JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

THE PRACTICE OF LEAN CONSTRUCTION PRINCIPLE IN JIMMA MUNICIPAL ROAD INFRASTRUCTURE PROJECTS: THE CLIENT'S PERSPECTIVE

A Thesis Submitted to School of Graduate Studies, Jimma University, Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Masters of Science in Construction Engineering and Management

By:

Girum Bezabih Zewde

March 2022
Jimma, Ethiopia

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Advisor: Dr. Engr. **TAMENE ADUGNA**

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March 2022
Jimma, Ethiopia

DECLARATION

I, Girum Bezabih, declare that this research entitled "The Practice of Lean Construction Principle in Jimma Municipal Road Infrastructure Projects: The clients' perspective" is my original work and has not been presented and will not be presented by me to any other University for a similar or any other degree award. Research submitted to the School of Graduate Studies of Jimma University in partial fulfillment of the Master of Science degree in Construction Engineering and Management.

Girum Bezabih Zewde

Signature _____

Date 22/06/2014

As research Adviser, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance, by Girum Bezabih Zewde entitled "THE PRACTICE OF LEAN CONSTRUCTION PRINCIPLE IN JIMMA MUNICIPAL ROAD INFRASTRUCTURE PROJECTS: THE CLIENTS' PERSPECTIVE" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

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By:

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ABSTRACT

The lean construction management system has recently got traction by different firms and organizations to achieve efficiency and effectiveness. Provided the importance of this system, this study aims to assess the Practice of Lean Construction Principle in Jimma Municipal Road Infrastructure Projects. With this objective the researcher targeted to create more understanding and momentum for the implementation of a lean management system in Jimma municipality infrastructure projects. All employees of Jimma Municipality involved with road projects were surveyed. Quantitative data were collected using a survey questionnaire and analyzed using descriptive and inferential tools. In both cases, the result reveals that the presence and practice of lean principles in road projects management were low. Among the Management Philosophy/Activity /Practice related to lean concept assessed avoiding defects (60.7%) and increasing output flexibility (60.7%) were reported to have more familiar compared to the rest. Whereas the use of prefabricated materials (67%) were less familiar in municipal road projects management. In addition, the level of awareness about the lean concept is encouraging (according to the survey result shows that majority of the participants about 60% had awareness) but the level of awareness is shallow.

The research also examined the extent of the application: the response about the extent of application of lean tools/techniques in the organization summarized as 16.7% very little application, 23.3% apply sometimes, 26.7% apply often and 20% apply always, the rest 13.3% respond don't apply. Accordingly the result shows that the extent of application of lean construction principle is very low. The respondents were also asked about the future implementation of lean construction: the overwhelming majority of the respondents about 90% agreed future implementation of lean construction for project management system.

The study also points out that, use of non-standard component and improper resource management stands out as the major challenges because these two attributes receiving by far the highest level of agreement which was 47.2% among the participants.

Finally, the last research question were answered through inferential analysis & the inferential analysis result shows that there is no significant difference in the level of lean concept awareness between employees in their response to the familiarity, implementation of the lean concept & barriers to lean implementation. Further, the result did not show a significant awareness difference between employees in terms of the lean construction management concept based on their demographic characteristics.

***Key Words**: Lean Thinking, Lean Principles, Lean Tools/Techniques, Lean Construction.*

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ACRONYMS

CAD	Computer Aid Design
ERA	Ethiopian Road Authority
GDP	Growth and Development Program
ISIS	International Standards Industrial Classification
JIT	Just in Time
KPI	key performance indicator
LCI	Lean Construction Institute
LPS	Last Planer System
MoFED	Ministry of Finance and Economic Development
NVA	Non Value Adding
PDCA	plan, do, check, and act
PMBOK	the project management body of knowledge
PMI	Project Management Institute
SPSS	Statistical Package for the Social Sciences
TPM	Total Productive maintenance
TPS	Toyota Production System
TQM	Total Quality Management
TVD	Target value design
VSM	Value Stream Mapping

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

The construction industry plays a significant role in the economy of developing countries (Ofori, 2006; Yimam, 2011). For example, in many developing countries, major construction activities account for about 80% of the total capital assets, 10 % of their GDP, and more than 50% of the wealth invested in fixed assets. In addition, the industry provides high employment opportunities, probably next after agriculture. As Idoko (2008) noted that many projects in developing countries encounter considerable time and cost overruns, fail to realize their intended benefit, or are even totally terminated and abandoned before or after their completion. Moreover, the development of the construction industry in developing countries generally lags far behind other industries in those countries and their counterparts in developed nations. Generally, as Ofori (2006) and Jekale (2006) concluded construction industry in developing countries failed to meet the expectations of governments, clients, and society as a whole.

Given the critical role the construction industry plays in Ethiopia and other developing countries, and the poor level of performance of the industry in those countries, improving the performance of the industry is an appropriate action (Yimam, 2011). Different works of literature show that project management is one of the major areas that need improvement. Sepani (2012 cited in Thomsen *et al.*, 2009) and stated that the construction project delivery system consists of three domains; the contract, the project organization, and the project operating system. Poor level of communication which focused on pursuing individual interest between these three parties, owner, designer, and contractor, contributed to the failure of the construction process and led to project suspension.

Over the past 20 years, innovations have brought major changes to the project organization and commercial terms, such as Design and Build and Partnering. However, these changes have done very little to improve construction in terms of efficient use of labour, equipment, and material (Singleton and Hamzeh, 2011). The project operating system has been largely neglected in construction. As cited in (Gebru, 2017), …, construction is not just the personnel's who are on the job site performing the actual construction, but that it also

includes many professionals who focus on research and development to discover new technologies and materials that improve the methods and processes of construction. (Abudayyeh et al, 2004).

Lean thinking has been applied with much success in many industries and service provider organizations to improve communication problems between three parties. Lean concepts can be applied to any recurring effort at work, home, or play. The construction industry recognizes it needs much improvement to keep pace with the ever-growing complexity of the built environment and to make progress toward the same efficiency gains other business sectors have achieved. Many believe Lean Construction is the way (Rodewohl, 2014). Lean Construction extends from the objectives of a Lean production system—maximizes value and minimizes waste to specific techniques, and applies them in a new project delivery process.

Lean theory, principles, and techniques, taken together, provide the foundation for a new form of project implementation. Building upon its roots in production management, Lean Construction produces significant improvements, particularly on complex, uncertain, and quick projects. The literature review investigation does not show specific research in applying lean concepts in municipal project delivery. To this end, this study is significant as it creates an avenue for the application of lean construction in Jimma Municipality projects by assessing and creating awareness and knowledge about the benefits of lean construction in project management.

1.2. Statement of the Problem

Construction projects are typically labour intensive and labour costs cover 30 % to 50 % of the whole project cost. Respectively many factors influence productivity in the construction industry. Inefficient management of construction labours can result in low output. labour productivity is one of the greatest significant aspects that disturb the physical growth of any construction project, (Jadhav and Wadalkar, 2017)**.** Further Jadhav and Wadalkar studied the time consumption of the average construction worker and identified that only 40% of a worker's time was productive, 55% unproductive time, and 5% personal time.(Jadhav and Wadalkar, 2017)

A recent study on Project Management Maturity in developing country including Ethiopia in the construction industry revealed that the construction process management maturity level was very low (Ayalew, 2016; Yimam, 2014). These facts demonstrate that the performance of the Ethiopian construction industry is characterized as poor in meeting project requirements such as cost, time, and quality (Ayalew, 2016). This is more visible in public projects such as municipal infrastructure projects. All management concepts would admit that there is no single prescription or formula possible for the successes of projects. However, by applying the various new project management concepts, most, if not all, present problems can be solved. (Jekale, 2006)

Further (Jekale, 2006) states traditional project management principles and tools alone are proving inadequate assistance to achieve and sustain improvements in the management of construction projects. To mitigate these and improve project performance introducing a new way of project management principles is important.

Therefore, the need for a new project management approach is compulsory, the researcher tries to introduce an existing alternative way of project management focuses on waste minimization and value maximization. In the world of scarcity, optimization is unlikely inevitable. Lean thinking and approach have been considered as one of the alternative options to bring efficiency and effectiveness in project management.

The lean construction management system is ideal to improve project performance and clients' satisfaction by reducing wastages, improving quality, and meeting delivery time (STEVE, 2013). To this end, this study aims to assess the Practice of Lean Construction Principle in Jimma Town municipal infrastructure road projects management system to create more understanding and momentum for practice.

1.3. Research Questions

The proposed study was attempted to answer the following key research questions:

1. Does lean concept management philosophy is familiar in Jimma municipal road infrastructure project management system?
2. What is the extent of the application of lean tools and techniques in Jimma municipality road infrastructure project management?

3. What are the major challenges affecting the implementation of lean construction principle for road infrastructure projects in Jimma?
4. Is there any significance difference between employees in terms of level of awareness of lean construction management based on their demographic characteristics?

1.4. Objectives

1.4.1 General Objective

The general objective is to assess the Practice of Lean Construction Principle in Jimma Municipal Road Infrastructure Projects.

1.4.2 Specific Objectives

The following specific objectives will be addressed:

- To assess the familiarity of lean concept related management philosophy in Jimma municipal road infrastructure project management system.
- To examine the extent of the application of lean tools and techniques in road infrastructure projects run by Jimma municipality.
- To identify major challenges those influence the implementation of lean construction principle in Jimma municipality construction projects.
- Examine if there is significant difference between employees in terms of level of awareness of lean construction management based on their demographic characteristics.

1.5. Scope of the Study

This study assesses the Practice of Lean Construction Principle in Jimma Municipality infrastructure project management to expand and introduce the available theoretical knowledge of lean. Since it is difficult to cover the whole infrastructure projects found in Jimma Town municipality, the study has delineated to sample road infrastructure projects and also it concentrates only client-side, to make the study manageable.

1.6. Significance of the Study

This study serves several purposes. Intialy, it introduces lean construction as an alternative knowledge for construction project management systems. Secondly to be aware of the client to what extent their organization familiar with lean construction principle without being aware of them and then create awareness about the benefit of lean construction management

principles. Moreover, as an icebreaker, this study could motive other researchers to consider lean construction in their studies thereby enhance knowledge and awareness among clients about alternative ways of the project management system that could improve project performance in terms of quality, cost, and time.

1.7. Organization of the Study

This paper has been organized into five chapters. The first chapter deals with the introduction part. This part establishes the background for the study by informing issues of concern or problem, gaps the study aims to address, and what the study hoped to achieve. The second chapter deals with a review of the related literature. It will provide an overview of the Ethiopian construction industry, the concept of project management, and the challenges of project management. In addition, this chapter also includes an empirical literature review related to the topic of the study. The third chapter presents research Methodology and design. It explains the scientific procedures followed to address the research questions. The fourth chapter will present data analysis, interpretation, findings, and discussion of the results. The last chapter concludes the study and forwards plausible recommendations based on the findings of the study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter focuses on a review of literature on the construction industry and Lean concepts. The main function of this literature review is to establish the academic and research areas that are relevant to the subject under study.

2.1. The Construction Industry

All civil works such as buildings, roads, waterworks, hydropower works, etc., can be grouped under the industry termed as Construction Industry. (Jekale, 2006) The construction industry is a fundamental economic sector that permeates most of the other sectors as it transforms various resources into constructed physical economic and social infrastructure necessary for socio-economic development. It embraces the process by which the physical infrastructure are planned, designed, procured, constructed or produced, altered, repaired, maintained, and demolished. (Mlinga, 1998 cited in Mallewo, 2014)

The industry comprises persons and organizations which include companies, firms, and individuals working as consultants, main contractors, and sub-contractors, material and component producers, plant and equipment suppliers, builders, and merchants. The industry has a close relationship with clients and financiers. The government is involved in the industry as a purchaser (client), financier, regulator, and operator. (Mallewo, 2014)

The role the construction industry plays in developing countries is quite significant. For example, in many developing countries, major construction activities account for about 80% of the total capital asset, 10 % of their GDP, and; more than 50 % of the wealth invested in fixed assets. (Jekale, 2004 cited in Yimam, 2011)

However, the construction industry follows the same process methodology in its traditional delivery method in which organizational barriers (fences) prevent contractor and designer relationships from developing. One result of this is that errors usually are not detected until after the work has been passed on. In the end, this process leads to costly rework. (Abdelrazig, 2015)

This indicates that [the] construction industry is still a driver for other industries in providing infrastructure for the success of this transformation particularly in developing countries that lacks [that] the basic infrastructure even to transform to the earlier industrial revolution phases. In order to cope with such a rapid and advanced transformation of the manufacturing industry in their respective transformation stages both developed and developing world needs an efficient construction industry with better performance. (Ayalew, 2016) Generally speaking, the focus during this age is largely on fulfilling humans' basic needs and major figurative and monumental ones. (Jekale, 2006)

2.1.1 Overview of Ethiopian Construction Industry

Cited in (Mekides, 2016), as it is studied in various researches, the construction industry is growing at a fast pace all over the world. In line with the growth of the construction industry, subsequent growth of construction companies are internationally observed. In our country Ethiopia, the growth and increasing demand for the construction industry have followed a similar pattern as observed in the trend of the world. Currently, construction is one of the sectors leading the way towards modernization and industrialization in Ethiopia. Different researches indicate that the construction sector in Ethiopia, generally in the world, contributes to about fifty percent 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 (Ethiopian Roads Authority in 2000, a study on Domestic Construction Industry)

Ethiopian Economic Association (fifth annual report on the Ethiopian Economy published in March 2007), the construction industry has important contributions to the Ethiopian economy, as demonstrated by its share in the GDP. The report has described that there has been increased investment in the development and expansion of various infrastructure projects like roads, airports, and residential and non-residential housing units in Ethiopia. (Mekides, 2016)

Table 2.1 The contribution of construction and agriculture to the GDP (%) (Mekides, 2016)

Description	Average share (1996/97- 2006/07)	Average share (1996/97- 2001/02)	Average share 2002/03- 2006/07)
Construction Value Added at current/GDP at current market prices	4.6	4.1	5.2
Agriculture value added at current/GDP at current prices	44.7	46.8	42.2

Beyond its contribution to the nation, the industry is also the 6th major contributor of the content infrastructure stock following South Africa, Egypt, Morocco, Algeria, and Nigeria (Construction Sector Report on Africa 2013 Cited in Ayalew, 2016)

Different researches show that the construction projects management in Ethiopia is not scientific. In line with this as it was confirmed during past studies, the performance of most construction projects was not good. The performance of projects was 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. The impact of proper project management on the performance of construction projects is a significant factor that lowers the overall performance of the project. This tells us we should sort out what is the case and find a solution, generally continuous research has to be done to benefit more from the industry as the country and also as an individual.

2.2. Construction Project Management

The construction industry's core business is under stander taking projects in generating new buildings or renovating existing ones for a variety of clients. So, this indicates that the primary concern of the construction industry projects. This shows the performance of the company means the performance of the project. Project is a collection of items and a series of activities performed by manual, machine, or combined. That determines the performance of activity-dependent on the productivity of items of activities. Nambo Kim et al. (2007 cited in Mekides, 2016) In our world construction resources are scarce, hard to obtain easily, and becoming expensive every day even though their demand is high. It is this reality that obliged us to utilize them efficiently and effectively. In other words, that is the basic reason why [the]

construction industry need[s] to be managed and professionalism in construction management assumes special significance. (Jekale, 2006)

The aspects of construction projects are time, quality, and complexity. The effect of all these aspects can be simply summarized under the term uncertainty. Getting control over the project means reducing uncertainty by collecting information and data about the current situation. (Salem, 2006, 168p cited in Rodewohl, 2014)

The management towards coordinating different workmen, availing the required machinery and material at the right time, executing the project economically and successfully, and controlling over the quality, time, and sequence of flow of construction in a well-planned and organized manner is called **Construction Project Management**. (Jekale, 2006)

According to Project Management Institute, (PMBOK® GUIDE - SIXTH EDITION, 1996), the discipline of project management can be defined as follows: Project management is the art of directing and coordinating human and material resources through the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, and quality and participation satisfaction.

Poorly managed projects or the absence of project management may result in Missed deadlines, Cost overruns, Poor quality, Rework, Uncontrolled expansion of the project, Loss of reputation for the organization, Unsatisfied stakeholders, and Failure in achieving the objectives for which the project was undertaken, (PMBOK® GUIDE - SIXTH EDITION, 1996)

Traditionally, three indicators have been used to evaluate the success of construction projects: cost, time, and quality. Kagioglou et al. (2001) contend that these measures are insufficient. Working in projects requires knowledge and skills about the rules and liabilities within the project. Especially in several fields of the construction business where some new attributes bring to bear. (Rodewohl, 2014)

Ideas for new approaches and the transfer of successful solutions from other fields serve as means to cope with old and new project challenges to improve the project results. Using special methods and principles for a special field means to analyze and mark out the corresponding area first of all. Only the purposeful use of lean principles can lead to better project values in the end. (Heidemann, 2010, p12 cited in Rodewohl, 2014)

2.2.1 Project work

Here the conceptual project work related to municipal infrastructure projects especially, road construction was the focus of the researcher. A project is a temporary endeavor undertaken to create a unique product, service, or result. (PMI, 2017)

Municipal infrastructure is defined in broad terms as 'the capital works required to provide municipal services. It includes all the activities necessary to ensure that the works are delivered effectively, such as feasibility studies, project planning, and capacity building to establish sound operational arrangements for the works. (Dplg, no date)

Road Project Definition: - Thus a road project is a linear repetitive engineered construction project requiring an external organization for its implementation and is a temporary endeavor undertaken to produce a unique product, the road infrastructure.

PMI (2000) managing a project includes: Identifying requirements, Establishing clear and achievable objectives, Balancing the competing demands for quality, scope, time, and cost, adapting the specifications, plans, and approach to the different concerns and expectations of the various stakeholders (PMI, 2004 cited in Assefa, 2008).

As it is stated in (PMI, 2017), traditionally, the project management metrics of time, cost, scope, and quality have been the most important factors in defining the success of a project. More recently, practitioners and scholars have determined that project success should also be measured with consideration toward the achievement of the project objectives. The source of many problems in the later phases of a project is the one-sided reflection on cost and time without considering the scope of work in a proper manner. That's why the challenge for the operators is to balance these three components which influence each other. (Oberlender, 1993, p4)

2.2.2 The challenges of a traditional Project management

As observed from different papers about project management and cited in (Rodewohl, 2014) The traditional view was changing over time due to more complex projects and thus more involved and bigger teams (Applebaum, 1982, 227p). From Koskela, 2000 point of view has the building industry completely changed considering the technology part of the industry in the last century and the branch was globally marked by problems. The reasons for this are poor management and organizational approaches (Koskela, 2000, 131p)

As it's known the history of project management goes back to Egyptian pyramid building, but till this time it faces a lot of challenges. This shows that the approaches used to manage projects need a paradigm change.

As mentioned in (Rodewohl, 2014) in traditional project management the main task of the project team and its root the problem are the coordination and balance of objectives, product, organization, and the environment.

The management must cope with a dynamic and complex system influenced by a variety of external factors. Thus a non-linear setting is given. (Koskela, 2000, 200pp cited in Rodewohl, 2014) Moreover, there is the fact about the fight for a limited amount of resources within the project (Bertelsen and Koskela, 2004, 7p)

Traditional project management has served this world to its best well. The new changing the environment however required this approach to adapt through changing some of its concepts and adding relevant management tools and theories to adjust to the powerful global competitive forces and new conditions facing organizations this time. It is this fact that led theorist and researchers to see into the new project management approach. (Jekale, 2006) Therefore, the need for a new project management approach is compulsory, the researcher tries to introduce an existing alternative way of project management focuses on waste minimization and value maximization. In the world of scarcity, optimization is unlikely inevitable.

2.3. Lean Management

Lean Management is a Management philosophy system developed from the Toyota production system. Lean management is a philosophy of rigorous continuous improvement that involves all employees, the goal of which is to constantly pursue the elimination of waste and reduction of variability, toward the pursuit of perfection in our processes and services. (Charron *et al.*, 2015)

2.3.1 Lean thinking and its roots

In (Howell, 1999), the term "lean" was coined by the research team working on international auto production to reflect both the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production (Womack et al., 1991)

In the 1990's several authors especially Womack et al., (1990) introduced into the world of production in Toyota and named the application of Toyota's approach as "lean production".

The term lean production or lean manufacturing got widespread describing a range of tools that have been developed in the preceding decades. (Stone, 2012, 113) The principles of lean production were developed in the 1960s within the whole system of producing and selling cars (Womack et al., 1990, 64pp).

In the first half of the 19th century, Toyota has been suffered big problems such as being forced by the government to produce cars they wanted to have, a small domestic market, a wide range of different requirements using a car, and high energy prices. The company was forced to act and the engineers introduced the Toyota Production System. (Womack et al., 1990, 46pp) The idea of lean production was born. (Rodewohl, 2014)

… Unlike Ford who had an almost unlimited demand for a standard product, Ohno wanted to build cars to customer order. Starting from efforts to reduce machine set up time and influenced by TQM, he developed a simple set of objectives for the design of the production system: Produce a car to the requirements of a specific customer, deliver it instantly, and maintain no inventories or intermediate stores. (Howell, 1999)

Furthermore, Toyota was able to offer many different types of cars because of the low production engineering costs. The relation between the customer and the producer became more and more important. Toyota figured out that the company needs to align their amount of produced goods with the amount the customer need for. The development of a build-to-order system was triggered. The aim was to identify the customer's preferences and buying behavior. The idea of the 'Pull-system' was born. (Rodewohl, 2014 cited in Womack et al., 1990, 64pp)

The lean approach is to create truly dedicated product teams with all the skills needed to conduct value specification, general design, detailed engineering, purchasing, tooling, and production planning in one room in a short period using a proven team decision-making methodology commonly called Quality Function Deployment (QFD). This method permits development teams to *standardize work* so that a team follows the same approach every time. Because every team in a firm also follows this approach, it's possible to accurately measure throughput time and to continually improve the design methodology itself. (Womack and Jones, 2003)

Lean thinking is lean because it provides a way to do more and more with less human effort, less equipment, less time, and less space; while customers with exactly what they want.

As mentioned in Eira, (2014) lean thinking is considered by Womack and Jones (2003) as the solution to eliminate waste and to generate a sequence of activities without interruptions thus leading to value creation and greater efficiency. According to these authors, the application of lean allows an organization to do more with fewer resources, while customers are closer to get exactly what they want (Womack and Jones, 2003; Atkinson, 2004).

To achieve these goals, Womack and Jones (1996) defined five **fundamental principles** to guide the lean thinking approach and apply them to any organization:

2.3.2 The five lean principles

i) Value

The critical starting point for lean thinking is *value.* Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) that meets the customer's needs at a specific price at a specific time. (Womack and Jones, 2003, 16)

Value-adding activities transform materials and information into products and services needed by the customer. Value is not necessarily economic; in the process environment, it is obtained when desired products and services are delivered. Wandahl and Bejder (2003) differentiate between product and process values. Product value relates to tangible aspects of a product, such as material composition, price of construction, flexibility, and so on. Process value in the construction environment relates to stages in the building process and interaction between producers such as time, communication, and so forth. The interaction between producers can best be represented by process value. Non-value adding activities use up resources but do not directly contribute to the product or service. (Forbes and Ahmed, 2011, p61)

As mentioned by Hines *et al*., (2008) and quoted in (Eira, 2014)… one of the greatest mistakes when defining value is the adopted perspective: value must be seen in the customer's outlook, rather than for the firms, functions, or departments.

ii) Value stream

Wherever a process exists, it is accompanied by a value stream that represents the actions needed to create a product or service from its inception as raw material until it reaches a customer in its completed form. ((Forbes and Ahmed, 2011, 62pp)

Value stream mapping (VSM) shows material and information flows required to produce outputs. It helps users to understand the process, identify sources of waste by distinguishing between NVA and value-added activities. (Forbes and Ahmed, 2011)

(Rodewohl, 2014) referring to Womack and Jones, (2003) book states every product underlies three management tasks: a problem-solving task, and information management task, and a transformation task. Focusing on a value stream means creating an environment where a product and its required activities can pass the three management areas in the most efficient way.

According to Hines and Taylor (2000:4), this second principle of lean thinking comprises the identification of "… *all the steps necessary to design, order and produce the product across the whole value stream …" cited by* Eira, (2014)

The central tool aiming for a value stream is the value stream mapping method. It means to focus and analyze the activities in detail. Drawing the material and information flow with a pencil helps to get into the bird's eye perspective and understand the process in total. (Rother and Shook, 2003, 37p cited in Rodewohl, 2014).

The completed value stream map of the current state reveals areas that can be improved. Typically, the map is studied by a team that understands the process and can make changes to the map to reflect recommended improvements. The map is changed to create a future state map with improved processes that maximize value-added time and minimize waste. (Forbes and Ahmed, 2011)

Piercy and Rich (2009) refer that mapping the steps through *value stream mapping*, which lists all the activities as well as the resources consumed, is the best way to identify the waste and the improvement opportunities. (Eira, 2014)

By illustrating the present process flow with the help of a mapping method supports to optimize the flow. The performance of a value stream can be operationalized by determining the attributes lead time, inventory, and operational costs. (Jarkko et al., 2013, 49pp Cited in Rodewohl, 2014)

iii) Flow

The goal of lean thinking is to have a continuous flow of a product from one activity to the next in a process without delays, stoppages, or storage as *work in process*. This concept is the so-called one-piece flow or single-piece flow. Examples of flow are:

• **Business flow**: Related to the information of a project (specifications, contracts, plans, etc.).

• **Job site flow**: Involves the activities and the way they have to be done.

• **Supply flow**: Refers to materials involved in a project. This is similar to any other supply chain. (Forbes and Ahmed, 2011)

The end objective of flow thinking is to eliminate all stoppages in an entire production process and not to rest in the area of tool design until this has been achieved. (Womack and Jones, 2003)

iv) Pull production

In the JIT philosophy, production is "pulled" from the system by the customer demand. This is the antithesis of mass production that is based on large batch sizes—a "push" philosophy in which production forecasts project customers' needs and produce outputs based on those assumptions. (Forbes and Ahmed, 2011)

This producing method presents a number of advantages, such as the ability to change when the customer wants a different product and to adapt the process and the final product or service to each customer or group of customers at a specific moment; the inexistence (or the existence of minimum amounts) of inventory; the clarity of the processes and easier error detection. (Abdi *et al.*, 2006; Teeuwen, 2011 cited in (Eira, 2014)

It is a whole set of principles enabling the user to deliver the right products in time to the right place with the right amount. The organization is in this way flexible on changes in demand. (Liker, 2004, 23p cited in Rodewohl, 2014)

v) Perfection

We hope you can now see the need to precisely specify the value and to identify every step in the value stream for specific products, then to introduce flow, and next to let the ultimate customer pull value from its source. However, much of the potential of lean thinking is lost unless you take the final principle to heart. (Womack and Jones, 2003) This final principle is perfection.

Forbes and Ahmed, (2011) in their book called 'Modern Construction: Lean Project Delivery and Integrated Practices' they refer Perfection may not be attainable in the construction environment, but represents a desirable future state—defects would be minimized, as would other categories of waste that delay delivery, incur an additional cost, and detract from meeting the customers' needs. Altogether perfection should be endlessly pursued however it will never be reached. (Eira, 2014)

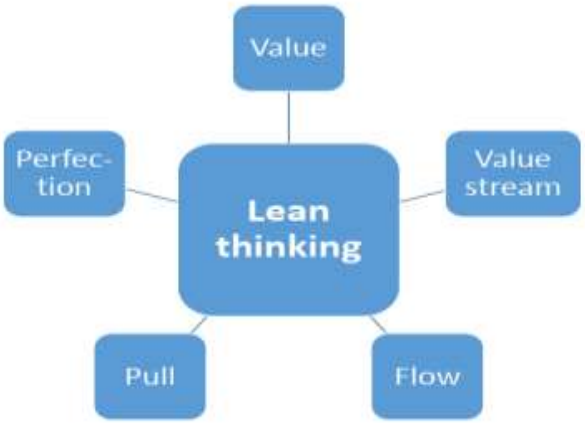

Figure 2.1 The five lean principles in reference to Rodewohl (2014)

As mentioned by Hines *et al*. (2002, cited in Eira, 2014) after applying the five principles, the organisation should return to the first one and pursue new opportunities for improvement. Perfection is time taking and it needs a scientific way to approach it. Now Kaizen comes here, the term Kaizen describes the aspiration for perfection and is part of the mentality of the Japanese.

As defined in the book by Forbes and Ahmed, (2011) **Kaizen** is the Japanese concept of continual incremental improvement. Literally, **Kai** means change, and **zen** means good; hence, Kaizen stands for ongoing changes for beneficial reasons on a never-ending basis.

The way to move further all the time is taken for granted here in contrast to the Western world which has another attitude to changes. It is necessary to distinguish between gradual and abrupt changes. The Kaizen idea stands for a gradual change and can be described as a continuous improvement process in the background of the day-to-day business. (Rodewohl, 2014)

The Kaizen approach encourages employees/stakeholders to develop and implement ongoing improvements to the systems that they are most involved with, thereby improving their job performance. It seeks to standardize processes and eliminate or reduce waste. (Forbes and Ahmed, 2011)

Wit and Meyer, (2010, 195pp cited in Rodewohl, 2014) Kaizen is a universal concept and can be applied in every kind of activity.

One important consideration for the adaptation of Kaizen to construction-related activities is that improvements are expected to be followed by a period of time for new methods/processes to be standardized. (Forbes and Ahmed, 2011)

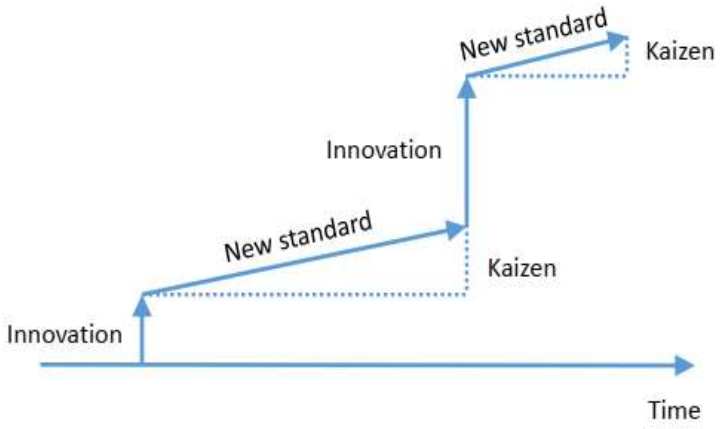

Figure 2.2 Maintaining improvement in reference to Wit and Meyer, 2010 (cited in Rodewohl, 2014)

2.3.3 Lean techniques/Tools

The lean principles can be realized and implemented by using lean techniques. It is the last element within a system but for the user the most visible and comprehensible one. In recent years a huge range of different tools has evolved. (Rodewohl, 2014)

As summarized by Seddon and Caulkin, (2007 cited in Rodewohl, 2014) the focus [of lean techniques/tools] should be on understanding the system and the thinking on causes and their effects.

2.4. Lean Construction

The success of lean principles in manufacturing and the benefits arising from its use is one of the main motivations for adopting lean principles in construction. (Egan, 1998 cited in Gao and Low, 2014)

Howell, (2000) describes lean construction as a new way to design and build capital facilities. Lean theory, principles, and techniques jointly provide the foundation for a new form of project management. It uses production management techniques to make significant improvements, particularly on complex, uncertain, and quick projects. Lean methods have reduced office construction costs by 25% within 18 months and schematic design time from 11 to 2 weeks. (Forbes and Ahmed, 2011)

Lean is a holistic, value-based approach to creating the built environment. Where almost all current approaches to managing design and construction assume that the process from conception to operation is a linear sequence of events, Lean has been developed to organize and reshape those familiar with the Architecture/Engineering/Construction (A/E/C) world realize is more like a non-linear labyrinth. Lean seeks to restructure the project's operating system to focus on what adds value and to smooth out the workflow. (Thomsen *et al.*, 2009)

2.4.1 Defining Lean Construction

Lean Construction extends from the objectives of a Lean production system—maximizes value and minimizes waste to specific techniques, and applies them in a new project delivery process. Lean theory, principles, and techniques, taken together, provide the foundation for a new form of project implementation. Building upon its roots in production management, Lean Construction produces significant improvements, particularly on complex, uncertain, and quick projects.

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.*, 2002)

Lean Construction Institute (LCI) is a US-based not-for-profit organization established in 1997. They define **Lean construction** as, "the application of lean thinking to the design and construction process, creating improved project delivery to meet client needs and improved efficiency for constructors."

The definition of lean construction due to (Koskela *et al.*, 2002) indicates that lean construction strives for the same goals as lean production, namely to eliminate waste and to maximize value. (Gao and Low, 2014)

Lean construction identifies what is valuable in a construction project and studies existing work processes to remove waste. Six Lean principles guide the modifications:

1. Identify value from the point of view of the customer.
2. Understand the streams of work by which value is delivered.
3. Achieve a smooth flow within work processes as waste is removed.
4. Employ pull planning so that nothing is made or delivered until it is needed.
5. Make continuous efforts to improve existing processes.
6. Develop and use applied technology to improve access to and use of information. (Bade and Haas, 2015)

Lean Construction is a production management-based approach to project delivery – a new way to design and build capital facilities. . . . Lean changes the way work is done throughout the delivery process. Lean Construction extends from the objectives of a lean production system – maximize value and minimize waste – to specific techniques and applies them in a new project delivery process. (Thomsen *et al.*, 2009)

2.4.2 Lean (construction) Principles

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According to The Construction Industry Institute CII identified five lean construction principle in their study PT 191: as cited in Forbes and Ahmed, (2011).

- Customer focus
- Culture and people
- Workplace organization and standardization
- Elimination of waste
- Continuous improvement and built-in quality

The principles of Lean construction consist of seven keys that are specific value, Identify and map the value stream, flow, pull, perfection, Transparency, process variability. Lean thinking can be redefined in the following three ways: They are unique custom products, Deliver instantly, nothing in stores. (Harris and McCaffer, 1997, cited in Radhika and S.Sukumar, 2017)

As stated in Sarhan *et al.*, (2017) currently there exists a variety of lean tools and techniques. And they try to summarize lean techniques/tools including their definition/explanation by referring to different authors/researchers as described in the table below.

Table 2.2 Summary of the lean tools/techniques that support the implementation of lean construction. (Sarhan et al., 2017)

Lean Tools/ Techniques	Definition	References
The Last Planner System (LPS)	To achieve lean goals of reducing waste, increasing productivity, and decreasing unpredictability, mainly through a social process, by trying to make planning a mutual attempt and by increasing the reliability of the commitment of team members. In construction, LPS was a method that forms workflow and deals with project variability.	(Lehman and Reiser, 2000; Watson, 2003); (Ballard and Howell, 1994; Salem et al., 2005)
Value Stream Mapping (VSM)	This tool establishes the current state of the construction process or supply chain to identify the wastes. The future state helps to develop improvement strategies.	(Arleroth and Kristensson, 2011)
Standardized Work	Flexible regimentation lean construction tool involving the development of a common way for performing specific construction processes based on the available evidence.	(Toussaint and Berry, 2013)
The 5S Process	The 5Ss are sorting, straightening, shining, standardizing, and sustaining the facilities and processes used in construction. The 5S process increases the productivity of	(Umstot, 2013)

Lean Tools/ Techniques	Definition	References
	the project since it reduces the time spent searching for supplies, tools, and equipment, etc.	
Kaizen	The Japanese word for continual improvement, Kaizen promotes the idea that every process can and should be continually evaluated and improved in terms of time required, resources used, resultant quality, and other aspects relevant to the process.	(Sniegowski, 2013)
Total Quality Management	Most of the substantial tools used to address construction performance issues are based on the concept of plan-do-act. Functions involve identification and evaluation of the problem, developing, and implementing solutions, and evaluating and measuring the results.	(CEC, 2005; Marosszeky et al., 2002)
Increased visualization	Communicating key information effectively to the workforce through posting various signs and labels around the construction site; workers can remember elements such as workflow, performance targets, and specific required actions if they repeatedly see them.	(Conte and Gransberg, 2001; Salem et al., 2005)
Fail-Safe for Quality and Safety	This is a lean construction tool that ensures no harm or minimum is sustained in the event of specific failures.	(Ogunbiyi, 2014)
Daily Huddle Meetings	These are held to obtain the full involvement of employees in issues regarding the project and to encourage employees to solve problems together. Two-way communication is the key to the daily huddle meeting process to achieve employee involvement.	(Adamu and Hamid, 2012; Aziz and Hafez, 2013; Ogunbiyi, 2014; Salem et al., 2005)
First run studies	First-run studies are utilized to remodel important tasks. Operations are scrutinized thoroughly, and ideas and suggestions are raised to explore alternative ways of doing	(Aziz and Hafez, 2013; Ballard and Howell, 1997;

Lean Tools/ Techniques	Definition	References
	the task. The PDCA (plan, do, check, and act) cycle is used to build up the first-run study.	Ogunbiyi, 2014)
The Five Why's	This is the lean construction iterative question-asking technique that elucidates "cause-and effect" mechanisms associated with a problem. It is a problem-solving tool that aims to find the root cause of a construction-related issue or problem. The questions are usually specific to the project and are not limited to five questions.	(Aziz and Hafez, 2013; El Kourd, 2009; Nielsen and Tezel, 2013)
Just in Time (JIT)	JIT in lean construction is a tool that ensures reduced flow times: production times and response times (end-to-end or between contractors and clients). JIT may include demand flow or continuous flow.	(Ogunbiyi, 2014)
Plan of Conditions and Work Environment in the Construction Industry	This is a lean construction tool that assures occupation safety and health management. It manages safety requirements through the risk management cycle consisting of continuous identification of risk, evaluation, and control.	(Aziz and Hafez, 2013; Ogunbiyi, 2014)
Concurrent Engineering	This is an improved design process characterized by rigorous upfront requirements analysis, incorporating the constraints of subsequent phases into the conceptual phase, and tightening of change control towards the end of the design process.	(Ballard and Howell, 2003; Koskela, 1992; 1994)
Error Proofing (Poka yoke)	Poka-yoke is a Japanese word which can be defined as "error proofing". Shingo introduced Poka-yoke devices as new elements to avoid defective parts from flowing through the process. It is a lean tool that engages all forms	(Abdelhamid and Salem, 2005; Conner, 2009)

Lean Tools/ Techniques	Definition	References
	of activities and devices that could help avoid an error from happening.	
Target value design (TVD)	This approach applies methods for the design to be developed in accordance with the constraints, especially cost (e. 'deign-to-cost' or 'design-to-targets'. TVD considers the customers'/clients' and stakeholders' vision to define such restrictions and deliver the required target values.	(Miron, Kaushik and Koskela, 2015)
Partnering	This approach lead[s] to collaboration and open exchange of information which implies a potentially radical change in the management practices and organizational structures.	(Barlow, 1996)
Total Productive maintenance (TPM)	This tool as an integrated approach to maintenance that focuses on proactive and preventative maintenance to maximize the operational time of equipment, TPM blurs the distinction between maintenance and production by placing a strong emphasis on empowering operators to help maintain their equipment.	(Al-Aomar, 2012; Asay and Wisdom, 2002)
Computer Aided Design (CAD)	In this approach, engineering designs may be created and tested using computer simulations and then transferred directly to the production floor where the machinery uses the information to perform production functions.	(Diekmann et al., 2004;Khanzode, Fischer & Reed, 2005)
Six Sigma	An organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and scientific method to make dramatic reductions in the customer defined defect rates.	(Linderman et al., 2003)

2.4.3 Waste in Construction

Muda is a Japanese word. Muda means 'waste', specifically any human activity which absorbs resources but creates no value. (Womack and Jones, 2003) Muda/Waste is "Anything that does not add value to the final product or service, in the eyes of the customer. An activity the customer wouldn't want to pay for if they knew it was happening" (LEAD, 2004, online).

The thinking of waste is related to the seven categories of overproduction, rework, transport, over-processing, inventory, waiting, and motion. Waste can be effectively-identified to the extant the customer has defined value. Ohno, (1988, 19p, cited in Rodewohl, 2014)

Howell, G.A., (1999) try to define and support the concept of waste with simple example to understand waste as follow: Waste is defined by the performance criteria for the production system. Failure to meet the unique requirements of a client is waste, as is time beyond instant and inventory standing idle. As a result, the construction industry is overwhelmed by delay and often has suffered cost and time overrun. Alsehaimi and Koskela [35] reported that poor project management was a dominant and common reason for delay in construction projects. Consequently, these problems associated with management, in particular, should be understood, and efforts need to be directed toward developing solutions and more efficient methods of operation [36]. The introduction of new production philosophies in construction requires new measures of performance Koskela [3], such as waste, value, cycle time, or variability. (Aziz and Hafez, 2013)

Aziz and Hafez, (2013) have undergone analysis of waste in construction and summarize as several partial studies from various countries have confirmed that wastes in the construction industry represent a relatively large percentage of production cost. The existence of the significant number of wastes in construction has depleted the overall performance and productivity of the industry, and certain serious measures have to be taken to rectify the current situation.

Cited in Aziz and Hafez, (2013) and Waste has been defined by Alarcon [39] as ''anything different from the absolute minimum amount of resources of materials, equipment, and manpower, necessary to add value to the product.'' In general, any losses produced by activities that generate direct or indirect costs but do not add value to the product from the point of view of the client can be called ''waste.'' Waste is measured in terms of costs; other

types of waste are related to the efficiency of the processes, equipment or personnel, and are more difficult to be measured because the optimal efficiency is not always known.

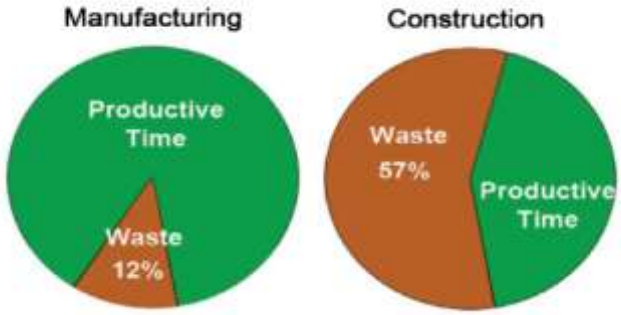

Figure 2.3 Waste percentage of time in manufacturing and construction in reference to Aziz and Hafez, (2013)

Lean construction seeks to reduce or eliminate waste in construction activities. Improving the efficiency of individual activities does not necessarily improve the efficiency of an overall process. Waste can occur in the handoffs from one activity to another or one trade to another, in the form of delays, defects that need to be corrected, and so on. Leanness is increased by reducing or eliminating the waste that occurs between activities in order to increase overall process efficiency. (Forbes and Ahmed, 2011)

2.4.4 Benefits of applying/Implementing Lean construction principle in Municipal Infrastructure projects

The application of lean principles results in better utilization of resources—especially labor and material. It also results in better construction quality in completed facilities, greater owner/client satisfaction, higher levels of safety, and ultimately greater profitability for clients, builders, and design professionals. (Forbes and Ahmed, 2011)

As presented in this theoretical framework, there are many advantages with implementing Lean into the organization. The major advantages can be summarized as gained flexibility through shorter lead time, decreased fixed assets through significant smaller storage, a strengthening of the staff and co-workers driving force and motivation by Decreased stress, Increased competence, Decreased frustration, Improved communication, Gained an understanding of the whole site, Broadened and more developed responsibilities, A more safe and secure workplace, A more safe and secure employment. (Rohman, 2007)

2.5. Gap Analysis

Different research papers witnessed that construction projects worldwide experiencing significant cost and time overruns, for this project management are one major cause. To enhance the construction industry in Ethiopia, improving labor productivity has a significant role since the construction industry involves the employment of a huge number of employees to carry out the work. In line with this, all the related stakeholders of the construction industry including the government should take their part in the improvement of construction labor productivity, (Mekides, 2016).

From various studies, the factor affecting construction labor productivity is related to contractor, consultant, client, and external factors, generally their project management approach is the main cause for poor performance as a whole. From this one can understand that the area needs continuous intervention by professionals.

Working on the improvement of construction project management is critical because the construction industry in Ethiopia has a greater impact on the development of other sectors.

Most researches study the project management case in general for example on infrastructure construction, but infrastructure construction by itself contains lots of core areas. This study aims to break up this and takes one core area called road construction and try to do on assessing the Practice of Lean Construction Principle awareness in municipal infrastructure project delivery system from viewpoint of client/municipality.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Research Area Study Setting

The study was conducted in Jimma Town. The town is situated in Oromia Regional State at about 335 KMs away from Addis Ababa city, in the Southwest direction. Geographically, the town is located at 7°40'0"N latitude and 36°60'00"E longitude. Topographically, the Jimma area might be divided into escarpment and alluvial plains.

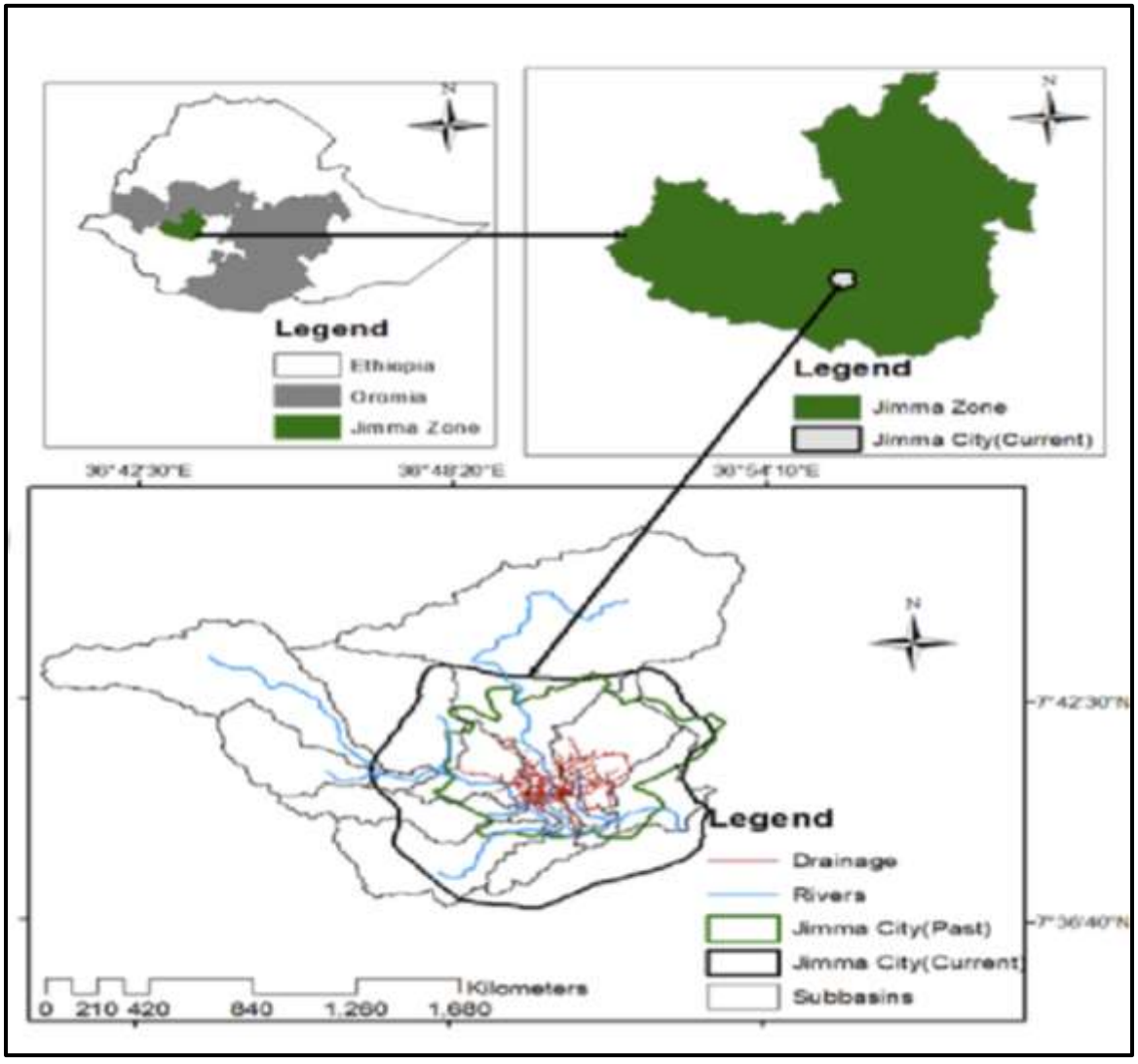

Figure 3.1 Location Map of Jimma Town (Source: Jimma Town Asset Management, 2010)

Table 3.1: The summary of Jimma Town road infrastructure:

Road Surface Material	Unit of Measurement	Length in km (7 m Equivalent Width)
Asphalt	KM	29.124
Cobble	KM	50.237
Gravel	KM	92.219
Earth	KM	95.454
Earth Pressed Road	KM	163.92
Large Block Stone	KM	0.22
Road Asset Sub Category	Unit of Measurement	Quantity
Round About at Grade	Number	7
Bridge	Number	8
Road Median	KM	3.9
Road Median Area	M2	5,090.50
Culvert	Number	227
Retaining walls	Meters	424
Krebs	Km	82.9
Traffic Sign post	Number	119

(Source: Jimma Town Asset Management, 2010)

3.2. Study Period

This research was carried out for five months. The five months will be sub-divided into different time frames to execute the research. This research started when the proposal was approved. The literature review was ongoing and undergone at every step of the research till the end. Observation, questionnaire building, validity testing, and piloting were completed on the 20th of May 2021. The collection of data, preparing results, and doing analysis started on the 3rd of June 2021 and was completed on the 25th of August 2021. Conclusions and recommendations were ready in September 2021 and the research paper was finalized accordingly.

3.3. The Research Design and Method

This research focuses on the Practice of Lean Construction Principle in municipal project management. It has both quantitative and qualitative components.

The research design refers to the researcher's overall plan for obtaining answers to the research question; it is a road map for achieving the objectives of the study. Research designs are plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis. (Creswell, 2009)

According to (Kothari, 2004) "A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure.

This research aims to assess the Practice of Lean Construction Principle in the Jimma Municipal Road Infrastructure Project Management system by considering road projects constructed in the last four years from 2009 – 2012 E.C. For this the study employs a descriptive research design.

The major purpose of descriptive research is the description of the state of affairs as it exists at present (Kothari, 2004). A descriptive survey was used to describe the topic accurately and in detail through the literature review which required large amounts of previous knowledge to be researched. The researcher aims to assess the actual situation of the Jimma municipal infrastructure project management system. Therefore, the researcher assumes that a descriptive research design is appropriate for this study for assessing the Practice of Lean Construction Principle awareness.

In Singh, (2006) Fundamental of research methodology and statistics books, the following are the main objectives of descriptive research: to identify present conditions and point to present needs; to study the immediate status of a phenomenon; facts findings and to examine the relationships of traits and characteristics (trends and patterns). In addition, descriptive research enables a researcher to obtain both qualitative and quantitative hence important to achieve the objective of this study. Generally, this research claims to be descriptive because it aimed to assess the Practice of Lean Construction Principle in the existing practice of municipal infrastructure project management.

3.4. Study Vriables

The study variables assessed in this research are both independent and dependent. Different indicators of the Practice of Lean Construction Principle in construction project management are considered as the independent variables and discussed in the literature review section.

Independent Variables:

- Management philosophy/activity/practice related to lean concept
- Awareness about lean construction management
- application of lean construction principle

- Implementation of lean construction tools/techniques
- Construction Wastes
- Barriers to the application of lean construction

Generally, the dependent variable was Practice of Lean Construction Principle in Jimma Municipal Infrastructure project management.

3.5. Population

This research focuses on the Practice of Lean Construction Principle in municipal project management practice. So, the researcher was considering people who launching and operating Jimma municipal infrastructure projects. Therefore, the target populations are client-side project employees who are actively acted and involved in all project phases (from start to operation) of public projects in the Jimma municipality; i.e. Jimma Town municipality infrastructure design, preparation & municipal revenue enhancement team staffs are considered. Moreover, purposively selected twelve major road infrastructure construction projects undergone with in the last four years 2009 – 2012 E.C are the subject of the study as well.

3.6. Sample Size and Sampling Procedures

The purposive sampling method was being employed to select twelve sample road projects undergone within the 2009 – 2012 E.C. period time. Investment cost, familiarity, and availability of relevant information are some of the criteria to be used to select projects purposively. Road infrastructure is emphasized in this study as it is directly linked to the development of the welfare of society. Additionally, road infrastructure utilizes the lion's share of the annual municipal project budget.

Since employed involved in road construction projects are small (less than 30) in number all the 30 staff were included in the study through census approach. In census inquiry, no element of chance is left and the highest accuracy can be achieved (Kothari, 2004).

3.7. Data Collection Process

Primary and secondary data were used for the study. Primary data was collected through a structured questionnaire and observation. On the other hand, secondary data was collected through reviewing related materials. The primary data was collected using a questionnaire; information was gathered from all 30 road infrastructures project management actors about the Practice of Lean Construction Principle awareness in their purposively selected road infrastructure projects. In the initial phase i.e. to obtain quantitative data survey questionnaire was administered in-person to all Jimma Municipality infrastructure process owner department employees involved in project work. The document analysis and observation were used to enrich the data obtained in each stage.

Questionnaire

The questionnaire was developed to gather information on the experts' knowledge to assess and measure the awareness level of lean construction principle in their project management. It includes the Likert scale type and rating scale questions. The questionnaire was designed based on the rigorous search of literature review related to lean construction principle awareness. Specifically, a survey questionnaire prepared was used to rank and perform analysis on the level of lean principles awareness on subjects of the study.

The survey was designed based on variables extracted from kinds of literature and organized in different parts which include a question related to respondent profiles, the extent of practice and level of importance of management philosophy related to lean concept, Awareness about lean construction management, implementation of lean tools/techniques, construction wastes, benefits and barriers of lean construction principle when adapted to municipal project management.

During questionnaire development, usually, a pilot study for testing the questionnaire is conducted. (Kothari, 2004, p17) This is to make sure that the questionnaire is clear for all respondents. Before actual use of the questionnaire, the researcher has gone through a pilot test by taking twelve participants, and based on their response slight modification was made.

The respondents are 30 staff's municipal infrastructure department experts who are involved from start to operation of projects.

Both distribution and collection of the questionnaire were handled by the researcher and assistant data collector jointly. The self-administered questionnaire was distributed to all Jimma municipal infrastructure department process owner staff and collected accordingly.

3.8. Data Processing and Analysis

The process of data analysis was gone through three steps. In the first step where data preparation takes place. This involves coding, cleaning, classifying, and tabulating collected data so that they are amenable to analysis. Then the data was analyzed using quantitative. Quantitative data obtained through the survey was analyzed using both descriptive and inferential tools. Descriptive statistics tools such as frequencies, percentage, mean, standard deviation analysis of variance were applied to answer descriptive questions that assess the practice of lean principles and examine the level of awareness. On the other hand, qualitative data were analyzed through a content analysis approach. Finally, both analyses were compiled; organized, and interpreted meaningfully in a way it answers basic research questions. Data analysis and management software such as SPSS was employed at all stages.

3.9. Ethical Considerations

The researcher followed ethically and morally acceptable processes throughout the research process. The data was collected with the full permission of the participants and confidentially without disclosing the respondents' identity (Deb, Dey and Balas, 2019).

Research ethics helps to protect the rights of respondents. Concerning this study, permission is obtained from Municipality and all respondents after clearly explaining the objective of the study. All information obtained from the respondents was treated with confidentiality without disclosure of the respondents' identity. The purpose of the study was communicated to relevant people to seek consent. Sources used in the study were appropriately recognized and cited.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

Introduction

This chapter presents the analysis of the data, its interpretation, and the results of the study. It is mainly classified into different sub-sections: descriptive statistical analysis, inferential statistical analysis, and discussion of the results. Each sub sections developed logically to lead consequently to the findings of the study.

4.1 Analysis of the data

This part is mainly concerned with preparing the data for analyses. It specifically includes the examination of the data, response rate, reliability test, and description of respondents'' demographic information. The researcher distributed a questionnaire for 30 participants and also rated the questions himself. Therefore, no participants were left out. The data collected were coded and fed into SPSS 20. Before analysis the data was also inspected visually as well as via plot and graphs to check missing values, identifying outlier and out of range values. Finally, the cleaned data were analyzed descriptively and inferentially to address research questions.

Reliability of the instrument

Table 4.1: Reliability test

Variables	N of Items	Cronbach's Alpha
Familiarity of lean related management concept	9	0.952
Implementation of lean tools	16	0.950
Benefits of lean principle	9	0.847
Municipality construction waste	8	0.888
Barriers to lean principles	15	0.950

Source: **from own data**

The reliability statistics table shows the worthiness of the scale's internal consistency. In other words, this refers to the degree to which the items that make up a given scale measure the same underlying construct. One of the most commonly used indicators of internal consistency is Cronbach's alpha coefficient. The corresponding Cronbach's test illustrates an alpha coefficient of 0.952 for the familiarity of lean related management concept, 0.950 for the implementation of lean principles, 0.847 for the benefits of lean principles, 0.888 for the municipality waste scale, and 0.950 for the barriers to lean principles. An alpha coefficient above 0.7 is desirable in terms of internal consistency (Pallant, 2007). The alpha results are in line with previous test findings and are good for the validity of this study.

Demographic profiles

Demographic variables of interest used in this study are gender, age, job position, work experience, and educational background. Sex wise the majority of the participants which accounts for about 90% were males. Only 10% were females.

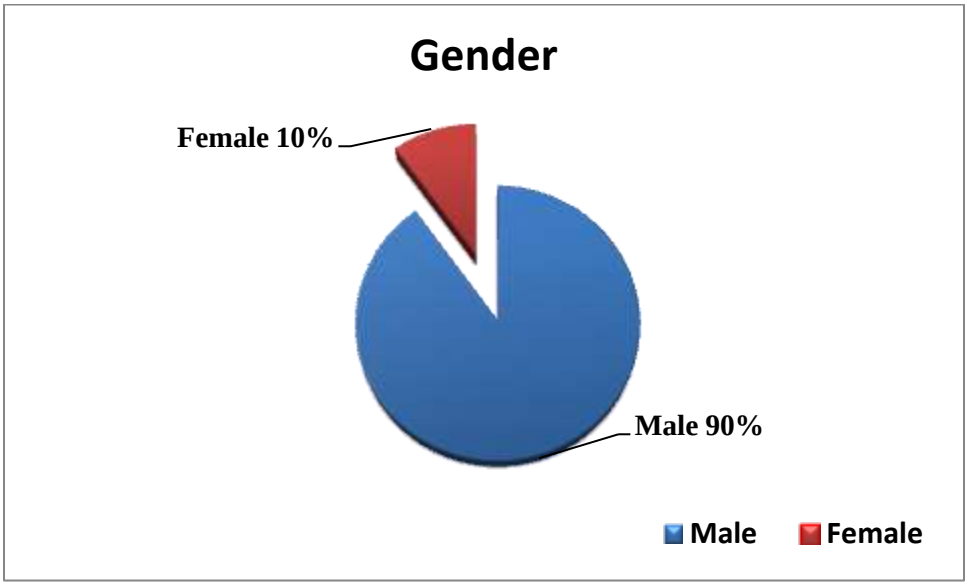

Figure 4.1 Gender of the respondents

In terms of the types of jobs the participants were involved with, 40% were project engineers (supervisors); 30%, were construction foreman and surveyors; the rest 30% were equally shared among the infrastructure development & management team; municipal revenue enhancement team; and infrastructure department team leaders. From these demographics, we can see that relevant people have participated in the study.

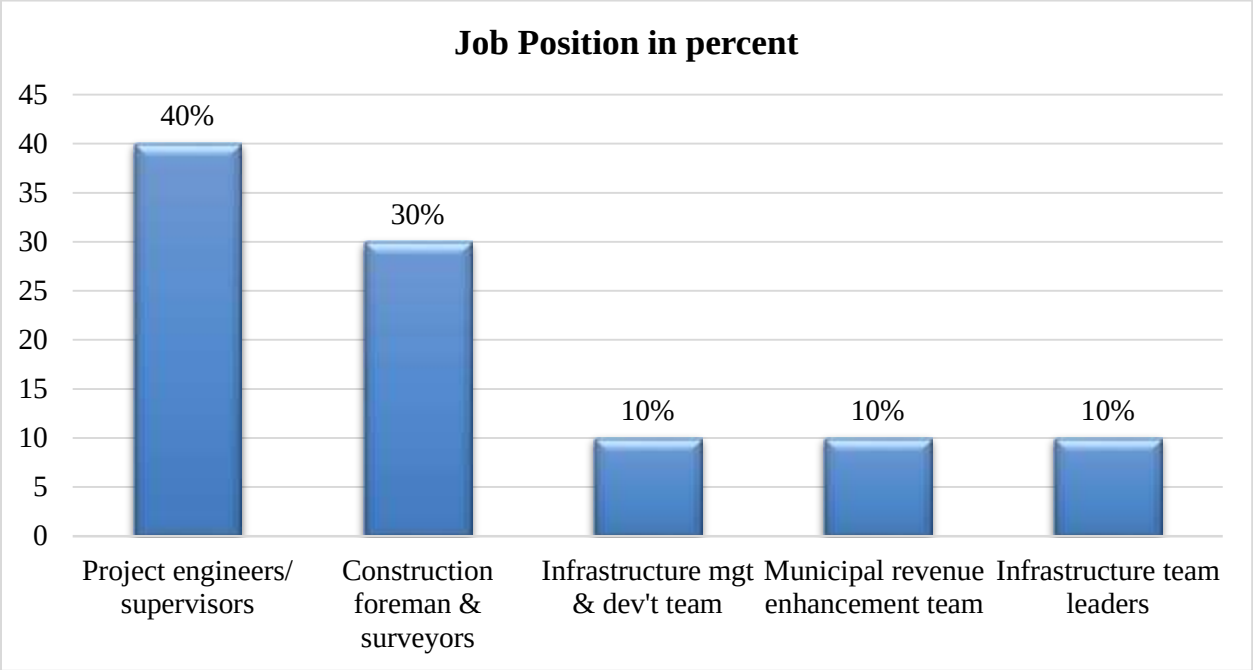

Figure 4.2 Job position

When it comes to educational background 80% of the participants hold a first degree, diploma and master's degree were 10% each as illustrated below in the table.

Table 4.2: Education

Educational background					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma	3	10.0	10.0	10.0
	BSc/BA	24	80.0	80.0	90.0
	Master's degree	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

Source: from own data

Age and work experience were measured in terms of years. The average age of the participants was 32 years. Minimum work experience was 2 years while the maximum was 12 years, on average participants had five years and five months. The average work-related experience was also five as can be observed in the table below.

Table 4.3: Age, work experience

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Work experience	30	2.00	12.00	5.4000	3.52919
Work related experience	30	1.00	12.00	4.8000	3.42808
Age	30	27.00	49.00	32.4000	6.33872
Valid N (list-wise)	30				

Source: from own data

So, the overall demographic variables of interest used in this study shows that most of the respondents have adequate in gender, age, job position, work experience and educational background in the road construction. This indicates that, the respondents was provided the required information for all items included in the questionnaire.

4.2 Descriptive Results

4.2.1 Familiarity and Awareness of Lean Management Concepts

The Lean theory, principles, and techniques jointly provide the foundation for a new form of project management. It uses production management techniques to make significant improvements particularly on complex, uncertain, and quick projects especially by reducing construction costs and schematic design time (Forbes and Ahmed, 2011). Here in this study conducted on Jimma Municipality the presence and practice of Management Philosophy /Activity/Practice related to lean concept indicated in Table below were assessed based on the responses of the employees of the municipality Infrastructure department. In other words, the respondents reported the use of these lean concept-related management philosophies in Jimma Municipality projects.

Table 4.4: Management Philosophy/Activity/Practice related to lean concept

	N	Min	Max	Mean	Std. D	Z	%
1. Waste minimization	30	1	5	3.30	1.29	- 0.13	55.2%
2. Establishing continues improvement	30	1	5	3.20	1.27	- 0.21	58.2%
3. Delivering what the client want	30	1	5	3.78	1.42	0.25	60%
4. Building and maintaining relationship	30	1	5	3.70	1.12	0.19	57,5%
5. Constantly seeking better ways to do things	30	1	5	3.50	1.38	0.031	51.2%
6. Avoid defects in the work done	30	1	5	3.80	.99	0.27	60.6%
7. Involving the whole project team	30	1	5	3.20	1.56	- 0.13	55.2%
8. Increasing output flexibility	30	1	5	3.80	.99	0.27	60.6%
9. Use of prefabricated materials	30	1	5	2.90	1.39	- 0.44	67%
Valid N (list-wise)	30						

Average population mean = 3.46 & SD= 1.27

Z score is used to interpret the mean scores for the nine lean concepts related to management philosophy investigated. The "Z score" is one of the most widely used statistical tools used to standardize score, provided population means and the standard deviation is known. As such, the Z score is also known as the standard score. The Z score varies in the range of -3 times the standard deviation to +3 times the standard deviation with a mean of zero and a standard deviation of one. The formula for the Z score of a variable can be derived by deducting the mean of the population from the given variable (which is a part of the data set or population) and then dividing the result by the standard deviation of the population. Mathematically, it is represented as:

$$\boldsymbol{Z = \frac{(X - \mu)}{\sigma}}$$

Where,

X = Variable from the population

μ = Mean of the population

σ = Standard deviation of the population

Z score is done by converting the raw scores into Z score or standardized score. A positive Z score implies a score that is higher than the mean, while a negative Z score implies a score less than the mean. The Z score value is negative for four variables (lean principles 1, 2, 7 & 9) and positive for five lean principles (3, 4, 5, 6 & 8) as illustrated above. The negative Z score indicates the amount of standard deviation less than the average population means. Therefore, the Z score values for waste minimization, continuous improvement, involving the whole project team, and use of prefabricated materials are 0.13, 0.21, 0.13, and 0.44 standard deviation lower than the average population meant score(Mean=3.46). These indicate that 55.2% of the respondents scored less than the average mean for waste minimization and involving the whole project team; 58.2% and 67% of respondents scored less than the average mean score for establishing continuous improvement principle and use of prefabricated materials respectively. The use of prefabricated materials and continuous improvement principles were by far less present and less practiced in projects that have been run by Jimma Town municipality.

On the contrary, the positive Z indicates the amount of the standard deviation above the average population score. Five variables (Delivering what the client wants, building and maintaining the relationship, constantly seeking better ways to do things, avoiding defects, and increasing output flexibility) had positive Z values as seen in the table above. Respondents scored 0.25, 0.19, 0.031, 0.27 and 0.27 standard deviation above the average population score respectively in these principles. In other words, the majority of the participants about 60% scored above the average mean score for three lean principles: delivering what clients want, avoiding defects, and increasing output flexibility. About 57.5% of respondents scored more than the average mean score in building and maintaining relationship principles and half of the respondents about 51.2% scored above the population mean value for constantly seeking better ways to do things principle. Therefore, avoiding defects in the work done and increasing output flexibility was by far the most familiar lean principle technique in municipality projects.

These analyses answer the first research question which aims to assess the familiarity of management philosophy related to lean concept in Jimma municipal road infrastructure project management system. Accordingly, among the nine Management Philosophy /Activity/Practice related to lean concepts assessed: avoiding defects (60.7%) and increasing

output flexibility (60.7%) are reported more familiar compared to the rest. Whereas in the use of prefabricated materials (67%) were less familiar in their municipal road projects management system.

The respondents unanimously indicated that the importance of all of the above management philosophy in contributing towards improving project management performance for municipality projects.

Next the researcher examine the level of lean concept awareness among employees. As illustrated in the figure below about 60% of the participants had awareness while about 40% were reported they had lack of awareness about lean concepts and principles. Even though, the researcher site and document observation don't confirm this response.

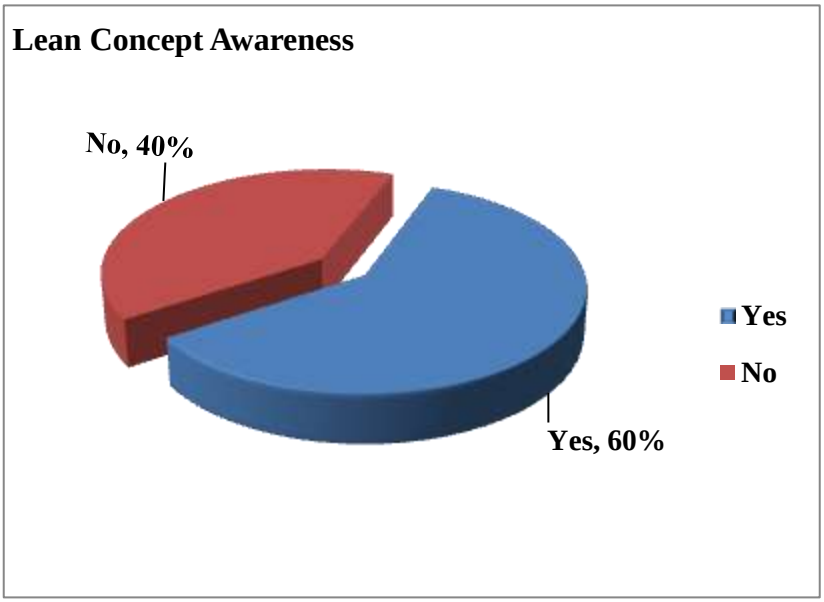

Figure 4.3: Awareness of lean concepts

In addition to the above general question, we asked the respondents about their awareness of lean related concepts 'Which of the following methods of lean construction concepts are you aware of? Check all that apply?' and their response are summarized below:

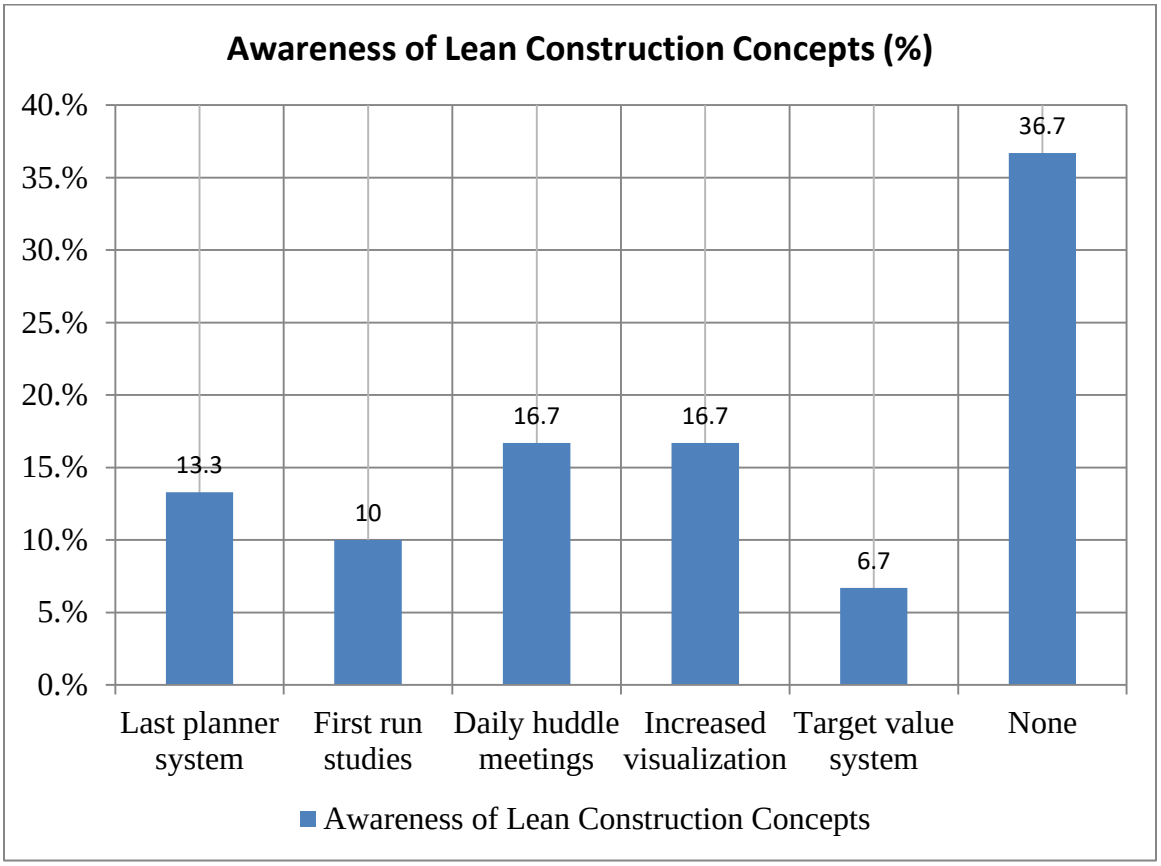

Figure 4.4: Awareness of Lean Construction Concepts

According to this survey, most of the respondents are not aware of lean construction concepts such as: Last planner system (only 13.3%), First run studies (10%), Daily hurdle meetings (16.7%), Increased visualization (16.7%), Target value system (6.7%) and those who do not aware any of the mentioned lean construction concepts are (36.7%).

4.2.2 Application of lean construction tools/techniques

The second research question was about the investigation of extent of lean construction tools application in Jimma municipality road infrastructure project management. The question formulated as "*What is the extent of application of the following techniques/tools in your organization?"* The following table particularizes the obtained responses.

Table 4.5 Application of lean construction tools/techniques in municipality projects

Lean tools/techniques		Scales						
		Very Little	Sometimes	Cum	Often	Always	Cum	Don't Know
Information management system (IMS)	count	4	5	9	12	3	15	6
Just-in-time (JIT) technique	count	6	3	9	9	6	15	6
Total quality management (TQM)	count	3	9	12	6	6	12	6
Continuous improvement programs	count	3	6	9	12	3	15	6
Use of prefabricated materials	count		12	12	6	9	15	3
Computer-aided design (CAD)	count		6	6	9	12	21	3
Preventive maintenance	count	6	3	9	9	9	18	3
Work place Optimization	count	3	6	9	12	3	15	6
Safety improvement program	count	6	15	21	6	3	9	
Concurrent engineering	count	6	6	12	12	6	18	
Last planner system	count	9	9	18	3	6	9	3
Daily huddle meetings	count	9	9	18	3	9	12	
PCWECI	count	6	9	15	6	6	12	3
Visual inspection	count	3	6	9	15	6	21	
Target value design	count	6	6	12	9	3	12	6
Six Sigma	count	6	3	9	9	6	15	6
	Average	**5**	**7**	**12**	**8**	**6**	**14**	**4**

In the table, an average of 12 people (40%) confirm that lean tools were either little applied or sometimes applied. Almost half of the participants 14(46.7%) reported the application of some of the techniques often in road projects management. Only 4(13.3%) individuals attested the lack of knowledge about most of the tools which were consistent with the response given for lean concept awareness. Computer-aided design (CAD), Visual inspection, Preventive maintenance, and concurrent engineering were techniques mostly

applied in the municipality road projects management. On the other hand, the Last planner system, Safety improvement program, Total quality management (TQM), Daily huddle meetings, Plan of Conditions and Work Environment in the Construction Industry (PCWECI), and target value design techniques were the least applied tools.

Generally, the response about the extent of application of lean tools/techniques in the organization summarized as 16.7% very little, 23.3% sometimes, 26.7% often and 20% always, the rest 13.3% respond don't know. Accordingly the result shows that the extent of application of lean construction principle is very low.

Following this, the respondents are asked "*Do you believe that Lean Construction will be implemented in Jimma municipal road projects management system?"* And their response summarized below:

Table 4.6 Implementation of lean construction

Implementation of lean construction					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	27	90.0	90.0	90.0
	No	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

When it comes to the future implementation of lean construction for municipal project management system the overwhelming majority of the respondents about 90% agreed about future implementation.

4.2.3 Barriers of Implementing Lean Construction

As illustrated in table below fifteen attributes were put to the respondents to identify major challenges influencing the application of lean construction tools and techniques. For this mean scores and standard deviation were computed. Since this statistic is raw value it at times means little and is difficult to interpret. Hence I converted these raw scores into a standard score using Z score statistics. A positive z-score indicates the raw score is higher than the mean average. A negative z-score reveals the raw score is below the mean average. If a z-score is equal to 0, it is on the mean.

Table 4.7 Barriers of lean construction implementation

	Barriers of lean technique implementation	Mean	SD	Z Score	%
1	Ineffective communication channels between construction team	3.9	1.24	0.24	40.9
2	Unfavorable organizational culture	3.9	1.16	0.24	40.5
3	The influence of traditional management practices	3.5	1.22	-0.10	46.1
4	Additional cost and high inflation rates	3.5	1.14	-0.10	46.1
5	Lack of committed leadership from top management	3	1.58	-0.52	30.15
6	Lack of knowledge of the lean construction approaches	3.8	1.42	0.15	44
7	Lack of technical skills, training of lean techniques	3.8	1.35	0.15	44
8	Lack of a robust performance measurement system	3.5	1.31	-0.10	46.1
9	Improper resource management	3.7	0.79	0.07	47.2
10	Lack of support from government for technological advancements	3.5	1.38	-0.10	46.1
11	Lack of technological adaptations	3.8	1.10	0.15	44
12	Use of non-standard components	3.7	1.21	0.07	47.2
13	Uncertainty in the supply chain	3.6	0.81	-0.02	49.6
14	Lack of provision of benchmark performance	3.5	0.94	-0.10	46
15	Slow decision making processes	3.9	1.16	0.24	40.5

Population Mean = 3.62
Standard Deviation =1.19

From the above table, seven attributes highlighted in the light-dark in the table had negative z-scores. Mean values for these attributes are 0.10, 0.02, and 0.52 standard deviation below the average mean (Mean= 3.62 & SD=1.19). As opposed to these the remaining 8 variables had positive z-score values which indicate changes or increment of mean values above-average population mean for positive attributes. Therefore, use of non-standard components(47.2%), improper resource management(47.2%), lack of knowledge of the lean construction approaches(44%), lack of technical skills training of lean techniques(44%), unfavorable organizational culture(40.5%), ineffective communication(40.9%), and slow

decision-making process(40.5%) was comparatively identified as the main challenges in the implementation of lean tools and techniques. Among these, the use of non-standard components and improper resource management stands out as the major challenges because these two attributes receiving by far the highest level of agreement which was 47.2% among the participants who took part in the study. And this analysis respond the third research question.

4.3Inferential Analysis

The inferential analysis aims to answer the last research question which inquires about the variety of responses among participants based on their demographic profile. Chi-square, t-test, and analysis of variance used analysis of the data. The first step is to check whether employees' responses significantly vary in terms of the awareness of the lean concept. The Chi-square test is used for this since the two variables measured were categorical. The second and third analyses examine whether the variation of perception exists between employees in terms of the extent of the application of lean principles, tools and techniques, and challenges affecting lean implementation.

4.3.1 Chi-Square

The following table is the first output of chi-square analysis and it illustrates percentage variation between male's and female's responses regarding lean concept awareness. The result shows that lack of knowledge about the lean concept was dominantly observed among men about 40%, no female had fallen in this category.

Table 4.8 Cross tabulation

Gender * Cross tabulation					
			Are you aware of lean construction concepts?		Total
			Yes	No	
Gender	Male	Count	15	12	27
		% within gender	55.6%	44.4%	100.0%
		% of Total	50.0%	40.0%	90.0%
	Female	Count	3	0	3
		% within gender	100.0%	0.0%	100.0%
		% of Total	10.0%	0.0%	10.0%
Total		Count	18	12	30
		% within gender	60.0%	40.0%	100.0%
		% of Total	60.0%	40.0%	100.0%

In terms of the association of response or whether the variation in response between males and females is statistically significant, it is important to observe the following table.

Table 4.9 chi-square test

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.22[a]	1	0.136		
Continuity Correction	0.756	1	0.385		
Likelihood Ratio	3.285	1	0.070		
Fisher's Exact Test				0.255	0.201
Linear-by-Linear Association	2.148	1	0.143		
N of Valid Cases	30				

a. 2 cells (50.0%) have an expected count of less than 5. The minimum expected count is 1.20.
b. Computed only for a 2x2 table.

The first thing we need to check is whether we have violated one of the assumptions of chi-square concerning the 'minimum expected cell frequency, which should be 5 or greater (or at least 80 percent of cells have expected frequencies of 5 or more). As we can see at the bottom of the table the minimum expected count is 1.20 which means we have violated the assumption. In this case, it is advisable to report Fisher's exact test of significance.

Pearson Chi-Square statistics which shows the correlation between males and females is 2.22, with an associated significance level of 0.255 (this is presented in the column labeled Exact Sig. (2-sided)/ (2-sided). To be significant the Sig. value needs to be .05 or smaller. In this case, the value of 0.255 is larger than the alpha value of 0.05, so we can conclude that our result is not significant. This means that the proportion of variation in lean concept awareness between males and females was not significantly different from one another. The result was also not different between respondents in terms of their job position as illustrated in the chi-square table below. Meaning there is no significant difference in the level of lean concept awareness between employees of the municipality based on their post.

Table 4.10 Job position

Chi-Square Tests						
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	9.167[a]	4	0.057	0.043		
Likelihood Ratio	12.288	4	0.015	0.030		
Fisher's Exact Test	7.812			0.066		
Linear-by-Linear Association	5.383[b]	1	0.020	0.024	0.011	0.007
N of Valid Cases	30					

a. 8 cells (80.0%) have an expected count of less than 5. The minimum expected count is 1.20.
b. The standardized statistic is -2.320.

Besides lean concept awareness, inferential analysis was also run to examine the variation of perception on lean tools implementation and barriers between employees based on gender and job position. An independent-samples t-test is used when we want to compare the mean score, on some continuous variable, for two different groups of subjects. An independent-samples t-test will tell us whether there is a statistically significant difference in the mean scores for the two groups (that is, whether males and females differ significantly in their response to the implementation of lean tools and barriers).

4.3.2 T-Test

Table 4.11: T-Test

Independent Samples Test										
		Levene's Test		t-test for Equality of Means						
		F	Sig.	T	df	Sig.	Mean Diff	Std. Er	95% CI Difference	
									Lower	Upper
Implementation of lean tools	Eqva	5.532	.026	2.088	28	.046	1.11806	.53535	.02145	2.21466
	Eqvna			6.364	26	.000	1.11806	.17568	.75694	1.47918
Barriers	Eqva	4.155	.051	-.441	28	.663	-.25185	.57145	-1.422	.91871
	Eqvna			-1.34	26	.191	-.25185	.18753	-.63732	.13362

Equal variances assumption is not violated since the significance level of Levene's test is greater than 0.05. To find out whether there is a significant difference between the two groups in their response in two variables we need to refer to the column labeled Sig. (2-tailed), which appears under the section labeled t-test for equality of means. The value in the Sig. (2-tailed) column for implementation of the lean tool is 0.045 which is less than the .05 cut-off value which means there is statistically significant variation between males and females in their response to the implementation of lean tools variable. Contrary to this significance value for barriers affecting lean implementation is greater than 0.05 indicating a lack of statistically significant difference between the two groups.

4.3.3 One-way

One-way ANOVA will tell you whether there are significant differences in the mean scores on the dependent variable across the three groups.

Table 4.12: Analysis of variance

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Familiarity of the lean related management philisophy	Between Gps	5.630	4	1.407	1.294	.303
	Within Gps	23.926	22	1.088		
	Total	29.556	26			
Implementation of lean tools	Between Gps	2.651	4	.663	.740	.574
	Within Gps	22.391	25	.896		
	Total	25.042	29			
Barriers to lean	Between Gps	4.516	4	1.129	1.388	.267
	Within Gps	20.342	25	.814		
	Total	24.859	29			

The main thing we are interested in is the column marked Sig. If the Sig. value is less than or equal to 0.05 then there is a significant difference somewhere among the mean scores on our dependent variables for the job position groups. Here all cases the significant value in the last column surpasses the cutoff value indicating no significant difference between the groups in their response to the familiarity of lean principles, implementation of lean tools, and barriers to lean implementation.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Literature shows that the Ethiopian construction industry is characterized by poor performance when it comes to meeting project requirements such as cost, time, and quality. Extant literature on projects run by Jimma municipality has shown similar poor performance. Thus introducing a new way of project management is crucial to mitigate project performance inefficiency. The lean construction management system has recently got traction by different firms and organizations to achieve efficiency and effectiveness. Provided the importance of this system, this study aims to assess the Practice of Lean Construction Principle in road projects run by Jimma Municipality. With this objective the researcher targeted to create more understanding and momentum for the implementation of a lean management system in Jimma municipality infrastructure projects.

So, the paper has investigated and tried to answer four basic questions. The first one was to assess the familiarity of lean construction principle in the Jimma municipal road infrastructure project management system. Among the Management Philosophy/Activity /Practice related to lean concept assessed avoiding defects (60.7%) and increasing output flexibility (60.7%) were reported to have more familiar compared to the rest. Whereas the use of prefabricated materials (67%) were less familiar in municipal road projects management. The researcher also examines the level of lean construction concept awareness among employees of Jimma municipality. The result shows that majority of the participants about 60% had awareness while a few about 40% was reported a lack of awareness about lean concepts and principles. Secondly, it examined the extent of the application: the response about the extent of application of lean tools/techniques in the organization summarized as 16.7% very little application, 23.3% apply sometimes, 26.7% apply often and 20% apply always, the rest 13.3% respond don't apply. Accordingly the result shows that the extent of application of lean construction principle is very low. The respondents were also asked about the future implementation of lean construction: the overwhelming majority of the respondents about 90% agreed future implementation of lean construction for project management system.

Concerning identifying major challenges influencing implementation of lean construction principle tools/techniques, results show the use of non-standard components(47.2%), improper resource management(47.2%), lack of knowledge of the lean construction approaches(44%), lack of technical skills, training of lean techniques(44%), unfavorable organizational culture(40.5%), ineffective communication(40.9%), and slow decision-making process(40.5%) were comparatively identified as the main challenges in the implementation of lean tools and techniques. Among these, the use of non-standard components and improper resource management stands out as the major implementation challenges because these two attributes receiving by far the highest level of agreement which was 47.2% among the participants.

The last research question were answered through inferential analysis & the result did not show significant awareness difference between employees in their response to the familiarity, implementation of the lean concept & barriers to lean implementation. Further, the result did not show a significant awareness difference between employees in terms of the lean construction management concept based on their demographic characteristics.

5.2 Recommendation

The following recommendations were made based on the results of the study;

- The familiarity of management philosophies/activities/practices related to lean concepts were checked in the road project management system run by Jimma municipality. The result shows only a few such as avoiding defects and increasing output flexibility were relatively reported visible. Important principles such as the use of prefabricated materials and practice of the principle of continuous improvement were less visible and little practiced in the municipal road project management systems. These could increase project timing and costs as well. Therefore, to harness the benefit of a lean management system all lean principle are equally needed to be considered and put into practice.
- Although the majority of the participants had awareness about the lean concept, the level of awareness was shallow. Majority of those who reported having awareness know some principles and tools. Therefore, awareness creation work is needed to provide more understanding about lean management systems to enhance their application.
- To address the implementation of lean construction management systems management should address challenges such as the use of non-standard components, improper resource management, lack of knowledge of the lean construction approaches, lack of technical skills, and training of lean techniques, unfavorable organizational culture, ineffective communication, and slow decision-making process.

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APPENDIXES

Data collection instrument (Questionnaire)

Appendix A: Survey Questionnaire

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

A Survey Questionnaire is to be completed by employees of the Jimma Municipality Infrastructure department.

Dear respondents,

This questionnaire is designed to solicit data for an MSc research entitled "***The Practice of Lean Construction Principle in Jimma Municipal Infrastructure Projects: The Client's Perspective"***.Your responses will be completely anonymous or are kept confidential and used only for academic purposes. I am grateful to you for taking your time and fill in this questionnaire. No matter how cautious it is, this study will not achieve its objectives without your assistance. Hence, I kindly request you to genuinely fill out and return the questionnaire.

You are invited to participate in this research because you are a major stakeholder in the infrastructure construction in Jimma Municipality.

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Jimma, 2021

Lean construction is an approach that tries to manage and improve construction processes with minimum cost and maximum value by reducing waste of materials, time, and effort.

Instruction for completing the questionnaire

Please put a "√" mark on the space provided to indicate your response where applicable. In the case where responses other than marks are required, please write your response in the space provided.

Part one:

1. **Background Information**

1.1	**Organization Name**	Jimma Town Administration Infrastructure Department	
1.2	**Gender**	☐ **Male**	☐ **Female**
1.3	**Position (work title) in the Department**	_____	
1.4	**Working experience in the Construction industry (Years)**	_____	
1.5	**Your General experience in work related to public road Infrastructure construction (Years)**	_____	
1.6	**Your Age**	_____	
1.7	**Educational background**	☐ Doctor Degrees (Ph.D.)	☐ Master Degree (MA/MSc)
		☐ Bachelor (BA/BSc)	☐ Diploma
		☐ Certificate	
		If other (Please specify) _____	

Part II: Familiarity & Awareness

2.1 Familiarity of lean concept related management system in your work process

2.1.1 Please rate to what extent (using a scale of 1-5) the following management philosophy/activities are familiar in your project management system (1 = not at all; 2 = very little· 3 = somewhat; 4 = moderately; 5 = to a large extent).

2.1.2 Please rate how important do you consider the following management philosophy/practices to be in contributing towards your project management performance (1 =not important; 2 = less important; 3 = neutral; 4 = important; 5 = very important).

management philosophy/activities/ practices in your projects	**2.1** Extent of familiarity					**2.2** Level of Importance				
	1	2	3	4	5	1	2	3	4	5
Waste minimization										
Establishing continues improvement										
Delivering what the client wants										
Building and maintaining the relationship with partners										
Constantly seeking better ways to things										
Avoid defects in the work done										
Involving the whole project team including contractors & specialists from design to construction										
Increasing output flexibility										
Use of prefabricated materials										

2.2 Awareness about lean construction management

2.2.1 Are you aware of lean construction concepts?

a) Yes ☐

b) No ☐

2.2.2 Which of the following methods of lean construction concepts are you aware of? Check all that apply?

Last planner system ☐

First, run studies ☐

Daily hurdle meetings ☐

Increased visualization ☐

Target value system ☐

None ☐

Part III: Application

3.1 Application of lean construction tools/techniques in municipality projects

3.1.1 What is the extent of application of the following techniques/tools in your organization?

*Please indicate the **extent of application** of the following techniques in your organization's project management system. Put "√" (mark) on the space provided to indicate your response by using the following: Where; 1=Never, 2=Very Little, 3 = Somewhat, 4= Often, and 5=Always.*

	Techniques/Tools	Likert Scale					Don't Know
		1	2	3	4	5	
1	**Information management system (IMS)** (IMS is used to create an inventory of the very large bill of materials. It provides information required by organizations to manage them efficiently and effectively.)						
2	**Just-in-time (JIT) techniques** (JIT refers to the just-in-time ordering of resources or materials						

	Techniques/Tools	Likert Scale					Don't Know
		1	2	3	4	5	
	when there is a need. This improves the efficiency and timely execution of projects.)						
3	**Total quality management (TQM)** (TQM refers to the organizational efforts to develop a permanent climate in which an organization continuously improves its ability to deliver high-quality products and services to customers.)						
4	**Continuous improvement programs** (incremental improvement of processes over time)						
5	**Use of prefabricated materials** (Such as precast concrete for ditch cover, manhole, etc.)						
6	**Computer-aided design (CAD)** (Use of Computer Systems in the Design Process)						
7	**Preventive maintenance** (involves tests, measurements, adjustments, and parts replacement, performed specifically to prevent faults from occurring)						
8	**Workplace Optimization - 5 S** (includes looking at the basics of a project, fundamental project steps, systematic approach in projects, quality determination and project safety improvements and adjustments)						
9	**Safety improvement program** (reducing fatalities and serious injuries on a construction site)						
10	**Concurrent engineering** (parallel execution of development tasks by multi-disciplinary teams to obtain an optimal product in terms of functionality, quality, and productivity)						
11	**Last planner system**						

	Techniques/Tools	Likert Scale					Don't Know
		1	2	3	4	5	
	(production planning system designed to produce predictable workflow)						
12	**Daily huddle meetings** (a way to follow up the highly variable events that affect assignments)						
13	**Plan of Conditions and Work Environment in the Construction Industry (PCMAT)** (way of introducing health and safety into the project execution)						
14	**Visual inspection** (increases the speed of operation and reduces the risk of choosing the wrong material through easy material identification)						
15	**Target value design** (the final project cost is considered a design parameter and design is made according to the target cost)						
16	**Six Sigma** (creating value for customers by reducing variability in the products and services through the use of statistical tools based on a sound cultural shift)						
17	Others (please write) ……. …….....						

3.2 Do you believe that Lean Construction will be implemented in Jimma municipal road projects management system?

Yes ☐

No ☐

Part IV: Lean Implementation Barriers

4.1 Barriers to the implementation of lean construction

4.1.1 What are the major types of barriers to the adoption of lean construction to municipal project management? Please choose the range (1 = Strongly Disagree; 2 = disagree; 3 = neutral; 4 = agree, and 5= Strongly Agree)

	Barriers to the application of lean construction principles in municipal projects	1	2	3	4	5
1	Ineffective communication channels between the construction team					
2	Unfavorable organizational culture					
3	The influence of traditional management practices					
4	Additional cost and high inflation rates					
5	Lack of committed leadership from top management					
6	Lack of knowledge of the lean construction approaches					
7	Lack of technical skills, training, and understanding of lean techniques					
8	Lack of a robust performance measurement system					
9	Improper resource management					
10	Lack of support from the government for technological advancements					
11	Lack of technological adaptations					
12	Use of non-standard components					
12	Uncertainty in the supply chain					
14	Lack of provision of benchmark performance					
15	Slow decision-making processes					