3	-0.8528		-0.3897296	

5S Method Data Collection sheets for Plastering Works					
Task Types:	Plastering Work		Observer:	GASHAW KIBRU	
Date	Tuesday 27/08/2024		Period	Week 8, Day 15	
Location	Ayat Tsebel around Mekedonia			Building Types	
Activity Location	5th and 6th Floor			2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2			330		
Input (Design Estimation)	Design Estimated Quantity		Unit	Data Source	Remarks
Cement	21.45		Bags	Site Physical Observation from design	
Sand	8.58		M3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice			Actual Utilized for 5S Methods	Remarks
Cement in bags	23.8095			22.37235	
Sand in m3	9.438			8.972106	
Waste	Actual Waste for Conventional Work Practice			Actual Waste for 5S Methods	Remarks
Cement in bags	-2.3595			-0.92235	
Sand in m3	-0.858			-0.392106	

5S Method Data Collection sheets for Plastering Works				
Task Types:	Plastering Work	Observer:	GASHAW KIBRU	
Date	Thursday 29/08/2024	Period	Week 8, Day 16	
Location	Ayat Tsebel around Mekedonia		Building Types	
Activity Location	6th Floor		2B+G+14 RESIDENT BUILDING	
Estimated Area to be Covered for the date in m2		336		
Input (Design Estimation)	Design Estimated Quantity	Unit	Data Source	Remarks
Cement	21.84	Bags	Site Physical Observation from design	
Sand	8.736	M3	Site Physical Observation from design	
Output(Actual Utilized)	Actual Utilized for Conventional Work Practice		Actual Utilized for 5S Methods	Remarks
Cement in bags	24.2424		22.77912	
Sand in m3	9.6096		9.1352352	
Waste	Actual Waste for Conventional Work Practice		Actual Waste for 5S Methods	Remarks
Cement in bags	-2.4024		-0.93912	
Sand in m3	-0.8736		-0.3992352	