A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction industry through the application of the Last Planner System: A Case of Ethiopian Construction Works Corporation

Nura Seyida Ahmed

A Thesis Submitted to the department of Civil Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of The Requirement for The Degree of Master's in Civil Engineering (Specialization in Construction Engineering and Management)

Office of Graduate Studies

Adama Science and Technology University

June, 2024

Adama, Ethiopia

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DECLARATION

I hereby declare that this Master thesis entitled "**A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction industry through the application of the Last Planner System: A Case of Ethiopian Construction Works Corporation**" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation. It is being submitted for the partial fulfillment for the award of the degree of Master of Science in Construction Engineering and Management at Adama Science and Technology University School of Civil Engineering and Architecture

Nura Seyida Ahmed	______________	____________
Name of student	Signature	Date

RECOMMENDATION

I hereby certify that I have read and evaluated this thesis entitled "**A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction industry through the application of the Last Planner System: A Case of Ethiopian Construction Works Corporation**" prepared under my guidance by Nura Seyida Ahmed submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Construction Engineering and Management. Therefore, I recommend that the candidate has fulfilled the requirements and hence he can submit the thesis to the department.

Bahiru Bewket Mitikie (PhD)	________________________	______________
Major Advisor	Signature	Date

APPROVAL SHEET

I hereby certify that all the correction and recommendation suggested by the board of examiners are incorporated into the final thesis entitled "**A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction industry through the application of the Last Planner System: A Case of Ethiopian Construction Works Corporation**" by Nura Seyida Ahmed.

Bahiru Bewket Mitikie (PhD)	____________________	__________________
Major Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis open defense by Nura Seyida Ahmed have read and evaluated his thesis entitled A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction industry through the application of the Last Planner System: A Case of Ethiopian Construction Works Corporation and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and management.

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LIST OF ACRONYMS

AEC	Architectural, Engineering and Construction
BCD	Building Construction Division
BCI	Building Construction Industry
BIM	Building Information Modeling
CII	Construction Industry Institute
CPM	Critical Path Method
ECWC	Ethiopian Construction Works Corporation
GDP	Gross Domestic Product
HDC	Housing Development Construction
LC	Lean Construction
LPC	Last Planner Concept
LPS	Last Planner System
LPSRL	Last Planner System Readiness Level
MIS	Mean Item Score
NVA	Non-Value Adding
OSR	Overall Score of Readiness
PERT	Program Evaluation and Review Technique
PPC	Percent Plan Complete
RII	Relative Importance Index
SPSS	Statistical Package for Social Science
TA	Tasks Anticipated
TMR	Tasks Made Ready
WWP	Weekly Work Plan

ABSTRACT

The building construction industry is a crucial sector for the Ethiopian economy as it contributes to national development through its impact on GDP, backward linkages to other industrial sectors, direct demand for labor, and contribution to national capital formation. However, Ethiopian construction project management faces numerous challenges due to its traditional project management approaches. These approaches are often inadequate when dealing with the dynamic and complex construction projects in the region. As a result, these challenges can adversely affect project delivery, productivity, and overall performance during the construction process due to their complexity and uncertainty. Therefore, it is essential to explore new alternatives that can bring creative improvements to the traditional production system. The Last Planner System is a well-known Lean Construction method that focuses on improving efficiency in the construction process. It aims to reduce delays and waste by promoting collaboration and commitment. This system provides a way to manage and monitor planning efficiency in construction effectively. Therefore, this study aims to address the barriers to implementing the Last Planner system and create a framework for its successful implementation. The research methodology involves data collection through questionnaires and interviews. The questionnaires were analyzed using Statistical Package for Social Sciences version 26 to compute Cronbach Alpha and descriptive statistics. The study results indicate a positive readiness for implementing the Last Planner System in the Ethiopian building construction industry, with identified barriers prioritized for mitigation. The developed framework demonstrates the potential for improving construction process efficiency and overcoming industry-specific challenges. In conclusion, this research provides valuable insights into the field of construction engineering and management in Ethiopia, offering a structured approach to enhancing efficiency and optimizing project outcomes by applying the Last Planner System. It is recommended that the government recognizes the advantages of implementing the LPS and supports the Ethiopian building construction industry in doing so. Additionally, the established framework should be implemented in actual building construction projects and assessed to improve the efficiency of the construction process in the Ethiopian building construction sector.

Keywords: Construction Process Efficiency, Construction Project Management, Ethiopian Building Construction Industry, Last Planner System

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the study

The construction industry is a very important sector for the Ethiopian economy. It contributes to national development through its contribution to GDP, backward linkages to other industrial sectors, direct demand for labor, and contribution to national capital formation (Mengistu & Mahesh, 2020). It plays a significant role in the country's economic growth and structural transformation, offering potential benefits in terms of job reallocation and poverty reduction.

However, the construction industry faces various challenges during the construction process, which can have an impact on project delivery, productivity, and overall performance, although these challenges differ from country to country (Daniel et al., 2017). It has been identified as a sector that generates a significant amount of waste during its operations. Non-value-adding activities in the construction process, such as waiting time, material handling, overproduction, inventories, rework, redundant activities, and the labor movement, all contribute to waste (Daniel et al., 2017). In the United States, the Construction Industry Institute (CII) has conducted meticulous studies, estimating that between 25% and 50% of construction costs are wasted due to the inefficiency of the traditional management system (Saad et al., 2017). Additionally, construction projects can face challenges due to factors such as inadequate project planning and management, resulting in increased costs, contractual disputes, and dissatisfaction among project stakeholders (Basar & Basar, 2023).

The relationship between delay and waste in the construction industry is multifaceted. Delays often lead to increased waste, while poor waste management can cause project delays. Kamarosisam et al. (2021) emphasize the importance of formalizing and centralizing waste management structures in Malaysia. It suggests that better waste management practices can help mitigate delays caused by waste-related issues (Kamarosisam et al., 2021). On the other hand, Ametepey et al., (2018) identifies project delays in Ghanaian local government construction projects, which can result in time and cost overruns. Poor waste management practices can exacerbate these delays (Ametepey et al., 2018).

Interestingly, although Formoso et al., (2002) do not directly connect waste to delays, it implies that managerial improvements can reduce material waste in Brazilian construction projects, potentially reducing delays as well. Therefore, it is crucial to address these issues simultaneously for optimal project outcomes.

Fortunately, there are strategies that can be implemented to break this cycle and enhance efficiency. These strategies include effective planning and scheduling to avoid delays and minimize waste. Another strategy is effective communication and collaboration among project teams, including project managers, engineers, contractors, consultants, and foremen, which is essential for successful project delivery (Basar & Basar, 2023). Basar and Basar (2023) added that inadequate communication, misinterpretation of project requirements, and lack of coordination could lead to errors, rework, and delays.

In Ethiopia, construction project management faces numerous challenges due to their complexity and can be fraught with uncertainty. As a result, traditional project management approaches, i.e., CPM and PERT are often insufficient when dealing with these dynamic and complex construction projects in the region. For instance, unforeseen site conditions and improper design can significantly impact project performance (Yadeta, 2019). These issues are often made worse by traditional management practices that fail to anticipate or adequately address them (Yadeta, 2019).

Muluken Tilahun et al. (2020) mentioned in their study that the building construction sector in Ethiopia faces challenges related to delay in construction industry development, policy implementation, corruption, weak capacity of contractors and consultants, lack of collaboration and professionalism, lack of benchmarking, and the nature of the construction industry.

Despite recognizing these challenges, there is a noticeable lack of knowledge and implementation of alternative management approaches that could potentially improve project outcomes in the Ethiopian building construction industry (Sahlu & Dinku, 2021). Ethiopian construction project experts are unfamiliar with lean methodologies that could enhance construction project success by promoting adaptability and efficiency (Garomsa, 2019).

Therefore, improving the performance of the construction industry requires identifying the state of the practices and devising improvement mechanisms. As a result, looking for a new alternative capable of bringing creative improvement to the traditional production system is very important (Saad et al., 2017). The use of new tools based on productivity, safety, health, and planning can ensure that construction's operations are carried out in a more planned way (Martins et al., 2020 ; Aburumman, 2023). As a result, experts are looking for new approaches and technologies, searching for the for the proper combination of various methods and techniques (Michalski & De, 2022).

One of the most significant Lean Construction methods, the Last Planner System, defined by the Lean Construction Institute as a collaborative, commitment-based planning system (Guerriero et al., 2017), is a very useful tool for the management of the construction process and the continuous monitoring of planning efficiency (Alsehaimi et al., 2014). The last planner system integrates several planning levels and gathers the relevant stakeholders into dedicated meetings, enabling the convergence of what should be done, what can be done, and what on-site workers will actually do based on reliable promises. Moreover, it enables a learning process based on the analysis of the PPC score (Plan Percent Complete, i.e., measurement of the proportion of promises made that are delivered on time) (Guerriero et al., 2017), and of the reasons for variability.

Although the last planner system is a strategy that reduces delay and construction process waste and breaks the delay and waste cycle in order to increase construction process efficiency, there are associated implementation barriers to the last planner system in building construction projects. However, from the literature, little attention has been paid to developing a framework that reduces associated LPS implementation barriers and enhances construction process efficiency through integrating LPS into construction projects in the context of the Ethiopian Building Construction Sector.

1.2 Statement of the problem

Efficient delivery of building construction projects is a complex matter that involves multiple stakeholders and processes. Joshi et al. (2023) indicates that several factors contribute to project efficiency, such as waste and time management, clear roles among team members, and effective collaboration.

The CPM and PERT are widely used traditional project management systems for creating a project's master plan. However, they lack operational clarity on task execution and cause inefficiency in project delivery (Venkatesh & Venkatesan, 2021).

The Last Planner System is a collaborative, commitment-based planning system (Guerriero et al., 2017), which is a very useful tool for the management of the construction process and the continuous monitoring of planning efficiency. It differs from CPM and PERT by providing detailed planning as work approaches, proactively addressing constraints, and ensuring all stakeholders are aware of work requirements (Sarhan, 2018).

The building construction sector in Ethiopia is characterized as a fragmented industry, with stakeholders working together but having different objectives and perspectives on work. This, in turn, leads to reluctance to collaborate (Balkhy & Sweis, 2021). Currently, the Ethiopian building construction industry relies on traditional construction management systems, resulting in inefficient project delivery processes and generating significant waste. These issues cause delays and low-value returns for clients. As a result, there is a need for the last planner system in Ethiopia. This system integrates multiple planning levels and brings together relevant stakeholders in dedicated meetings. Its purpose is to ensure that there is a convergence between what needs to be done, what can be done, and what on-site workers will do, all based on reliable promises. Implementing this system will help increase construction process efficiency in the Ethiopian building construction industry.

Therefore, the Last Planner System implementation readiness, barriers to adopting a collaborative-based philosophy, and to achieve a change in the construction culture, and framework development for the successful implementation of LPS is needed.

1.3 Objective of the Study

1.3.1 General objective

The general objective of this thesis is to develop a structured framework that utilizes the Last Planner system to enhance the construction process efficiency in the Ethiopian building construction industry.

1.3.2 Specific objectives

The specific objectives of this research are:

- To investigate the last planner system implementation readiness of Ethiopian building construction industry by using mean item score and overall score of readiness.
- To prioritize barriers in the implementation of the last planner system in the Ethiopian building construction sector
- To develop and validate a framework for implementing the LPS that enhances building construction efficiency in the Ethiopian building construction sector.

1.4 Research questions

The research question for this study is as follows:

- How can the building construction industry in Ethiopia be evaluated for its alignment and readiness to implement Last Planner System?
- How can the barriers to the implementation of the Last Planner system be prioritized?
- How can a framework be developed to enhance the effective implementation of the Last Planner system to improve the efficiency of the Ethiopian building construction process?

1.5 Scope of the study

The scope of this study is limited to the construction process stage of a building construction projects currently under construction by the Ethiopian Construction Works Corporation (ECWC) in Addis Ababa, Ethiopia. The study specifically examines the planning, controlling, and management aspects of the project. To develop a framework, existing literature and the insights gathered from questionnaires and interviews conducted with professionals at the building construction sites were taken into consideration.

1.6 Limitations of the study

Every study has limitations, and this research is certainly no exception. This study evaluated the readiness for implementing LPS, identified barriers to implementation, and created a framework to enhance efficiency in the Ethiopian building construction industry. However, some limitations in terms of context and methodology could affect the study's results. Specifically, the study focused on the construction process stage of building projects by the Ethiopian Construction Works Corporation, which may restrict the framework's applicability to other construction phases or different project types. Additionally, the framework developed may be specific to the Ethiopian context and may not be directly applicable to other construction industries or regions without further validation and adaptation. The framework's validation relied on expert interviews, which could introduce bias or limited perspectives compared to real-world project implementations.

1.7 Significance of the study

The study investigated the readiness of the Ethiopian building construction industry to implement the Last Planner system. Moreover, the findings of this study offer a foundation of knowledge for construction companies to enhance construction process efficiency by utilizing the Last Planner system. This allows construction companies, government agencies, and regulatory bodies to concentrate on the most effective barriers to implementing the Last Planner system and overcome them.

In addition, the study establishes a framework that takes into account the local context of the Ethiopian building construction industry (including socio-cultural and operational factors) to guarantee the successful implementation of the Last Planner system, overcoming any barriers.

1.8 Organization of the Document

This thesis consists of five chapters. The first chapter provides an overview of the thesis. It begins with a background to the research and emphasizes the statement of the problem, research objective, and research questions. It additionally outlines the research scope, the significance of the study, the limitations, and the structure of the thesis.

Chapter two presents a review of the literature on the Ethiopian building construction sector and the challenges in the Ethiopian building construction sector. It also assesses strategies to enhance construction process efficiency in the Ethiopian building sector. Furthermore, the chapter highlights the readiness for implementing the last planner system and the barriers that arise during its implementation in the Ethiopian building construction sector.

Chapter three addresses how the thesis was carried out. It describes the processes involved in achieving the aim of this study, including the research design, target population, sources of data, sampling techniques, data collection tools and methods, and data analysis techniques. This section also covers the validation and reliability of the study.

Chapter four presents a summary of the results of the analysis based on the data gathered through the process of questionnaires and interviews. This includes the comparison of findings with the existing body of knowledge. A detailed discussion of the findings is also included.

Chapter five is the conclusion and recommendation. It draws the final statement of the overall finding and suggests possible strategies for the problem of the study based on what has been discussed in the previous chapters.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 The Ethiopian building construction sector

The construction industry is a very important sector for the Ethiopian economy. In Ethiopia, as in most developing countries, it has made a significant contribution to the growth of the economy through infrastructure development and job creation (Kuhil & Seifu, 2019). Despite its significant contribution, it faces various issues and challenges, such as inefficiencies and losses resulting from non-value-adding activities similar to those of other developing nations, possibly with greater severity (Ayfokru, 2023).

Waste management, specifically non-physical wastes in construction, is a relatively new practice in Ethiopia, and a study by Tafesse (2021) revealed that a significant amount of project time, around 30 to 40%, is wasted on non-value-adding activities like overproduction and waiting-related inefficiencies. In general, Ethiopian construction firms struggle with project delays, cost overruns, quality issues, low customer satisfaction, and construction process waste.

Traditional project planning and scheduling methods, such as the Critical Path Method (CPM) and bar charts, have been the mainstay in the building construction sector of Ethiopia. These conventional methods focus on a push system where the project manager and scheduling team dictate the sequence and timing of activities, often without regular updates or collaborative input from the team executing the work (Jin, 2013).. However, these methods have limitations, particularly in their ability to adapt to changes and manage the complexities of construction projects, which often result in projects not being executed on time, within budget, or to the desired quality (Limenih et al., 2022).

The Last Planner System (LPS), a lean construction tool, has been introduced as an alternative to traditional methods to address these issues. LPS transforms the traditional push system into a pull system, emphasizing collaboration, commitment, and the ownership of the project schedule by the workforce. It includes tools such as the master schedule, look-ahead schedule, and weekly work plans, which are designed to improve the reliability of planning and the efficiency of workflow (Jin, 2013).

In the context of Ethiopia, the adoption of LPS has been proposed to enhance the current construction management system, with the expectation of achieving time, cost, quality, and claim-related benefits (Limenih et al., 2022). However, the implementation of LPS faces barriers such as labor-related issues, internal working environment challenges, stakeholder resistance, exogenous factors, and material-related constraints (Limenih et al., 2022).

2.2 Deficiencies in Traditional Building Construction Process

Due to the construction industry's high variability, poor performance and unsafe working environment, it has become crucial to seek innovative and creative solutions and alternatives that ensure better and more optimized management techniques that could minimize the sources of wastes and increase the performance of the construction process (Saad et al., 2017).

In a case study by Parekh et al. (2020) to compare the Critical Path Method (CPM) and the Last Planner System (LPS) with respect to the planning and scheduling of the Metro Rail Project in Ahmedabad, Gujarat, it was observed that the Last Planner System is more appropriate to use in order to avoid time-overruns and consecutive cost overruns.

The majority of traditional construction sites are based on management modes such as push instead of pull, which generates additional storage costs, and the site of construction become condensed by materials without adding value for the customer, which leads to negative impacts on quality, especially under weather conditions (Saad et al., 2017).

It has been contended by the Lean Construction Institute (2014) that about 57% of productive time waste can be found in the construction industry. These wastes have been attributed to the inadequacies of the current project management tools (Ansah et al., 2016). In traditional construction projects, value-added activities (direct work) don't exceed 32% of the time spent on site, and more than 50% of scheduled tasks are not carried out on time (Saad et al., 2017). The study added that most of the traditional construction sites are poorly organized and can be considered the main causes of accidents on the site of construction.

Table 2. 1: The comparison of traditional and lean construction management

Factors of Comparison	Traditional construction(Gantt, CPM, PERT)	Lean Construction (LPS)
Main focus	▪ Focuses on time ▪ Identify start and end dates ▪ Helps to identify task r/ships ▪ Resource critical path might happen(Milano, 2019). ▪ Push strategy	▪ Focuses on resource and the relationship between them ▪ Pull strategy
Waste elimination and value adding	▪ Lack of waste elimination character (Ansah et al., 2016), (Parekh et al., 2020), (Saad et al., 2017).	▪ Identify and remove non-value adding activities throughout the project life cycle (Ansah et al., 2016), (Parekh et al., 2020), (Saad et al., 2017).
Collaboration among stakeholders	▪ Rigidly hierarchical structure ▪Lack of mutual collaboration ▪Absence of performance indicators (PPC,TA, TMR) (Ansah et al., 2016), (Parekh et al., 2020), (Saad et al., 2017).	▪ Scheduling, piloting, and coordination with all the stakeholders of the project ▪ Collaboration and sharing of multilateral issues ▪ Controlling of the variance of the construction process by measuring the PPC (Ansah et al., 2016), (Parekh et al., 2020), (Saad et al., 2017).

Site organization	▪Poorly organized construction site	
Scheduling	▪Master scheduling	▪ Master scheduling ▪ Phase scheduling ▪ Lookahead planning ▪ Weekly work planning (WWP) ▪ Daily plan
	▪The system empower managers to be the sole planners.	▪The system empowers front-liner planners
	▪Corrective	▪Preventive
	▪Strategic planning (Kim, 2002)	▪Production planning (Kim, 2002).
Coordination	▪Following orders (Kim & Park, 2006)	▪Keeping promises (Kim & Park, 2006)
Optimization	▪Specific activity (Kim & Park, 2006)	▪Entire project (Kim & Park, 2006)

2.3 Enhancing construction process efficiency in the Ethiopian building construction sector

The enhancement of the construction process in the Ethiopian building construction sector can be approached by addressing several key challenges and implementing strategic improvements. The lack of knowledge and application of value engineering principles among Ethiopian construction project experts is a significant barrier to efficiency and cost effectiveness (Garomsa, 2019). This gap in expertise leads to conventional management practices that result in project delays, cost overruns, and poor quality outcomes. To address this, there is a need for capacity building and training in value engineering to optimize resource utilization and minimize waste.

The Last Planner System (LPS) has been identified as a critical tool for enhancing construction processes by improving productivity and reducing waste (Aslam et al., 2020; Khanh & Kim, 2013). In the context of the Ethiopian building construction sector, the implementation of LPS could address prevalent issues such as delays, cost overruns, and quality concerns (Limenih et al., 2022). LPS encourages a collaborative approach to planning and control, which involves all stakeholders in the construction process, from foremen to project managers, fostering a sense of ownership and commitment to the project schedule (Gao & Low, 2014).

Waste in the construction industry refers to inefficiencies and losses resulting from non-value-adding activities. Despite being associated with physical waste, it can also stem from wasteful operations. Construction management often neglects to address non-value-adding activities, with studies focusing on consequences rather than root causes (Ayfokru, 2023).

The study by Sahlu and Dinku (2021) found that construction companies primarily focus on addressing physical wastes, neglecting non-physical wastes like waiting time, unnecessary transportation, movement, and defective works. These non-value-adding activities, according to lean construction theory, are often overlooked. Unnecessary transportation and movement, including smoking, drinking, and chatting, are also observed in Ethiopian construction companies (Sahlu and Dinku, 2021).

LPS originates from the lean production philosophy with the main objective of reducing the waste within construction by maintaining constant flow, to providing maximum value to the product / project in a sustainable way, and to continuously improving over time, which generally improves the construction process of the building construction sectors (Venkatesh & Venkatesan, 2021).

In recent years, many developing countries have started to implement lean in their projects in order to minimize waste and maximize value. The implementation framework must be robust enough to consider the cultural, political, social, environmental and economic attributes to the developing countries (Prabaharan & Shanmugapriya, 2023).

2.4 Lean construction

Lean construction is a theory of lean production that was introduced into the construction industry as a new model (Li et al., 2020). Despite the differences between construction operations and supply chains compared to (production) manufacturing, the principles of lean can still be applied. LC aims to achieve the same objectives as lean production, which include eliminating waste, reducing cycle time, improving continuously, reducing variability, promoting continuous flow, and implementing pull production control (Ansah et al., 2016). The International Group for Lean Building coined the term LC to develop a method for minimizing the waste of resources, time, and effort during building activities (Francisco, 2024).

The development of LC is unbalanced across the world. The United States, Britain, Brazil, and other countries have significant advantages concerning LC theory and its practical application although is not well known in actual construction projects in Mainland China (Li et al., 2020).

Building and infrastructure project construction involves various professions and non-professionals. This collaborative approach can result in disjointed efforts and a difficult coordination process. Unfortunately, this complexity can inject non- value-added activities and processes into the construction industry's supply chain. These non-value-added factors lead to inefficiency and low production, posing considerable problems for the entire business. The previously described Lean building principles might address these issues and boost production (Francisco, 2024).

The construction industry spends almost equivalent time in Non-value adding (NVA) activities (57%), as compared to the time spent by manufacturing towards value-adding activities (62%) (Prasad & Venkatesan, 2021). Carefully planned and properly executed application of lean principles have been found to cause significant improvements in the quality, safety and efficiency of construction projects (Prasad & Venkatesan, 2021).

Lean Construction is advocated as a valuable approach in the construction industry due to its focus on waste reduction, value generation, collaborative efforts, improved project performance, and addressing industry challenges. By minimizing or eliminating waste in the construction process, Lean Construction aims to enhance efficiency and cost-effectiveness. Emphasizing the importance of maximizing value for clients, Lean Construction encourages the joint effort of all project participants to optimize project outcomes and enhance client satisfaction. Through the application of lean manufacturing principles, Lean Construction offers a new and robust approach to dealing with the inefficiencies of traditional project management models, ultimately leading to improved project and financial performance in the construction industry**.**

The Last Planner System has become one of the most well-known and widely used Lean construction tools for planning and control. In some cases, it is even used interchangeably with the term Lean construction, as it is a practical tool to apply Lean thinking principles in the construction industry (Francisco, 2024).

2.5 The Last planner system

The traditional management systems such as Critical Path Method (CPM), and PERT are a widely used system for creating a project's master plan. However, they lacks operational clarity on task execution (Venkatesh & Venkatesan, 2021; Khanh & Kim, 2016). It is often criticized for providing no assurance that the work is ready to start whenever required, which affects the workflow. CPM and PERT hinders collaboration between project personnel and can isolate other stakeholders from the planning process (Mahmoud et al., 2019).

The Last Planner System is a key tool in the Lean Construction philosophy, promoting agile and proactive management during construction work (Andújar-Montoya et al., 2020). It is a technique that shapes workflow and addresses project variability in construction. LPS proposes a way to achieve more with less effort, less equipment, fewer personnel, and less space, and targets reaching what indeed adds value to clients in the leanest way. Its main goal is to deliver value to clients most efficiently by eliminating waste through optimized processes that focus on the core competencies of the production value chain (Raol, 2021). It involves phases like a master schedule, phase scheduling, look-ahead planning, and weekly work plan. The Last Planner is the person or group accountable for operational planning, that is, the structuring of product design to facilitate improved workflow, and production unit control, that is, the completion of individual assignments at the operational level (Salem, 2015).

Lean concepts are being adopted by the construction sector as an alternative to traditional management techniques. Planners are encouraged by the Last Planner System (LPS) methodology to concentrate on workflow links as opposed to task execution. Managing handoffs, keeping promises, making sure prerequisites are ready, and maintaining the flow of tasks and transactions are examples of core actions (Shehab et al., 2023).

Bhargav et al. (2015) added that the Last Planner System was created to address the shortcomings of the traditional construction management systems, particularly the PPC and Reasons for Non-Completion charts. According to the authors, a solid theory of planning and scheduling is essential, along with a more appropriate approach that tackles critical aspects of the planning and scheduling function. Last Planner system is widely regarded as the leading production planning method that takes a master plan as its input. It was developed to enhance the reliability of workflow and minimize uncertainty or variability, which is often, neglected in traditional project management approaches. Consequently, this method leads to a reduction in overall waste. The schedule based on LPS is regularly updated and adjusted based on implementation and indexes such as PPC. This is in stark contrast to traditional schedules, which lack dynamic adjustment and updates.

According to Daniel et al. (2017), the LPS is a production planning and management methodology for construction developed in the 1990s for the construction industry. It supports the development of collaborative relationships among those doing the work. In the LPS approach, managing project production, planning and control are integrated; however, in the traditional approach, managing project production, planning is separated from control (Daniel et al., 2017).

Tayeh et al. (2018) in their study explained the Last Planner Concept (LPC) as an applied technique in which construction executives and crew leaders cooperate with each other to arrange work plans. The outcome work plans will be executed with a high level of reliability, therefore enhancing work constancy and expectedness.

The Last Planner system (LPS) is a production planning and control system that has been successfully implemented on construction projects to increase the reliability of planning, increase production performance, and improve workflow in design and construction operations (F. Hamzeh, 2015). It challenges the old practices of developing schedules and pushing them from top management down to frontline people to execute. It advocates collaborative planning, performing collaborative constraint analysis, and learning from plan failures. The Last Planner System is not only a system for production planning and control but also an enabler for social exchange on construction projects. It institutionalizes coordination and communication by incorporating them into everyday activities and into a managerial structure for project planning and control, team building, and continuous improvement (F. Hamzeh, 2015).

The nature of the LPS and its continuous improvement feature also allow for a deeper understanding among the project team through their investigation of reasons for the non-completion of tasks. Many researchers also claimed that LPS, through its collaborative approach, encourages teamwork, enables proactive involvement, promotes participation, transparency, and improves communication and coordination (Perez & Ghosh, 2018).

The Last Planner System is a planning, monitoring, and controlling system used to achieve Lean Construction targets by reducing waste, increasing productivity, and improving workflow reliability (Limenih et al., 2022). Planning and controls are considered internal factors, and improvements in these processes have been identified as one of the most effective ways to increase efficiency in the construction industry (Perez & Ghosh, 2018).

The lack of adequate planning and the use of inexperienced workers contribute to the incidence of production flow waste on site. It is worth noting that the occurrence of any of this waste has a cumulative effect on the production process. When one operation is delayed, it will affect the entire production or construction process, thus leading to a lack of flow in the entire process and an increase in production flow waste (Daniel et al., 2017). LPS has the potential to minimize production flow waste in the construction process in order to enhance the process because of its ability to reduce uncertainty and risk inherent in the production process. It was found that implementation of LPS within projects created predictable and reliable project plans in full detail, identified and removed constraints before they became obstacles, improved logistics at sites and supported the completion of projects within agreed durations, and costs (Abdelaal et al., 2015).

The Last Planner System (LPS) implementation offers several benefits to the construction industry, as evidenced by various studies. The primary advantages include improved productivity, enhanced efficiency, and reduced waste, which are critical in addressing the longstanding issue of low productivity in the Architecture, Engineering & Construction (AEC) industry (Heigermoser et al., 2019). LPS is known to facilitate better project management by ensuring that projects are executed on time, within budget, and with the desired quality (Limenih et al., 2022). It also contributes to workflow continuity, which is essential for the timely delivery of construction projects.

The results of a questionnaire of Norwegian Contractor Company, all of which had already begun implementing lean practices, revealed that 51% of the employees agree or partly agree that the implementation of lean construction has been successful for their respective companies (Olav et al., 2018). Additionally, the results indicate that the companies experiencing increased productivity are the ones that incorporate Lean Construction elements most frequently in their organizations and projects (Olav et al., 2018).

A consistent finding was that employees who came straight out of school had less trouble adopting a lean mindset. This is most likely because they possess no earlier experience related to the current state of daily operations (Olav et al., 2018).

Moreover, the application of LPS has been correlated with improved project performance, including adherence to schedules, cost management, and guaranteed work quality. The strategic application of lean construction principles, including LPS, can lead to significant benefits such as environmental protection, economics and time savings (Tamošaitienė & Starta, 2019).

In conclusion, the Last Planner System is a valuable tool for enhancing the management of construction projects. Its implementation can lead to more reliable planning, better supply chain integration, and reduced workflow time, ultimately contributing to the success of construction projects (Fernandez-Solis et al., 2013). However, the full potential of LPS can only be realized when the construction industry overcomes the barriers to its implementation, such as resistance to change and the need for greater knowledge and skills among professionals.

2.5.1 Components of the Last Planner System

2.5.1.1 Master Scheduling

Master scheduling is a planning process that takes place at the beginning of a project. It involves creating a schedule that outlines all the work to be done throughout the project (Mahmoud et al., 2019). Master schedule includes project-level activities and identifies major milestone dates mostly in relation to contract documents and the owner’s value proposition (F. Hamzeh et al., 2012). It is a comprehensive overview of the entire project, including all work packages, main activities, durations, and their sequence. The master schedule is based on design criteria and client objectives, which serve as the project schedule. Phase managers and subcontractors develop the plan, identifying work releases for production (Gao & Low, 2014). It is used to determine the main actors, the sequences of buildings, and the milestones that should be accomplished during the steps of the project.

The main purpose of the master schedule is to ensure that all milestones and the entire project can be executed on time. The master schedule shows the start and end dates of the tasks and how they progress in terms of flow. The focus in this schedule is on the most important tasks, while less important tasks, such as those with short durations, should not be included in the master schedule or can be included as part of other tasks' work content (Junnonen & Seppänen, 2004). Since it is an approximate plan, errors in estimating costs and quantities of work should be considered. The master schedule initiates the strategic planning of the project and defines the timing of different phases of that project, taking into consideration that the master schedule has the lowest level of detail.

2.5.1.2 Phase Scheduling

Phase scheduling is a crucial step within the Last Planner system where the master plan is divided into distinct phases. This process involves developing elaborate work plans and establishing goals for the project team. It generates a schedule covering each project phase, such as foundations, structural frames, or finishing (F. Hamzeh et al., 2012). Phase planning acts as a bridge between the master plan and look-ahead planning. Phases are defined by milestones, and the individuals responsible for each phase work together to develop the plan. This process helps teams understand the project, their roles, and project success requirements. It also allows them to anticipate constraints (Ribeiro & Costa, 2018).

Phase scheduling applies a technique known as "pull planning," where teams work backward from a clearly defined milestone (Junnonen & Seppänen, 2004). The purpose is to identify detailed tasks required to reach the milestone and establish conditions of satisfaction for task handoffs. Usually, this process takes place six to twelve weeks in advance, depending on the lead times needed to remove constraints. The advantage of this approach is that it allows the individuals responsible for the work to be involved in the planning process. As a result, a strong sense of ownership is developed among the entire project team, leading to improved reliability and accountability (Venkatesh & Venkatesan, 2021). Phase scheduling sets the foundation for subsequent LPS processes such as look-ahead planning and weekly work planning, ensuring that the work can and will be executed according to plan.

2.5.1.3 Look ahead Planning (LAP)

Lookahead planning is the initial stage of the production planning process, serving as a bridge between long-term and short-term planning (Fernandez-Solis et al., 2013). It makes scheduled tasks ready to be performed, shields activities on the weekly work plan from variations by removing constraints, sizes capacity to work flow, produces a backlog of workable activities, and designs how operations are performed. As to Santos and Tokede, (2017), look ahead planning identifies and lists upcoming assignments, consulting experts for feasibility, procuring materials and equipment, adjusting plans as necessary, and creating a list of pre-assignment activities. It extends the planning horizon for 6-8 weeks and is determined by project characteristics, planning system reliability, and lead times for information, materials, labor, and equipment (Gao & Low, 2014).

According to the study by Ribeiro and Costa, (2018), look ahead planning ensures that the required resources are available and identifies any activities that may face resource shortages. Its primary objective is to regulate the workflow within the production system. The look-ahead planning is checked for prerequisites: work, surface readiness, labor available, equipment available, materials available, plans available, and favorable external conditions (Saad et al., 2017).

Look-ahead planning uses a pulling and screening system to ensure workflows are integrated into work packages. However, new tasks, or "new tasks," can emerge during the execution week that were not anticipated or planned to be completed within the given period. These tasks disrupt workflow and impose a burden on planning, as they tap into limited resources. The reliability and success of the look-ahead process depend on its ability to properly plan, account for, and anticipate all required tasks (Shehab et al., 2023).

Through look-ahead planning, project management focuses on future work, taking actions in the present to make that work possible. Weekly work plans are based on the look-ahead plans and outline daily tasks for completing assigned work (Santos & Tokede, 2017).

2.5.1.4 Weekly Work Plan (WWP)

The weekly work plans in the LPS are the most detailed form of planning. The last planners are responsible for selecting activities to be implemented, which can be included in the first week of the Lookahead plan, also known as the Weekly Work Plan. The LPS is derived from the look-ahead plans and uses the Last Planner System to convert tasks into actionable items. This creates an inventory of ready-made work (Gao & Low, 2014).

The weekly work plan is generated during weekly meetings, where the contractor's tasks for the next day or week are discussed. These meetings serve to plan the work that will be done in the upcoming week, covering topics such as weekly plans, safety issues, quality issues, resources, construction methods, and any on-site problems that arise.

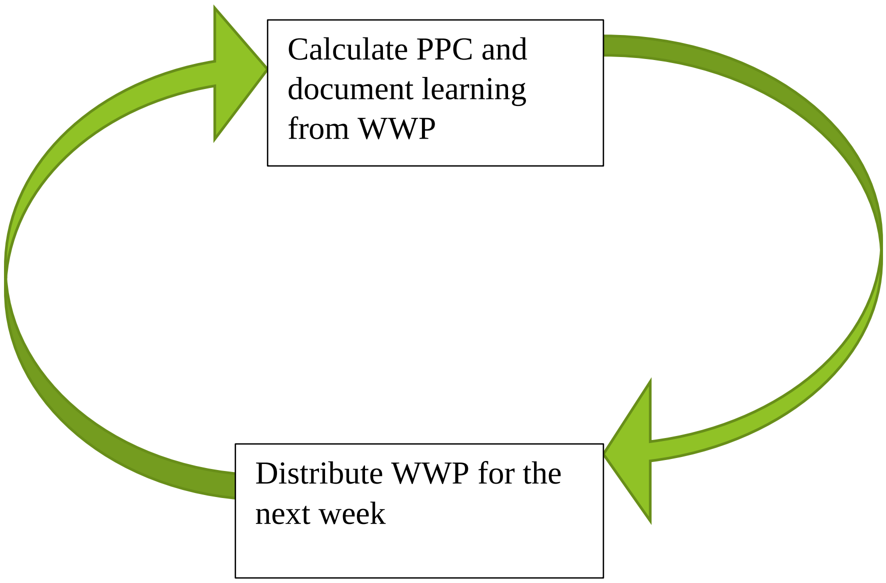

Figure 2. 1: Weekly planning cycle

2.5.1.5 Percent Plan Complete (PPC)

The Last Planner System incorporates a quantitative measure known as the Percent Plan Completed (PPC) to monitor progress. Percent Plan Complete (PPC) is a metric used to track the performance of reliable promising at the weekly work plan level by measuring the percentage of tasks completed relative to those planned (Muchtar, 2010). Therefore, it gauges the reliability of the planning system. LPS thus helps assess the reliability of work plans and initiates preparations to perform work as planned. PPC is not a direct measure of project progress, but rather a measure of the extent to which promises are kept, and hence, the extent to which future workload may be predictable (F. Hamzeh et al., 2012). This measure is obtained by dividing the number of completed tasks by the total number of tasks scheduled for the week. In the event of any setbacks or failures, they are identified and addressed promptly. Maintaining a high PPC is crucial for ensuring accurate work projections and the timely completion of tasks. This facilitates the preparation of jobs according to the predetermined schedule (Gao & Low, 2014).

The continuous evaluation and learning from setbacks are fundamental for enhancing project planning. PPC assesses the proportion of commitments fulfilled within the stipulated time frame. It can be computed by dividing the number of activities completed as planned by the total number of planned activities. Monitoring the project progress is accomplished by using PPC, also referred to as the percentage of planned completion (Hussain et al., 2015).

Percent Plan Complete (PPC) should be measured to enhance projects and promote continuous improvement. If the PPC is low, it indicates that practitioners are not on the right track and need to identify the Reasons for Non-Completion (RNC). This helps assess the alignment between planned and completed work. As part of the PPC measurement process, the reasons for non-completion of assignments in the weekly plan need to be recorded to learn from mistakes, such as lack of equipment and tools, labor shortage, delayed materials, unanswered information, or restricted work area access. Higher PPC values generally indicate better quality, reliability, scheduling effectiveness, and work efficiency. Statistics suggest that general engineering construction teams typically achieve a PPC of around 50%, but this can be increased to 80% with the use of LPS (Jin, 2013). The analysis of causes based on PPC extends beyond WWP activities and includes the entire production process. Adjustments may be made to look-ahead plans and even the project's master plan, if necessary.

Percent planned complete, or PPC, is the most often used statistic for assessing planning reliability. It compares the percentage of work that are actually completed to the percentage of jobs that are planned for a specific period. The number of activities that were effectively finished and prepared for execution by identifying and removing their restrictions is measured by tasks made ready (TMR), whereas tasks anticipated (TA) measure how well look-ahead planning was anticipated a few weeks in advance. These TA and TMR measures contribute to a more thorough assessment of LPS performance, improved alignment of short- and long-term plans, and a more successful and cohesive implementation of LPS (Shehab et al., 2023). Based on this theory and a review of several pieces of literature, a summary of the components of the last planner system is presented in Table 2.2 below. (Jin, 2013).

Table 2. 2: Summary of the Last planner system Components

LPS Components	Time Horizon	Activities During Each Phase
Master Schedule		Set milestones (F. Hamzeh & Bergstrom, 2010)
Phase Schedule	6-12 weeks	Divide the master plan into different stages to improve further detailed and information work plans (Tayeh et al., 2018)
Lookahead Plan	2-6 weeks	The activities constrains are identified and removed(material, equipment, submittal schedule, coordination) (Mahmoud et al., 2019), Ensuring that all prerequisites are available ,task definition, proper sequencing of the task, matching workload and capability of those who perform the task (F. R. Hamzeh et al., 2015)
Weekly Work Plan	Days in one week	Weekly work assignments, reliable promising, measure PPC, learning from failure (F. Hamzeh & Bergstrom, 2010)

2.5.2 The Last Planner System implementation principles

The Last Planner System (LPS) is a tool used in construction projects to plan and control production. It includes key elements such as the master schedule, phase schedule, look-ahead schedule, pull planning, work-in-progress limit, percent plan complete, improved visualization, 5S procedures, regular huddle meetings, first-run studies, fail-safe for quality, value stream mapping, and affordable working planning (Khanh & Kim, 2016; Tayeh et al., 2018).

The goal of LPS is to improve planning reliability, enhance production performance, establish consistent workflows, and address uncertainties. However, research suggests that LPS implementation is often incomplete, resulting in gaps and compromised schedule reliability. The look-ahead plan and weekly work plan (WWP) are critical components of LPS. The look-ahead plan involves analyzing constraints and making necessary preparations in advance for each task, while the WWP evaluates the outcomes of action courses through failure reason analysis and percent plan complete measurement (Khanh & Kim, 2016 ; Lindhard & Wandahl, 2015; Tayeh et al., 2018). According to Heigermoser et al. (2019), the LPS encompasses several tools: master scheduling, phase scheduling, weekly work planning, PPC, workable backlog, daily huddles, constraint analysis, variance analysis, visual management tools, reliable promising, and improvement.

Master Scheduling outlines the major phases and milestones of the project, while Phase Scheduling involves more detailed planning for the near future. Weekly Work Planning defines specific work assignments, and PPC measures the percentage of completed tasks compared to the planned ones. Workable backlog buffers ensure a continuous workflow, and constraint analysis helps identify and eliminate any constraints. Variance analysis examines deviations to learn from mistakes and improve future performance. Visual management tools, such as color-coded 4D construction simulations, enhance communication among team members. A reliable promise ensures that commitments can be relied upon and fulfilled. Finally, improvement involves regular reviews of processes and outcomes to identify areas for enhancement. (Heigermoser et al., 2019)

These tools and processes are designed to work together to enhance the overall management of construction projects. They increase workflow reliability and minimize waste. It is crucial to integrate these elements into a coherent system to successfully implement LPS. In conclusion, by effectively utilizing these tools, significant improvements in project performance can be achieved. The positive correlations between LPS implementation and construction project performance support this (Venkatesh & Venkatesan, 2021).

By utilizing these vital elements of LPS and monitoring their respective indicators, project participants can gain insights into the status of the Last Planner System, identify areas for improvement, and make informed decisions to enhance its effectiveness in project execution. Some of the LPS principles by different authors summarized in a table format.

Table 2. 3: Last Planner System principles

Last planner principles	**References**
Availability of all plans at different levels for all project participants Master schedules with milestone details Tasks are planned in increasing detail as task execution approaches Tasks are planned with those directly executing them Re-plan as needed Collaboratively identify and remove constraints Improve workflow reliability Start well-defined, sized, and sequenced tasks Secure and reliable promises Continuously learn from failures to prevent future occurrences Underload resources for increased reliability Maintain a ready-to-execute backlog Percent Plan Complete	(Venkatesh & Venkatesan, 2021)
Improved visualization Regular huddle meeting First run study Planning in greater detail as time gets closer to executing the work	(Tayeh et al., 2018).

Involve task performers in developing the work plan. Identifying and removing work constraints ahead Making reliable promises Coordinate and negotiate with trade partners and project participants to drive work execution. Learning from planning failures	(F. Hamzeh & Bergstrom, 2010)

2.6 Readiness of Construction Industry towards Implementing Last Planner System

Organizational culture plays a crucial role in fostering lean readiness, with change management and continuous improvement being the lowest attributes ranked in the case study organization (Prasad & Venkatesan, 2021). Behaviors that emerge from LPS implementation, such as social networks, learning, continuous improvement, systematic thinking (plan, do, check, act), establishing clear production goals, and treating construction projects as production systems, are indicators of the LPS implementation level (Fauchier & Da Alves, 2013).

The readiness of the construction industry towards implementing the Last Planner System (LPS) in lean construction varies globally, as evidenced by the research conducted in different countries. In Sri Lanka, the construction industry shows interest in adopting lean construction and LPS, but faces challenges such as a lack of knowledge and skills, and resistance to change (Priyadarshana et al., 2022). Similarly, in Indonesia, the readiness level for LPS implementation is moderate, with challenges including a lack of confidence and resistance to change (Utomo Dwi Hatmoko et al., 2018). The study in Addis Ababa indicates that the current construction management practices are not aligned with LPS principles, and there is a need for a conceptual framework to enhance the implementation of LPS (Limenih et al., 2022).

Globally, the construction industry has encountered poor implementation and integration of lean concepts, despite the potential benefits of LPS in improving waste reduction, cost, and time efficiency (Tamošaitienė & Starta, 2019). In India, the implementation of LPS has shown explicit improvements in schedule performance and implicit improvements in coordination, collaboration, and trust within project teams (Kovvuri et al., 2016). The literature review in Venkatesh & Venkatesan (2021) identifies the benefits, critical success factors, barriers, and drawbacks of LPS, suggesting that addressing the difficulties faced during LPS implementation could translate to project success and instill confidence in industry practitioners.

In conclusion, while there is recognition of the benefits of LPS in lean construction, the readiness of the construction industry to implement LPS is influenced by various factors, including knowledge and skill gaps, resistance to change, and the need for a supportive framework. The industry's willingness to adopt new management technologies and the successful integration of LPS with other technologies like BIM could further enhance productivity and efficiency. The studies suggest that, with the right strategies and support, the construction industry can move towards a more widespread adoption of LPS.

The lean readiness factors have been broadly categorized into six themes/focus areas, viz., top management commitment & leadership, organizational culture, employee engagement, customer focus, communication, technology & process management (Prasad & Venkatesan, 2021).

Table 2. 4: Last Planner System implementation readiness factors

Last Planner System Readiness Theme	**Last Planner System Readiness Factors (principles)**	**Authors**

Top Management Commitment and Leadership	Support and commitment to new initiatives by providing needed infrastructure Dedication of time by top management to ensure the adoption of initiatives for continuous improvement Commitment from the organization to economic and financial objectives along with growth and long-term survival Humble leadership with mutual respect for subordinates and peers	(Prasad & Venkatesan, 2021), (Aghayev et al., 2020)
Customer Focus	Project selection based on organizational competencies Participation of the client in the project's planning and development Existence of a mechanism for determining the needs of and adding value to customers Value is monitored and measured continuously during the project lifecycle	(Prasad & Venkatesan, 2021),
Organization Culture	Strategic efforts and business goals, connected by systemic thinking Cooperation between the organization and all of its stakeholder's viz., customers, suppliers, etc. Non-hierarchical culture, reduced barriers to creativity and innovation from all organizational levels	(Prasad & Venkatesan, 2021),
	Focus on team collaboration in a project- or management-related environment	

Employee Involvement and Engagement	Employee initiative to support projects and activities for continual improvement Participation of lower-level or junior staff in project review meetings Efforts of the employees are recognized and are rewarded Full participation of the workforce in all activities	
Communication	Regular communication on strategy and vision of key initiatives Communicating with all employees the purpose, vision, strategy, goals, and Communication Objectives of the business Information exchanges across the hierarchy-horizontal and vertical Coordinate and negotiate with trade partners and project participants to drive work execution.	(Prasad & Venkatesan, 2021),
Project Planning	Standardization of meetings for short- and long-term planning Emphasis on short-term planning Use of a transparent, understandable master plan	(Prasad & Venkatesan, 2021),

	Participation of crew members and last planners in collaborative planning; Inclusion of only work packages without constraints in short-term plans Involve task performers in developing the work plan	
Project Monitoring and Control	Use of indicators to assess schedule accomplishment Focus on ensuring that the project is executed as planned instead of variance detection Utilizing metrics to assess performance and taking remedial actions based on the causes of non-completions of plans Identifying and removing work constraints ahead Making reliable promises	(Prasad & Venkatesan, 2021), (Aghayev et al., 2020)
Inventory and Wastage Control	Inventory planning and procurement based on production plan Pull based approach Rationalized planning and location of material stockyard facilities suiting to site and Work requirements Procuring supplies in the required sizes, lengths, and dimensions on the job site	`(Prasad & Venkatesan, 2021),

Table 2. 5: The implementation level of LPS in different countries of the world

Country	Implementation Level	Benefits Gained	Authors
USA	Established	Improved project predictability Reduced rework Enhanced collaboration	Ballard (2000), Howell et al.(1993)
Brazil	Growing	Increased schedule reliability Improved communication	Formoso et al.(2016), Alves et al. (2017)
Sri Lanka	Pilot Projects	Potential for reducing waste and delays	Karunasena et al. (2018)
China	Limited Adoption	Studies suggest potential benefits, but large-scale implementation not widespread	Li et al. (2013), Zhang et al. (2017)
UK	Moderately Implemented	Varied results depending on project context	Vrijhoef and Robinson (2007), Aier et al. (2017)
India	Emerging	Growing interest, pilot projects underway	Gupta et al. (2018), Pande et al. (2020)
Germany	Pockets of Adoption	Used in some sectors, further research needed	Schmidt et al. (2011), Bergh et al. (2015)

As reviewed and indicated in Table 2.5 above, the use of LPS technology has been extensively embraced in Western states, yielding positive outcomes. However, this technology is still in a nascent stage in developing countries.

Though lean construction has more benefits, implementing them in the construction industry has become a challenging one, especially in developing countries (Prabaharan &

Shanmugapriya, 2023). The categories of barriers to implementing LPS in construction are found to be similar in both developing and developed countries (Sarhan, 2018).

2.7 Barriers in the implementation of the Last planner system

Barriers to implementing the Last Planner System (LPS) vary across different geographical and organizational contexts. In Egypt, the construction industry faces challenges such as a lack of market knowledge on LPS and resistance to change from traditional practices (Aboseif & Khallaf, 2020). Similarly, in Sri Lanka, the adoption of LPS is hindered by a lack of knowledge and skills among professionals, as well as organizational resistance to change (Heigermoser et al., 2019).

The Vietnamese construction industry identifies the master schedule as the most critical aspect of LPS, with barriers arising from the relationships between owners, contractors, and consultants (Khanh & Kim, 2013). In the broader context, resistance to implementing LPS, involvement of multiple parties in projects, and the need for commitment from top management are significant barriers (Venkatesh & Venkatesan, 2021). The Sri Lankan construction industry also faces challenges specific to the master planning and phase planning stages of LPS implementation.

In Indonesia, the readiness for LPS implementation is moderate, with challenges including a lack of confidence and resistance to change (Utomo Dwi Hatmoko et al., 2018). Lastly, in China, while some components of LPS are in place, there are still barriers related to the organizational culture and the structure of the construction industry (Gao & Low, 2014).

In the construction industry, successfully implementing a lean tool like LPS requires a commitment to learning, changing, and focusing on people and philosophy rather than just tools and methods (F. R. Hamzeh, 2011). While many organizations are implementing the Last Planner System, scholars have reported barriers and constraints in the implementation process (Perez & Ghosh, 2018).

Bhargav et al. (2015) found that firms in the UK and Finland have only implemented three main LPS tools, primarily focusing on short-term planning. The study highlighted the effective implementation of look-ahead planning as a major problem. Similarly, a study of over 100 projects in Chile concluded that only selected elements of the LPS were effectively deployed. Specifically, the make-ready (look-ahead planning), workable backlog, and corrective action aspects were not widely implemented. The study also emphasized the lack of supply chain integration as a major problem.

The study by Lindhard & Wandahl (2015) found that the root of failure in execution processes often starts in the look-ahead plan, where problems are overlooked. This could be caused by a lack of knowledge, indicating a potential barrier to effective implementation. To enhance the effectiveness and dependability of the planning process, the paper suggests incorporating foremen in look-ahead planning, which could significantly contribute to improving the overall level of PPC.

Perez and Ghosh (2018) examined typical shortfalls of LPS implementation, such as an incomplete PPC process, underutilization of look-ahead plans, a lack of guideline practice for schedule updating, and a lack of a structured order for the introduction of LPS onsite (Murguia, 2019). Khanh and Kim's (2016) study identifies several barriers to the successful implementation of the Last Planner System (LPS). These include a lack of understanding of key LPS concepts, limited use of LPS elements, inadequate administration of information for learning and corrective actions, weak communication and transparency among participants, and a lack of integration in the production chain. In conclusion, addressing these barriers is crucial for successful LPS implementation and realizing the benefits of improved construction processes and project performance.

In conclusion, common barriers to LPS implementation include resistance to change, lack of knowledge and skills, organizational culture, and the complexity of stakeholder relationships. Addressing these barriers requires tailored strategies that consider the unique context of each construction industry.

Despite the advantages of the LPS, research has shown that many organizations face significant hurdles when implementing the system (F. Hamzeh, 2015). An implementation framework may help such organizations develop a better implementation plan, foresee implementation hurdles, invest resources in the change process, successfully implement the LPS, and sustain this success.

Table 2. 6: studies on the Last Planner System implementation challenges

Authors	Implementation challenges/ Barriers
Deevi, (2024)	Cultural resistance, organizational constraints and insufficient government support.
Wandahl, (2014)	Mis-conceptualization and mis-implementation of Lean Construction, The knowledge of Last planner system.
Hamzeh (2009)	Organizational inertia, human capital constraints, technological barriers and general resistance to change.
(F. Hamzeh, 2015)	The lack of an implementation plan, lack of experience with lean, unclear strategic goals, limited buy-in from superintendents and project managers, and the lack of training despite the fact the owner was sponsoring the implementation process.
(Madushanka & Ranadewa, 2022)	Unexpected delays, non-presence of skilled planners, coordination between team members, lack of commitment, lack of resources, time availability, and inflexibility of the project proposals.
(Fernandez-Solis et al., 2013)	Lack of leadership, organizational inertia, resistance to change, lack of training.
(Demirkesen et al., 2019)	Lack of top management support, misperception about Lean practices, lack of information sharing and integrated change control.
(Murguia, 2019)	Integration and communication, LPS-knowledge Resistance to Change, Firm Size (Small Firm).
(Khanh & Kim, 2013)	Low implementation of advanced technology, language and culture issues, and lack of training for the project managers.

(Moyo & Chigara, 2023)	The lack of government support and inconsistency in government policies.
(Thakkar & Shah, 2021)	Resistance to change and culture, Design Detailing and Process, Culture & human attitudinal issues, lack of co-ordination and Communication.
(Prabaharan & Shanmugapriya, 2023)	Insufficient government support, lack of top management involvement, low awareness about Lean construction techniques & concepts, lack of coordination between the participants of the firm.
(Huaman-Orosco & Erazo-Rondinel, 2021)	lack of government policies to encourage the use of Lean, Lack of collaborative work between academia and the construction industry, High cost of implementation, low empowered capacity of people in the organization delays decision making, Low knowledge of Lean among university graduates.
(M. E. A. Ahmed & Wong, 2020)	Lack of incentive by the government, Lack of common goal between various firms, Legal and contract issues, lack of organization culture.
(Sarhan, 2018)	Influence of traditional practices, unfavorable organizational culture, lack of technical skills about lean techniques and lack of understanding of lean approaches.

The Last Planner System can only be applied fully and effectively in construction by focusing on improving the whole process, where all parties have to be committed and work together to overcome obstacles that may arise from conventional contractual preparation (Mohammad Asri & Mohd Nawi, 2015).

However, in order to achieve the successful implementation of lean construction, barriers are inevitable. In an attempt to understand the barriers, the review of the various pieces of literature enabled the author to identify and generalize the specific barriers into six different categories.

Table 2. 7: Categories of Last Planner System implementation barriers

Categories of barriers	The barriers	Authors
Managerial	Organizational constraint, Lack of top management support, and resistance due to organization culture.	Deevi, (2024), (Demirkesen et al., 2019).
Financial	High cost of implementation.	(Huaman-Orosco & Erazo-Rondinel, 2021),
Educational	Low knowledge of the Last planner system, and Low knowledge of Lean among university graduates	Wandahl, (2014), (Huaman-Orosco & Erazo-Rondinel, 2021).
Governmental	Insufficient government support, Lack of incentive by the government, and inconsistency in government policies;	Deevi, (2024), (M. E. A. Ahmed & Wong, 2020), (Moyo & Chigara, 2023).
Technical	Lack of technical skills about lean techniques, lack of training for the project managers, lack of understanding of lean approaches, low awareness about lean construction techniques, low implementation of advanced technology,	(Sarhan, 2018), (Khanh & Kim, 2013), (Fernandez-Solis et al., 2013), (Prabaharan & Shanmugapriya, 2023).
Attitudinal/ Cultural	Influence of traditional practices, Resistance to Change,	(Sarhan, 2018), (Murguia, 2019), (Thakkar & Shah, 2021).

2.8 Research Gaps

Based on a comprehensive literature review, multiple studies have evaluated the readiness and barriers to implementing the Last Planner System (LPS) in construction projects worldwide. However, there is a research gap regarding the readiness level and barriers for implementing LPS in the Ethiopian building construction industry. Therefore, this study focuses on assessing the current state of LPS implementation preparedness and prioritizing barriers in the local context.

Moreover, it is necessary to conduct research in Ethiopia to explore the contextual factors that contribute to obstacles in implementing LPS, which are missing from the literature. Consequently, this research analyzed how managerial, financial, educational, governmental, technical, and cultural conditions affect the adoption of LPS methodologies by construction companies. By understanding the perspectives of stakeholders, such as project managers, consultants, and engineers, this study filled the gap by identifying the challenges and opportunities for successful LPS implementation. These challenges include aspects related to management, finance, education, government, technology, and attitudes and cultures.

Despite the numerous advantages of LPS, there has been a lack of emphasis on developing a comprehensive framework to mitigate obstacles to LPS implementation and enhance construction process efficiency in the Ethiopian building construction sector. Therefore, the author addressed this point by developing a structured framework for successful LPS implementation in the Ethiopian building construction industry to enhance construction process efficiency.

By addressing these research gaps, we can enhance our understanding of the readiness level and challenges associated with implementing LPS in the building construction industry in Ethiopia. Ultimately, this will facilitate the development of a framework for the successful adoption of LPS.

CHAPTER THREE

3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter clearly defines methods and procedures implemented to achieve the specific objectives of this research. These methods and procedures were chosen based on the type of study undertaken and the anticipated outcomes. The research primarily focused on analyzing the problems associated with the three core objectives outlined above. This section provides a detailed explanation of the methodology and design used to conduct the research. It includes an overview of the research approach, including information about the study area, research design, target population, sampling techniques, sources of data and its collection methods, tests employed to ensure questionnaire reliability and validity, and ethical considerations.

3.2 Study Area

The research was conducted in Addis Ababa city, which is a major construction hub in Ethiopia, located at 9.0192° N, 38.7525° E. The building construction projects governed by the Ethiopian Construction Works Corporation (ECWC) in Addis Ababa City were the focus of the study. The Ethiopia Construction Works Corporation was selected because it is the largest public construction corporation in Ethiopia.

The establishment of ECWC as a Federal Government Public Enterprise was initiated by the Council of Minister Regulation No. 366/2015 on December 18, 2015. On September 28, 2016, the Corporation underwent amendments through Council of Ministers Regulation No. 390/2016 (http://www.ecwc.et.com). It was founded by the amalgamation of three former public enterprises: the Ethiopian Road Construction Corporation (ERCC), the Ethiopian Water Works Construction Enterprise (EWWCE), and the Prefabricated Building Parts Production Enterprise. The Ethiopian government makes up part of the financing shortfall for the construction sector from the public budget.

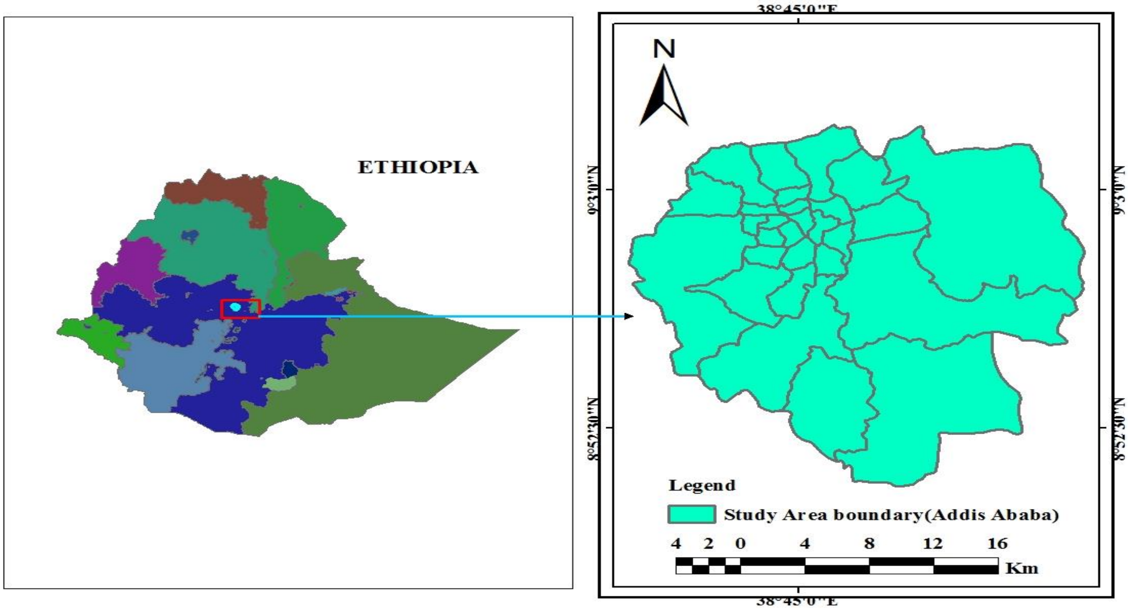

Figure 3. 1: Location of the study area

Source: shape file

3.3 Research Design

The mixed methodology approach, comprising both quantitative and qualitative methodologies, was used in this study. As applied in this study, the quantitative methodology helps to identify the LPS readiness factors and critical barriers to implementing LPS in the Ethiopian building construction industry and explain their meanings after appropriate statistical analyses and interpretations. Qualitative methodology allow researchers to control the response environment, control the order in which issues are discussed, and learn about things that can be observed only with difficulty (Gao & Low, 2014). In addition to quantitative methodology, qualitative methodology was used in this study to provoke discussion of complex topics, and provide rich and complete data. It were also used as a form of triangulation.

This was done to support and confirm the data collected from the survey. By combining both methodologies, their combined disadvantages are reduced, while their combined advantages enhanced in this study (Sarhan, 2018). Finally, both qualitative and quantitative methods were utilized to develop a framework for improving the construction process in the Ethiopian building construction sector through the application of the Last Planner System. The overall applied steps of the research have been summarized and presented in following figure 3.2.

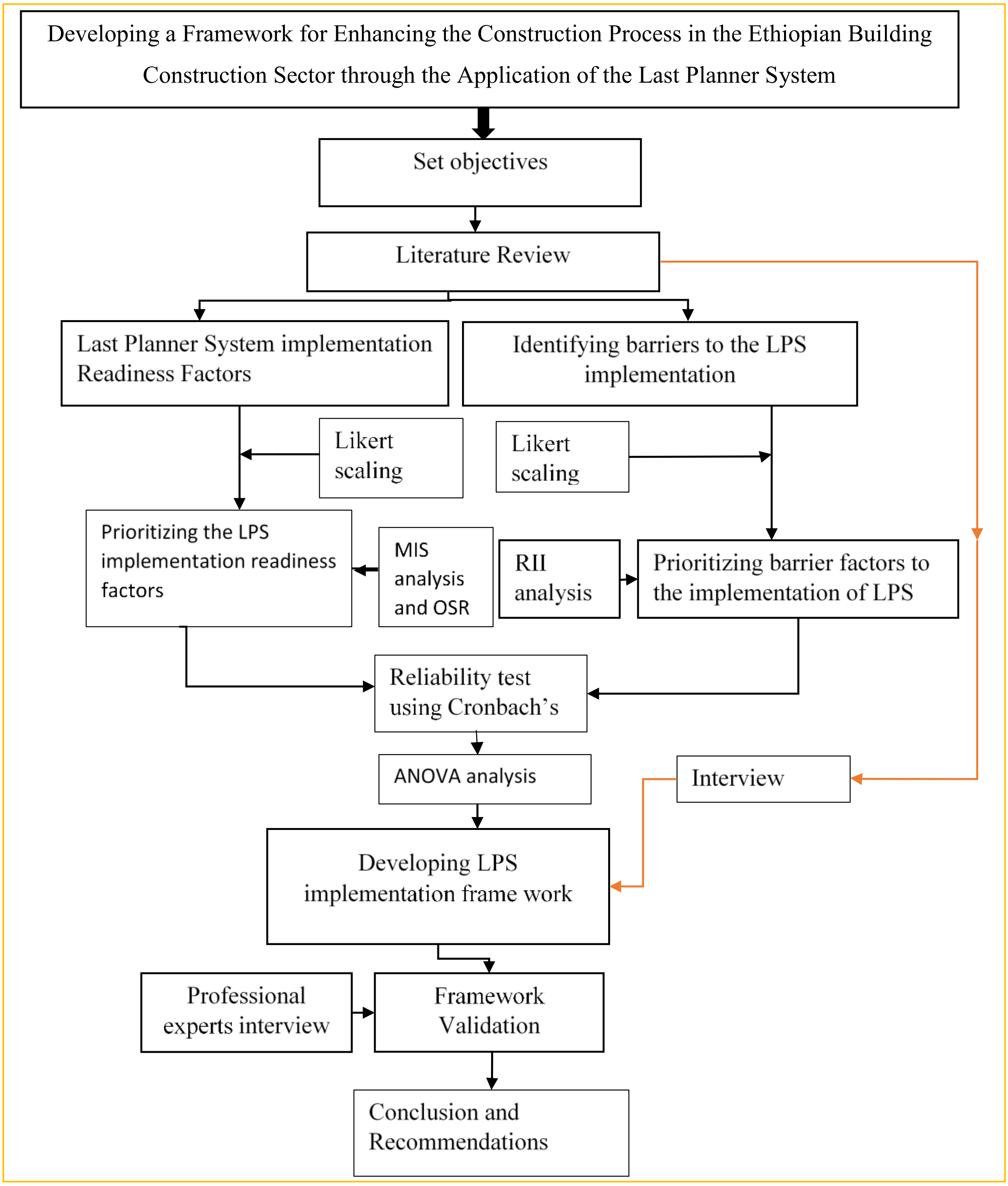

Figure 3. 2: Research Design flow chart

Source: researcher's own research design

3.4 Target Population

According to Kumar (2010), the target population, or research population, refers to a group of individuals or objects that share common characteristics or traits. In the context of this study, the target population is the specific group from which the research sample is selected. The targeted population was building construction projects undertaken by the Ethiopian Construction Works Corporation. The questionnaire forms were distributed and collected by the researcher in hard copies.

Table 3. 1: Ethiopian construction works corporation's building projects

NO.	Project name	Location
1	Nifas Silk Lafto General Hospital Building Construction Project (Lot1&2)	Addis Ababa
2	Nifas Silk Lafto Sub City Administration Building(NSLSCAB)	Addis Ababa
3	A.A teachers association 2B+G+9 mixed used & B+G+7 hospital building	Addis Ababa
4	Client name:4B+G+21 FDARA Head Office Building	Addis Ababa
5	Educational Assessment and Examination service Renovation project	Addis Ababa
6	G+B+8 Tebita ambulance head office building project	Addis Ababa
7	Ethiopian statistics service project	Addis Ababa
8	Ministry of Justice Head Quarter Renovation & Compound Work	Addis Ababa
9	Addis Ababa Entrance And Exit Market Center Project	Addis Ababa
10	Public Service Transport Depot construction Project Yeka (Administration Building)	Addis Ababa
11	Public Service Transport Depot construction Project Yeka site (Agreement II)	
12	Kolfe Woreda 02 Urban G+5 Health Center & Other Related Miscellaneous Buildings & Site Work	Addis Ababa
13	Jemo modern Bus Depot construction project (Contract One)	Addis Ababa
14	Jemo modern Bus Depot construction project (Contract Two)	Addis Ababa

15	Jemo modern Bus Depot construction project (Contract Three)	Addis Ababa
16	Gulele Public Service Project	Addis Ababa
17	FEDRE HOPR Renovation Work	Addis Ababa
18	Kolfe Keranio Sub City General Hospital Building Project	Addis Ababa
19	Public service Akaki site (administrative Building)	Addis Ababa
20	Public service Akaki site for modern bus depot project Additional block	Addis Ababa
21	Public service Akaki site for modern bus depot Site work	Addis Ababa
22	Live Stock And Related Shades Construction Project Phase Two	Addis Ababa
23	Design & Build of Housing Development Projects to Akaki Kality Sub City Woreda 05	Addis Ababa
24	Design & Build of Chaka Housing Development Projects	Addis Ababa
25	Design and Build of Prefabricated Housing development projects Nifas silk Lafto sub-city	Addis Ababa
26	Design and Build of the F.D.R.E Commando and Airborne Force Quarter Building Complex Project at Koye Feche	Addis Ababa
27	National Intelligence and Security University College Project	Addis Ababa
28	Design and Build of Apartment at Kirkos sub City Woreda 06 (Kasanchis site)	Addis Ababa
29	Design and Build of KAM Ceramic Tile Manufacturing Project	Addis Ababa
30	Design and Build of Apartment at Addis Ketema sub City Woreda 06 Paulo's site	Addis Ababa

Source: ECWC organizational development

3.5 Sampling Techniques

3.5.1 Sampling of Target population

Census sampling techniques were the sampling techniques that were employed in this research for the target population. It refers to a complete enumeration, where data is collected from every single member of a population. Ethiopian Construction Works Corporation is currently undertaking thirty building projects in Addis Ababa under the HDC-Project Charter and the BCD-Project Charter. All buildings were taken as a sample of the population for this study due to the small size of the population.

3.5.2 Sampling of the Respondents

Sampling techniques are mainly divided into two main categories: probability sampling and non-probability sampling. In probability sampling, each member of the population has an equal chance of being selected for the final sample. In contrast, non-probability sampling refers to any sampling method that does not provide a means of calculating an individual's or a group's likelihood of being selected from the population (Aburumman, 2023). The selection of instances or participants in non-probability sampling does not need to be random or even statistically significant. However, there must be a good reason for including situations or people over others. This study uses purposive non-probability sampling in selecting the research participants in order to ensure that only those with adequate knowledge of the subject participated in the study.

3.6 Sources of Data

For this study, both secondary and primary data sources were utilized. Primary data was collected from experienced professionals, including project managers, consultants, contractors, site engineers, and Forman, in building construction projects undertaken by the Ethiopian Construction Works Corporation.

On the other hand, secondary data were obtained from previously conducted researches, journals, international conferences, and published articles. These sources were used to identify problems and develop criteria for analyzing the primary data.

3.7 Data collection tools and Methods

The data collection methods used for this study were both qualitative and quantitative in the form of close-ended questionnaires and interview.

3.7.1 Questionnaire

A questionnaire is the best tool to collect responses from different respondents, allowing them to respond at the time and location of their convenience (Aghayev et al., 2020). It is the primary method for data collection in this study. A draft questionnaire was created based on a literature review to satisfy the research objectives. This data collection method was used because of its ability to collect an extensive range of attitudes from individuals, to deal with a large number of respondents, to have better generalizability of the results, as well as its cost-efficiency. Moreover, this method is compatible with the quantitative approach, which allows the statistical testing of the collected data to obtain meaningful interpretations that make the survey more perceivable.

The questionnaire was carefully reviewed, revised, and modified, incorporating feedback from experts. It was also tested for reliability and consistency by conducting a pilot study and examining the initial responses. This was done to confirm the relevance of the LPS barriers and implementation readiness factors identified from the literature in the Ethiopian building construction sector context.

In order to get valid and reliable data from a reasonable number of respondents, the design of the questionnaire is crucial (Aghayev et al., 2020). The questionnaire contained a covering letter that explains the study purpose, the way of filling out the questionnaire, the study goal, and the confidentiality of the information for encouraging a high response, as shown in the Appendix. It consisted of three sections. The first part of the questionnaire is intended to collect data about the respondent's profile. Queries in this part are about the respondent's position in the organization, level of education, and years of experience.

The second part of the questionnaire is about the Last Planner System implementation readiness factors in the building construction sector. The factors rated on a scale of 1 to 5, 1 being the factor with lowest importance/ relevance to the last planner system readiness and 5, for factor with highest importance/ relevance for last planner implementation readiness in the context of Ethiopian building construction sector.

The third part of the questionnaire consisted of 16 challenges to the implementation of the Last Planner System. These challenges were identified through a literature review. Respondents were asked to indicate their level of agreement with these challenges in relation to the Ethiopian building construction industry. A five-point Likert scale was used to measure agreement and disagreement in this section. The scale ranged from 1 (not important) to 5 (extremely important). The use of this scale was considered appropriate for this research.

The researcher distributed the questionnaire forms in hard copies. It was collected from experienced professionals, including project managers, consultants, site engineers, and Forman, in building construction projects undertaken by Ethiopian Construction Works Corporation.

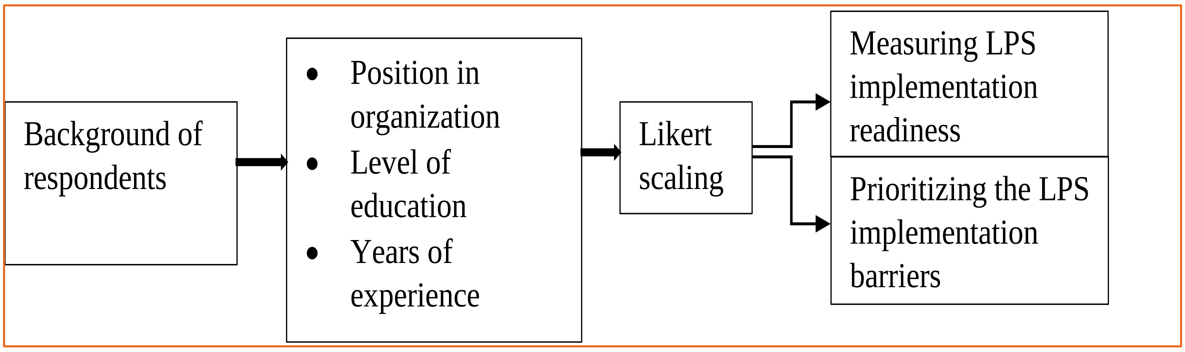

Figure 3. 3: Design and flow of Questionnaires

3.7.2 Interview

Interviews can provoke discussion of complex topics, and they provide rich and complete data. In addition, it allow researchers to control the response environment, control the order in which issues are discussed, and learn about things that can be observed only with difficulty (Gao & Low, 2014). Interviews were used as a form of triangulation in this study.

Project managers, project consultants, and engineers were selected for interviews. This was because they could provide detailed information on how the projects were planned, controlled and managed. According to S. Nayyef et al., (2022), direct interview with (10%) of respondents were sufficient to discuss and clarify the few contradictions during the questionnaire. As a result, ten participants were interviewed for this study.

The interview was also formatted in such a way that the interviewees explained their understanding of the project management system adopted within the project. Each of the interviewees provided the researcher with their own account of how planning and forecasting of labour and materials occurred within the project, this was basically based on their professional experience.

3.8 Data Analysis

The collected data were analyzed by using the statistical package for social sciences (SPSS) software with version 26 and Microsoft Excel Version 2016. Aghayev et al., (2020) identified that companies in the Sri Lankan construction industry with a mean score exceeding 3.00 are ready to apply Lean methodology. In this study, MIS was used to indicate the implementation readiness of Ethiopian building construction sector.

$$\text{MIS} = \frac{5V1+4V2+3V3+2V2+V1}{V5+V4+V2+V3+V1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ 1$$

Where, V5, V4, V3, V2, V1 = variables operationalized as barriers to LPS implementation.

In addition, the overall score of readiness (OSR) was calculated to indicate the implementation readiness of the Ethiopian building construction industry. Finally, the results of MIS an OSR was compared and analyzed.

The Relative Importance Index (RII) method has been extensively applied in construction management studies for determining attitudes with regards to surveyed factors (Tayeh et al., 2018). It was used in this study to analyze the collected data and develop a ranking of the challenges faced in implementing the Last Planner system in the Ethiopian building construction industry. The RII value ranges from 0 to 1, with a higher value indicating a greater degree of impact and pervasiveness of the challenges of implementing the Last Planner system (S. Ahmed & Sobuz, 2014).

These rankings allow for a comparison of the relative importance of the factors as perceived by the respondents. The discussion will focus on the challenges that are classified as the most significant in implementing the Last Planner system in the Ethiopian building construction industry. A five-point Likert scale was adopted, ranging from 1 (not important) to 5 (extremely important), and transformed into the relative importance index (RII) for each factor as:

$$RII = \frac{\sum W}{N * A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Equation\ \ 2$$

Where W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), and N is the total number of respondents. Higher the value of RII, more important was the Barrier to implement the method.

The data for this study were collected independently from respondents involved in various building construction projects. Therefore, it is important to analyze and ensure the reliability and validity of the data collected. In cases where the questionnaire included multiple Likert questions, Cronbach's α was used as the most common test for reliability (S. Ahmed & Sobuz, 2014). Cronbach's α measures the internal consistency of the challenges identified in this survey, with values ranging from 0 to 1. A higher value indicates a higher degree of consistency among the items (Cronbach, 1951). Previous studies have suggested that an α value between 0.70 and 0.95 indicates high internal consistency and is considered acceptable (S. Ahmed & Sobuz, 2014). Furthermore, analysis of variance (one-way ANOVA) was employed to test the differences in barriers evaluation between the different groups of professional experts.

3.9 Validity and Reliability of Study

3.9.1 Validation of data

Data validation was carried out to determine whether the collected data sample adhered to the predetermined standards. Before distributing the questionnaire, a pilot interview was conducted to evaluate question clarity and eliminate any language barriers or ambiguous statements. It also aimed to estimate the average time participants needed to complete the survey. The pilot interview involved using sample questions administered to project managers, contractors, and consultants who were carrying out building projects for the Ethiopian Construction Works Corporation. After considering the feedback and suggestions received during the pilot interview, the final version of the questionnaire was subsequently developed.

In addition to the pilot survey, the author used data triangulation and investigator triangulation to validate the study. Data triangulation involves gathering information from multiple sources to validate and support research findings. In this study, the author gathered evidence from literature and questionnaires, which provided a strong foundation and allowed them to compare and contrast their findings with previous research. Investigator triangulation involves comparing research findings with those from other studies conducted by different researchers or research teams. It was used to validate and confirm the consistency of the results across various researchers and contexts.

3.9.2 Reliability of Data

Reliability refers to the truthfulness and the degree to which the data or measured outcomes are consistent and repeatable across time. The internal consistency and reliability of the questions in the questionnaire was tested using Cronbach's alpha coefficient (α) with the reliability-testing tool in SPSS. It's value ranges between 0 to 1.

Table 3. 2: Cronbach's Alpha test result of readiness factors

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.857	.867	29

Source: Survey result, (2024)

Table 3.2 presents the results of the Cronbach's Alpha reliability test for fifteen number of samples for all items. As depicted in Table 3.2, the coefficient of internal consistency of the reliability test for the LPS readiness factors is found to be 0.867, which satisfies the reliability test requirement. This implies that 86.7% of the answers provided by the respondents regarding readiness factors have excellent reliabilities.

3.10 Ethical Consideration

The study has been conducted by considering ASTU (2021) post-graduate studies guidelines. The participants in the questionnaire were informed of the purpose of the study and permission was given from their side before answering the questions. The interview that took place in person a consent form was asked to be signed by the interviewee, to ensure that they have understood the purpose of the study, and that they are agreeing upon being interviewed and giving information to be used in the study. The consent form also asked if they would wish to read the final work before it being public, to ensure that the information that were gathered from their interview was truthful.

CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Introduction

This chapter deals with the statistical procedures used to analyze data, results, discussion and interpretation. The data was analyzed with the aid of SPSS version 26 software. As a result, demographic characteristics of respondents are provided along with the results on implementation readiness and the barriers to the last planner system implementation in Ethiopian building construction industry, in a case of Ethiopian Construction Works Corporation to further discuss them in order to get a better understanding for the outcomes.

4.2 Response rate and demographic characteristics

4.2.1 Response rate of respondents

The response rate is useful in determining the effectiveness of the questionnaires returned in the survey. The response rates of this study were calculated after surveying questionnaires. For content validity and framework validation, the response rate is 100%. For the implementation Readiness investigation of LPS and its implementation barriers prioritization, the response rate was computed and presented in Table 4.1.

Table 4. 1: Response rate of respondents

	FREQUENCY	PERCENTAGE
DISTRIBUTED	90	100%
RESPONDED	85	94.4%
REJECTED	5	5.6%
NET	80	88.9%

Source: Own survey (2024)

Out of the 90 questionnaires that were sent, 80 were completed, resulting in an 88.9 percent response rate. Baruch (1999) suggested that the response rate of 60% with a standard deviation of 20% for professional populations is acceptable. The use of census sampling improved the external validity, allowing for the generalization of the primary data to a larger population. This statistically sound response rate ensured the achievement of external validity (Moyo & Chigara, 2023)

Out of the 90 questionnaires, 10 were given to consultants, 35 to foremen, 30 to site engineers, 10 to contractors and 5 to project managers. Out of the 85 questionnaires that were collected, 10 were returned by consultants, 10 by contractors, 5 by project managers, 28 by site engineers, and the remaining 32 by foremen.

4.2.2 Profile of respondents

This section provides the general information of participants, which includes the respondent's job position, educational status, and years of experience. The educational level of the participants of the study, expressed in percentage, indicated that (30.9%) were second-degree holders (M.Sc.), and (69.1%) were found to have a first degree (B.Sc.). The education level of the participants are literate and they have a better understanding of the topic and grasp the research's subject matter, making them excellent participants for this study to achieve the established objective. Figure below illustrates the educational level of the participants of the study.

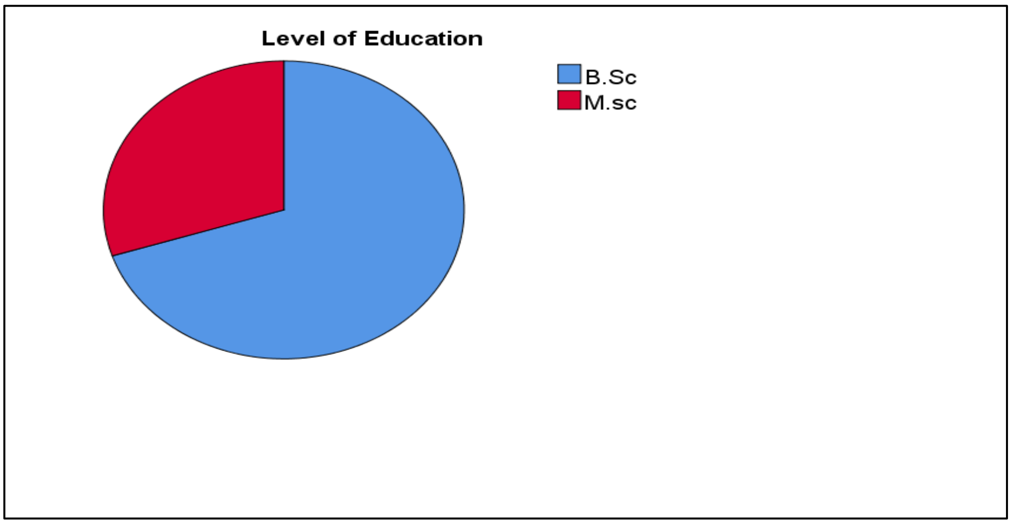

Figure 4. 1: Educational level/ Academic qualification of respondents

The total grouping of respondent's work position, which is important to determine their association with the subject matter of the questionnaire, has been estimated. Through this, 35% were found to be site engineers, 12.5% from contractors and consultants, and 40% from Forman, and 6.25% from project managers. The results of respondent's job position are presented in figure 4.2 below.

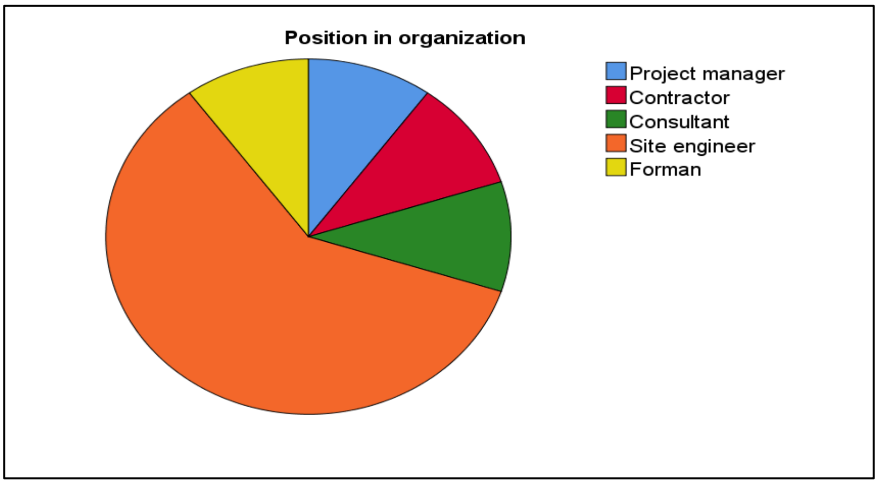

Figure 4. 2: work position of the respondents

The working experience of the participants of the study, expressed in percentage, is 0-5 years of experience (35%), 6-10 years of experience (30%), 11-15 years of experience (25%), and more than 15 years (10%). The majority of participants have a good experience level and it is believed by study that respondents had sufficient knowledge and understanding of the topic; this makes them dependable and credible sources of information. The work experience of the respondents is presented in figure 4.3 below.

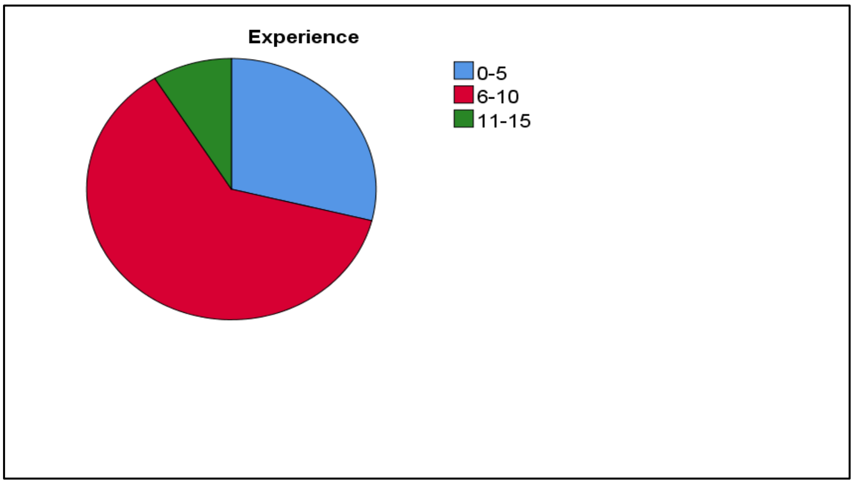

Figure 4. 3: Work experience of the respondents

4.3 Lean Readiness Level of Ethiopian building construction industry

The first part of the questionnaire aims to assess the Last Planner System Readiness Level (LPSRL) of the Ethiopian building construction industry. The main research question it addresses is whether the Ethiopian building construction industry has suitable conditions in place to support the implementation of the Last Planner System. The responses were ranked using a five-point Likert scale.

Table 4. 2: LPS implementation readiness factors MIS analysis

Mean Item Score (MIS) Analysis			
Readiness Factors	**Mean**	**Std. Deviation**	**Rank**
Participation of crew members and last planners in collaborative planning	4.40	.667	2
Emphasis on short-term planning	4.40	.493	1
Project selection based on organizational competencies	4.30	.785	3
Formalization of the planning and control process	4.20	.877	4
Regular communication on strategy and vision of key initiatives	4.20	.879	5
Use of a transparent, understandable master plan	4.10	.542	6
Value is monitored and measured continuously during the project lifecycle	4.10	.835	7
Cooperation between the organization and all of its stakeholder's viz., customers, suppliers	4.00	.776	9
Use of indicators to assess schedule accomplishment	4.00	.779	10
Strategic efforts and business goals, connected by systemic thinking	4.00	.450	8
Humble leadership with mutual respect for subordinates and peers	4.00	.789	11
Inclusion of only work packages without constraints in short-term plans	3.90	.701	12

Inventory planning and procurement based on production plan	3.90	.704	14
Standardization of meetings for short- and long-term planning	3.90	.542	13
Commitment from the organization to economic and financial objectives along with growth and long-term survival	3.90	.707	15
Focus on team collaboration in a project- or management-related environment	3.80	.603	16
Efforts of the employees are recognized and are rewarded	3.80	.877	18
Information exchanges across the hierarchy i.e horizontal and vertical	3.80	.753	17
Focus on ensuring that the project is executed as planned instead of variance detection	3.70	.644	18
Employee initiative to support projects and activities for continual improvement	3.70	.785	19
Full participation of the workforce in all activities in identifying and removing constraints	3.70	.788	20
Participation of the client in the project's planning and development	3.60	1.207	23
Support and commitment to new initiatives by providing needed infrastructure	3.60	.804	22
Dedication of time by top management to ensure the adoption of initiatives for continuous improvement	3.60	.493	21
Utilizing metrics to assess performance and taking remedial actions based on the causes of non-completions of plans	3.50	1.292	25
Position in organization	3.50	1.124	24
Participation of lower-level or junior staff in project review meetings	3.40	.667	26

Tasks are planned in increasing detail as task execution approaches	3.30	.644	28
Existence of a mechanism for determining the needs of and adding value to customers	3.30	.461	27
Hierarchical culture, reduced barriers to creativity and innovation from all organizational levels	2.80	.753	29
Average MIS	**3.78**		

Figure 4. 4: Current planning practices in Ethiopia that resemble LPS

Table 4. 3: LPS implementation readiness level

Readiness Level (%)			
Elements	Mean	Max. Possible score	Percentage
Support and commitment to new initiatives by providing needed infrastructure	3.60	5	0.72
Dedication of time by top management to ensure the adoption of initiatives for continuous improvement	3.60	5	0.72
Commitment from the organization to economic and financial objectives along with growth and long-term survival	3.90	5	0.78
Humble leadership with mutual respect for subordinates and peers	4.00	5	0.8
Project selection based on organizational competencies	4.30	5	0.86
Participation of the client in the project's planning and development	3.60	5	0.72
Existence of a mechanism for determining the needs of and adding value to customers	3.30	5	0.66
Value is monitored and measured continuously during the project lifecycle	4.10	5	0.82
Strategic efforts and business goals, connected by systemic thinking	4.00	5	0.8
Cooperation between the organization and all of its stakeholder's viz., customers, suppliers	4.00	5	0.8
Non-hierarchical culture, reduced barriers to creativity and innovation from all organizational levels	2.80	5	0.56
Focus on team collaboration in a project- or management-related environment	3.80	5	0.76

Employee initiative to support projects and activities for continual improvement	3.70	5	0.74
Participation of lower-level or junior staff in project review meetings	3.40	5	0.68
Efforts of the employees are recognized and are rewarded	3.80	5	0.76
Full participation of the workforce in all activities in identifying and removing constraints	3.70	5	0.74
Regular communication on strategy and vision of key initiatives	4.20	5	0.84
Information exchanges across the hierarchy i.e horizontal and vertical	3.80	5	0.76
Formalization of the planning and control process	4.20	5	0.84
Standardization of meetings for short- and long-term planning	3.90	5	0.78
Emphasis on short-term planning	4.40	5	0.88
Use of a transparent, understandable master plan	4.10	5	0.82
Participation of crew members and last planners in collaborative planning	4.40	5	0.88
Inclusion of only work packages without constraints in short-term plans	3.90	5	0.78
Use of indicators to assess schedule accomplishment	4.00	5	0.8
Focus on ensuring that the project is executed as planned instead of variance detection	3.70	5	0.74
Utilizing metrics to assess performance and taking remedial actions based on the causes of non-completions of plans	3.50	5	0.7

Inventory planning and procurement based on production plan Pull based approach	3.90	5	0.78
Tasks are planned in increasing detail as task execution approaches	3.30	5	0.66
Overall score of readiness (OSR)	**3.69**		**73.86**

In this study, out of the 80 responses collected, participation of crewmembers and last planners in collaborative planning and Emphasis on short-term planning obtained the highest LRL with a mean score of 4.40, followed by project selection based on organizational competencies with a mean score of 4.30. Despite these two high mean scores, hierarchical culture and reduced barriers to creativity and innovation from all organizational levels received the lowest score, steady at an average of 2.80.

Considering the mean score of all readiness factors, the average mean score of Ethiopian building construction industry is 3.78. Aghayev et al., (2020) identified that construction industry with a mean score exceeding 3.00 are ready to apply Lean methodology. Thus, it indicates that the Ethiopian building construction industry is ready to apply the LPS, which is one of the lean construction tool.

Additionally, according to Utomo Dwi Hatmoko et al. (2018), the professional respondents' implementation readiness for LPS is determined through a readiness assessment, classified into five levels: none (0-25), poor (25-50), moderate (50-75), high (75-100), and excellent (100). The results from the respondents indicate that the overall score of readiness (OSR), as calculated in Table 4.3 below, is 73.86, which indicates a moderate implementation readiness of the Ethiopian building construction industry.

To summarize, both the MIS and OSR analyses indicate that the building construction industry in Ethiopia is ready to implement the Last Planner System. However, readiness alone is not enough to apply the system. Framework development is required, as demonstrated in the next section of this study.

4.4 Reliability Analysis for LPS implementation readiness factors

After collecting data from the main study sample, it is important to assess the reliability of the instrument used in the actual research context. To determine the reliability of the data, Cronbach's alpha was calculated. Cronbach's alpha values range from 0 to 1, where 0 indicates the weakest reliability and 1 indicates the strongest. Within this range, alpha values are categorized as follows: $\alpha \geq 0.9$ (excellent), $0.9 > \alpha \geq 0.8$ (good), $0.8 > \alpha \geq 0.7$ (acceptable), $0.7 > \alpha \geq 0.6$ (questionable), $0.6 > \alpha \geq 0.5$ (poor), and $\alpha < 0.5$ (unacceptable) (George & Mallery, 2016).The survey revealed that the alpha value for this study was 0.851, which falls within the good range. This indicates that the collected data can be considered trustworthy.

Table 4. 4: Reliability Test for LPS implementation readiness

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.851	.863	29

4.5 Last Planner System implementation barriers in the Ethiopian building construction industry

Table 4. 5: Ranking of Barriers for Last Planner System Implementation

Items	**W**	**RII**	**Rank**
Organizational constraints	323	0.79	6
Insufficient government support	302	0.77	8
Lack of knowledge of the Last planner system	371	0.93	1
Cultural resistance	303	0.78	7
Human capital constraints	301	0.75	10
Technical barriers	346	0.87	2
The lack of an implementation plan	325	0.81	4

Lack of experience with lean	290	0.73	11
Lack of commitment	335	0.84	3
Lack of top management involvement	302	0.76	8
High cost of implementation	324	0.80	5
Lack of incentive by the government	279	0.62	14
Lack of common goal between various firms	279	0.62	13
Legal and contract issues	324	0.72	12
Influence of traditional practices	236	0.52	15
Lack of understanding of lean approaches.	290	0.64	16

As stated above a survey was conducted to prioritize the barriers to Last Planner System Implementation in construction. The survey was administered to Project managers, contractors, consultants, engineers and foremen participated in ECWC projects.

Table 4.5 above displays the results of the ranking of barriers to implementing the Last Planner System in the Ethiopian building construction industry (ECWC) based on respondent feedback. From Table 4.5, it is clear that the primary barrier is “Lack of knowledge of the Last planner system" (RII: 0.93). Actually, this is a critical fact in the Ethiopian building construction industry, since any training for the managers and staffs identifies challenges and areas of improvement. Additionally, “Technical barriers", “Lack of commitment” and “the lack of an implementation plan” are identified as significant barriers, with average ratings of "0.87", “0.84’’, and “0.81” respectively. “Cultural resistance" (RII: 0.78) and “Lack of top management involvement” (RII: 0.76) and “organizational constraints” (RII: 0.79) are moderately important in terms of their impact on Last Planner System implementation. Accordingly, the overall ranking of RII and that of Project managers, contractors, consultants, site engineers and foremen of all sixteen LPS implementation barriers were considered important with RII >0.6 (Moyo & Chigara, 2023).

These findings support previous research conducted by Howell, (2014), which highlight the Lack of knowledge of the Last planner system. This emphasizes the crucial role of knowledge of the Last planner system in ensuring the successful implementation of the Last Planner system. Knowledge of the Last planner system leads to smoother and more transparent implementation, resulting in increased construction process efficiency.

The findings also indicate that there is a significant obstacle for building construction firms attempting to implement the Last Planner system due to a misperception about its practices. This suggests that the potential benefits of implementing the Last Planner system have yet to be fully understood by the majority of building construction professionals. Lack of information sharing and control is another key barrier to Last Planner system implementation as identified by the survey respondents. This finding aligns with the notion that effective communication channels are essential for managing uncertainties and changes in a project. Insufficient information sharing can result in flawed processes during Last Planner system implementation (Howell et al., 2017).

The involvement of the last planners in the planning phase, a key feature of LPS, is minimal in the industry. Reasons include the organizational culture, low recognition given to the last planner, and the reluctance to get the participation of the last planner in the planning phase as organizations to perceive last planners to have low levels of motivation and lower capacity to deal with complexities of the planning phase. In the private sector, a reason for the low involvement of the last planner was given as their tendency to provide planning inputs for their own convenience rather than for achieving the project objectives (R & Sukumar, 2020).

The lack of government support and inconsistency in government policies is of concern for Ethiopia, where the bulk of construction projects originate from the government. As the government is the major client in the construction industry and they set policies that affect the construction industry, it is expected that they drive the Last agenda (Moyo & Chigara, 2023). There is a need to improve the understanding of the LPS in Building construction industry of Ethiopia in order professionals be able to respond to these barriers.

4.6 Reliability Analysis for LPS implementation challenges

Table 4. 6: Reliability Analysis for LPS implementation challenges

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.948	.942	16

From Table 4.6 above, the survey revealed that the alpha value LPS implementation challenges was 0.948, which falls within the good range. This indicates that the collected data can be considered trustworthy.

4.7 Differences in the Evaluation of the Barriers

A statistical analysis of Variance (ANOVA) is employed to examine the equality of means among two or more groups (Balkhy & Sweis, 2021). The methodology contrasts the means of the various groups to ascertain if there are any statistically significant disparities between them. The null hypothesis posits that the means of all groups are equal, while the alternative hypothesis postulates that the mean of at least one group is distinct from the others. ANOVA allows us to determine if the differences between the groups are statistically significant and, thus, potentially meaningful.

To test the differences in barriers' evaluation among the five different groups of professional experts, ANOVA was employed. Table 4.8 below shows the results of ANOVA tests. The table shows that P-value is larger than $\alpha = 0.05$ for all barriers. Therefore, it can be said that the project managers, contractors, the consultants, site engineers and the foremen had the same understanding of the significance of hindrance for all barriers. Moreover, null hypothesis is accepted. To understand the difference between the five groups regarding barriers, post hoc analysis was conducted as shown in table 4.9 and the differences were found negligible.

Null hypothesis: There is no significant difference in response among respondents based on their work position in their organization.

Alternative hypothesis: The mean of at least one group is distinct from the others and post hoc test is important.

Table 4. 7: ANOVA analysis

Barriers	ANOVA				
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.828	4	.207	1.950	.110
Within Groups	9.027	85	.106		
Total	9.855	89			

Table 4. 8: Post Hoc Tests

Multiple Comparisons						
Dependent Variable: Barriers						
Tukey HSD						
(I) Position in organization	(J) Position in organization	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Project manager	Contractor	.00000	.15362	1.000	-.4282	.4282
	Consultant	-.20690	.15362	.663	-.6351	.2213
	Site engineer	-.05172	.11733	.992	-.3787	.2753
	Forman	.20690	.15362	.663	-.2213	.6351
Contractor	Project manager	.00000	.15362	1.000	-.4282	.4282
	Consultant	-.20690	.15362	.663	-.6351	.2213
	Site engineer	-.05172	.11733	.992	-.3787	.2753
	Forman	.20690	.15362	.663	-.2213	.6351

Consultant	Project manager	.20690	.15362	.663	-.2213	.6351
	Contractor	.20690	.15362	.663	-.2213	.6351
	Site engineer	.15517	.11733	.678	-.1718	.4822
	Forman	.41379	.15362	.063	-.0144	.8420
Site engineer	Project manager	.05172	.11733	.992	-.2753	.3787
	Contractor	.05172	.11733	.992	-.2753	.3787
	Consultant	-.15517	.11733	.678	-.4822	.1718
	Forman	.25862	.11733	.188	-.0684	.5856
Forman	Project manager	-.20690	.15362	.663	-.6351	.2213
	Contractor	-.20690	.15362	.663	-.6351	.2213
	Consultant	-.41379	.15362	.063	-.8420	.0144
	Site engineer	-.25862	.11733	.188	-.5856	.0684

Interview Results

In this thesis, 10 professional experts were interviewed to collect further information about the LPS implementation readiness and barriers. The experts were selected on the basis to be construction professionals with renowned experience. All the interviewees in this research supported the finding from the questionnaire analysis. Conversely, the interviews offer novel insights into the LPS.

During the interviews, the participants were asked about their familiarity with LPS, which is a lean construction tool. The project manager stated that he had previous knowledge of Lean construction, specifically the Last Planner System. The consultants and engineers were not familiar with the term, although some of the principles were being implemented within the organization. However, they expressed interest in working on a Last Planner System project in the future. All participants acknowledged that effective project delivery hinges on communication, teamwork, and leadership. According to the interviewees, efficient management and planning, education and training, adoption of a continuous improvement culture, and analysis of the Last Planner System are significant factors in successfully implementing Last Planner System.

In the case of LPS implementation barriers, the project manager argued that the main barrier is the human factor due to lack of commitment and insufficient training. The production system is collaboratively designed in the kick-off pull-planning meeting; however, efforts decline to sustain the flow during execution and control. The second barrier is the belief that LPS is a reporting system (e.g. PPC or Lookahead spreadsheets) for the top management, instead of the tools being facilitators for the learning process. The third problem is the institutionalized problem of lack of anticipation to problems and insufficient responsiveness of the logistics department to remove constraints. Thus, this lack of commitment leads to a focus on looking for the 'guilty' instead of identifying root causes and solving problems. To mitigate this, some facilitators are described such as the definition of lead times in logistics, training to staff and subcontractors, and a clear definition of short-term metrics.

The consultant stated that LPS is a learning process to improve planning. The first barrier to achieve good results is a lack of commitment. The expert argued that to solve this, psychological and sociological studies are needed. As such, people need to understand that LPS meetings are meant to achieve collaboration, rather than to accuse others on what they did wrong.

The engineer posited that LPS helps to reduce the variability in the construction process, thus, helps to improve the schedule compliance. The expert contended that LPS implementation requires a cross-project implementation as top management should assign enough resources and support for effective implementation. In their view, changing people's mindset is a difficult task and takes time. The expert argues that LPS is not properly implemented, however, foremen and subcontractors have learnt that they must plan in hands with production engineers. Lack of lessons learnt and self-criticism are also pitfalls.

Drawing from the questionnaire responses and expert viewpoints, it is evident that there is a requirement for the design of a guide to raise awareness across the larger community. In response to this identified gap, the present study formulates a framework for the implementation of the Last Planner System, with the intention of supporting professionals in the industry and optimizing the advantages they stand to gain.

Table 4. 9: Main finding from the interview

	Finding
Support for the findings from questionnaire analysis	Efficient management and planning, education and training, and adoption of a continuous improvement culture, are significant factors in successfully implementing Last Planner System Project manager's previous knowledge Last Planner System Communication, teamwork, and leadership are important factors for successful project delivery.
New insight	Education on lean construction as a whole, and more specifically on the Last Planner System (LPS), should be offered at higher learning institutions.

4.8 Strategic framework for LPS implementation

Last Planner System frameworks are guidelines for implementing Last Planner System to control and monitor the performance of construction projects (Ugurlu et al., 2021). It's goal is to paint a vivid picture for building construction industries in Ethiopia to begin LPS journeys. Considering the abundant potential benefits of LPS in enhancing the efficiency of building construction projects, it is necessary to establish a strategic framework for the successful implementation of LPS in Ethiopian construction projects.

The framework was developed based on the responses provided by the respondents of the questionnaire, who clearly emphasized that awareness of the Last Planner System, implementation commitment, top management support and implementation plan are core success components for successful Last Planner System implementation. The recommended implementation framework is shown in Figure 4.5 and includes the following steps:

Identifying the readiness of LPS implementation

The Last Planner System (LPS) holds great potential for enhancing construction project delivery in Ethiopia. However, evaluating the industry's preparedness is essential to ensuring successful implementation. The readiness level of LPS implementation on building construction projects in Ethiopia can be considered medium as shown in the result and discussion section above. It is important to emphasize that to fully benefit from LPS, organizations, and other stakeholders must implement them. Therefore, developing a framework in this study begins with identifying the readiness level of LPS in the Ethiopian building construction industry.

Develop strategies for LPS implementation

The organization should have a clearly articulated purpose for implementing the LPS and increasing the reliability of production planning and control. It should be part of strategic goals not just operations. Creating a sense of urgency shows the implementation team the detrimental impacts of poor planning and the urgent need to implement the LPS.

Government body request for Building Construction Industry to implement the LPS

Government support for Lean Construction practices could be improved by implementing policies or incentives that encourage the adoption of the Last Planner System (LPS). To ensure the success of LPS, it is crucial to develop standard contractual clauses that promote collaborative planning, risk sharing, and open communication. This can be accomplished by collaborating with industry stakeholders to establish best practices and model contracts that facilitate the implementation of LPS within existing regulatory frameworks. A strong commitment is needed at all levels of the organization, including the heads of each organization, division managers, and even middle-level managers, to achieve the planned change.

Identify stakeholders and nucleus team

The nucleus team should be entrusted with the implementation process before it starts and during the implementation life. Thus, the team should develop goals, identify training needs, recognize implementation hurdles, develop implementation steps, and perform necessary adjustments. The team should involve front line managers and last planners from different disciplines and trades. The team should also put the opinion leaders in charge and work on involving as many individuals in the organization as possible. Without the momentum of many individuals, little meaningful change will occur. Team incentives for reaching the stated goals may also be formulated by the team after securing buy-in from top management. The nucleus team should set the short and long-term goal for implementing the LPS

Building construction industry identify, Prioritize and categorize challenges

When developing a framework for the future, the nucleus team identifies potential challenges and communicates them to the organization. Additionally, the team highlights opportunities and provides strategies to seize them. In order to effectively implement LPS in the Ethiopian building construction industry, it is important to categorize the barriers according to their severity, based on the analysis conducted. The top LPS implementation barriers discussed in this study categorized in to barrier themes, allowing for a more focused approach towards addressing them. These themes are managerial, financial, governmental, technical, educational, and cultural related barriers.

Developing a sector for each challenges and assign responsibility for each nucleus team

The challenges, which are categorized into themes, require specific sectors to work on them to increase awareness of LPS implementation and reduce barriers. To address skill gaps, training institutions (such as construction training centers) should develop and provide LPS-specific training programs for construction professionals at all levels. Government agencies (such as the Ministry of Education and construction sector ministries) should support these LPS training programs. Local construction professionals should adapt LPS to cultural nuances. It is important to promote a culture of continuous improvement that embraces adaptation based on the local context.

LPS Phases implementation

The Last Planner system comprises several components, each of which involves a set of activities. The framework delineates the various phases and offers guidance on establishing connections between these phases within the LPS. The framework also outlines how activities transition between different phases of the last planner system and how their effectiveness is assessed.

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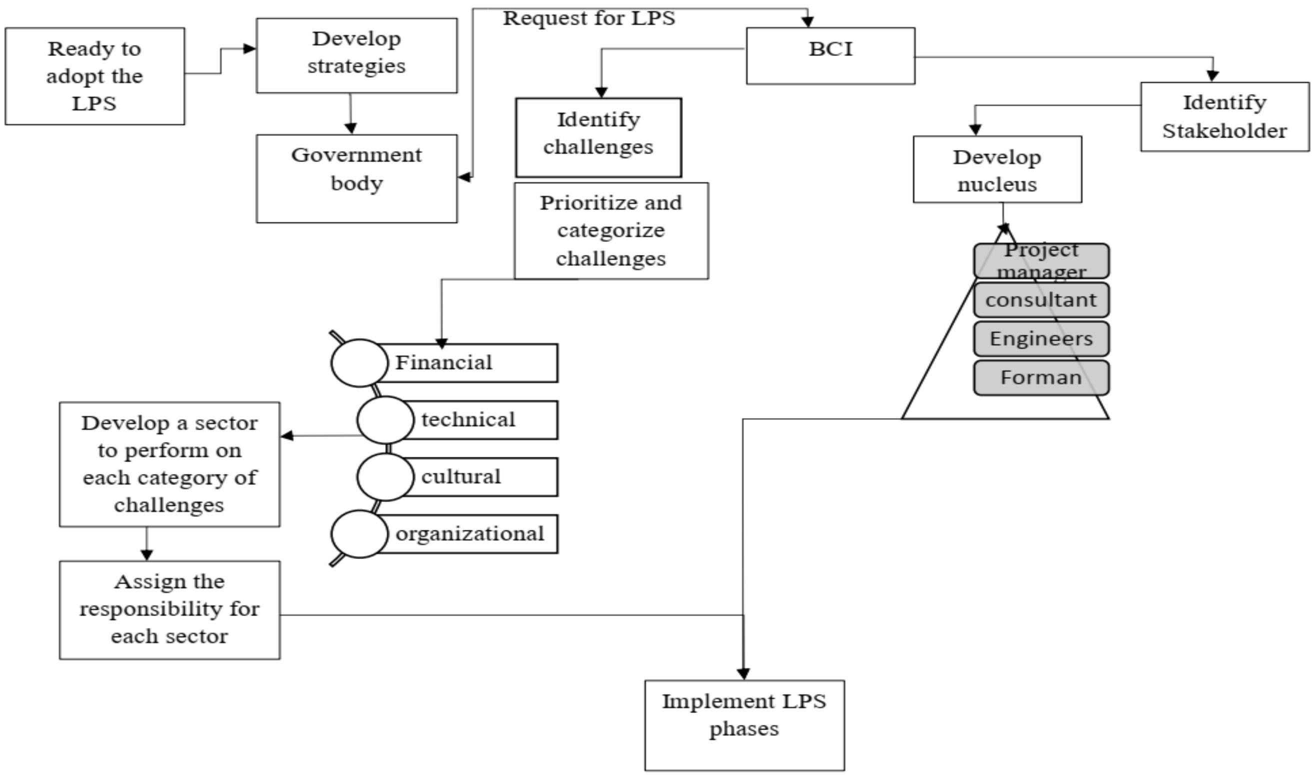
Ready to adopt the LPS
Develop strategies
Government body
Request for LPS
BCI
Identify challenges
Prioritize and categorize challenges
Identify Stakeholder
Develop nucleus
Project manager
consultant
Engineers
Forman
Financial
technical
cultural
organizational
Develop a sector to perform on each category of challenges
Assign the responsibility for each sector
Implement LPS phases

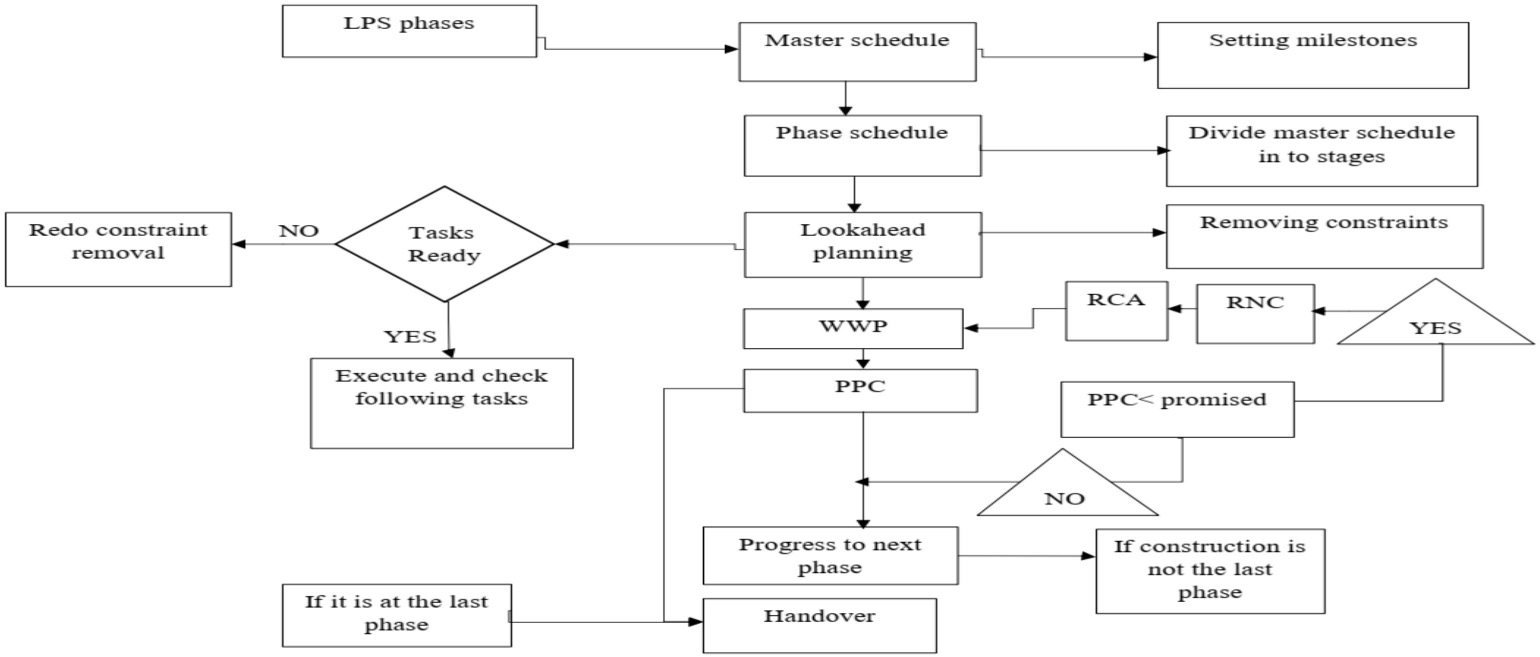

Figure 4. 5: Framework for LPS implementation

4.9 Framework Validation

The validation of the framework was carried out through the utilization of an interview methodology from the perspective of experts. A total of five professional experts were involved in the interview process. The rationale behind selecting professionals from this diverse range was to ascertain different viewpoints regarding the proposed LPS implementation framework and to assess its efficacy when applied in the construction sector of Ethiopia.

Informed consent letters were distributed to each participant, outlining the confidentiality measures associated with the obtained data. The initial session commenced with a concise presentation elucidating the study's objectives, followed by an overview presentation on the Last Planner system. During this session, the interviewee was briefed on the development process of the evaluated LPS framework.

The researcher introduced the suggested implementation framework and deliberated on how the underlying themes were formulated to address the challenges in implementing LPS as identified by the participants. Following that, the attendees were provided with a series of inquiries. This process aimed to unearth underlying assumptions shaping their perspectives and opinions on particular issues (Ahiakwo, 2014). Throughout the interview sessions, in cases where responses were vague or unclear, the experts were prompted with additional questions to clarify their responses.

Each participant was given the opportunity to elaborate on the themes underpinning the proposed framework. It was noted by the participants that these themes were advantageous for the LPS implementation framework tailored for the building construction industry in Ethiopia. Upon the conclusion of each interview, the experts were expressed gratitude for their involvement.

Table 4. 10: Background information of experts involved in the validation of the framework

Expert Description	Years of Experience	From Industry	From Academia
Expert 1	10	Project manager	
Expert 2	11	Project manager	
Expert 3	8	Engineer	
Expert 4	15		Associate professor of Civil engineering
Expert 5	12		Associate professor of Civil engineering

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The Last Planner System is a production planning system that aims to achieve a predictable and reliable workflow. However, its application in the Ethiopian building construction industry has not been extensively explored. This study seeks to develop a framework for implementing the Last Planner System to enhance construction process efficiency. Consequently, the study examines the readiness of the Ethiopian building construction industry to adopt the Last Planner System and prioritizes the barriers to its implementation.

The results show that the overall score of readiness (OSR) for Ethiopian building construction industry: a case of Ethiopian construction works corporation (ECWC) is 73.86 % (moderate level). This means that actually several elements of LPS have already taken place. In addition**,** considering the mean score of all readiness factors, the average mean score of Ethiopian building construction industry is 3.78 which is greater than minimum mean score of three (3). Thus, it indicates that the Ethiopian building construction industry is ready to apply the LPS, which is one of the lean methodology.

This study also focuses on determining the barriers hindering a successful Last Planner System implementation. In this respect, an in-depth literature review was assessed to reveal the barriers of Last Planner System implementation in the construction industry. Then, questionnaire was sent out to professional experts of project managers, contractors, clients, site engineers and Forman of ECWC for ranking the barriers based on a Likert scale. These construction professionals considered 16 factors currently hampering the implementation of last planner system in the construction industry and prioritized based on the determined RII. Some main challenges of LPS implementation have been identified, such as a lack of knowledge of the Last Planner System, lack of collaboration among stakeholders, resistance to change, lack of support from the top management, the need of extra financial incentives, etc.

The results of this study indicate that despite the differences in objectives, roles, and nature of work among project managers, contractors, consultants, site engineers, and foremen, all groups share similar or closely aligned ideas about the barriers to implementing LPS. This suggests that there is potential for establishing connections between these groups and fostering future collaboration.

The findings of this investigation could be valuable in enhancing the management of building construction projects in Ethiopia. It might be helpful to improve the ways of increasing building construction process efficiency not only in ECWC projects but also in other projects across the country that might share some similarities with ECWC projects. Therefore, building construction companies can utilize this framework to enhance the adoption and implementation of the Last Planner System. Additionally, companies can employ the tool used in this study to assess their readiness to adopt last planner system, gain insights into the necessary factors for implementing LPS, or study the barriers that impede the implementation process of last planner system.

5.2 Recommendation

The following recommendations are suggested in this thesis.

- It is recommended that the government understands the benefits of implementing the LPS and supports the Ethiopian building construction industry in its implementation.
- Providing training to raise awareness and overcome barriers to LPS implementation. Additionally, promoting lean practices during tertiary education is recommended.
- The developed framework should be applied in real building construction projects and evaluated to enhance the efficiency of the construction process in the Ethiopian building construction sector.
- Future studies should be conducted using case studies to examine real implementation and the barriers faced.
- Implementing LPS is often a lengthy and sometimes burdensome process, despite promising improvements in planning, control, and coordination. Therefore, practitioners seeking to implement it for the first time need to be committed and patient, knowing that planning and control are dynamic and iterative processes.
- Although the framework developed in this research facilitates the implementation of the Last Planner System in Ethiopia, an implementation guide should be developed to further simplify the implementation of LPS and Lean Construction in Ethiopia.

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APPENDICES

Appendix I: Questionnaire

A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction Sector through the application of the Last Planner System: A Case study for Ethiopian Construction Works Corporation

Dear sir/Madam,

I am Nura Seyida Ahmed, a postgraduate Construction Engineering and Management (CEM) student presently pursuing M.sc thesis at Adama Science and Technology University, Adama, Ethiopia. As you are a professional/academician with immense experience in the subject area, I seek your valuable inputs on this questionnaire, which shall be immensely valuable. By participating, you will be contributing to the alignment/readiness of the Ethiopian building construction industry to implement LPS, and Identifying key challenges/barriers faced in implementing Last Planner System in Ethiopian building construction industry.

The inputs of this questionnaire shall be considered for the ongoing thesis work only and shall be kept fully confidential.

Thank you for your Cooperation

Nura Seyida

ASTU, Adama, Ethiopia

This questionnaire contains three parts. The first part is personal detail, the second part is Last Planner System implementation readiness factors in building construction sector, and the last part is Last Planner System implementation challenges/barriers in the Ethiopian building construction industry.

Part I: Personal Details

1. Your Name (optional)

2. Name of Organization

3. Level of Education

☐ Degree ☐ M.sc ☐ PHD ☐ other

4. Type of organization

☐ Government ☐ Private

5. Position in Organization

☐ Project manager ☐ Contractor ☐ Consultant ☐ Site engineer
☐ Forman ☐ Other

6. Experience

☐ 0-5 ☐ 6-10 ☐ 11-15 ☐ above 15

Part II: Last Planner System implementation Readiness Factors in Building construction sector

Please rate the factors on a scale of 1 to 5, 1 for factor with lowest importance/relevance to Last Planner implementation readiness and 5 for factor with highest importance/ relevance for Last Planner implementation readiness in your project.

Mark (✓) only one square per row

Question number	**The Last planner system Readiness factors**	Not at all important	Slightly important	Moderately important	Very important	Extremely important
		1	**2**	**3**	**4**	**5**
1	Support and commitment to new initiatives by providing needed infrastructure					
2	Dedication of time by top management to ensure the adoption of initiatives for continuous improvement					
3	Commitment from the organization to economic and financial objectives along with growth and long-term survival					
4	Humble leadership with mutual respect for subordinates and peers					
5	Project selection based on organizational competencies					
6	Participation of the client in the project's planning and development					
7	Existence of a mechanism for determining the needs of and adding value to customers					
8	Value is monitored and measured continuously during the project lifecycle					
9	Strategic efforts and business goals, connected by systemic thinking					
10	Cooperation between the organization and all of its stakeholder's viz., customers, suppliers					

11	Non-hierarchical culture, reduced barriers to creativity and innovation from all organizational levels					
12	Focus on team collaboration in a project- or management-related environment					
13	Employee initiative to support projects and activities for continual improvement					
14	Participation of lower-level or junior staff in project review meetings					
15	Efforts of the employees are recognized and are rewarded					
16	Full participation of the workforce in all activities in identifying and removing constraints					
17	Regular communication on strategy and vision of key initiatives					
18	Information exchanges across the hierarchy i.e horizontal and vertical					
19	Formalization of the planning and control process					
20	Standardization of meetings for short- and long-term planning					
21	Emphasis on short-term planning					
22	Use of a transparent, understandable master plan					
23	Participation of crew members and last planners in collaborative planning					
24	Inclusion of only work packages without constraints in short-term plans					
25	Use of indicators to assess schedule accomplishment					
26	Focus on ensuring that the project is executed as planned instead of variance detection					
27	Utilizing metrics to assess performance and taking remedial actions based on the causes of non-completions of plans					
28	Inventory planning and procurement based on production plan Pull based approach					
29	Tasks are planned in increasing detail as task execution approaches					

Part III: Last Planner System implementation challenges/barriers in the Ethiopian building construction industry

Please indicate your level of agreement with the Last Planner System barriers/challenges in the context of your organization.

Question number	**LPS implementation Barriers**	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
		1	***2***	***3***	***4***	***5***
1	Cultural resistance					
2	Organizational constraints					
3	Insufficient government support					
4	The knowledge of Last planner system					
5	Human capital constraints					
6	Technological barriers					
7	The lack of an implementation plan					
8	lack of experience with lean					
9	Lack of commitment					
10	Lack of top management involvement					
11	High cost of implementation					
12	Lack of incentive by the government					
13	Lack of common goal between various firms					
14	Legal and contract issues					
15	Influence of traditional practices					
16	Lack of understanding of lean approaches.					

Appendix II: interview

Interview on LPS readiness implementation in Ethiopian building construction industry

1. What is your current designation in your organization?
2. How long you have worked in your Organization?
3. What are the current planning and control practice on your projects?
4. What is your familiarity with the term Last planner system?
5. Who are the key players / participants involved in the planning and control process in your organization?
6. How collaboration, communication, and teamwork be important aspect for successful delivery of projects?
7. What do you think are the barriers to the implementation of the last planner system?

THANK YOU FOR YOUR TIME!

Appendix III: interview for the framework Validation

Subject Title: Participate in a research study "A Framework for Enhancing the Construction Process Efficiency in the Ethiopian Building Construction Sector through the application of the Last Planner System: A Case study for Ethiopian Construction Works Corporation"

Dear Sir/ Madam,

I am Nura Seyida, a M.Sc. Student studying in Construction engineering and management at Adama Science and Technology University (ASTU). The project aim develop a framework for Last Planner System implementation in Ethiopian building construction industry. The framework will help the Ethiopian building construction industry to successfully implement last planner system practices.

You are humbly invited to participate in an interview to reflect on whether the framework can be applied in the Ethiopian Building construction industry, and provide suggestions for any improvements, which may help in the implementation of the framework.

This interview will only take 15-20 minutes. Your transcripts or the notes taken during the interview will be sent to you for justification prior to reporting. In appreciation of your contribution, you will receive the results of the interviews. Please to contact me by emailing me (details below).

Should you have any questions, please contact me via email, nuseyid1@gmail.com or mobile phone: +251954514315

Many thanks for your consideration of this request.

Nura Seyida

M.Sc. Student

Adama Science and Technology University (ASTU)

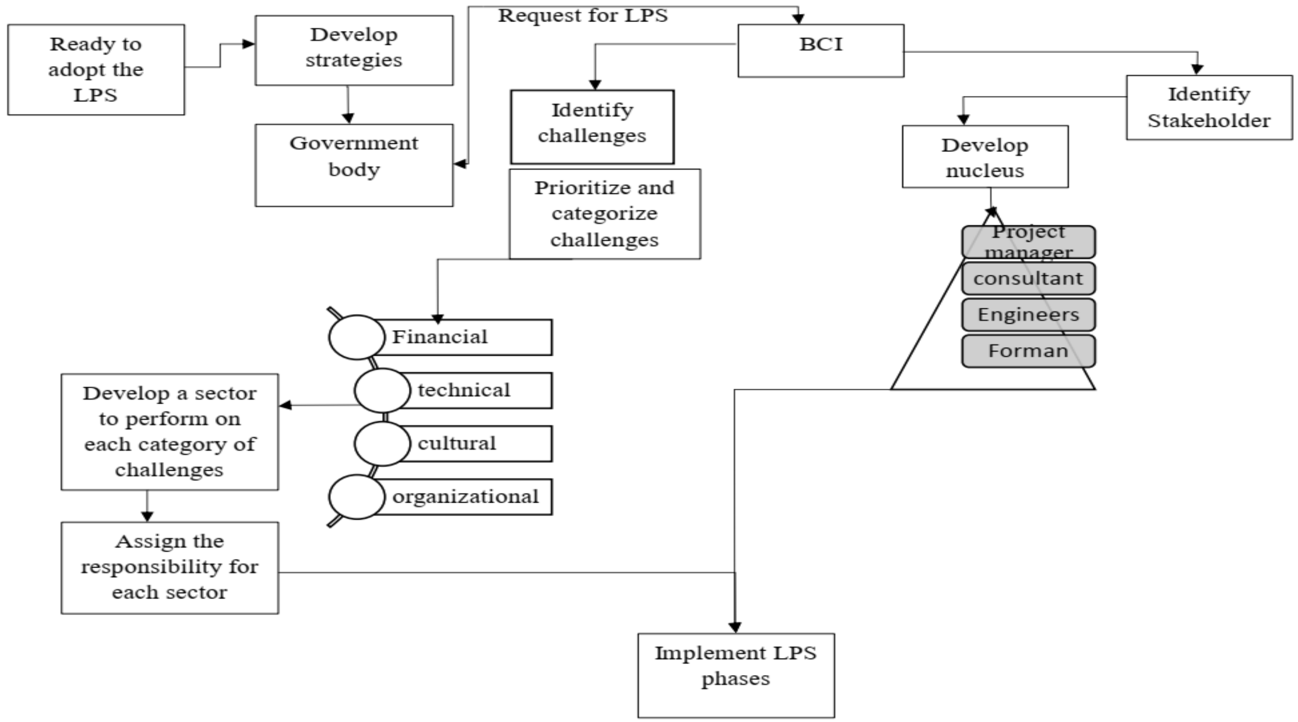
Validation work

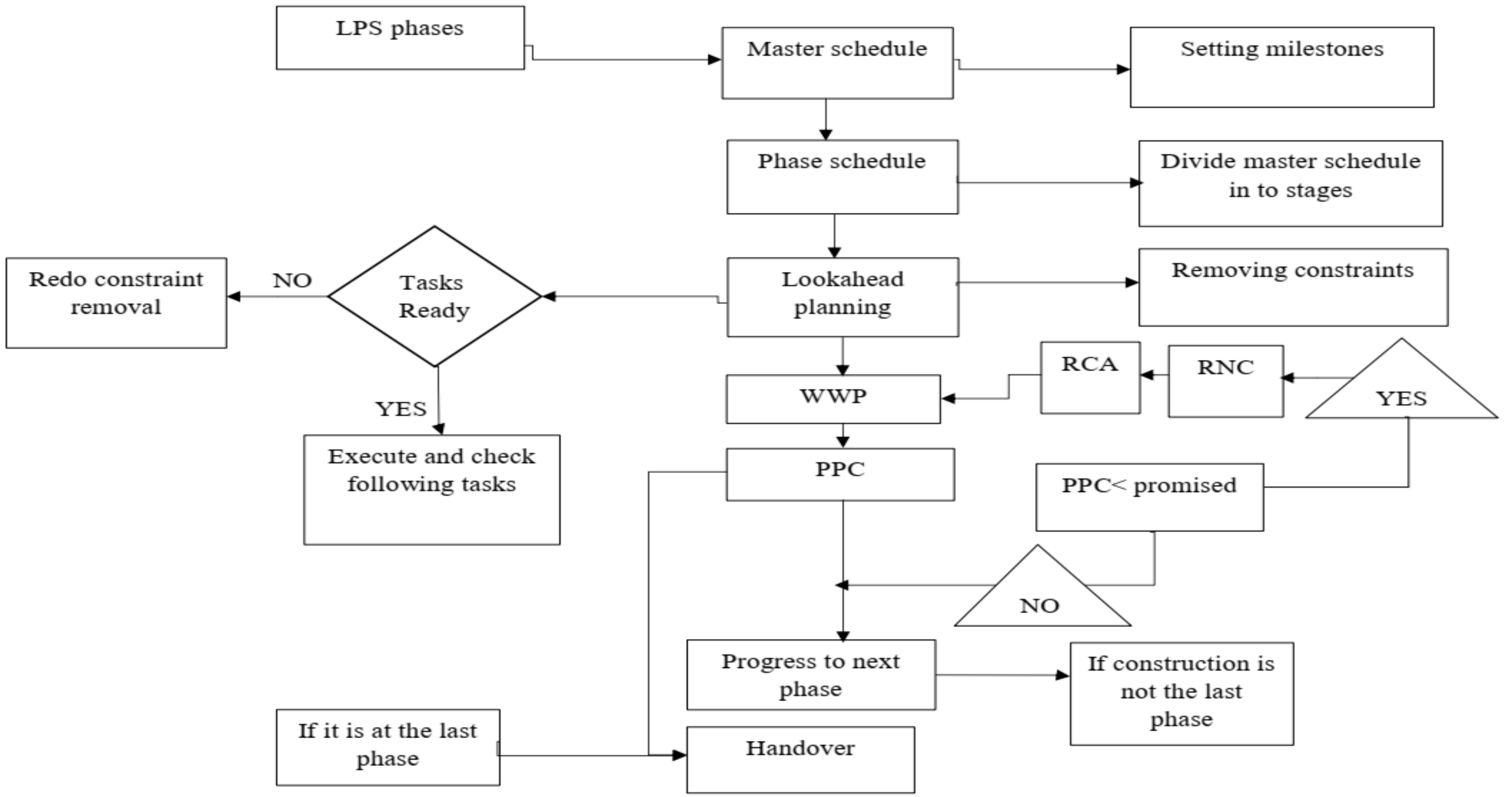
Part 1: The last planner system implementation framework

In this part of validation work, the figure of the developed framework is shown below.

Part II: Questions for validation of the framework

1. Do you think it is important to implement a lean construction in the Ethiopian building construction industry?
2. Do you think the barriers identified are comprehensive? Are they appropriate? Do you think more factors need to be added?
3. Do you think the framework can contribute to improving the performance of projects and organizations in the Ethiopian building construction industry**?**
4. Do you have suggestions on the Last Planner System implementation framework developed?


Ready to adopt the LPS
Develop strategies
Government body
Request for LPS
BCI
Identify challenges
Prioritize and categorize challenges
Identify Stakeholder
Develop nucleus
Project manager
consultant
Engineers
Forman
Financial
technical
cultural
organizational
Develop a sector to perform on each category of challenges
Assign the responsibility for each sector
Implement LPS phases


LPS phases
Master schedule
Setting milestones
Phase schedule
Divide master schedule in to stages
Redo constraint removal
NO
Tasks Ready
Lookahead planning
Removing constraints
RCA
RNC
YES
WWP
YES
Execute and check following tasks
PPC
PPC< promised
NO
Progress to next phase
If construction is not the last phase
If it is at the last phase
Handover