Study on Labour Productivity Improvements Using Lean Construction Principles in Public Residential Building Construction Projects in Addis Ababa, Ethiopia

Abebe Getu Tolcha

A Thesis Submitted to the Department of Civil Engineering,

College 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

May, 2025

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DECLARATION

I hereby declare that this Master Thesis Entitled "**Study on Labour Productivity Improvements Using Lean Construction Principles in Public Residential Building Construction Projects in Addis Ababa, Ethiopia**" 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.

Abebe Getu Tolcha		
Name of Student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "**Study on Labour Productivity Improvements Using Lean Construction Principles in Public Residential Building Construction Projects in Addis Ababa, Ethiopia**" prepared under my guidance by Abebe Getu submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Construction Engineering and Management. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

Lemma Beressa (Dr.)	____________________	________________
Advisor Name	Signature	Date

APPROVAL SHEET

I, the advisors of the thesis entitled "**Study on Labour Productivity Improvements Using Lean Construction Principles in Public Residential Building Construction Projects in Addis Ababa, Ethiopia**" and developed by Abebe Getu; hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Abebe Getu have read and evaluated the thesis entitled "**Study on Labour Productivity Improvements Using Lean Construction Principles in Public Residential Building Construction Projects in Addis Ababa, Ethiopia**" and examined the candidate. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and Management.

Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head	Signature	Date
College Dean	Signature	Date
Office of Post Graduate Studies, Dean	Signature	Date

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LIST OF ACRONYMS

NAICS: North American Industry Classification System

SPSS: Statistical Product and Service Solution

TPS: Toyota Product System

LIST OF ABBREVIATIONS

AAHB: Addis Ababa Housing Bureau

BLS: Bureau of Statistics

CES: Current Employments Statistics

CII: Construction Industry Institute

CLP: Construction Labour Productivity

CMS: Construction Management Software

GDP: Gross Domestic Product

KPIs: Key Performance Indictors

LCP: Lean Constructions Principles

LP: Labour Productivity

PMP: Poor project management practices

QA: Quality Assurance

RMS: Real-time monitoring systems

Std.: Standard

TFP: Total Factor Productivity

WD: workforce dynamics

ABSTRACT

Labor productivity in public building construction projects in Ethiopia is a crucial factor for project success, yet it often falls short of optimal levels. This research mainly aims is to access Labour Productivity Improvements techniques through lean construction principles in public residential building construction projects in Ethiopia for the case Addis Ababa. For this study both qualitative and quantitative research methods were used. The primary and secondary data were collected mainly by questionnaire, researcher observation and interview. The study result indicated that labour productivity management at building construction projects is low. Actually, a lot of contractors are inexperienced in assessing labor productivity on their projects because they are, don't such aware the advantages, or think it's hard to do. Key factors influencing labor productivity at construction sites include material shortages, insufficient follow-up, work variations, and other related issues. Hence, contractors are recommended implement lean construction principles and tools to improve labour productivity. The result indicated above 40% labour productivity improves by implementing the combination of conventional and lean construction tools like; Cross-Functional Teams, 5S, Just-in-Time Delivery, PDCA, Identify and eliminate any non-value-added activities, diminish work cycle time, determine crew size of the workers and some conventional labour productivity improvement techniques. Those techniques are a better labour productivity improvement strategies that shall implemented at construction site in Addis Ababa.

Keywords: Building Construction, Productivity, Labor Productivity Improvements, Lean Construction Principles, Ethiopia.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry stands as a cornerstone of economic development, infrastructure provision, and societal progress worldwide (Kraemer, 2016). Within this expansive sector, building construction projects represent vital undertakings that shape urban landscapes, provide infrastructure and drive economic activity. Whether it's the construction of residential buildings, commercial complexes, or public infrastructure, these projects play a pivotal role in shaping the physical environment and meeting societal needs (Plachta, 2020).

Public building construction projects represent a vital component of societal development, as they encompass the creation of essential facilities such as government offices, educational institutions, healthcare centers, and cultural venues. The successful planning and execution of these projects contribute significantly to the provision of critical infrastructure and public services, ultimately shaping the quality of life within communities. The main resources for building construction projects include raw materials, machinery, equipment and labour force are very essential for successful project completion (Molla *et al.*, 2020). Labor productivity within building construction projects represents a critical aspect of project success, encompassing the efficient utilization of resources to ensure timely and cost-effective which need more improvement aspects.

Lean construction principles, focusing on waste reduction, value enhancement, and collaborative frameworks like the Last Planner System (Ayalew, 2019), began gaining traction in Ethiopia around the mid-2010s, with academic research formalizing their application by 2019 through studies that identified 15 critical lean elements to improve contractors' capabilities. Progress has been gradual but marked by increased implementation in real estate and infrastructure sectors, evidenced by analytical hierarchical models developed for Addis Ababa firms to reduce construction waste, though broader adoption faces challenges like limited understanding of lean tools and inconsistent policies.

The integration of lean construction principles and practices an advancement techniques to enhance productivity within building construction projects (Fraíz, 2021). Lean construction is a method of designing production systems that minimize waste in materials, time, and effort to maximize value generation. It applies the same principles as lean production to enhance productivity and efficiency in construction activities. Traditionally, key factors in construction have focused on workflow reliability and labor flow. However, lean construction shifts this perspective by emphasizing the concepts of flow and value creation. It aligns with the core goals of lean production, such as reducing cycle time, eliminating waste, minimizing variability, fostering continuous improvement, implementing pull production control, and ensuring continuous flow, all of which guide the application of lean construction principles in building projects.

This research seeks to delve labour productivity improvements within the potential impact of applying lean construction principles, aiming to drive meaningful improvements in LP which a milestone for a public building construction project efficiency and overall project success in Ethiopia. The findings of this study are expected especially concerning public building projects, grapples with persistent challenges related to construction productivity (specifically labour productivity), necessitating immediate to have practical implications for stakeholders involved in public residential building construction projects, including governments, contractors, and industry professionals. It provide insights into more reliable and comprehensive labor productivity improvement techniques through application of lean construction principles which assist in optimizing resource allocation, improving project scheduling, identifying productivity bottlenecks, and implementing targeted improvement techniques in residential building construction sector.

1.2 Statements of Problem

Ethiopia's construction sector, particularly within public building projects, is significantly hampered by low labor productivity. This inefficiency manifests as persistent cost overruns, project delays, and the suboptimal utilization of resources(Muhammad, 2022). While lean construction principles offer potential solutions for enhancing productivity, existing research lacks a tailored approach that integrates these principles effectively within Ethiopia's specific construction context. Consequently, critical local factors contributing to low productivity such as variability in worker skills, prevalent workflow waste, and the limited adoption of lean methodologies remain inadequately explored and addressed in the literature.

This study directly addresses this gap by focusing on labor productivity challenges in Addis Ababa's public construction projects. The method creating a hybrid approach that thoughtfully combines established lean construction principles with conventional management techniques. This integrated methodology is designed to provide practical, effective solutions for boosting labor productivity within the unique operational environment of Ethiopia's public construction sector.

1.3Research Questions

The following questions were posed in order to achieve the objectives of this study.

- ❖ What are the current trends of LP improvements in public building construction projects?
- ❖ What are the primaries factors influencing LP in public building construction projects?
- ❖ How do lean constructions principles contribute to labour productivity improvements in public building construction projects?
- ❖ How does the better labor productivity improvement techniques developed and implemented in public building construction projects?

1.4 Research Objectives

1.4.1 General Objectives

The general objective of this research is to access Labour Productivity Improvements techniques through lean construction principles in public building construction projects in Ethiopia for the case Addis Ababa.

1.4.2 Specific Objectives

Specifically the study;

i. To assess the current practices of labor productivity management in public building construction projects.
ii. To identify the key factors affecting labor productivity in public building construction projects.

iii. To compare conventional labour productivity improvements techniques and that achieved by using lean construction principles.
iv. To develop better labour productivity improvement techniques in public building construction projects in Ethiopia in case of Addis Ababa.

1.5 Significance of the Study

This study is significant for Ethiopia's construction industry by directly confronting low labor productivity in public projects, offering practical hybrid solutions integrating lean principles. It identifies key barriers (skill gaps, workflow waste) and proposes actionable strategies to reduce costs, delays, and optimize resources, thereby enhancing performance, competitiveness, and setting new efficiency/sustainability benchmarks. For the scientific community, it addresses a major research gap by providing novel empirical insights into labor productivity drivers within Ethiopia's unique context and advancing knowledge through tailored hybrid lean-conventional techniques, offering a valuable framework for adapting productivity methodologies in similar developing economies.

The findings hold vital significance for Ethiopian policymakers, providing evidence-based insights to guide interventions (e.g., skills development, lean promotion) for more efficient, sustainable, and cost-effective public construction, ensuring better value for investment.

1.6 The Scope of the Study

Conceptually, this study aims to give a thorough understanding of labor productivity improvements using lean construction concepts in residential public building construction projects, with a geographical focus on Addis Ababa, Ethiopia. Most the research indicates that many construction projects fail to be completed within their contracted timelines and budgeted costs. Thus, this research studies mainly assess the critical factors that affect labour productivity and the improvements techniques (Lean principles) to boost the labour productivity on residential public building construction projects in Addis Ababa.

1.7. Organization of the document

The research will contain 5 different chapters

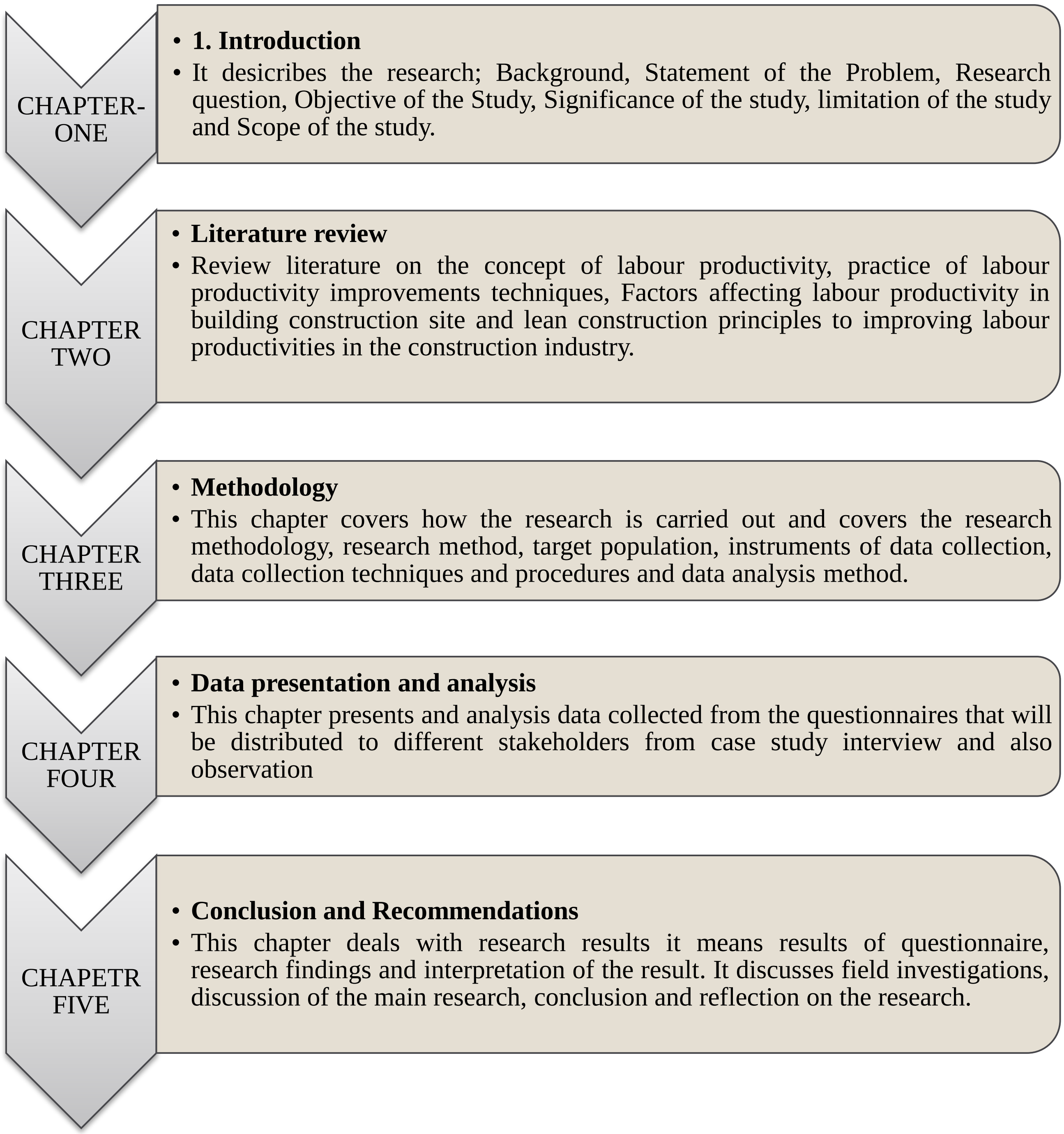

Figure 1. 1 Organization of the Study

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Construction Industry

The construction industry plays a crucial role in the national economy by facilitating the organization and provision of spaces for various other economic activities to occur. Attar (2012) indicated that construction is a vital sector of the national economy for all countries around the world. It revenues up an important serving of the nation's total employment and its significant contribution to a nation's revenue as a whole (Al-kbisbeh, *et al.*, 2020). As it is studied in various researches, the construction industry is growing at a fast pace all over the world that defined in different ways based on the nature of the construction projects and features of the industry.

While (Hyari, 2016) sees construction as an aggregation of businesses engaged in closely related activities, (Davis *et al.*, 2016) suggest that construction refers to all types of activities associated with the erection and repair of immobile structures and facilities. There are three levels to define construction within the literature. At one extreme, construction is referred to as an economic activity that involves the entire construction process from producing raw and manufactured building materials and components, and providing professional services such as design and project management, to executing the physical work on site (Sui Pheng, 2011).

Overall, it is a key segment of the economic sector that converts various resources into constructed physical infrastructure essential for socio-economic development. This sector encompasses the entire process of planning, designing, procuring, constructing or producing, modifying, repairing, maintaining, and demolishing this infrastructure. Although construction projects utilize numerous resources, they face challenges and risks, and each project tends to be more labor-intensive compared to other sectors. There has been lack of attention given to the resource management, specially labour productivity management at site (Engineering, 2016). Yates and McTague noted that in most of the building construction projects, labor costs account for between 30 and 50% of a project's total cost (Sultan et al., 2019a). Therefore, this is observed as an accurate replication of the economic success of the sectors operation which is assessed in following topics.

2.2 Construction Project Managements

Kerzner defined Project Management as “Project management is the planning, organizing, directing, and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives. Furthermore, project management utilizes the systems approach to management by having functional personnel (the vertical hierarchy assigned to a specific project (The horizontal hierarchy)”. McGraw-Hill dictionary defines the Project management as the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction (York *et al.*, 2003). In addition to project management institute (2004) define it as: skills, tools and management processes required to undertake a project successfully (Mohd et al., 2015). There are many definitions to project management, but the Project Management Body of Knowledge defined PM as “the application of knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder’s needs and expectations from a project”.

Construction project management does not differ much from project management in general; Walker defined it as “The planning. Co-ordination and control of a project from conception to completion on behalf of a client requiring the identification of the client’s objectives in terms of utility, function, quality, time and cost, and the establishment of relationships between resources, integrating, monitoring and controlling the contributors to the project and their output, and evaluating and selecting alternatives in pursuit of the client’s satisfaction with the project outcome”. Construction project management has the same main objects as project management which are cost, time and performance, but in construction PM its cost, time and quality as Walker mentioned, which did not change fundamentally but may be took a wider range in referring to people and the importance of working through others, also in construction project management client satisfaction is one important key to project success as well as the objectives and goals of the company itself (Najmi, 2011).

Today, construction projects are more intricate than ever. To ensure a project progresses smoothly, stays on schedule, and remains within budget, thousands of tasks must be meticulously managed. Successfully completing a construction project necessitates careful planning and distribution of available resources. Key resources such as labor, equipment, and materials demand focused management oversight. The availability of these resources is often unpredictable due to seasonal shortages, labor conflicts, equipment failures, competing needs, delayed shipments, and various other uncertainties. Nevertheless, if time schedules and cost budgets are to be met, the work must be supply with the necessary workers, equipment, and materials when and as they are needed on the job site (Charles, 1995).

(House, 2010) on the other hand argue that construction projects are somewhat difficult to manage and meet these requirements due to the nature of the industry; such as complex and unique nature, mobile workforce, ingrained culture, working conditions, and project-based setup, diverse sub-contractors and suppliers (Ahn *et al.*, 2010).

2.3 Construction Performance Managements

Performance refers to the manner in which a task, activity, or function is carried out or executed and the effectiveness, efficiency, or quality of the outcome or results achieved in relation to a specific goal or standard (Affecting, 2016). The performer can be either an individual or a group of individuals working together collaboratively, characterized by a performer's mindset, deep immersion in a stimulating environment, and active participation in reflective practice. Construction performance refers to the efficiency, quality, and effectiveness with which construction projects are carried out and completed which encompasses various aspects of the construction process, including project management, scheduling, cost control, safety compliance, and quality of workmanship, adherence to specifications and regulations, and overall project delivery.

Defining performance as being on-time, on-budget, and meeting quality expectations, Kashiwati (2002) concluded that construction is a business issue and not an engineering technical issue: “a layman can identify whether the contractor finished on time, on-budget, and whether the owner’s expectations were met”. He suggested that addressing a business problem solely through technical specifications will not result in improved performance.

According to (Abushaban et al., 2010) concluded, Construction performance measurements are essential tools used to evaluate and assess the progress, efficiency, and success of construction projects include:

Schedule Performance: This measurement evaluates how well the project is adhering to the planned schedule by tracking key milestones, comparing actual progress against the project timeline, and identifying any delays or deviations that may impact the overall schedule.

Cost Performance: Cost performance measurement involves monitoring and controlling project expenses to ensure they align with the budget by evaluating actual costs against the budget, identifying cost overruns or savings, and implementing cost-saving strategies to keep the project within budget.

Quality Performance: Quality performance measurement assesses the quality of workmanship, materials, and final deliverables in construction projects through monitoring adherence to quality standards, conducting inspections, and addressing any defects or deficiencies to maintain high-quality outcomes.

Safety Performance: Safety performance measurement focuses on ensuring a safe work environment for construction workers and minimizing the risk of accidents or injuries on site.

Productivity Performance: Productivity performance measurement evaluates the efficiency of labor, equipment, and resources in construction projects by using productivity metrics such as labor hours per task, equipment utilization rates, and resource allocation to optimize project efficiency.

Stakeholder Satisfaction: Stakeholder satisfaction measurement assesses the level of satisfaction and feedback from project stakeholders, including clients, contractors, suppliers, and regulatory authorities.

Construction performance management involves the planning, monitoring, and assessment of construction projects to guarantee their completion is efficient, timely, within budget, and meets the necessary quality standards. This is achieved by setting clear objectives, defining key performance indicators (KPIs), establishing targets, and implementing strategies to reach the desired results. It also involves tracking progress, identifying areas for improvement, and taking corrective actions to address issues and optimize project performance.

The performance of building construction projects against what was planned can be measured and evaluated using a large number of performance indicators that could be related to various dimensions (groups) such as time, cost, quality, client satisfaction, business performance, health and safety (Enshassi *et al.*, 2007). They also argue that time, cost, and quality represent the three main dimensions of performance measurement. If they have also said that time, cost and quality are the three major and fundamental performance elements they might add time, cost, and quality are the three key dimensions to the evaluation of performance. On the other hand (Lafhaj *et al.*, 2016) stated that the application of sound Project Management practices provides construction project stakeholders with the means to meet their objectives which is described in terms of meeting the intended, purpose, the level of quality, time, cost; and safely and while protecting the environment.

According to (Ayalew et al., 2018), the success of a project is measured by the extent to which it meets the predetermined criteria of cost, time, safety, resource allocation, and quality as determined by the owner which are quite difficult to meet in most construction projects.

2.4 Productivity in Construction Industry

The construction industry is a varied segment of the national economy that utilizes a broad array of limited resources. Consequently, productivity in this sector is not solely focused on individual tasks but rather on the industry as a whole. There is no universally accepted method for defining productivity in construction operations. In general terms, construction productivity can be simply illustrated by an association between an output and an input (Civil *et al.*, 2014).

Although labour productivity in the construction industry is essential for the survival and growth of construction organizations (Alaghbari et al., 2019b), labour productivity in construction has fallen behind other industries in most of the world and has declined continuously for decades. Over the years, studies have examined construction productivity trends, revealing that most countries have experienced a decline in total factor productivity. About 30–40% of the total construction project cost is expended on labour (Adebowale and Agumba, 2023). The field of research focused on construction labor productivity (CLP) has consistently drawn the attention of scholars in both developed and developing nations, resulting in various initiatives aimed at enhancing CLP.

The definition of productivity varies based on the application area, level of measurement, availability of data, and the objective of measurement (Olofsson, 2012) described productivity as a concept that is commonly used in theoretical and applied discussions, despite it being ambiguous and lacking a consistent definition. Table 2.1 shows sample productivity definitions adopted by different studies. According to (Fayek, 2018), there are two major reasons for misconceptions about productivity measurement in the construction industry, the first of which involves the perception about what productivity is, while the second concerns the use of industrial engineering productivity measurement techniques in construction contexts.

Table 2. 1 Definitions of Construction Productivity from different sources

No.	**Sources**		**Definitions**
	Author/s	**Year**	
1	Lowe	1987	Productivity as representing the efficient use of various factors of production.
2	Chau and Walker	1988	Productivity as a ratio of output produced to input used per unit of time.
3	Thomas et al.	1990	Relationship between outputs per unit of effort employed to produce that output.
4	Vrat et al.	1998	Productivity as a ratio of the output produced to the factors of production.
5	Crawford & Vogl	2007	Productivity as the output potential of a production process, based on input resource.
6	Pekuri et al.	2011	Productivity as a relationship between the output produced by a system and quantities of input resources utilized to produce that output.
7	CII	2013	Productivity as a ratio of output to input for a given process.
8	Phusavat	2013	Productivity as indicating ability to use input resources to generate products and goods.
9	Vogl and AbdelWahab	2015	Productivity as a measure of the efficiency with which the economy turns inputs, such as labour and capital, into output.

In general, productivity can be defined as a ratio of outputs to inputs, showing effectiveness and efficiency in utilization of resources. The most commonly used categorization of a production system in the construction industry involves three main levels: task or activity, project, and industry (Fayek, 2018). Activity-level productivity metrics are the most frequently utilized measures in the construction sector, assessing the performance of specific construction tasks, such as concrete placement and steel erection. In contrast, project-level productivity metrics evaluate the performance associated with a group of activities necessary for the construction of a specific facility. Meanwhile, industry-level productivity measures provide a comprehensive evaluation of productivity across the entire industry sector.

2.4.1. Construction productivity measurements at different levels

The nature of the construction process points to a need for measures of construction productivity at three levels:

At Activity Level; Tasks pertain to particular construction activities, such as concrete placement or the erection of structural steel. Task-level metrics are commonly employed in the construction industry and primarily consist of single-factor measures that concentrate on labor productivity. For instance, RS Means has been publishing task-level metrics for many years(Mewis *et al.*, 2020). Task based average crew production rates reported by RS Means are estimates of the quantity of work produced by a given crew in an eight hour workday. Here, the denominator is the sum of the hours worked in a "crew day". Accordingly, the greater the value of output in a crew day, the better is the performance and a higher mean output as an increase in the labor productivity with regard to that activity. CII holds the output (concrete placed volume, for example) constant and calculates the man-hours needed to achieve that output(Costa *et al.*, 2006). In this scenario, the denominator represents fixed output while the numerator indicates the number of labor hours. Therefore, for a specific output level, fewer labor hours are preferable. In this context, reduced labor hours lead to increased task labor productivity.

Both RS Means and CII task labor productivity metrics provide clear measurements of output and labor hours in their reported values. These metrics are straightforward to comprehend and are commonly utilized in the industry as fundamental estimating tools. To distinguish these from other formulations, we refer to them as “raw metrics,” which denote the ratios of input to output. These are regarded as crude metrics since they are unit dependent and not normalized for outputs and labour hours. For example, relative wage costs of particular labor inputs and the output are likely to change over time with factors such as greater use of information and automation technologies, more costly construction equipment, and changes in construction practices.

The CII Benchmarking and Metrics Program are project-based, with productivity being one of many components. The aggregate CII task level metrics include the received productivity values for a given task being the average productivity for the task (also called the baseline measure) and all other observed values. These observed raw task productivity statistics are then sorted into a distribution. With this ranking, the raw productivity scores can be divided into quartiles.

An alternative to the raw measurements that were previously presented is a task productivity index. A reference data collection that sets the baseline value for one or more index components is the anchor of a dimensionless figure known as an index. In order to account for changes in relative prices over time, an index may incorporate extra data, such as a deflator value, in addition to representing a ratio of raw measurements. Users can focus on changes in the index's value rather than the precise form of the underlying metric because it is dimensionless.

At Project Level; Project-level metrics are more complex because a project consists of multiple tasks. One task, like the work required installing concrete, has different inputs and outputs than another, such the labor required to erect structural steel. Hence, without adjusting, it is not possible to combine individual raw labor productivity measures into a project-level labor productivity statistic. Another way to track changes in project productivity over time is to use a project-level productivity index, where the reference data set is the baseline at time zero, and the numerator for each component of the index is the average value of the corresponding task productivity from subsequent data sets, with the values for task weights and baseline values in the denominator being taken from this reference data set.

With this method, the index is computed as the quotient of two ratios, where the number of field work hours is the denominator and the value of construction finished is the numerator. A baseline value for the construction value to field work hours ratio can be established using a reference data set(Annison, 2011). The baseline value for the ratio serves as the denominator in the index computation. To analyze how an individual project measures up against the baseline, its ratio of value put in place to field work hours is placed in the numerator of the index.

At Industry Level; At the industry level, productivity defined as the amount (or value) of output generated per unit of input serves as an indicator of industrial efficiency. BLS publishes two common measures of productivity: (single factor) labor productivity and multifactor productivity

(Bureau and Statistics, 2011). The value of items produced for sale divided by the number of working hours is how the Bureau of working Statistics (BLS) determines labor productivity. Multifactor productivity measurements provide a more complete picture of industrial production since the value of output can be impacted by outside variables unrelated to labor, including advances in technology. By taking into account inputs from output, labor, capital, and intermediate purchases, the BLS evaluates multifactor productivity. Compared to a single-factor measure like labor productivity, multifactor productivity may be thought to be a more accurate representation of productivity; yet, it necessitates a lot more data collection work. Furthermore, the BLS does not compile or disseminate construction industry productivity data.

This appears to be due to the lack of suitable data (Wang, 2004). Some have argued that measuring construction industry productivity is challenging due to the large number of small firms operating on a minimal profit margin, and to the industry fragmentation (Bernstein, 2003). Nevertheless, the BLS continues to track productivity metrics for other sectors that appear to share similar characteristics (such as full-service dining establishments, bars, and car repair and maintenance) [NAICS code: 7221]).

Using output deflators is a key part of measuring productivity. The BLS has recently created a number of producer price indices for the nonresidential sector, which have improved the estimates of investments in the BEA's National Income and Product Account tables. The BEA and BLS may work together to create additional nonresidential building construction indexes, including price indexes for hospitals, highways, retail, communication, power, and lodging structures (Lally, 2009). Initiatives like these enhance the quality of current statistics and yield additional advantages for measuring productivity.

Generally Labour productivity at activity level is defined as Labour productivity is measured as a ratio of actual direct work hours per install quantity or quantity issued (Chan, 2004), at project level; Quantity-based approach that measures construction productivity as actual work hours per installed quantity (Lo Turco et al., 2009) and at Industry level; Use of output per labour hour or output per labour cost in constant dollars.

2.4.2. Productivity measurement on Construction Sites

Construction productivity measurements refer to the process of quantifying and evaluating the efficiency and effectiveness of construction activities, processes, and resources in achieving project objectives (Furniss et al., 2022) . It is advisable to set up a system that can track productivity trends over time and across several locations, even while each contractor or owner is free to use their own approach for monitoring labor productivity on a site. To produce such results, much work is required to collect data at the regional or national level over a number of years. The performance of important trades, the effect of project size, type, and location, as well as other important influences on projects, should all be included in the productivity indices derived from statistical data.

The metrics that will be useful for data compilation must be agreed upon in order to develop industry-wide performance standards. After this agreement is made, productivity data gathered from different owners and contractors may be compared and examined to create tailored metrics for each significant area of the construction sector. Thus, a contractor or owner can compare its performance with that of the industry average ('Measuring Construction Site Productivity A seven-step framework for success', 2022). Additionally, the same activity may be assessed by different individuals using various methods, leading to productivity values that are not directly comparable.

Input/ Output: There needs to be agreement on the metrics that will be useful for data compilation in order to develop industry-wide performance standards. Following this agreement, specific measures can be developed for each significant segment of the construction industry by correlating and analyzing productivity data gathered from different contractors and owners.

However, this current measurement approach has the drawback of being overly simplistic, failing to capture the actual on-site conditions by not considering various factors that influence site activities. While this model may provide a useful estimate of labor productivity, it cannot be similarly applied to assess the productivity of organizational and off-site staff, management personnel (whose inputs and outputs are not easily defined), or productivity at the firm level.

Experience-based models: The initial efforts to measure and comprehend productivity in the construction industry were largely grounded in the experiences of engineers and contractors. In an era devoid of advanced technology and measurement methods, productivity on construction sites was assessed through experience-based estimates derived from daily observations. Despite significant technological advancements and the availability of various measurement techniques, surveys indicate that over 20% of contractors still depend on the experience and insights of estimators for most of their calculations. This reliance clearly affects the accuracy and reliability of estimates, as it is subject to personal biases and can be quite subjective. When employing models and techniques that heavily rely on experience, the most dependable estimates can be achieved by integrating that experience with historical project data. However, such empirical approaches do not ensure consistent estimates due to the absence of an effective mechanism to connect current situations with past patterns.

Measuring Productivity Using Milestone:

Another common method is to use project milestones to measure productivity. At the beginning of a project, construction managers and other administrative staff of general contractors set specific milestones that must be completed by specific dates. After a predetermined period of time (one or two weeks), staff meetings are held to review the progress of the project and discuss the completion percentage of the milestones. During these sessions, the overall work progress plan is evaluated, and the project's overall productivity is calculated by looking at the percentage of activities completed, usually with the use of project planning software. Despite being easy to use, the milestone technique does not provide any information that could be used to pinpoint the reason for a possible productivity loss. Additionally, it lacks the ability to define productivity on-site and provides no numerical figures that would allow construction managers to compare weekly production to data that has already been collected. One could argue that rather than being a widely recognized scientific approach that produces precise and safe results, this approach is more of an experience-based, widely used methodology.

Activity model (Work sampling): Over the years, numerous labor productivity models based on work-study concepts have been developed and put into practice. Three general categories can be used to group those models: task, activity, and delay models. According to the interviewees, the most popular and extensively used work-study models were thought to be activity models. The foundation of activity models is work sampling, a technique that uses statistical sampling theory to quantify labor use over time. Probability theory is the foundation of work sampling. To estimate the proportion of time spent on a particular activity by the work process, the number of observations of that activity divided by the total number of observations of all activities is used. In the work process developed on the project site, the percentage of time spent on an activity will differ little from the actual time spent on that activity if there are enough random observations made from a big group of craft activities. Observation tours, time lapse photography, video recording, and other methods can all be used to gather the necessary data. It is important that sampling is conducted randomly, and without bias by trained construction or maintenance analysts.

Additionally, the method is simple to use, reasonably priced, and it gathers valuable information throughout project execution that is not typically gathered by other ways. Additionally, it interferes little or not at all with the worker's regular activities. On the other hand, human error and the potential for low accuracy of outcomes are some significant drawbacks. Additionally, work sampling is often viewed with mistrust by foremen and craftspeople and does not distinguish between original and reworked work.

Factor models: Based on the variables that influence a crew's production rather than an individual's, factor models are multivariate techniques to predicting that productivity. The statistical study of staff productivity and associated factors is part of the factor quantification process(Yiakoumis, 1987). They are useful instruments for gauging and forecasting site-level productivity due to their precision and applicability. In order to produce more accurate results while simultaneously taking into account a large number of components, the several factor models that are currently in use have implemented a variety of mathematical and statistical techniques and software. However, based on the literature review and interviews, the main drawback of those models is that, although they can be used to gauge the productivity of a particular project at the site level, they do not account for interactions between different projects, making them challenging to implement at the corporate level.

Cost reporting method: Instead of using statistical or mathematical methods or tools, many construction companies try to estimate their productivity rates by tracking and comparing project expenditures, usually based on the simplistic idea that work becomes ineffective as costs increase. To compare the costs of related projects, a database containing historical data on material, labor, and other expenses is necessary. In addition to evaluating the productivity of a specific project, this data, which can be obtained from previous projects, is used to predict future productivity trends. One advantage of this kind of technique is that it is very simple and easy to use. On the other hand, it does not pinpoint the root of possible low productivity, and data collection may become a costly and time consuming procedure, with high possibilities for human errors in estimating input and output, when compared to other available techniques for measuring productivity (Malisiovas, 2010).

2.5 Factors Affecting Construction Productivity

In addition to being the key to greater competitiveness, productivity is also one of the fundamental components of the erection industry that contributes to its expansion and survival, since it is crucial to the profitability of most construction projects. The construction industry faces many challenges in Ethiopia, but one of the most significant challenges is low labour productivity in building construction projects (Al-kbisbeh, *et al.*, 2020). Therefore, identification and evaluation of factors affecting labor construction productivity have become a critical issue facing industries for a long time in order to increase productivity in construction (Muhammad et al., 2022). The construction industry's labor productivity is influenced by a wide range of factors, including supervision, resource availability, project uniqueness, work organization, labor availability, technological changes, management (good or bad), labor organizations, wages, worker training, motivation, weather conditions, location, uncertainty, performance monitoring, and others. It is necessary to have knowledge and understanding of the various aspects affecting construction labor productivity in order to focus on the essential actions to reduce project cost overruns and project completion delays, thereby improving productivity and overall project performance.

Different researchers have studied the factors that affect construction labour productivity and the key factors are summarized and categorized based on their characteristics as stated bellow; According to (Sharma, 2017), the factors are summarized and categorized in to five groups according to their characteristics, namely: Project Uniqueness, Technology, Management, Labor Organization, Real Wage Trends and Construction Training. Where (Tomeczek, 2022), groups the factors as; Motivation and experience of the workforce, Organization of the work, Type and condition of tools and equipment provided to the worker, and Continual monitoring of performance. Although (Al-Kbisbeh, *et al.*, 2020), categorize the factors as: Skilled labor availability, Technology utilization, Offsite fabrication and modularization and Use of industry best practices.

The aforementioned studies' casual variables for low labor productivity are critically analyzed in this study, which summarizes and divides the elements into twelve groups based on their characteristics; Firstly, variables connected to design; second, work/execution plan; third, materials; fourth, equipment and technology; fifth, labor; sixth, health and safety; and seventh, supervision 8. Project-related characteristics; 9. Work quality-related elements; 10. Characteristics of leadership, coordination, and organization; 11. Characteristics of owners and/or consultants; and 12. External factors. The sections that follow go over these factors:

2.5.1 Design Related Factors

During construction, most projects encounter some modifications to the design, drawings, and specifications. If drawings or specifications are unclear and contain errors, production is expected to decrease since field workers are unclear of what needs to be done. The task may therefore be postponed until clear instructions are given, or it may need to be terminated entirely. As it is studied in different researches, there is a 30% loss of productivity when work changes are being performed (Govan, 2021). Design-related problems that reduce labor productivity include incomplete drawings, inaccurate designs, and design modifications.

2.5.2 Work plan Related Factors

In order to compensate for early project delays and finish the allocated task on time, it is frequently necessary to condense the total time frame for a subsequent activity. However, timetables are frequently under-resourced on many projects, so a properly updated schedule that accounts for the delays may show that the project will be completed on time without shortening the duration of individual activities. From a professional scheduling perspective, incorporating float into the project's overall plan may allow schedule compression without speeding up individual work tasks.

Because it will reduce the overall length and allow the contractor to complete all of the remaining work, compressing the timeline may need the contractor to put in more work for the desired task. Schedule compression, when linked with overtime, often results in major productivity losses due to shortages of material tools or equipment to support the extra labor’s, resulting in difficult for planning and coordinating the task, and unavailability of experienced labors (Pitroda et al., 2019). Lost labor productivity might result from poor project initiation procedures, inefficient work scheduling, or a shortage of personnel or necessary construction equipment. Two common reasons for lost worker productivity are not having a working schedule and not changing the schedule.

2.5.3 Material Related Factors

In the construction sector, one of the most important variables affecting productivity is poor material management. If necessary resources are not available at the right time and location, it might reduce project productivity. The size of the construction site and the material storage location has a significant impact on productivity because laborers require extra time to move required materials from inappropriate storage locations, thus resulting in productivity loss (Journal *et al.*, 2015). The second difficulty is the usage of inferior materials, which often result in subpar production and may be rejected by supervisors, which affects productivity.

2.5.4 Equipment and Technology Related Factors

Construction projects' productivity is frequently impacted by the type and size of equipment used. Choosing equipment that is appropriate for the work conditions at a construction site and has the right features will help to boost job-site productivity. According to earlier studies, the primary contributing causes to low productivity are a lack of equipment and frequent equipment breakage, as these factors cause workers to take longer to finish specific tasks.

Overall productivity on construction sites is also impacted by technological advancements, which can drastically alter skill requirements. Goodrum and Haas have demonstrated that as technology advances, labor productivity will increase by 30% to 45%. While literature describes how technology can increase each task's productivity, it should be noted that there is a cost involved in using technology, and increasing labor productivity is not the ultimate goal. For example, capital investment in technology can be increased to improve labor productivity, but this approach may not be the optimal solution when overall costs and benefits are considered (Butry et al., 2009).

A decrease in productivity is typically brought on by a lack of technological developments for machinery, frequent equipment breakage, and an inadequate amount or quality of tools and equipment to meet project requirements.

2.5.5 Labor Related Factors

Research indicates that labor is a key factor in achieving high productivity. The main labor-related reasons for low productivity on building projects are as follows. To make projects productive, there should be enough workers with the necessary training and expertise. Because inexperienced and unskilled workers take longer to finish tasks and may need to redo them, labor incompetence can be seen as one of the potential reasons for a decline in productivity.

Misunderstandings among workers occur in disputes over duties, which cause numerous errors that require rework and, as a result, lower worker productivity. Lack of compensation and increased laborer age negatively affect labor productivity because labor speed and strength decline over time and reduce productivity (Muhammad et al., 2022).

One of the primary causes of low productivity on projects is an overcrowded workforce. The misconception that more workers equate to more productive labor is one of the reasons for overstaffing. The primary characteristics that have a negative impact on labor productivity are inexperience, high absenteeism, ineptitude, drug and alcohol usage, an overcrowded workforce, poor relationships among coworkers, indiscipline, and personal issues.

2.5.6 Health and Safety Related Factors

The facility experiences a variety of accident types, including fatalities and complete work stoppages for several days. The crew that the injured employee worked for is reduced in size when an accident results in their hospitalization. Small accidents resulting from nails and steel wires can stop work and, thus, decrease productivity (Windy *et al.*, 2020). Having safety equipment and a safety officer on staff makes it simpler for employees to comprehend and follow safety regulations, which can reduce accidents and increase productivity.

2.5.7. Supervision Related Factors

To move forward with the work, the supervisor must inspect the work. For instance, the contractor's inability to pour concrete prior to a formwork and steel work inspection reduces worker productivity. Supervisors may request that a particular task be redone if the necessary work is not completed in accordance with the designs and specifications. Among the main causes of low worker productivity are supervisors' unclear instructions, frequent changes in leadership, supervisor ineptitude, and supervisor absence.

2.5.8. Project Characteristics Related Factors

Features that affect productivity in construction projects include contract type, site congestion, uniqueness, complexity, scale, and appropriate site layout for temporary facilities. Construction projects are intricate, one-of-a-kind, and frequently challenging. Construction projects are seldom precisely planned or constructed in the same way as earlier ones. Every project must be different from its predecessors due to environmental elements such the physical location, weather, and scenery. Additionally, aesthetic considerations contribute to each project's individuality. Major project characteristics are significantly impacted by these elements. While most construction personnel find this uniqueness to be an attractive element for a career in construction, it can have an adverse effect upon construction productivity (Abdullahi, 2023).

Project uniqueness requires changes to construction processes, which require workers to go through a learning curve at the beginning of each project activity. To achieve significant productivity, each crew member needs enough space to perform their tasks without being impacted by other crew members and interference is likely to occur when more laborers are assigned to perform a specific task in a fixed amount of space. The types of activities and construction methods also influence labor productivity (Windy *et al.*, 2020).

Additionally, stores, lunchrooms, rest areas, restrooms, entrances, and exits are all a long walk or drive away and for employee, which lowers overall productivity (Association for the Advancement of Cost Engineering (AACE) International Recommended Practice No. 25R-03, 2004). A poorly designed website may also lead to a decrease in productivity.

2.5.9. Quality of Work Related

Quality of work related issues have an influence on the productivity of labour on the construction projects (El-Gohary et al., 2011). Among the quality-related problems that impact labor productivity by increasing labor lost hours are ambiguous specifications, rectification or correction of tasks, and rework. Unclear specifications, job corrections and rectifications, and rework.

2.5.10. Leadership, coordination and Organization Related Factors

In the construction sector, management makes productivity advancement more difficult. Past studies found that poor management was responsible for over half of the time wasted on a job site (Zhan et al., 2019). Profitability and success are dependent on effective management.

According to earlier studies, the construction industry now lacks formal training. Practical considerations include businesses finishing the higher share of nonunion employment are the cause of this lack of training. Contractors typically have a highly mobile workforce. Because of this, contractors are frequently reluctant to spend money on training someone who might eventually work for someone else. The result may be a decrease in the construction workforce average capability level (Haan *et al.*, 2020). Additionally, as they supply the majority of the resources for the construction project, they have an impact on site productivity. Poor scheduling and communication between the project office and the head office are significant factors that contribute to brief project interruptions, in addition to cash flow problems.

Gundecha asserts that managers' abilities and dispositions significantly impact output. The cause of low production is ineffective and uncaring management. Managers that are dedicated and experienced can get amazing achievements out of ordinary employees. The capacity and willingness of employees to work determines how well they perform on the job. The creation of both is accelerated by management. Knowledgeable workers are necessary for advanced technologies, and they provide quality work under managers with professional qualifications. The best possible use of technological and human resources can only be ensured by competent management.

One of the key elements influencing the productivity of construction workers is motivation. When employees' own goals align with those of the organization, motivation is most effective.

Factors such as payment delays, a lack of a financial motivation system, non-provision of proper transportation, and a lack of training sessions are grouped in this topic (Manley et al., 2011).

2.5.11. Stakeholders Related Factors

Preconditions are factors that affect a construction site's productivity through the actions of external parties. They are not controllable by the project management; however, the consultant project manager can control them to some extent by applying integration management (Abdullahi, 2023).

Client: These are one of the most important bodies which influence the productivity of the project site by changing their requirement; the project scope (Acar, 2022). Unless preceding design revision and engineering control are accomplished before the execution of works, this activity results in changes and additional design being produced, this momentarily deprives the contractor of design knowledge. Research conducted in other nations indicates that the rise in the proportion of change orders is closely correlated with the decline in production. At other time clients may limit the project completion time but providing design changes in such a case the contractor may be forced to use overtime works which has also similar effect in reducing productivity (Said, 2023).

Consultant/Designer: These are some of the key players influencing the construction site's total productivity. It is well known that one of the most crucial components of the building process is design information, which is provided in the form of drawings and specifications. Unless the engineering information is appropriately scheduled and controlled like other resources it will cause loss of productive time of workers (Wang, 2021). Among the elements that fall under this category are the following: Owner-related financial concerns, such as delayed payments, miscommunication between the owner, consultant, and contractor, and a lack of general contractor support.

2.5.12. External Factors

Weather is a critical factor in any construction project, but for external work such as formwork, T-shape work, concrete casting, external plastering, external painting, and external tiling, adverse winter weather conditions such as winds and rains reduce productivity and can even completely stop the project(Windy *et al.*, 2020). Law and order, governmental stability, and other elements are necessary for the construction industry to operate at high levels of productivity. Government taxation laws affect the growth of plants and employee motivation. Extreme weather, such as extreme heat or cold, will also increase absenteeism and turnover. Examples of natural factors affecting labor productivity gleaned from previous studies include geographic conditions and the weather at the employment site. Other factors, such as fuel, water, and minerals, also have an impact on production to some extent. It has been discovered that very hot, cold, or rainy weather has a significant negative influence on productivity.

In addition to the expense of holiday compensation, employees who work on holidays typically experience a decrease in productivity. Since employees are working and away from their family over the holidays, it might be considered a morale component or factored separately. There is typically a productivity loss to account for in either case. Among the elements that fall under this category are the following: Unstable political situations, holidays, and unfavorable weather (heat, rain, etc.).

2.6. Improvements of Construction Labour Productivity

The construction industry has many difficulties when it comes to productivity issues.Regardless of the size of the organization, productivity is one of the most crucial elements influencing its ov erall performance, and labor performance is typically the source of issues. The performance of labour is affected by many factors and is usually linked to the performance of time, cost, and quality (Dheenadhayalan, 2015). So it needs improvements to boost the construction industry for economic development of the countries.

Examining the extensive body of research on construction productivity, these elements are releva nt to studies on lean construction, business process reengineering, motivation and reward scheme s, and construction duration.reported on an exploratory study into the personal constructs of site management personnel, highlighted the need to fully understand the factors influencing construct ion labor productivity before discussing productivity improvements, and bemoaned the lack of dr ive on the part of construction researchers to understand the construction workforce with referen ce to their productivity. This is because these efforts to advance the pursuit of labor productivity improvements can be helpful in demonstrating trends, but they may not always provide an accura te picture.

As a result, time and money can be saved. Reducing labor productivity variability with respect to available workload and capacity (work hours) is necessary to enhance project performance. The time difference between what was anticipated and what really happened in terms of work start times and duration is known as the variation that impacts labor productivity and need to be minimized. A set of graphs for factors affecting labor productivity was presented which could help improve labor productivity and projects' performance (El-gohary et al., 2012).

2.7. Lean Application in Construction Industry

Lean construction is a new way of thinking about construction production management. It initiates productive flows to create control systems that minimize losses at every stage of the operation. It is about reducing the costs by cutting waste, innovating by engaging people and organizing the work-place to be more efficient (Dqg *et al.*, 2015), that can be traced to Toyota Production System (TPS). A widely used definition is that Lean Construction is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value," (Koskela *et al.*, 2007). Lean construction is not just another specific approach to construction, but rather a challenger of the conventional understanding and practice of construction (Abdelhamid *et al.*, 2020).

In the construction business, "lean applications" refers to using lean concepts, principles, and tools across the building construction project's phases. This calls upon total transformation of the conventional way of construction (Matyja, 2016). And focus on getting things right, in the right place, at the desired time and in desired quantity (Akdogan, 2017). The intensity of the pursuit for the operational application of lean tools in the construction projects is on the increase; this is due to the realization by construction companies of the potentials of an effective lean project development process in reducing project completion time, design and supply chain management integration, ease in constructability, environmental sustainability, flexibility, process control, and increased in the quality of new projects (Nikakhtar *et al.*, 2015).

Recent researches and discussions have been carried out using lean construction tools and techniques in many countries all over the world such as Nigeria by (Issa, 2013), Ecuador by (Bari, 2012). Efforts have been made to improve the project delivery system, work structuring, design, supply chain, project controls, and productivity on construction sites by implementing lean concepts and methods. According to (Koskela, 1992), there were 11 basic principles to Lean Construction, which were to reduce the share of non-value-adding activities, increase output value through systematic consideration of client requirements, reduce variability, reduce cycle time, minimize the number of steps, parts and linkages, increase output flexibility, increase process transparency, focus control on the complete process, build continuous improvement into the process, balance flow improvement with conversion improvement and benchmarking.

Later, (Jones, 1997) have simplified further the Lean Construction principles stated by (Koskela, 1992) into five Lean Construction principles, which are specified value from the clients' perspective mapping the value stream, make the value-creating flow, establishing client pull at the right time and pursue perfection for continuous improvement. These five principles are further confirmed by Lean Enterprise Institute (Fujimoto, 2009) and (Marhani *et al.*, 2013) as able to be implemented to the total flow process and its sub-process in the construction industry. On top of that, by implementing these five principles would lead the least amount of accomplishment, materials and resources while maintaining the needs (Arif *et al.*, 2013).

2.7.1. Wastes in Building Construction Projects

In building construction, waste is defined as anything that uses resources but produces no value. There are three types of waste: Muda, Muri, and Mura. Muda includes seven different types of waste or non-value-adding activities: (1) overproduction, (2) waiting, (3) transportation, (4) over-processing, (5) inventory, (6) movement, and (7) defect products. Muri is about overburden when workers or machines are overworked. Mura is unevenness, when some workers and machines work below their capacities for some of the time, while others may overproduce (Salem *et al.*, 2006). According to (Abdel-Hamid, 2007), type of wastes in building Construction Projects are summarized as follows;

Overproduction: In construction, this type of waste occurs when a task is completed before the next task in the sequence is ready to start.

Inventory: It is where equipment and raw materials are kept. One benefit of the big quantity supply is that it reduces transportation costs; however, there are drawbacks as well, such as the expense of storage and management, and the fact that the materials will take up more space in the shop, leaving less room for other items. Moving from "just in case" inventory to "just in time" inventory is the goal of lean construction.

Transportation: Delivery of the material to inventory and moving the materials from the inventory to the work point using a crane or machine are both included in transportation; therefore, a logistic flow map is necessary to optimize the flow of transportation, which includes worker transportation and the movement of machinery to the work site.

Displacements or motion: The operators' motion to find the tools and materials will have a detrimental influence on the quality of the task since workers' energy will be diverted to non-value-adding activities. According to (Abdel-Hamid, 2007), a worker walking between seven to nine km each day to searching for a plan, tools, materials or moving between several working points in the project.

Over-processing: Include using too expensive tools or robust equipment more than need; also the use of two packing's instead of one, moreover the excess of meetings or double-checking the product is considered as over-processing.

Defects: Defects affect work synchronization and demotivate operators because they may be penalized for their mistakes. Defects include anything that is done incorrectly the first time and needs to be redone, which will take time and materials to fix.

Waiting: Waiting for material, equipment, labour, information, plans, permission, or completing proceeding work, could cause to interrupt the synchronizations of sequences of work or even breakdowns some part of work or the entire project.

Not Utilizing Talent: The non-use of staff skills is considered as the eighth source of waste because the companies do not take advantage of a great potential that is available and that can produce creative ideas and generates added value for the customer (Latham, 2016).

In order to boost the construction industry's performance, innovation is crucial. Prior research has shown that innovation champions are essential forces behind innovation; just like lean construction principles persuade other stakeholders with captivating stories or future-focused visions.

2.7.2. Lean construction principles in Ethiopia

Lean construction concepts were largely absent in Ethiopian industry practices before the 2010s. The construction sector faced systemic issues like project delays, cost overruns, and waste, but conventional management approaches dominated. Early academic interest emerged through studies benchmarking global lean practices. Researchers like Ayalew et al. (2016) highlighted Ethiopia's construction industry performance gaps, indirectly laying groundwork for lean adoption 11. International publications (e.g., Koskela's lean theory) entered Ethiopian academia, though practical applications remained scarce.

Ethiopia's construction industry faces chronic inefficiencies, including project delays averaging 30-50% beyond deadlines, cost overruns exceeding 20% of budgets, and material waste consuming 15-30% of resources. Lean construction principles offer transformative solutions to these challenges by eliminating waste and maximizing value. The Ethiopian context requires culturally and economically adapted approaches to implement six core principles effectively (Achamyelew Maru et al., 2025).

Table 2.1. Ethiopian Lean Principle Prioritization Framework

Principle	Adoption Rate	Impact on Performance	Ethiopian Innovation
5S Implementation	42%	35% reduction in waste	Tea Ceremony Audits
Cooperative Relationships	28%	40% fewer delays	Shared Risk Pool Contracts
Continuous Feedback	31%	30% faster problem-solving	Medemer Action Reviews
Respect for People	38%	50% accident reduction	Yilugnta Safety Culture

2.7.3. Application of Lean Construction Tools to Improve Labour Productivity

There are several lean tools that we can apply to improve labour and overall construction productivity at site. So, these techniques permit to map out the value stream, identify & remove waste, produce value to the construction stakeholders, and lead organizational change. Among several lean tools to boost construction labour productivity were; 5S (Sort, setting in order, Shine, Standardize, Sustain), Kaizen, Just-In-Time, Gemba, Takt-Time lean Tools, PDCA (plan, do, check & act), Standardized Work and Value Stream Mapping.

(Abdel-Hamid, 2007) focused on improving construction labor productivity in Egypt by applying two lean construction tools (Kaizen or continuous improvements and reducing variability of labor productivity). Among the kaizen are the project management index, performance ratio, and disruption index. The potential advantages include better demand management, shorter cycle times, enhanced output, higher employee engagement, and higher profits and revenues. The results achieved illustrate the power of lean concepts and techniques and their applicability to improving a productivity of construction projects (Zabelle, 2002).

Rashid and Mohammed (Rashid, 2006) indicated that by implementing takt time at construction site resulted an increase of 10 % in construction labour productivity would yield approximately billion savings annually to the British economy. Additionally, Alarcon and Yiu conclude that as the improvement in planning reliability on labour force for labour based construction projects can bring significant productivity improvements in construction projects. For instance, some studies have shown that 50% of improvement in the planning reliability on labour force can increase productivity up to 35.0% (Yiu et al., 2013). The optimal use of human resource in every construction business increases productivity and, therefore, any firm with the desire to stay on top cannot undermine its workforce that shows a proper monitoring and improve labor productivity from 40 % - 60% to 60% - 70% (Journal and Engineering, 2017).

2.7.4. Benefits of Applying Lean principles in Building Construction Projects

The economic benefits include a reduction in construction time and project costs, an improvement in the quality of the work, inventory control, risk reduction, and project delivery. The social benefits include increased worker and labor productivity, high employee satisfaction, customer satisfaction, and improved health and safety. The environmental benefit is to reduce waste which makes the construction green (Issa, 2013).

Lean construction aims to reduce non-value-added tasks, whereas the traditional construction industry prioritizes the timetable of all activities and ignores them. Most traditional construction sites use "push" management techniques rather than "pull" ones. 54% of the conventional construction management methods include critical path method, breakdown structure, earned value analysis fail to deliver the project on time, on budget and quality standards.

But the lean construction adopting the Toyota production system which is work on optimizing all processes from all fields, ranging from design, production, and management (Rojo, 2002). Moreover the world search for construction productivity improving techniques like lean construction instead of conventional construction methods to reduce the waste and maximize productivity of building construction projects (Bari et al., 2012), the lean construction is considered more profitable and worthy more than the conventional method, since as the waste minimized the profit will increase. According to (Ayalew et al., 2016a), the benefits from implementing Lean Construction in Ethiopian construction industry shows, that greater productivity (89%), improved sustainability/reduced waste (87%), great customer satisfaction (85%), reduced project schedule (77%) and high quality construction (75%) are the top five expected.

2.7.5. The Challenges of Implementing Lean Construction

Many construction projects are facing lack of support from the top management to implement lean construction. Without continuous supports from the top management, the stakeholders involved in the construction industry may face numerous difficulties in adopting Lean Construction principles (Alinaitwe, 2009). A number of challenges for promoting and implementing lean construction in in construction industry were raised by (Pan et al., 2020) are;. There is no clear definition of lean construction and its standard, particularly when integrated into the scoring system of procurement, organizations and practitioners are locked in the conventional methods of construction and therefore are reluctant to change their mind-sets, lack of demonstration to stakeholders what and how they could benefit from investing in lean construction, lack of effective coordination between different stakeholders is important to the implementation of lean. Furthermore, the establishment of standards and assurance in the manufacturing process were identified as the primary obstacles to the adoption of Lean

Construction methods. This will give impact in the implementation of Lean Construction specifically to the labors' productivity.

(Howell, 1999) added that human attitude is one of the main aspects that slowed down the execution of Lean Construction in building construction projects, especially during the physical implementation phase. According to (Park, 2006) the attitude of the stakeholders concerned in a construction project towards the Lean Construction practices was a sensitive factor that in actual fact influenced the success of implementing Lean Construction principles.

The stakeholders involved in a construction project needed to be given ample training to enable them to possess the necessary knowledge and expertise in implementing Lean Construction concept (Abdullah *et al.*, 2009). It could require time and effort to train and educate the staff. In order to increase training and education comprehension and enhance the lean construction idea, top management should play a significant role.

The application of Lean building was hindered by the absence of reward systems or incentives in a building project. To guarantee the construction project's success, adequate finance sources are essential. The provision of contingency cost will help the construction project from inflation or additional construction cost due to instability of the construction markets (Arif *et al.*, 2013).

2.8. Overview of Ethiopian Construction Industry

Construction is one of the industries driving Ethiopia's modernization and industrialization at the moment, and its growth and increasing demand have followed a similar pattern to the global trend. According to various surveys, the building sector in Ethiopia, as well as most other countries, contributes about half of the total capital. It is also said that the construction industry is being the second largest employer in the country and it's also an engine for technology, innovation and overall development (Ayalew et al., 2016b).

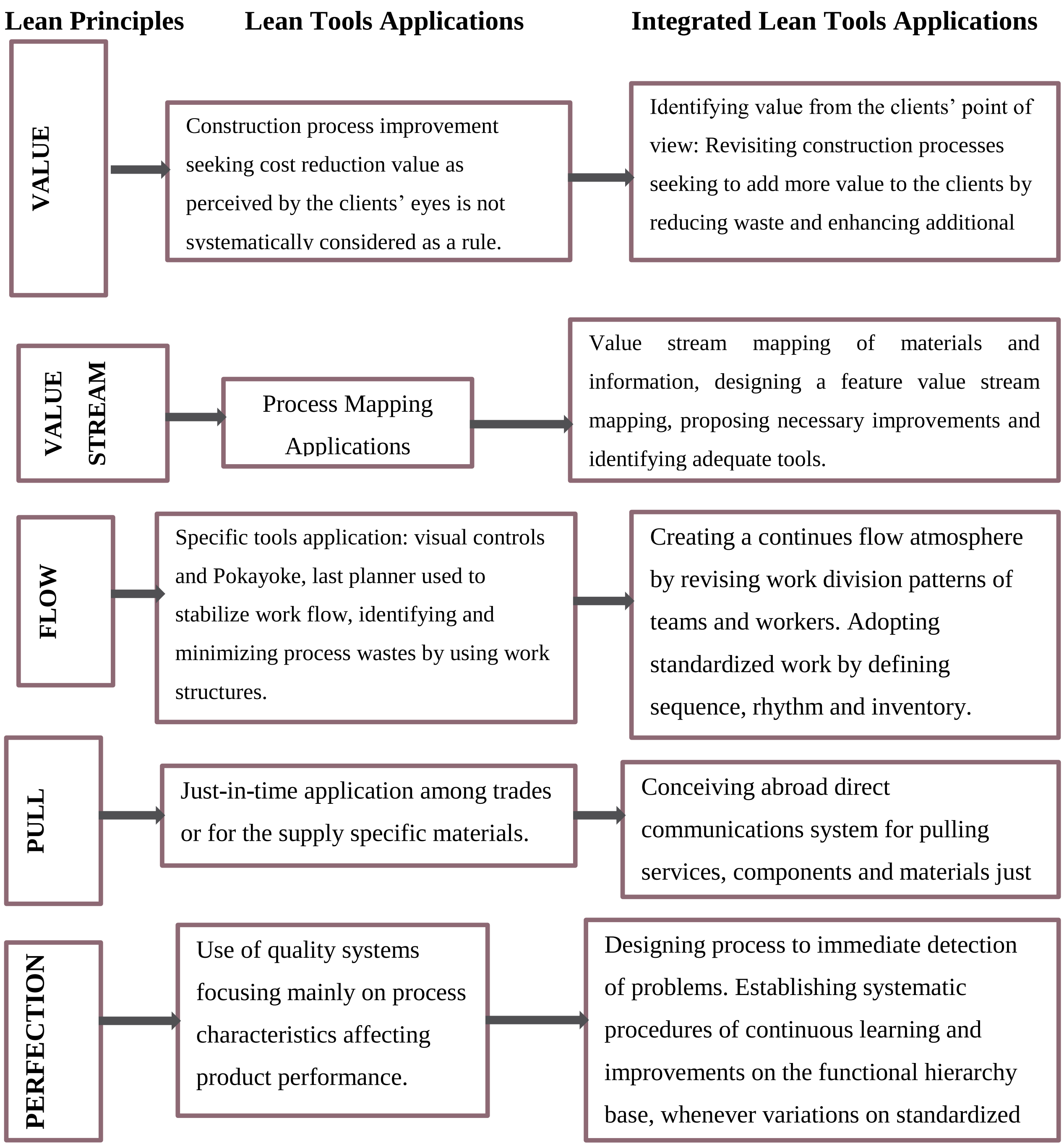

Figure 2. 1 Examples of Lean Tools Implementations in Construction Sectors (Picchi, 2015)

As numerous scholars have observed, Ethiopia's construction sector serves as a springboard for the expansion of numerous other businesses. Building projects, in particular, demand a lot of input from other businesses. For instance, they require a variety of metal products, clay products, cement, and cement products, among other things; as a result, the growth of these industries will surely follow the growth of the construction industry. Similarly, as more homes were built and renovated, there was a greater need for furniture for the home, which indirectly led to the expansion of the furniture industry. All in all, the building business is a sector that can entertain big micro companies, that is widely labor based.

According to Ethiopia's Federal Democratic Republic's Industry Policy, the nation's policies are placing a particular emphasis on the building sector. The construction industry is one of the three economic sectors that the Ethiopian government has identified as receiving particular focus in order to support the country's economic development. However, the general state of the domestic construction industry in Ethiopia is still characterized by inadequate capital base, old and limited numbers of equipment, low levels of equipment availability and utilization, deficiencies in technical, managerial, financial and entrepreneurial skills, limited experience and participation of the private sectors in construction and consultation works, and insufficient and ineffective use of labor-based building construction projects (Tesfahunegn, 2006).

According to the Ethiopian Economic Association (Geda, 2011) the construction industry has important contributions to the Ethiopian economy, as demonstrated by its share in the GDP. According to the research, Ethiopia has seen a rise in investment in the construction and enlargement of a number of infrastructure projects, including highways, airports, and residential and non-residential housing units. The role of the construction industry in terms of creating employment opportunities especially in urban areas is becoming visible as it is reported by Ethiopian Economic Association (Engineering, 2016).

2.8.1. Public Building Construction Projects in Ethiopia

Today's building construction industries are expanding globally and using a lot of resources. Because of poor resource management, building construction projects in developing nations use a lot of resources while they are being completed. Like most of African countries like, Ethiopia is depends on the improper resource management including labour force productivity on BC projects (Ali *et al.*, 2020).

According to Redfin Corporation in the US classify the major residential buildings can categorized as the following (Zemedkun, 2022): Single-Family Home, Condominium, Cooperatives and Multi-family homes are the least common type of residential building. From these all condominium and cooperative residential buildings are very familiars in Addis Ababa as a public residential building. There are several public residential buildings construction projects underway in Addis Ababa, Ethiopia. Some of the notable projects include: Addis Ababa Housing Development Project, Addis Ababa Integrated Housing Development Project, Addis Ababa Condominium Housing Project and Addis Ababa Social Housing Project are a part of the public's residential building construction projects enhanced to address the housing shortage in Addis Ababa and improve living conditions for its residents (Article, 2022).

2.8.2. Productivity in Ethiopian Construction Industry

Various studies demonstrate that Ethiopian building project management is not scientific. Accordingly, the majority of construction projects did not perform well, as previous studies have proven. The performance of projects were usually measured with the tendency of projects to be completed within the specified time, budgeted cost and quality standards stated in the specification and contract documents (Ayalew et al., 2016b).

The productivity of the Ethiopian construction industry can be measured in various ways, such as labor productivity, capital productivity, and overall efficiency of the construction process. The impact of low LP on the performance of construction projects is a significant factor that lowers the overall performance of the project (Rashid, 2006). A (Chia, 2010), conduct a research on International Comparisons of Malaysian Construction LP for estimating the construction labour productivity of 79 selected countries, which include five African countries (Egypt, Ethiopia, Madagascar, Mauritius and South Africa). According to the Chia F. research finding result shows Ethiopia is ranked 76th from 79 countries and the 5th (last) from countries of Africa where; Madagascar, Mauritius, South Africa and Egypt are 1st, 2nd, 3rd, and 4th respectively (Chia, 2010). Therefore, construction labour productivity in Ethiopia needs improvements to boost the construction industry which play great role in countries economic developments.

2.9. Gap analysis from literatures

One of the main issues facing Ethiopia's building construction sector is the control of construction labor productivity (CLP). There is a strong demand for labor in the building construction sector, and labor expenses and resources often account for a large percentage of project expenditures. Labor costs typically constitute approximately 40–60% of total construction costs (Sarijari et al., 2023). Specifically, labor productivity is difficult to measure and is often determined by referring to the fundamental resources utilized, which may not always give a reliable picture of labor productivity on the job site but can be useful in showing trends. These characteristics show a fragmented approach to addressing complicated challenges and emphasize the areas that need development to advance the pursuit of labor productivity improvements.

The comparative analysis of (Chia, 2010) indicates that Ethiopia is ranked the 5th (last) from five African countries and 76th among the 79 selected countries labour productivity on real measurement basis. The productivity of construction workers in Ethiopia's building construction industry is significantly impacted by the country's status. Moreover, the current construction labour productivity of Ethiopian building construction industry is relatively low compared to other countries due to several factors (Tam *et al.*, 2021). Therefore, it needs an improvement by effectively using our potential in the Ethiopian residential building construction.

Recently, lean construction has been successfully implemented in the construction industry for waste reduction and to improve project performance (increase customer satisfaction, planning practice, and safety hazards prevention) as well as improving of construction productivity (Ikuma et al., 2012). However, the applicability of lean construction in building construction projects of Ethiopia is very low due to lack of knowledge about lean construction principles, lack of industry support, lack of standards of lean construction guides and lack of labour awareness about lean construction tools and principles. Therefore, this study is introduce some lean tools implementation in construction projects and develop a better techniques to improve labour productivity in residential building in Addis Ababa of Ethiopia.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

The methodology employed in this thesis work is included in this chapter, along with details on the research strategy, research design, research location, case study, questionnaire design, questionnaire content, reliability and validity tests, and data analysis procedures.

3.2. Description of the Study Area

The largest city and capital of Ethiopia, Addis Ababa, is the subject of this study. It is located at an average elevation of 2,355 meters (7,726 feet) above sea level and functions as the nation's administrative, economic, and cultural hub. The city's skyline features a mix of modern high-rise buildings, government institutions, educational facilities, and healthcare centers, and with various a corridor development infrastructure construction initiatives underway to representing the ambitions and growth of the city.

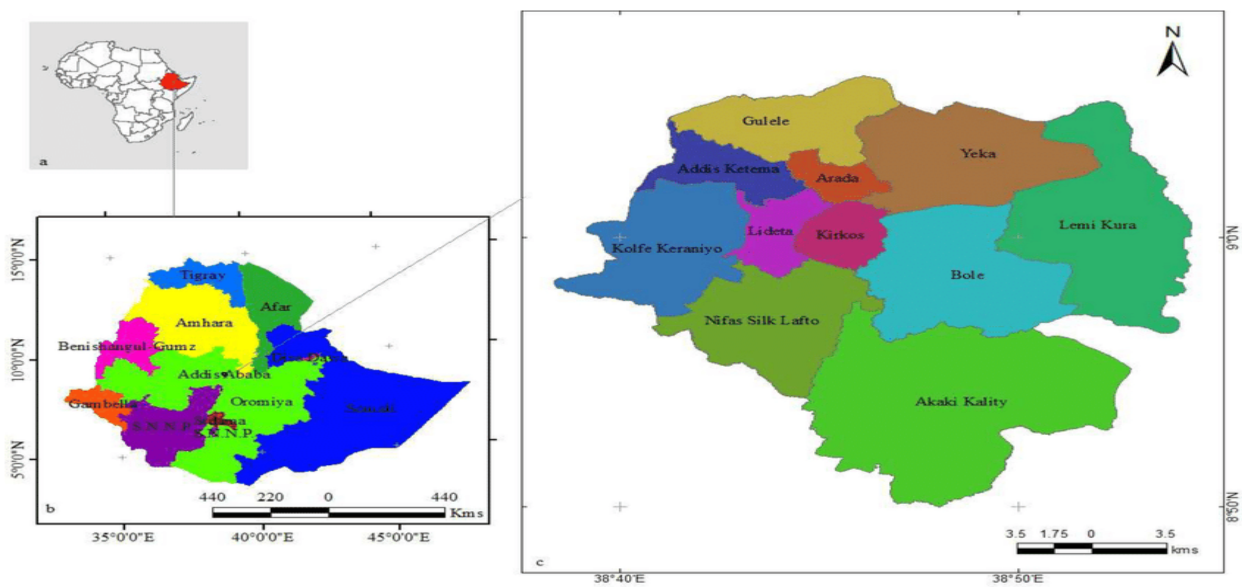

Figure 3. 1 Map of Addis Ababa City

3.3. Research Design

This research is both qualitative and quantitative aiming to access Labour Productivity Improvements techniques through lean construction principles in public building construction projects in Ethiopia for the case Addis Ababa. The study uses both primary and secondary data to achieve its goal. The researcher employed interviews and site observation to gather primary data for the questionnaire. In the case of Addis Ababa, the questionnaire was created to collect data on labor productivity practices, factors influencing labor productivity, and methods of improving labor productivity on public building construction projects.

On the other hand interview was conducted for the construction professionals on selected project those encountered labour productivity management practices and challenges to assess the current practice of labour productivity improvement, factor affecting labour productivity at site and labour productivity improvement techniques that to develop the better labour productivity improvements in public building construction projects in the case of Addis Ababa.

The interviews were also used to enhance reliability of the data obtained by questionnaire and site observation. Previously conducted studies, the internet, books, journals, and various articles in published documents were the sources of the secondary data. The secondary data had used as a source for identification of labour productivity management and factor affecting it. In simple graph the research design had done by the following procedure.

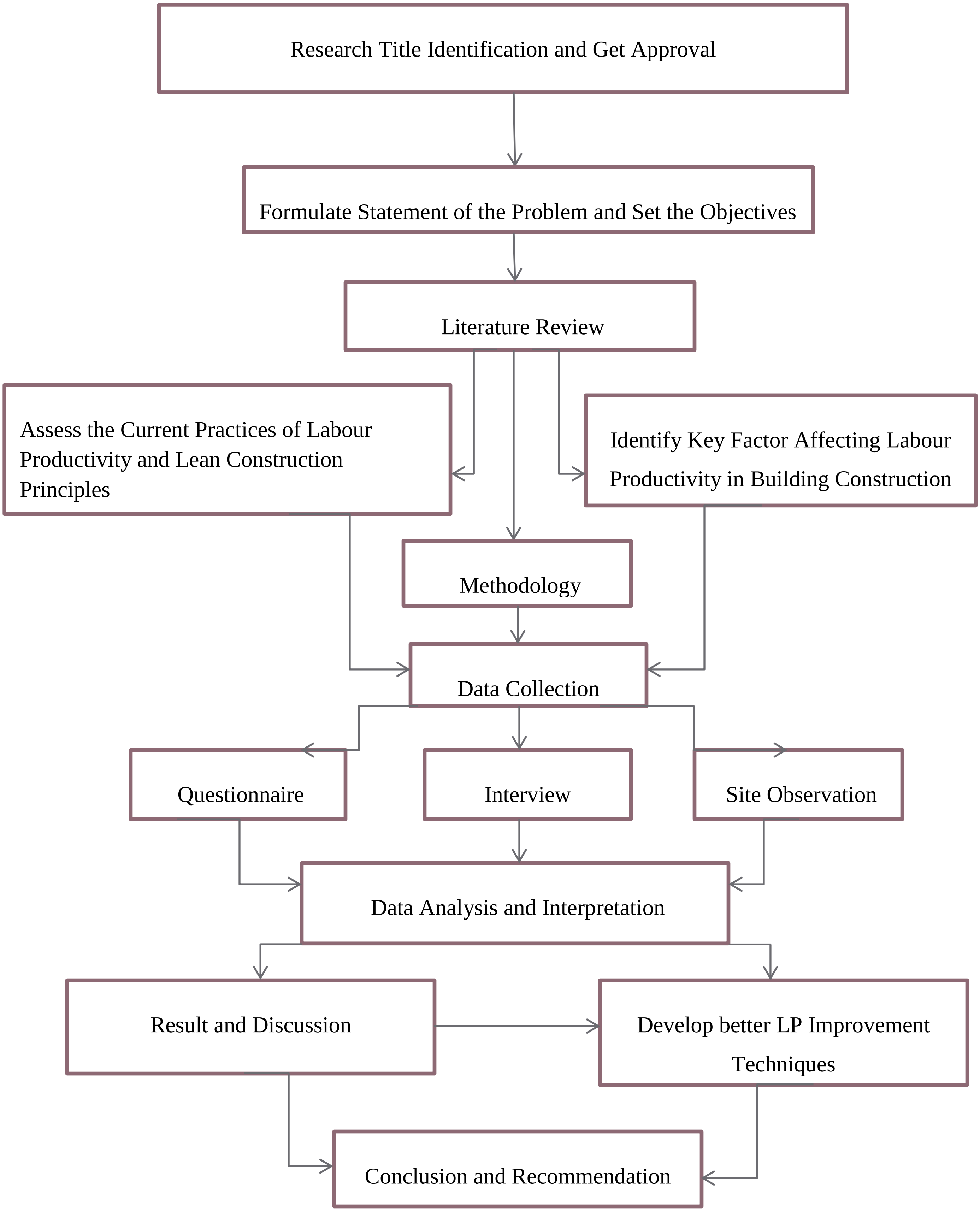

Figure 3. 2 The process of Research Operation

3.1.1. Interview for Construction Professionals

The interview is defined as the method of asking questions to gain both qualitative and quantitative data (Taherdoost, 2021). In quantitative questions, interviewees select their choices in a limited range of responses provided by the researcher; on the other hand, qualitative questions aim to obtain the interviewee's descriptions to a specific question(Taherdoost, 2021). Interviews are therefore used to gather detailed information from the participants' experiences by interpreting their labor productivity management practices, labor productivity improvement strategies, and associated issues on their construction projects for residential public buildings.

3.1.2. Site Observation by Researcher

y visualizing events, behaviors, interactions, and processes, first-hand information is obtained through observation data gathering techniques. The researcher used site visits to observe how the site was set up, how worker safety was provided, how workers communicated, and to compile information on the impact of high labor productivity and the strategies employed to mitigate it in construction projects. The researcher studied labor productivity management and enhancement strategies at construction sites for six months while residential public buildings were being built.

3.2. Sources of data

The data were collected from both primary and secondary sources. First-hand information gathered by the candidate via questionnaires, interviews, and site visits (observation) at the chosen construction businesses that develop residential public building projects in Addis Ababa comprised the primary data. The secondary data came from a variety of previously conducted studies, websites, books, journals, and articles in public documents. The secondary data served as criterion for creating and evaluating the primary data as well as a source for identifying problems.

3.3. Target Population

The aggregate or totality of all items, subjects, or individuals that meet a set of criteria is referred to as the population. A smaller population can be studied more extensively at a fixed cost than a larger population, so it is important to decide what population is really of critical importance (Ishtiaq, 2019). The population of this research is targeting General contractors classified

GC1/BC1 – GC3/BC3 registered in Addis Ababa and currently participating on construction of residential public building construction projects. The construction stage of those projects constructed by the mentioned constructors' grade is currently under construction. The research focus is only on GC1-3 and BC1-3 construction companies that on executing public residential building construction projects in Addis Ababa due to the fact that construction of buildings uses many labours with various positions. Because those selected categories are have highly need labour force and that shall improve to boost the construction sector productivity.

3.4. Sample Size Determination

The following table shows a sample data adopted from Addis Ababa Housing Development Corporation 2024, 9 Months Final Report that used to determine a sample size of this research.

Table 3. 1 Sample Population Data

No.	Site(Location)	Number of Blocks	Number of Houses	Number of Contractors
1	Furi (Hana)	1	60	1
2	Jamo (Gara)	1	40	1
3	Bole (Ayat-2)	23	3,380	19
4	Bole (Beshale)	27	3,612	24
5	Kolfe -2	6	800	6
6	German ring	7	1,007	5
7	Kolfe -1,3	2	300	2
8	Ayer-Tena	2	155	2
9	Entoto	5	200	5
10	Tulu-Dimtu	1	115	1
12	Phsae-1	10	420	9
12	Phase-2	10	700	8
13	Phase-3	16	704	15
14	Phase-4	24	1,024	22
Total		**135**	**12,517**	**120**

Sources: Addis Ababa Housing Development Corporation 2024, Nine Months Final Report

At the locations listed above in the table, a total of 120 GC1, GC2, and GC3 contractors are actively engaged in the construction of residential public building projects. There were 60 GC1/BC1 contractors, 30 GC2/BC2 contractors, and 30 GC3/BC3 contractors among the contracting companies that made up the sample group. A number of formulae are available to determine sample size one of which is based on a proportion. For populations that are large, (Cochran, 1963) developed an equation to yield a representative sample for proportions.

$$n_0 = \frac{z^2pq}{e^2} \quad \text{..Equation (3.1)}$$

Where;

Z = Z value (e.g. 1.96 for 95% confidence level)

n_0 = required sample size,

p = proportion of the population having the characteristic (0.5 is used)

q = 1-p =1-0.5= 0.5

e = the margin of error or degree of precision (9% is used here).

Researchers recommend that proportion of the population (p) may be known from prior research or other sources; and in case of no information or if it is unknown to use p = 0.5 which assumes maximum heterogeneity (dissimilarity) (i.e. a 50/50 split). The degree of precision is the margin of error (e) that is acceptable.

$$n_0 = \frac{1.96^2 * 0.5 * 0.5}{0.09^2} = 118.57 \approx 119$$

But this sample size may take long time and higher cost to cover and Cochran also developed a formula for finite population correction for proportions.

$$n_{new} = \frac{n_0}{1+\frac{n_0-1}{N}} \quad \text{...Equation (3.2)}$$

Where;

n_0 = the sample size,

n_{new} = required sample size, and

N = the population size.

There are 120 General Contractor's grade with GC1-GC3 and Building Contractors grade with BC1-BC3 participating on construction of residential public building at 135 blocks of all sites in Addis those of their construction stage were undergoing during assessing this data.

Therefore, $$n_{new} = \frac{119}{1+\frac{119-1}{120}} = 60$$

The sample size is 60 General Contractors and Building Contractors Categorized from GC1-GC3&BC1-BC3 from 120 Construction companies which currently constructing residential public building construction projects at the above mentioned sites were selected based on the above sampling method and criteria from the total population of 120. Those selected sample represent the rest construction companies status in order to assess the current practices of labour productivity management practices, factors affecting productivity and improving labour productivity in construction industry by different mitigation techniques and lean construction principles on selected residential public building projects in Addis Ababa, a wide range of General and Building Contractors available and the projects construction stage is under-construction were targeted.

3.5. Sources of data

The study collected data from both primary and secondary sources. First-hand information gathered by the candidate via questionnaires, interviews, and site visits (observation) at the chosen construction businesses that develop residential public building projects in Addis Ababa comprised the primary data. The secondary data came from a variety of previously conducted studies, websites, books, journals, and articles in public documents. The secondary data served as criterion for creating and evaluating the primary data as well as a source for identifying problems.

3.6. Data Collection Method

The main techniques for collecting the research data were questionnaires, interviews, and site inspections. Site visits and field observations were also used to collect information on labor productivity management strategies that primarily impact labor productivity on project sites.

3.6.1. The Research Questionnaire Design

The questionnaire design was undertaken to determine the opinion of the workers beside the contractors, regarding the labour productivity in selected residential public building construction projects in Addis Ababa. It was designed in such a way that it ensures to address the objectives of the study categorized by different parts.

The purpose of the first section of the questionnaire was to collect information about the respondents and the profile of the construction businesses. The questions in this section were designed to collect information about the contractors' employment position, work experience, and project performance. The purpose of the questionnaire's second section is to gather information regarding contractors' and employees' knowledge and comprehension of productivity in building projects. The third section covers the different facets of productivity management practices, factors that influence labor productivity, methods for improving labor productivity, and a summary of lean construction principles. It also asks respondents about the frequency and impact of these principles, as well as their general experiences applied to residential public building construction projects.

The elements found in earlier studies will serve as the foundation for creating a questionnaire to examine their impact on building construction productivity and workers' understanding of lean construction concepts to increase productivity on the job site. The fourth part is an interview question for professionals on construction site to fill a gap may not answered in questioners and triangulating it for the clarity of the concept about labour productivity improvement techniques and lean construction principles on residential public building construction projects.

It was necessary for the questionnaire to be simple, easy for responders to understand, and uncomplicated so that the researcher could appropriately analyze it. There are both open-ended and closed-ended questions. Respondents chose the response they thought was most appropriate from a variety of options for the closed-ended questions. Only a few instances where the response alternatives were reasonably broad were open-ended questions employed. It was constructed using the 5 point Likert scale to show the responders level of agreements with the constructed questions regarding the labour productivity and its improvement techniques. The respondents were asked to tick in a provided boxes under 1 to 5 numbers which designed 1 for 20%, 2 for 40%, 3 for 60%, 4 for 80% and 5 for 100% in a percentage that to make the suitable designation.

3.6.2. Interviews

Interview was done for representative professionals working on site of selected from each construction companies (GC/BC1-3) professionals that undertaking residential public building construction projects in Addis. Around 9 an interview questions developed and asked the professionals with the following continues question for more clarifications on the issue raised. Over all the questions for the professionals mainly focus on labour productivity management awareness and its practices, factors affecting labour productivity at project site, labour productivity improvement techniques and knowledge on lean construction principles especially for productivity improvements.

3.6.3. Observations

In addition to helping the researcher examine the site's real state, on-site observations were utilized to verify that respondents' answers to the questionnaire were reliable by triangulating an interview and questionnaire data collected.

3.7. Data Analysis and Interpretation Techniques

This research employed data analysis to transform raw data into meaningful insights. The initial phase involved preparing the data by cleaning and organizing it into a usable format. Statistical analysis was conducted using SPSS version 26 and its findings were presented using descriptive statistics like; frequencies, percentages, and mean scores. These mean scores were then interpreted, and the data was ranked based on the average mean value.

In this study, a measurement scale 1 to 5 was used to determine the degree of applicability, the level of factor impacts and labour productivity improvements techniques at construction sites.

Respondents were asked to rank the current practices of labour productivity management, factors affecting labour productivity and its improvement techniques in this case in residential public building construction projects in Addis.

The current practices of labour productivity managements and impact level of factor affecting labour productivity at building construction projects were analyzed using Likert scale measurement, 5= Very High (≥4.5 and ≤5), 4= High (≥3.5 and ≤4.49), 3= Medium (≥2.5 and ≤3.49), 2= Low (≥1.5 and ≤2.49) and 1= Very Low (≥1 and ≤1.49). Whereas frequency of occupancies for factor affecting labour productivity at building construction projects and labour productivity improvement techniques were analyzed by 5= Very Often (≥4.5 and ≤5), 4= Often (≥3.5 and ≤4.49), 3= Sometimes (≥2.5 and ≤3.49), 2= rarely (≥1.5 and ≤2.49) and 1= Never (≥1 and ≤1.49) Likert scale measurements. As it was previously mentioned, the various factors influencing LP were ranked using an average mean value. These rankings were meant to compare respondents' perceptions of the factors' frequency of occurrence as well as their perceived level of effect.

3.8. Data Validity and Reliability

Often referred to as validity and reliability, survey data correctness and consistency are essential components of research technique. These concepts ensure that the research findings are trustworthy and can be generalized to a larger population.

3.8.1. Data Validity

To ensure validity, this study employed a two-pronged approach: Firstly, experts in the field reviewed the questionnaire for content relevance and clarity, a process known as face validity. Based on their feedback, the questionnaire was revised. Second, prior to final data collecting, a pilot research was carried out to assess the validity of the questionnaire and improve the survey methodology. This ensured the instrument was capable of gathering accurate data. Questionnaire was tested on 58 respondents in determining the validity of the current practices of LP management, factor affecting LP at project site, improvement techniques of LP and trends of lean construction tools and principles to improve labour productivity at construction project sites in case of residential building projects in Addis Ababa, Ethiopia.

3.8.2. Data Reliability

Reliability is the extent to which an instrument consistently measures what it is supposed to measure. The study evaluated the internal consistency of the questionnaire used to gather cross-sectional data using the Cronbach alpha coefficient. For labor productivity management practices, a factor impacting labor productivity, and labor productivity improvement techniques at construction project sites, the Cronbach alpha coefficient which is based on the average correlation across items was calculated using SPSS software. The results are shown.

Determining the alpha coefficient is the most widely utilized technique in research to measure internal consistency. Always the value of the Cronbach alpha could be between 0 and 1 and internal consistency is said to be high when the Cronbach's alpha coefficient could approach to 1. According to previous researchers if Cronbach’s Alpha is $\alpha \geq 0.9$ the internal consistency of the scale is high; If Cronbach’s Alpha is $0.9>\alpha \leq 0.7$ the scale has internal consistency If Cronbach’s Alpha is $0.7>\alpha \leq 0.6$ the internal consistency of the scale is acceptable If Cronbach’s Alpha is $0.6>\alpha \leq 0.5$ the internal consistency of the scale is weak If Cronbach’s Alpha is $\alpha < 0.5$ the scale has no internal consistency.

3.9. Ethical Consideration

All subjects gave their informed consent before the study started. They were assured of their right to withdraw at any time and given a thorough description of the nature, methodology, and goal of the research. To protect confidentiality, respondents were instructed not to include their names on the questionnaires, and all data collected through questionnaires and interviews was strictly used for academic purposes. Furthermore, all sources used in the study were properly acknowledged, ensuring ethical research practices.

3.10. Limitation of the research

The limitation of this study was restricted to a few residential public building construction projects in Addis Ababa that were only in the ongoing stage of construction. Its primary focus was on the effects of labor productivity and methods for improving it on the job site through the application of lean construction principles.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1. Introduction

The purpose of this chapter is to present the study's findings and discussions. Additionally, it explains the quantitative study findings that are presented in written form as well as tables, charts, and figures. Although each outcome was briefly examined, certain results were followed by a longer discussion. The survey on selected construction companies which undertaking residential public building construction projects in Addis Ababa is done for assessing labour productivity management practices, investigating major factors impact labour productivity and productivity improvement techniques, especially by using lean construction principles on the projects.

4.2. General information and profiles of respondents

This part mainly designed to provide general information about the respondents in terms of the construction companies (General and Building contructors) with respect its grade categories, proffesionals job titles/position and their experience that selected in this study as a targeted population.

Table 4. 1 Summary of questionnaire distribution and response rate

Total No. of Questionnaires Distributed		Successfully Returned	Number of accepted questionnaires
72		58	55
percent	100%	80.60%	76.39%

4.2.1. Respondents' Job Titles/Occupations

Table 4.1 shows that Site Engineers constitute the largest group (37.93%) of respondents, Office Engineers represent the second largest group (32.76%), General Foremen contribute a notable percentage (17.24% and Project Managers, representing only 12.07% from the total of respondents. As a result, the majority of responders are office and site engineers. It indicates that they have a supervisory responsibility to ensure that everything is proceeding according to plan during the initiatives.

Table 4.1 Distribution of Respondent's occupation

No.	**Respondent's Position**	Number of respondents	Number of returned	Population Rate
1	Project Manager	8	7	12.07%
2	Site Engineer	22	22	37.93%
3	Office Engineer	19	19	32.76%
4	General Forman	11	10	17.24%
Total		60	58	100%

4.2.2. Respondents' Work Experiences

The majority of respondents (35%) have 10-15 years of work experience, followed by those with 5-10 years (27%) and 0-5 years (20%). Those with over 15 years of experience represent 18% of the sample. The experiences of respondents on building construction projects help to understand lean construction principles to improve labour productivity in construction of residential public building projects

Figure 4. 1 Respondents Work Experience

4.3. The Practices of labor productivity management in Residential public building construction projects

The data gathered focused on awareness of workforces, practices of labour productivity measurements, workforce skills and training, work processes and workflows, performance monitoring and evaluation, incentives and rewards, as well as barriers and challenges were discussed as follows.

4.3.1. Awareness and Practices of Labour Productivity at site

The survey resulted show staff strongly agree with work cycle time unutilized is negatively impacts on labour productivity score average mean value of 3.73. This highest mean value score implies that, impracticable for work cycle time at site is not such emphasized. The task sequencing overlooked was 2.36 and the staff awareness on crew size with respective activities is only moderate with an average mean value of 2.11.

Table 4. 2 General productivity awareness and practices results from respondents

No.	**Awareness and Practices of Labour Productivity at site**	Mean	Std. Deviation
1	Work cycle time (unutilized)	3.73	0.622
2	Task sequencing is overlooked	2.36	0.802
3	Staff awareness on crew size with respective activities	2.11	0.567

Addressing these identified gaps in staff awareness on work cycle time usability, keep task sequencing and crew size with respect to activities were lead to improve labour productivity for better outcomes on public residential building construction projects in Addis Ababa.

4.3.2. Labour Productivity Measurements Practices at site

Survey result indicated a mixed picture regarding labor productivity measurement practices at the site, but with significant space for improvement. While tracking labor hours per unit work completed is relatively common with an average mean of 1.95 and the implementation of output standards remains weak (Means = 1.87, 1.85, and 1.78). This highest mean value implies that the labour hr. /work unit is not practicable at site and they primarily focuses on cost and time management, rather than measuring actual output.

Table 4. 3 A summary table show labour productivity measurement practices at construction site

No	**Labour Productivity Measurements Practices at site**	Mean	Std. Deviation
1	Record and implement labour hour per unit work is unpractical	1.95	0.756
2	Compute labour output standards with actual labour output performed.	1.87	0.883
3	Record and implement labour cost per unit work completed.	1.85	0.731
4	Labour output standards implemented on sites	1.78	0.937

. These findings highlight a need to strengthen the site's use of output-based productivity measures for improving labour productivity at site.

4.3.3. Work force and Construction site Managements Practice

The data collected through questionnaire from the respondents about construction site management and work force at the site which have an influence on construction labour productivity in rating and summarized. While communication channels, site layout, and worker supervision are generally acknowledged as important a result with an average mean of 2.51, 2.42, and 2.20 respectively. The implementation of incentive programs for the laborers, health and safety regulations, and collaborative planning seems less consistent with an average mean of 1.80, 2.20, and 2.05.

Table 4. 4 A summary table shows work force construction site management practices

No.	**Work force and Construction site Managements Practice**	Mean	Std. Deviation
1	Facilitating effective communication channels.	2.51	1.086
2	Appropriate site layout to workers freely movements	2.42	0.875
3	Managing workers under proper supervision of professionals	2.2	0.704
4	Work by utilization rate of professionals at site.	2.05	0.803
5	Planning incentive programs and motivating workers	1.8	0.65
6	Continuous follow up and feedback mechanisms.	2.11	0.712
7	Plan and Implement as workers health and safety regulations.	2.2	0.951
8	Collaborative planning and coordination among project teams.	2.05	1.008

Observations and interviews with site professionals confirm these findings. They often report challenges in implementing these practices consistently, citing a lack of clear procedures, inadequate training for staff, limited resources, and communication barriers. The high standard deviations across many measures also point to a lack of consistency in how these practices are applied.

4.4. Factors Affecting Labour Productivity in Public Residential Building Construction Projects

To make it easier for the responders to grasp, the thirty-three criteria are summed up and divided into nine groups based on their attributes. The thirty-nine factors were rated by the respondents according to their frequency of occurrence and degree of influence. Below is a detailed discussion of the fifteen criteria that respondents scored according to their frequency of occurrence and degree of influence. These factors were ordered by averaging their mean values.

4.4.1. Major Factors Affecting Labour Productivity with respect to level of Impact

The rate provided by the respondents for the 39 parameters influencing labor productivity for the construction of residential buildings in Addis Ababa, Ethiopia, was taken into consideration when conducting the study. The survey results revealed that a significant influence of various factors on labor productivity at public residential building construction sites.

The top 15 factors, with average mean value scores ranging from 3.82 to 3.25, indicate a strong influence on productivity, highlighting the need for addressing these challenges. The highest mean value 3.82 implies that the most responders were strongly agreed as lack of materials were the most consequence for labour productivity affecting at site. The most prominent factors are material shortages with mean value of 3.82, inadequate site-wide communication with mean value of 3.66, lack of work progress follow-up with mean value of 3.63, and others significant concerns like poor resource management, low worker motivation, delays in decision-making, insufficient training, Lack of using working plans, Owner's financial difficulties, Low-grade materials, Overly full work force, Insufficient communication between the involved parties, Financial issues and cash flow and Inappropriate site Organization were putted as follows with their respective rated orders by an average of mean value.

Table 4. 5 a summary of top fifteen factors affecting labor productivity at building constructions

No.	Key factors affecting labor productivity at building constructions level of impact	Responsible Stakeholders	Mean	Std. Deviation
1	Lack of Materials	Contractor	3.82	0.716
2	Inadequate site-wide communication	Contractor	3.66	0.978
3	Lack of follow up the work progress	Contractor	3.63	0.676
4	Poor resources management	Contractor	3.63	0.752
5	Lack of technological advancements for machineries	Contractor	3.5	0.874
6	Low motivation and morale	Labour	3.48	0.953
7	Delays in reaching a decision	consultant	3.48	0.831
8	Lack of Training for workers	Contractor	3.46	0.852
9	Lack of using working plans	Contractor	3.36	0.672
10	Owner's financial difficulties	client	3.32	0.789
11	Low-grade materials	Contractor	3.32	0.789
12	Overly full work force	Contractor	3.3	0.685
13	Lack of communication between the stakeholders	3Cs	3.27	0.863
14	Financial issues and cash flow	Contractor	3.25	0.879
15	Inappropriate site Organization	Contractor	3.25	0.769

Observations and interviews with site professionals reinforce the survey findings, approving the need for improved material procurement strategies, robust communication channels, effective work monitoring systems, and comprehensive training programs. These findings highlight the crucial role of management practices in mitigating these challenges and enhancing overall labor productivity improvements at public residential building construction sites.

However, of the 15 criteria that were ranked with an average mean value, 11 (73%) of the essential aspects fell under the responsibility of contractors, 3 (20%) fell under the responsibility of consultants, and 1 (7%) fell under the responsibility of the client.

4.4.2. Major Factors Affecting Labour Productivity with Respect to their Frequency of occurrence

As previously stated, the mean value of the study was determined by considering the rates of the respondents for the 39 criteria affecting labor productivity on Addis public residential building construction projects. The analysis of the questionnaire results on factors affecting labor productivity in residential building construction projects reveals that the top factors influencing productivity by frequency of occurrence were include a Lack of Materials with an average mean value of 3.82, Lack of follow-up on work progress with a mean of 3.71, and Work order modification or variation (mean = 3.58). These factors were occurred frequently at site indicate that logistical issues and project management inefficiencies significantly hinder labour productivity. Other notable factors repeatedly faced public residential building construction projects were include inadequate communication with mean of 3.49 , poor resource management 3.42, and delays in decision-making, all of which reflect systemic challenges within project execution that affect labour productivity.

Table 4. 6 a summary of top ten factors affecting labor productivity by occurrences of frequency at building constructions

No.	**Key factors affecting labor productivity at building constructions frequency of occurrence**	N	Sum	Mean	Std. Deviation	Variance
1	Lack of Materials	56	210	3.82	1.249	1.559
2	Lack of follow up the work progress	56	204	3.71	0.896	0.803
3	Work order modification or variation	56	197	3.58	1.15	1.322
4	Lack of technological advancements for machineries	56	193	3.51	0.979	0.958
5	Lack of using working plans	56	193	3.51	0.92	0.847
6	Inadequate site-wide communication	56	192	3.49	0.767	0.588
7	Poor resources management	56	188	3.42	0.786	0.618
8	Delays in reaching a decision	56	188	3.42	1.066	1.137
9	Lack of communication between stakeholders	56	186	3.38	0.972	0.944
10	Lack of facilities (utilities)	56	183	3.33	0.963	0.928

From site observations and professional interviews, it is evident that these issues are pervasive in the construction industry. The lack of materials often leads to downtime, while insufficient follow-up and communication can create bottlenecks. Moreover, the frequent modification of work orders disrupts workflow and increases frustration among workers. Addressing these core issues through improved planning, resource allocation, and communication strategies is essential for enhancing labor productivity on construction sites. Overall, a multifaceted approach that includes better logistical support and stakeholder engagement is crucial for overcoming these barriers to productivity.

4.5. Labour productivity improvement techniques in building construction projects

The questionnaire results on labor productivity improvement techniques (both conventional and lean) in residential building construction projects reveal a clear prioritization among various techniques. The highest-rated technique, implementing lean construction principles with an average mean of 3.86, underscores the importance of efficiency and waste reduction in enhancing productivity. Following closely, set realistic goals and offer recognition to workers with a mean of 3.79 highlights the motivational aspect of goal-setting and acknowledgment in fostering worker engagement. Other notable techniques include encouraging teamwork and collaboration with a mean 3.61 and ensuring proper supervision and guidance indicate mean value of 3.54, which emphasize the significance of a supportive work environment.

The lower-rated techniques, such as mitigating weather-related risks of mean value 2.21 and ensuring workers' health and safety protocols of mean value 2.70, suggest that while these factors are crucial, they may not be perceived as immediate drivers of productivity compared to more direct management practices. The standard deviations indicate varied perceptions among respondents regarding certain strategies, particularly in teamwork and communication.

Table 4. 7 a summary of top ten labor productivity improvements at building constructions projects

No.	labour productivity improvement techniques in building construction projects (conventional and lean)	Mean	Std. Deviation
1	Implementing a lean construction elements (collaboration, last planner, waste reduction, pull planning, value stream mapping, target value …)	3.86	1.271
2	Set a realistic goals and offer recognition with the workers.	3.79	1.345
3	Encouraging teamwork and collaboration among workers.	3.61	1.545
4	Ensuring proper supervision and guidance for workers.	3.54	0.713
5	Implementing standardized work procedures.	3.54	0.914
6	Ensuring effective communication channels between project managers and laborers (proper leadership practices).	3.5	0.953
7	Offering incentives for high-performing workers.	3.41	1.29
8	Properly measure labour force performance	3.29	0.948
9	Implementing training programs for construction workers.	3.18	1.13
10	Promoting a culture of accountability and responsibility among workers	3.13	0.896

Although, site observations and interviews with professionals corroborate these findings, emphasizing that effective leadership, clear communication, and employee recognition are pivotal for enhancing labor productivity. Integrating lean concepts and encouraging teamwork became essential tactics, highlighting the necessity of a comprehensive approach to project management that strikes a balance between productivity, employee happiness, and safety.

4.6. The comparative level of conventional labour productivity improvements with achieved by using lean construction principles techniques

Knowledge of and comfort with the lean concept the result indicated that 48% of participants are aware of the Lean Construction concept. The responses to the majority of other lean construction-related questions, however, differ. The questionnaire results show a clear preference for lean construction principles over conventional labor productivity improvement techniques in public residential building construction projects. The top ranked labour productivity improvement techniques according to the questionnaire results shows;

Form Cross-Functional Teams (Mean = 4.50): This high mean score suggests a strong consensus among respondents that collaborating across different project disciplines is highly effective to improving productivity. This reflects the value of shared knowledge, innovation, and efficient problem-solving that cross-functional teams shall be offered.

Just-in-Time Delivery (Mean = 4.11): This principle, focused on work what is to be executed, how much quantity to be worked and optimizing material flow, is also highly regarded as the respondents strongly agree with this technique.

Involving Stakeholders in Planning (Mean = 3.91): This underscores the importance of a collaborative and comprehensive approach to project planning for greater efficiency at building construction sites to improve labour productivity.

Eliminating Non-Value-Added Activities (Mean = 3.63): This score indicates a strong understanding of the need to streamline workflows and eliminate unnecessary steps for greater productivity.

Conventional Techniques: While lean construction principles dominate, conventional techniques like ensuring supervision with an average of mean value 3.57, ergonomics of mean 3.48, and performance-based incentives of mean 3.29 were still hold moderate value. This suggests that a balanced approach combining conventional labour productivity improvement techniques with lean construction principles would be most effective.

Table 4. 8 a summary of top ten comparative levels of conventional labour productivity improvements with achieved by using lean construction principles at building constructions

No.	The comparative level of Conventional labour productivity improvements techniques with achieved by using lean construction principles	Mean	Std. Deviation	Category	
				Conventional LP Imp't Techniques	LC Principles Lp Imp't Techniques
1	Form cross-functional teams to collaborate on projects, share knowledge, and drive innovation in construction processes.	4.5	0.661	√	√
2	Implement a just-in-time delivery system to reduce waste, lower costs	4.11	0.779		√
3	Involve all stakeholders in the planning process to create a more efficient and collaborative construction schedule.	3.91	1.164		√
4	Identify and eliminate any non-value-added activities.	3.63	0.906		√
5	Ensuring supervision and support for workers	3.57	0.97	√	
6	Ergonomics and Workplace Safety	3.48	0.763	√	
7	Implement performance-based incentive to motivate workers.	3.29	0.803		√
8	Providing activity assignments with work standards.	3.27	0.587	√	
9	Train leaders and other workers at all levels.	3.23	0.853		√
10	Implement error-proofing mechanisms to prevent mistakes and defects in construction processes.	3.2	0.773		√

Improving labor productivity in Ethiopian construction industry public residential construction projects is one of the study's main goals. As it is described in the above table; the top ten labour productivity improvement techniques identified and ranked with their an average of mean value were; 1) Form cross-functional teams, 2) Implement a just-in-time delivery, 3) Involve all stakeholders in the planning process, 4) Identify and eliminate any non-value-added activities, 5) Ensuring supervision and support for workers, 6) Ergonomics and Workplace Safety, 7) Implement performance-based incentive to motivate workers, 8) Providing activity assignments with work standards, 9) Train leaders and other workers at all levels and 10) Implement error-proofing mechanisms to prevent mistakes and defects in construction processes.

On-site observations and interviews with professionals likely reinforce these findings. Professionals were having witnessed firsthand the benefits of lean principles like reduced waste, improved communication, and increased worker empowerment. Additionally, I conducted a sample work activity on a construction site, focusing on the implementation of lean tools such as 5S (Sort, Set in order, Shine, Standardize, and Sustain) and the PDCA (Plan, Do, Check, Act) cycle to enhance the concrete batching to casting process executed by four crews. By applying the 5S technique, we organized the workspace, eliminated waste, and established clear standards for maintaining order. Simultaneously, we apply the PDCA technique to systematically plan our operations, execute tasks, monitor performance, and make necessary adjustments to improve labour productivity at site.

The results of this intervention were impressive; labor productivity increased from 46 cubic meters per day to 64.4 cubic meters per day, representing remarkable 40% improvements which were executed by four concrete batching to casting crews. This significant improves shows the effectiveness of lean tools like 5S and PDCA in optimizing construction processes and improving labour productivity on-site.

The focus on implement 5S, PDCA, Just-In-Time, waste reduction, continuous improvement, and value creation is resonating with industry professionals. While conventional methods still have a role, with integration of lean principles and tools were the key to improving labor productivity and project efficiency in public residential building construction projects.

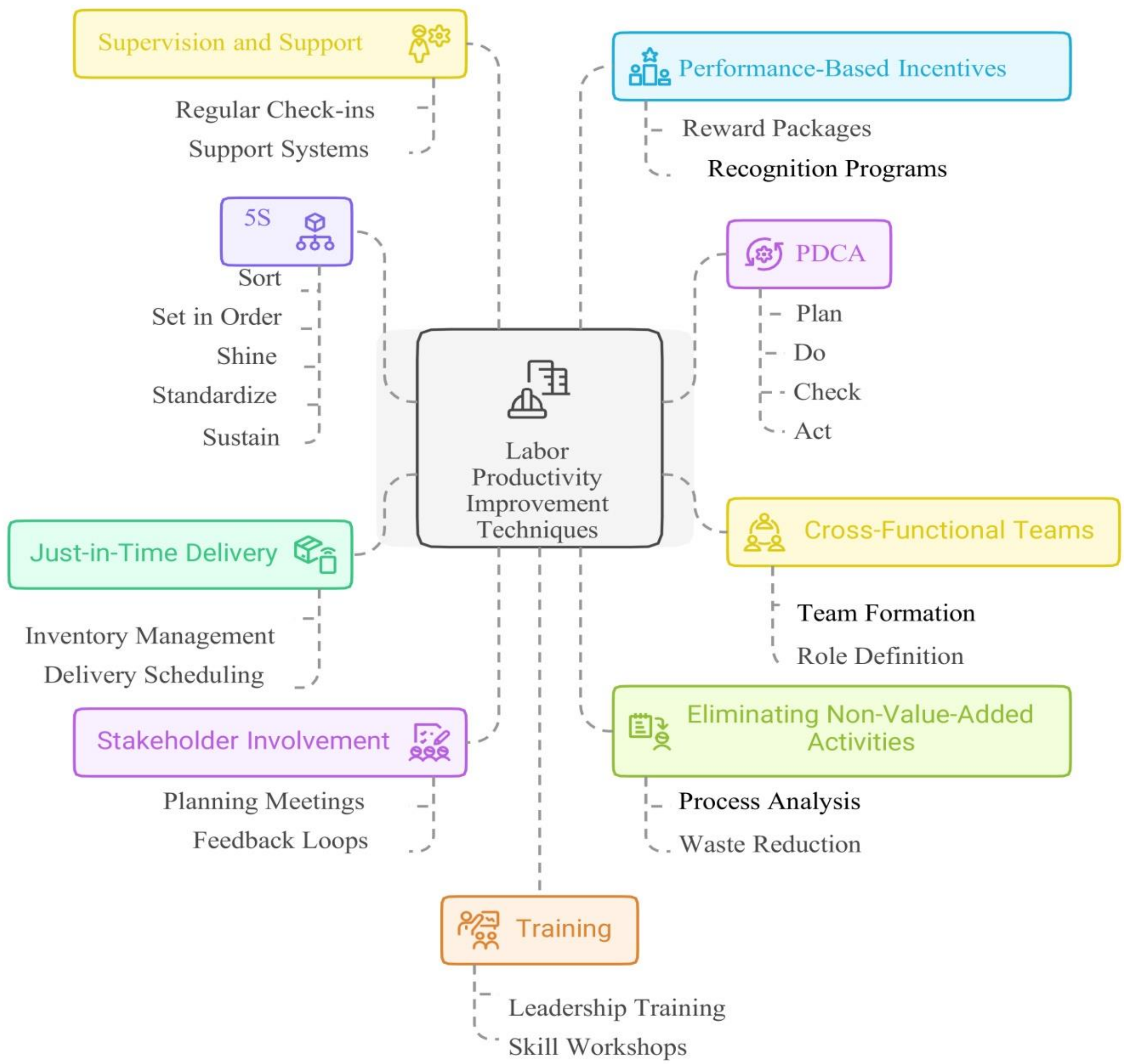

Figure 4.6 Better Labour Productivity Improvement Techniques in Building Construction site

A construction project's successful completion and the expansion of the business overall are both greatly impacted by high productivity. The study's conclusions can serve as focal points for applying lean construction techniques and tools to increase worker productivity in public residential construction projects. The Contractors, can use the identified techniques for the improvement of labour productivity and successfully complete the projects within its budget and duration.

CHAPTER FIVE

CONLUSION AND RECOMMENDATION

Results from the questionnaire survey, professional interviews, researcher observations, and a discussion of the results in accordance with the literature review were presented in the preceding section. Conclusions drawn from the study's findings are presented, along with pertinent recommendations.

5.1. Conclusion

This study assessed labour productivity improvement techniques through lean construction principles in residential public building construction in Addis Ababa of Ethiopia. The construction industry in Ethiopia, particularly in Addis Ababa, is a vital contributor to the country's economic growth and development. It plays a crucial role in providing housing, infrastructure, and commercial spaces, driving huge number of employment, and supporting other sectors. Whereas, productivity in the building construction industry a critical issues that refers to the efficient use of resources, including labor, materials, and time to achieve a specific output.

Among construction productivity Labor Productivity is a key component of overall construction productivity, representing the output generated per unit of labor input. In Ethiopia's construction sector, labor productivity remains a significant challenge, often affected by factors such as: Lack of Materials, Limited Technological adoption, lack of follow up workers progress, work variations orders, poor side-wide communications and collaborations and others which need improvement techniques to tackle those challenges of labour productivity in public residential building construction projects in Addis.

But labor productivity improvement practices in residential public building construction projects in Addis Ababa is conventional productivity improvements based which identified during from the findings of this study. Conventional labour productivity improvement techniques most of the selected projects used were; strict supervision, use work plan, fulfill health and safety requirements, and facilitate ergonomics and working spaces for the workers. While, Lean construction principles and tools, focused on eliminating waste, improving collaboration, use last planner system, efficient schedule, proper assigning crew size to the work and fostering continuous improvement, offer a potential solution to these challenges. By implementing those of lean construction elements, such as: Cross-Functional Teams, Just-in-Time Delivery, 5S, Involve all stakeholders in the planning process, PDCA, Identify and eliminate any non-value-added activities and some conventional techniques should adopt as a better labour productivity improvement techniques in public residential building construction projects.

Finally, the labour productivity improvements techniques have been practiced in Addis were more conventional based. Those often fall short of achieving optimal labour productivity where, Lean construction principles and tools provide a more holistic and comprehensive techniques to tackle the challenges of labor productivity improvements in residential public building projects.

5.2. Recommendation

Based on the findings of the study, the following recommendation made for public residential building construction sector and others respective stakeholders in Ethiopian building construction industries. Lean construction tools offer comprehensive and effective techniques to solve the challenges of labor productivity and its improvement techniques in construction of public residential building projects.

- ❖ The sector shall implement lean construction principles and techniques to; reducing labour costs, employee displacement, reducing the duration of the construction project, improving the quality of construction (by reducing variations and changes in the construction project), improving labour productivity at site.
- ❖ Effectively implemented lean construction principles by giving orientation on waste reduction, assign a proper crew size to the work, adequate training, considering of use of maximum available materials and good relationship between the workers to improve labour productivity.
- ❖ Focus on lean techniques; Cross-functional Teams, pull planning, Just-in-Time Delivery, Involving Stakeholders in Planning, Eliminating Non-Value-Added Activities to improve labour productivity in building construction projects.

- ❖ Integrate conventional practices (strict supervision, work plan, health & safety for worker) with Lean tools (Just-in-Time, 5S, PDCA, Cross- functional teams) at construction site improve labour productivity more than forty percent.
- ❖ Aware and train construction workers on lean construction principles and tools to boost labour productivity at site

Overall, the recommendations emphasize the need for a strategic shift towards lean construction principles and techniques in Ethiopia's public building construction projects. This shift, combined with the continued use of effective conventional practices, holds the potential to significantly improve labor productivity and drive a more efficient and sustainable construction sector.

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APPENDIX

Appendix-A

No.	The Practices of labor productivity management in Residential public building construction projects	N	Sum	Mean	Std. Deviation	Variance
1	Impact of poor labor productivity on the performance of project	56	205	3.73	0.622	0.387
2	Facilitating effective communication channels.	56	138	2.51	1.086	1.18
3	Appropriate site layout to workers freely movements.	56	133	2.42	0.875	0.766
4	Project performance to be completed within the planned time	56	130	2.36	0.802	0.643
5	Plan and Implement as workers health and safety regulations.	56	122	2.22	0.956	0.914
6	Managing workers under proper supervision of professionals.	56	121	2.2	0.704	0.496
7	Staff awareness on labor productivity management	56	116	2.11	0.567	0.321
8	Continuous follow up and feedback mechanisms.	56	115	2.09	0.727	0.529
9	Work by utilization rate of professionals at site	56	113	2.05	0.803	0.645
10	Collaborative planning and coordination among project teams.	56	112	2.04	1.018	1.036
11	Record and implement labour hour per unit work completed	56	107	1.95	0.756	0.571
12	Compute labour output standards with actual labour output performed.	56	103	1.87	0.883	0.78
13	Record and implement labour cost per unit work completed.	56	102	1.85	0.731	0.534
14	Plan incentive programs & motivating workers	56	99	1.8	0.65	0.422
15	Labour output standards implemented on sites	56	98	1.78	0.937	0.877
	Valid N (list wise)	56				

Appendix-B1

No.	Key factors affecting labor productivity at building constructions level of impact	N	Sum	Mean	Std. Deviation	Variance
1	Lack of Materials	56	214	3.82	0.716	0.513
2	Inadequate site-wide communication	56	205	3.66	0.978	0.956
3	Lack of follow up the work progress	56	203	3.63	0.676	0.457
4	Poor resources management	56	203	3.63	0.752	0.566
5	Lack of technological advancements for machines	56	196	3.5	0.874	0.764
6	Low motivation and morale	56	195	3.48	0.953	0.909
7	Delays in reaching a decision	56	195	3.48	0.831	0.691
8	Lack of Training for workers	56	194	3.46	0.852	0.726
9	Lack of using working plans	56	188	3.36	0.672	0.452
10	Owner's financial difficulties	56	186	3.32	0.789	0.622
11	Low-grade materials	56	186	3.32	0.789	0.622
12	Overly full work force	56	185	3.3	0.685	0.47
13	Lack of communication between stakeholders	56	183	3.27	0.863	0.745
14	Financial issues and cash flow	56	182	3.25	0.879	0.773
15	Inappropriate site Organization	56	182	3.25	0.769	0.591
16	Poor workers' health	56	182	3.25	1.405	1.973
17	Lack of equipment and tools	56	182	3.25	0.858	0.736
18	Frequent damage of equipment’s	56	181	3.23	0.972	0.945
19	The absence of supervisors	56	179	3.2	1.394	1.943
20	Misconception of labors	56	176	3.14	0.749	0.561
21	Lack of facilities (utilities)	56	175	3.13	0.854	0.73
22	Overwhelming workload	56	175	3.12	0.935	0.875
23	Work order modification or variation	56	173	3.09	0.611	0.374
24	The supervisor's unclear instructions	56	169	3.02	0.356	0.127
25	Workers' incompetence	56	168	3	0.467	0.218
26	Owner Intervention	56	163	2.91	0.996	0.992
27	Lack of Safety tools	56	163	2.91	0.695	0.483
28	Where to store materials	56	163	2.91	0.581	0.337
29	Construction-related errors (rework)	56	162	2.89	0.623	0.388
30	Lack of General support to the contractor	56	162	2.89	0.966	0.934
31	Project complexity	56	162	2.89	0.966	0.934
32	Accidents during construction	56	161	2.87	1.028	1.057
33	Worker insubordination	56	142	2.54	0.738	0.544
34	Project size	56	142	2.54	0.66	0.435

35	High absenteeism	56	141	2.52	0.738	0.545
36	Weather-related effects (rain, wind, …)	56	136	2.43	0.684	0.468
37	Supervisors' lack of competency	56	128	2.29	0.986	0.971
38	Holidays	56	106	1.89	0.947	0.897
39	Unforeseen Conditions	56	97	1.73	1.183	1.4
	Valid N (list wise)	56				

Appendix-B2

No.	Key factors affecting labor productivity at building constructions frequency of occurrence	N	Sum	Mean	Std. Deviation	Variance
1	Lack of Materials	56	210	3.82	1.249	1.559
2	Lack of follow up the work progress	56	204	3.71	0.896	0.803
3	Work order modification or variation	56	197	3.58	1.15	1.322
4	Lack of technological advancements for machineries	56	193	3.51	0.979	0.958
5	Lack of using working plans	56	193	3.51	0.92	0.847
6	Inadequate site-wide communication	56	192	3.49	0.767	0.588
7	Poor resources management	56	188	3.42	0.786	0.618
8	Delays in reaching a decision	56	188	3.42	1.066	1.137
9	Lack of communication between stakeholders	56	186	3.38	0.972	0.944
10	Lack of facilities (utilities)	56	183	3.33	0.963	0.928
11	Lack of Training for workers	56	177	3.22	1.166	1.359
12	Low-grade materials	56	174	3.16	0.877	0.769
13	Financial issues and cash flow	56	165	3	0.638	0.407
14	Inappropriate site Organization	56	165	3	0.72	0.519
15	Owner's financial difficulties	56	163	2.96	0.637	0.406
16	Workers' incompetence	56	160	2.91	0.617	0.38
17	Lack of equipment and tools	56	156	2.84	0.714	0.51
18	Accidents during construction	56	153	2.78	0.854	0.729
19	Frequent damage of equipment’s	56	148	2.74	0.521	0.271
20	Lack of General support to the contractor	56	147	2.72	1.14	1.299
21	Project complexity	56	147	2.72	0.529	0.28
22	Project size	56	149	2.71	0.762	0.58
23	Where to store materials	56	147	2.67	1.187	1.409
24	Lack of Safety tools	56	147	2.67	1.139	1.298
25	Worker insubordination	56	146	2.65	1.22	1.49
26	The absence of supervisors	56	142	2.58	1.013	1.026
27	Overly full work force	56	141	2.56	0.788	0.621
28	Poor workers' health	56	138	2.51	0.814	0.662

29	High absenteeism	56	138	2.51	0.858	0.736
30	Overwhelming workload	56	136	2.47	0.9	0.809
31	Low motivation and morale	56	135	2.45	0.689	0.475
32	Misconception of labors	56	134	2.44	0.996	0.991
33	The supervisor's unclear instructions	56	132	2.4	0.531	0.281
34	Owner Intervention	56	120	2.18	0.58	0.337
35	Construction-related errors (rework)	56	116	2.11	0.956	0.914
36	Unforeseen Conditions	56	107	1.95	1.079	1.164
37	Holidays	56	103	1.87	1.055	1.113
38	Weather-related effects (rain, wind, …)	56	95	1.73	1.008	1.017
39	Supervisors' lack of competency	56	86	1.56	0.938	0.88
	Valid N (list wise)	56				

Appendix-C

No.	labour productivity improvement techniques in building construction projects	N	Sum	Mean	Std. Deviation	Variance
1	Implementing a lean construction principles	56	216	3.86	1.271	1.616
2	Set a realistic goals and offer recognition with the workers.	56	212	3.79	1.345	1.808
3	Encouraging teamwork and collaboration among workers.	56	202	3.61	1.545	2.388
4	Ensuring proper supervision and guidance for workers.	56	198	3.54	0.713	0.508
5	Implementing standardized work procedures.	56	198	3.54	0.914	0.835
6	Ensuring effective communication channels between project managers and laborers (proper leadership practices).	56	196	3.5	0.953	0.909
7	Offering incentives for high-performing workers.	56	191	3.41	1.29	1.665
8	Properly measure labour force performance	56	184	3.29	0.948	0.899
9	Implementing training programs for construction workers.	56	178	3.18	1.13	1.277
10	Promoting a culture of accountability and responsibility among workers	56	175	3.13	0.896	0.802
11	Clear work schedules and deadlines for construction tasks.	56	173	3.09	0.978	0.956
12	Monitoring and analyzing labor productivity data to identify areas for improvement.	56	162	2.89	1.021	1.043
13	Implement workforce motivating packages	56	160	2.86	1.285	1.652
14	Provide adequate and proper tools and equipment to workers	56	157	2.8	0.796	0.633
15	Implementing quality control measures to reduce rework	56	154	2.75	0.769	0.591
16	Ensuring workers health and safety protocols	56	151	2.7	0.658	0.433
17	Limit overtime working to avoid fatigue.	56	149	2.66	0.611	0.374
18	Mitigate weather-related risks	56	124	2.21	0.825	0.681
	Valid N (list wise)	56				

Appendix-D

No.	The comparative level of conventional labour productivity improvements with achieved by using lean construction principles	N	Sum	Mean	Std. Deviation	Variance
1	Form cross-functional teams to collaborate on projects, share knowledge, and drive innovation in construction processes.	56	252	4.5	0.661	0.436
2	Implement a just-in-time delivery system to reduce waste, lower costs.	56	230	4.11	0.779	0.606
3	Involve all stakeholders in the planning process to create a more efficient and collaborative construction schedule.	56	219	3.91	1.164	1.356
4	Identify and eliminate any non-value-added activities.	56	203	3.63	0.906	0.82
5	Ensuring supervision and support for workers	56	200	3.57	0.97	0.94
6	Ergonomics and Workplace Safety	56	195	3.48	0.763	0.581
7	Implement performance-based incentive to motivate workers.	56	184	3.29	0.803	0.644
8	Providing activity assignments with work standards.	56	183	3.27	0.587	0.345
9	Train leaders and other workers at all levels.	56	181	3.23	0.853	0.727
10	Implement error-proofing mechanisms.	56	179	3.2	0.773	0.597
11	Job Scheduling and Sequencing	56	178	3.18	0.765	0.586
12	Promoting teamwork and collaboration among workers.	56	177	3.16	0.781	0.61
13	Quality Control Inspections	56	169	3.02	1.408	1.981
14	Establish standardized work procedures	56	148	2.64	0.616	0.379
	Valid N (list wise)	56				

Questionnaire to Residential Public Building Construction Projects

Adama Science and Technology University

Graduate Studies Program

Research Topic: "**Labour Productivity Improvements Using Lean Construction Principles in Public Building Construction Projects**"

This research survey is designed to fulfill an academic requirement for an MSc program in Construction Engineering and Management at the Adama Science and Technology University. I can assure you that the research data will only be used solely for the academic purpose and will be treated with strict confidentiality. Particular mentioning of names will not be required anywhere.

Your open and prompt response is highly appreciated.

Definition

Productivity is a multidimensional term, the meaning of which can vary, depending on the context within which it is used. In the context of construction productivity, it refers to the efficiency and effectiveness with which construction projects are completed. It is a measure of how well resources such as labor, materials, equipment, and time are utilized to achieve project goals and deliver the desired outcomes. Construction productivity can be measured in various ways, including:

- ❖ Most commonly used single factor measure of productivity is the labor productivity, the ratio of output to either employment or labor hours.

Labor Productivity = Output/Labour Input

- ❖ Multi/Total factor productivity measures use a weighted average of all inputs in the denominator.

Total Factor Productivity = Construction Output/Resources Used

Improving construction productivity involves implementing strategies and best practices that enhance resource utilization, streamline workflows, eliminate waste, and optimize project performance.

OBJECTIVES OF THE SURVEY

The objective of the survey is to gather reliable information so as to achieve the following research objectives;

1. To assess the current practice of labor productivity management in construction projects
2. To identify the key factors affecting labor productivity in building construction projects
3. To examine the comparative level of conventional labour productivity improvements and achieved by using lean construction principles and
4. To propose/develop better labour productivity improvement methods/techniques in public building construction projects.

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February, 2025
Adama, Ethiopia

I. General Information of Respondents and Projects

1. What is your position in the firm?

   Project Manager ☐ Office Engineer ☐ Site Engineer ☐ General Forman ☐

2. Total years of your experience in the construction industry:

   Below 5 years ☐ 5-10 years ☐ 10-15 years ☐ above 15 years ☐

3. What is your building construction project category?

   G^{+0-6} ☐ G^{+6-12} ☐ G^{+12} and above ☐

4. What is the progress/status of the project (ahead/lag) as per the schedule)?

   Ahead from the schedule ☐ as per the schedule ☐ lags from the schedule ☐ not known ☐

II. Tabulated questions on specific objectives of the research in form of 5-point likert scale

From your experience, how do you rate the level of your agreement for the following labour productivity management practices on your organizations?

Please mark from 1-5, in the table below: 5 to be the very high practiced and 1 to be not practiced at all.

Very High = 5, High = 4, Medium = 3, Low = 2 and Very Low = 1

No	Questions	Degree of Applicability				
		1	2	3	4	5
A/01	**The current practice of labor productivity management indicators** (indicate your level of agreements)					
1	Staff awareness on labor productivity management					
2	Project performance to be completed within the planned time					
3	Impact of poor labor productivity on the performance of project					
4	Labour output standards implemented on sites.					
5	Planning incentive programs and motivating workers					
6	Record and implement labour cost per unit work completed.					
7	Record and implement labour hour per unit work completed					

8	Compute labour output standards with actual labour output performed.					
9	Work by utilization rate of professionals at site.					
10	Appropriate site layout to workers freely movements.					
11	Collaborative planning and coordination among project teams.					
12	Facilitating effective communication channels.					
13	Plan and Implement as workers health and safety regulations.					
14	Managing workers under proper supervision of professionals.					
15	Continuous follow up and feedback mechanisms.					

By Five-point Likert scale/level of Agreement shows both level of effects and frequency of occurrences.

- ❖ **Rate of level of Impacts**; Very High = 5, High = 4, Medium = 3, Low = 2 and Very Low = 1
- ❖ **Rate of Frequencies of occurrences**; Very Often=5, Often=4, Some Times=3, Rarely =2 and Never =1

No	**Labour Productivity Factors**	Rate of Level Impact					Frequency of Occurrence				
		1	2	3	4	5	1	2	3	4	5
A/01	**Key factors affecting labor productivity at building constructions (indicate level of impact and its frequency of occurrence)**										
I	**Supervision Related Factors**										
1	The supervisor's unclear instructions										
2	Delays in reaching a decision										
3	Work order modification or variation										
4	Supervisors' lack of competency										
5	The absence of supervisors										
III	**Material Related Factors**										
6	Lack of resources										
7	Low-grade materials										
8	Where to store materials										
IV	**Equipment and Technology Related Factors**										
9	Lack of equipment and tools										
10	Frequent damage of equipment’s										

11	Lack of technological advancements for plants										
V	**Labor related Factors**										
12	Low motivation and morale										
13	Workers' incompetence										
14	Overly full work force										
15	Misunderstanding of labors										
16	Worker insubordination										
17	High absenteeism										
VI	**Health and safety Related Factors**										
18	Accidents during construction										
19	Lack of Safety tools										
20	Poor workers' health										
VII	**Project Related Factors**										
21	Inappropriate site Organization										
22	Lack of facilities (utilities)										
23	Project complexity										
24	Project size										
VIII	**Organizations Management Related Factors**										
25	Poor resources management										
26	Lack of using working plans										
27	Lack of follow up the work progress										
28	Lack of Training for workers										
29	Overwhelming workload										
30	Inadequate site-wide communication										
31	Construction-related errors (rework)										
32	Financial issues and cash flow										
IX	**Stake Holders Related Factors**										
33	Owner's financial difficulties										
34	Owner Intervention										
35	Insufficient communication between parties										
36	Lack of General support to the contractor										
X	**External Factors**										
37	Weather-related effects (rain, wind, …)										
38	Unforeseen Conditions										
39	Holidays										
XI	**Others(please specify)**										

From your experience, how do you rate the level of your agreement for the following labour productivity improvement techniques?

Strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2 and Strongly disagree = 1.

No	**Labour Productivity Improvement Techniques**	Degree of Agreement				
		1	2	3	4	5
C/03	**labour productivity improvement techniques in building construction projects**					
1C	Set a realistic goals and offer recognition with the workers.					
2C	Clear work schedules and deadlines for construction tasks.					
3C	Implementing standardized work procedures.					
4C	Provide adequate and proper tools and equipment to workers					
5C	Ensuring workers health and safety protocols.					
6C	Properly measure labour force performance					
7C	Limit overtime working to avoid workers fatigue.					
8C	Implementing quality control measures to reduce rework					
9C	Monitoring and analyzing labor productivity data to identify areas for improvement.					
10C	Implementing training programs for construction workers.					
11C	Promoting a culture of accountability and responsibility among workers					
12C	Ensuring effective communication channels between project managers and laborers (proper leadership practices).					
13C	Ensuring proper supervision and guidance for workers.					
14C	Encouraging teamwork and collaboration among workers.					
15C	Implementing workforce motivating packages.					
16C	Offering incentives for high-performing workers.					
17C	Mitigate weather-related risks					
18C	Implementing a lean construction principles					

From your experience, how do you rank the level of your agreement for the following labour productivity improvement techniques traditionally and using lean construction principles?

Please mark from 1-5, in the table below: 5 to be the very high improving and 1 to be very low improving labour productivity.

Very High = 5, High = 4, Medium = 3, Low = 2 and Very Low = 1

D/04	**The comparative level of conventional labour productivity improvements with achieved by using lean construction principles (indicate your level of improvements)**	Degree of Agreement				
		1	2	3	4	5
I	**Conventional Labor Productivity Improvement Techniques Indicators in Public Building Construction Projects**					
1D	Ensuring supervision and support for workers					
2D	Providing activity assignments with work standards.					
3D	Ergonomics and Workplace Safety					
4D	Promoting teamwork and collaboration among workers.					
5D	Job Scheduling and Sequencing					
6D	Quality Control Inspections					
7C	Limit overtime working to avoid workers fatigue.					
II	**Labor Productivity Improvements Techniques Indicators by Lean Construction Principles in Public Building Construction Projects**					
7D	Implement performance-based incentive to motivate workers					
8D	Involve all stakeholders in the planning process to create a more efficient and collaborative construction schedule.					
9D	Identify and eliminate any non-value-added activities.					
10D	Establish standardized work procedures					
11D	Implement a just-in-time delivery system to reduce waste, lower costs.					
12D	Train leaders and other workers at all levels.					
13D	Implement error-proofing mechanisms to prevent mistakes and defects in construction processes.					
14D	Form cross-functional teams to collaborate on projects, share knowledge, and drive innovation in construction processes.					

III. Interview questions

1. Is labor productivity measured in your projects?
2. What is your labour productivity measurement technique? Is output per worker hours/ output per inputs of material, labor & machineries/ Jobs completed per jobs scheduled
3. What was the more challenges/reason to not measure labour productivity at your site? Lack of awareness/ Negligence / It is too costly/ No knowledge about it/ difficult to measure labour productivity at site
4. In your opinion, what are the key factors that impact labor productivity in residential public building construction projects? And which of them are faced your projects?
5. Have your company implemented any conventional techniques to improve labor productivity? If so, can you provide examples?
6. Have your company implemented any lean construction principles to improve labor productivity? If so, can you provide examples?
7. List the merit of using lean construction principles to improve labour productivity?
8. Is conventional method or lean construction principles more effective to improve labour productivity in your projects? Can you discuss by examples?
9. Have you any recommendation for proposing/developing the better labour productivity improvement techniques in residential public building construction project