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

ASSESSMENT OF LEAN CONSTRUCTION PRACTICE ON BUILDING CONSTRUCTION PROJECTS: A CASE OF JIMMA CITY

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

By

WONDIMAGEGN GEBEYEHU GANEBO

April 2021

Jimma, Ethiopia

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

ASSESSMENT OF LEAN CONSTRUCTION PRACTICE ON BUILDING CONSTRUCTION PROJECTS: A CASE OF JIMMA CITY

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

By

Wondimagegn Gebeyehu Ganebo

Advisor: Eng. BIEN MAUNAHAN (Assistant Prof.)

Co-Advisor: Eng. MEBRATU ABERA (MSc.)

April 2021

Jimma, Ethiopia

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

ASSESSMENT OF LEAN CONSTRUCTION PRACTICE ON BUILDING CONSTRUCTION PROJECTS: A CASE OF JIMMA CITY

By

Wondimagegn Gebeyehu Ganebo

APPROVED BY BOARD OF EXAMINERS: -

Main Advisor Engr. Bien Maunahan (Assistant Prof.)	Signature	Date
_____	_____	_____/____/____
Co-advisor Engr. Mebratu Abera (MSc.)	Signature	Date
_____	_____	_____/____/_____
External Examiner Dr. Bahiru Bewket	Signature	Date
_____	_____	_____/____/_____
Internal Examiner Engr. Teshome Boja	Signature	Date
_____	_____	_____/____/_____
Chairperson Engr. Mamaru Dessalegn	Signature	Date
_____	_____	_____/____/_____

April 2021

Jimma, Ethiopia

DECLARATION

I declare that this research entitled "Assessment of Lean Construction Practice on Building Construction Projects: A Case of Jimma City" is My original work and has not been submitted as a requirement for the award of any Degree in Jimma University or elsewhere.

Wondimagegn Gebeyehu Ganebo _____ _____

Candidate Signature Date

As research Adviser, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance by WONDIMAGEGN GEBEYEHU GANEBO entitled "ASSESSMENT OF LEAN CONSTRUCTION PRACTICE ON BUILDING CONSTRUCTION PROJECTS: A CASE OF JIMMA CITY" and recommend and would be accepted as a Partial fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

Eng. Bien Maunahan (Assistant Prof.) _____ _____

Main Advisor Signature Date

Eng. Mebratu Abera (MSc.) _____ _____

Co-Advisor Signature Date

ABSTRACT

Lean Construction is a new Practice of Designing and Managing Construction Projects to reduce project time, cost, and wastages of resources, and it adds maximum value for the Project. The implementation of Lean Construction Practices includes culture, plans, techniques, tools, and concepts to maximize value while minimizing all construction waste forms. However, this Practices are still not fully implemented on building construction projects in Ethiopia. Due to this, there are many problems with building construction projects in Ethiopia, like cost overrun, delay, and wastage of resources, etc. The study aims to assess the Lean Construction Practice on building construction projects in a Jimma City using descriptive type of research. For this descriptive study, questionnaires were designed and distributed for purposively sampled consultants and contractors involved in building construction projects in Jimma city. Therefore; to achieve the objectives of the study both quantitative and qualitative data collection methods were used. Hence, the data was collected through a structured questionnaire, semi structural interview and observations then analyzed and presented by table, chart and graphs using MS word and excel sheet. The result of the study identified that LC practices implemented on building construction projects in the case of Jimma city are regular performance measurement of site workers, identification of client needs, project needing immediate attention is given more importance, strict criteria for the selection of a subcontractor and involvement of project participants in the making of schedules based on their RII value. Also it determined that 50% of respondents have average level of awareness on LC Practices and 46% respondents have said that the implementation of LC practices on building construction projects is effective. The study concludes that; some of the lean construction practices are implemented, firms have average level of awareness and partially effective implementation of LC practices to minimize construction wastes and add value for building construction projects in Jimma City. Therefore, training and workshop on lean construction practices are necessary to increase its level of implementation for stakeholders involved in building construction projects.

Keywords: *Building construction, Lean construction, Lean principles, Lean techniques, and Lean tools.*

ACKNOWLEDGMENT

I would like to acknowledge My special thanks to the almighty GOD for empowering and giving to me inner courage and strength to accomplish My Educational career one-step further. I would like to express also My sincere gratitude to My Advisor Engr. Bien Maunahan (Assistant Prof) and Co-Advisor Engr. Mebratu Abera (MSc.) for their excellent and constructive comments, continued guidance, and great support for this research's successful accomplishment.

Secondly, I would like to thank Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering, Construction Engineering and Management chair for all their limitless efforts to guide me through My work and provide to me useful reference materials.

Additionally, I would like to acknowledge Dilla University for giving me such a precious chance to study Master of Science in Construction Engineering and Management.

Finally, I would like to thank My Family Specially My Wife Brahanesh Gebeyehu, My Father Mr. Gebeyehu Ganebo, My Brothers Gizahun Gebeyehu and Ayalew Gebeyehu, and My Sister Zelalem Gebeyehu, who encouraged and supported me in every aspect of the situation, even finalizing this research paper and to my Mother Agegnehush Belango, who sacrifice her life to me in every aspect of my life and may God rest in peace her soul. My Friends for their constructive Comments and Reviewing this Research Paper.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYM

EEA	Ethiopian Economic Association
GDP	Growth Domestic Product
GC	General Contractor
IGLC	International Group of Lean Construction
JiT	Jimma Institute of Technology
JIT	Just In Time
JU	Jimma University
LC	Lean Construction
LPs	Lean Practices
LCI	Lean Construction Institute
RII	Relative Importance Index
TPS	Toyota Production System

CHAPTER 1

INTRODUCTION

1.1 Background

The concept of Lean Construction is derived from the concepts and theory of Lean Production and developed in the Toyota Production System (TPS) by Ohno in the 1990s, whose main principles are the elimination of wastes in any production process and activities to cause a reduction in the process cycles, an improvement in product quality and increment in the efficiency of projects (Babalola et al., 2019). Lean Construction (LC) is defined as the combination of operational research and practical improvement in design and construction with an adaption of lean manufacturing principles and practices to the end-to-end design and construction process (Remya et al., 2019).

Lean Construction is defined as an integrated system to combine production management theories, construction management theories, and the construction industry's characteristics. Moreover, lean construction is also a management system that aims to reduce waste and achieve customers' requirements (Zhang, 2019). Lean Construction's theories deliver the best quality, at the lowest cost, and the shortest lead-time to its clients and achieve the desired project requirements (Pontes et al., 2008).

Lean construction is a new practice of designing and managing construction projects to reduce project time, cost and reduce wastages of resources, and it adds maximum value for the client (Sholanke et al., 2019). The main aim of Lean Construction is to minimize all non-value-adding activities or wastes related to resources and time in construction projects (Aslam et al., 2019). The term 'Waste' in Lean Construction terminology has a broad meaning and forms that include multiple types(Tafazzoli et al., 2020). However, waste from the lean concepts includes material waste and all kinds of waste generated in the production process. Such wastes include delay, over-processing and ordering, excess motion, labor and inventory, defects, and other non-value-add activities for construction projects (Babalola et al., 2019). Many studies have identified the causes of waste in construction projects. Ohno (1988) suggests that the causes of waste are related to overproduction, waiting, transportation, over-processing, inventory, movement, and defects (Sarhan et al., 2019).

By minimizing wastes, Lean Construction Practices pursues maximizing the generation of value for the owner (Tafazzoli et al., 2020). Initially, LC emphasizes waste reduction from the technical and operational perspective and then eliminates harmful relationships while promoting teamwork between the supply chain managers. Therefore, it is important to ensure waste generation is minimized in construction processes and activities (Remya et al., 2019).

Much research on Lean Construction Practices globally aimed to reduce environmental degradation because of waste from construction and facilitate the maximization of clients' value. It has maximized benefits and improved workflow reliability in the construction industry in developed and developing countries (Sholanke et al., 2019).

Several construction companies have attempted to implement Lean Construction Practices worldwide (USA, UK, Germany, China, Chile, Brazil, India, Nigeria, Egypt, etc.). However, most of the companies have applied this management philosophy to their understanding of Lean Construction Principles. (Bajjou and Chafi, 2018).

Lean Construction Practices' implementation is still not well established in the construction industry than other sectors like the manufacturing industry, in the construction industry view of the stakeholders in acceptance of Lean Construction Practice as a departure from the traditional construction process (Babalola et al., 2018). It is due to the lack of a clear idea of the main Lean Construction Practices, including techniques and tools that constitute the Lean Construction concept (Bajjou and Chafi, 2018). Lean Construction is understood as a new model for project management, thereby challenging traditional construction and project management. One of the major barriers to implementing Lean Concepts in construction is the low level of awareness among construction industry construction professionals.

As a result, the construction industry is characterized by many wastes, including overproduction, lead time, transportation, inappropriate processing, inventories, unnecessary movements, rework, and making do wastes. It can only be achieved by adopting lean production systems in the construction industry, thus, Lean Construction (LC). The LC approach and its importance have been discussed as the strong approach for project management (Richard et al., 2016). The research on Lean Construction is more focused on the theoretical part and less on the actual practice, and its implementation in construction projects lagged behind the manufacturing sector. Lean

Construction Practices' successful implementation is limited to few construction companies (Aslam et al., 2019).

So, to bridge this gap in research and improve the level of awareness of the current state knowledge of Lean Construction Practices and implementation of its principles, techniques, and tools among construction stakeholders in the Ethiopian construction industry that this study expected to assess Lean Construction Practice on Building Construction Projects, a case of Jimma City.

1.2 Statement of the Problem

The conventional project management approach in construction industry is not effective for complex projects anymore due to the traditional construction project management (Marwa, 2013). Many researchers have stated that fast, complex, and uncertain projects cannot be managed through conventional ways. The fast-track projects with long, complicated supply chains involving many companies and subject to multiple, extensive process design changes have complex flow management that has failed miserably (Richard et al., 2016).

However, construction projects have been faced with many problems such as poor quality of works, cost, and time overruns. Consequently, Lean Construction Practice is a way of mitigating this problem (Sholanke et al.,2019). Implementation of Lean Construction Practices, including principles, strategies, tools, and ideas, is one of the most effective methods for improving project management in the construction industry to maximize construction projects' value while minimizing all waste varieties (Primayuda et al.,2019).

Still, in construction work done and ongoing projects, there are few signs of implementing these Lean Construction Practices, and the effort of improvement in practice looks to be missing. Construction companies seem to know that Lean Construction is a clever solution to reduce waste and improve construction projects' productivity. Nevertheless, the companies still have trouble understanding how to implement the tools and utilize them in their projects. To understand how Lean is used in the construction industry, it is necessary to see how far the industry has come, find if there are obstacles and significant thresholds, and point to where the next steps might be (Ragnhild, 2019). The research on Lean Construction is more focused on the theoretical part, and less on the actual practice, and its implementation in construction lagged behind the manufacturing sector. Lean Construction Practice's successful implementation is limited few numbers

construction companies and still not fully implemented in construction projects (Aslam et al., 2019).

In Ethiopia, Lean Construction Practices are not yet fully implemented on Building Construction Projects to obtain its maximum benefits to reduce project time, cost, and resources. Many Building Construction Projects in Ethiopia like cost overrun, delay, lack of quality and wastage of resources, etc. To this end, because of these reasons, the researcher is interested in this study title to assess the Lean Construction Practices on Building Construction Projects in the case of Jimma City.

1.3 Research Questions

1. What are the Lean Construction Practices implemented on Building Construction Projects in Jimma City?
2. What are the levels of awareness of Lean Construction Practices among firms in the Building Construction Projects in Jimma City?
3. How can be Lean Construction Practices Efficiently implemented on Building Construction Projects in Jimma City?

1.4 Objectives of Research

1.4.1 General Objectives

This research's main objective is to assess the Lean Construction Practice on Building Construction Projects in Jimma City.

1.4.2 Specific Objectives

The Specific Objectives of this research listed as follows:

1. To identify the Lean Construction Practices implemented on Building Construction Projects in Jimma City.
2. To determine the level of awareness of Lean Construction Practices among firms on Building Construction Projects in Jimma City.
3. To evaluate the Efficiency of Implementing Lean Construction Practices on Building Construction Projects in Jimma City.

1.5 Scope and Limitation of the Study

In the construction industry, there are many firms and stakeholders. However, it is hard to cover all construction projects involved in construction industry due to the wider nature of the industry. Therefore, the scope of the study was assessing Lean Construction Practice in Building

Construction Projects sector only. Also, the targeted population was Building Construction projects in Jimma city; the samples were Consultants and Contractors involved in these projects. The study was limited on a few number of construction projects actively under construction, willingness of respondents to give enough data, lack of awareness of the respondents on the study, grade of consultants and contractors in Jimma city.

1.6 Significance of the Study

The study is significant for different construction projects stakeholders to consider the Lean Construction Practices. Furthermore, this study would help construction regulatory bodies, construction professionals, construction firms, research students, and educators to identify the Lean Construction Practices and effectiveness of implementing its principles, tools and techniques on Building Construction Projects. This study contributes to Ethiopia's construction industry by analyzing the minimization of waste of resources, maximization of value of projects, and implementing Lean Construction Practices on Building Construction Projects for stakeholders.

1.7 Research Structures

Figure 1.1 below shows the Research Structures described in their sequential order.

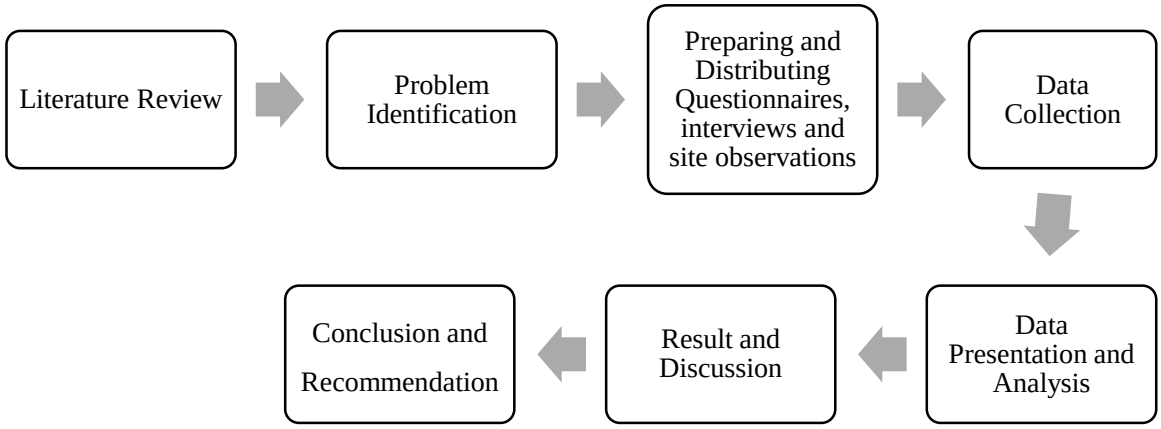

Figure 1.1 Research Structures

CHAPTER 2

LITERATURE REVIEW

2.1 General Overview

The construction industry has both a direct and indirect impact on a given national economy. According to (EEA,2008) the construction industry contributes to the Ethiopian economy, which recently shares 5.6% of the GDP. Different studies show that the Ethiopian construction industry's performance is poor in meeting project requirements such as cost, time, and quality. Realizing these situations, Lean Construction has significant benefits for improving the construction industry's performance (Ayalew et al., 2016).

Lean thinking involves added value, continuous improvements, flattened organizational structures, the elimination of waste, teamwork, the efficient use of resources, and cooperative supply chain management (Zhang, 2019).

Lean Construction is a way of designing production systems to minimize waste of time, materials, and efforts, maximizing the amount of value on Projects. Different studies on Lean Construction Practices globally are expected to reduce environmental degradation due to waste from the Construction industry and enable the maximization of value for Clients. Though, Lean Construction Practice is a way of mitigating these problems (Sholanke et al.,2019). According to Akinradewo et al. (2018) waste reduction, effective administration of materials on-site, improved lifecycle cost, good project coordination, improved safety on-site, and greater productivity are the six benefits of implementing Lean Construction Practices.

Several research types are being done in the recent past to adopt lean management principles in construction sites worldwide. There are many challenges in implementing Lean Construction Practices in construction industries (Remya et al., 2019).

In Ethiopia, the past studies show that the influential barriers that will hinder the implementation of Lean Construction Practices in the Ethiopian Construction Industry. From these realities, it can be concluded that at least there is some Level of Awareness among professionals about Lean Construction even though Lean Construction is still not practiced in the Ethiopian Construction Industry (Ayalew et al., 2016).

2.2 Concept of Lean Construction

The concept of Lean Construction is traced from Lean production theory and developed in the Toyota Production System (TPS) by Ohno in the 1990s. Lean Construction is defined as the combination of operational research and functional development in design and construction with an adaption of lean manufacturing principles and practices to the end-to-end design and construction process (Remya et al., 2019). The key concept of Lean Construction is to enable the flow of steps by reducing the non-value-added activities, which are time, resource, or space consuming. It emphasizes process improvement through the decrease of duration for each activity. The concept of Lean Construction provides the base for the grounds of project management (Radhika and Sukumar, 2017).

The Lean philosophy arises to integrate into the construction industry as a new construction project management method aiming to eliminate waste and create value to the customer(Tejas and Ashwini, 2018). Lean Construction has advanced from Lean manufacturing principles. Lean Construction and its various tools like the Last Planner System, Just in Time, Total Quality Management, and Continuous Improvement have received a lot of attention in developing nations (Mahashabde, 2016). In 1993 at a conference of the International Group of Lean Construction, Koskela proposed lean construction. The International Group of Lean Construction (IGLC) and the Lean Construction Institute (LCI), as two leading lean construction research institutions, have been set up since Lean Construction was first introduced. Today, an increasing number of studies focus on this research area (Zhang, 2019). LC is a concept that involves applying lean manufacturing principles or lean thinking into the construction industry (Richard et al., 2016). The lean concept is all about getting the right things to the right place at the right time, in the right quantity, while minimizing waste and being open and responsive to change (Adegbembo et al., 2016). It focuses on reducing waste, increasing value to the customer, and continuous improvement (Bhargav et al., 2015).

According to Radhika & Sukumar (2017) Lean construction aims to achieve customer satisfaction by using less of everything, i.e., materials, money, and resources. The main aim of Lean construction is to minimize all non-value-adding activities related to resources and time in construction projects (Aslam et al., 2019).

Mohd et al. (2013) stated that the key concept of lean construction is described in Fig 2.1 below; Hence, it is important for the stakeholders to responsible and chooses the best approach of the key concepts that right to be implemented in their construction sites.

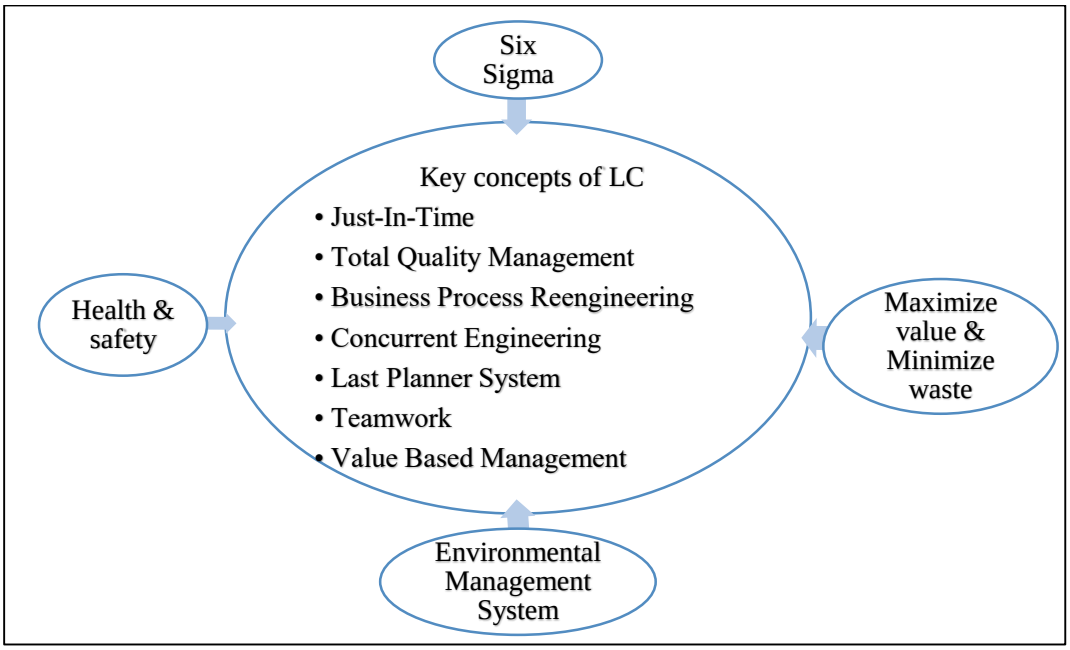

Figure 2.1 The Key Concept of Lean Construction (Mohd et al., 2013)

Generally, Lean Construction has become an effective way to design construction systems, aiming to reduce all waste forms and create the customer's maximum value. It is beneficial to the customer since it has fewer defects to the contractor. It uses fewer resources and external systems such as the environment since it decreases the waste (Saygili et al., 2019).

2.3 Principles of Lean Construction

Lean Construction principles refers to the approaches, strategies, and tools used in achieving the objectives of the concept of Lean Construction (Sholanke et al., 2019). Lean primary principles were practiced to include reducing waste within the value stream, synchronizing, aligning, providing transparency as part of the planning process, and integrating Transformation Flow Value production theory as part of the lean implementation process (Adegbembo et al., 2016). Lean Construction uses the same Lean Production principles to reduce waste and increase productivity and effectiveness in construction work (Tejas and Ashwini, 2018).

The principles of LC converge to the sustainability objectives in two main ways. First, through the focus on the concept of waste-reduction. Secondly, through the concept of 'value,' LC could

be useful to clients aiming for both business and environmental and social excellence simultaneously (Sarhan et al., 2019). Lea construction Principles state that only conversion activities add value, and these should be made more efficient, whereas non-value-adding flow activities should be reduced or eliminated (Ayalew et al., 2016).

Mahashabde (2016) and Dinesh (2017) states that Lean construction will on the five principles that will maximize profit and reduce waste. These are: -

1. **Specify Value**: The customer's needs define it through the management of tools and simulation. These are characterized by the client's satisfaction with delivery (Dinesh, 2017)
2. **Mapping the Value Stream**: Identifies the stream required to make a product. Mapping raises the performance possibilities during construction. 'Value Stream' is identified through value stream mapping (Mahashabde, 2016).
3. **Flows**: It is a basic unit of analysis in LC. It ensures the activities in a continuous flow in the stream (Dinesh, 2017) .
4. **Pull**: It delivers the product according to the needs of the customer's just in time
5. **Perfection**: Always obtain the customer's need in perfection and expect continuous removal of waste in the flow process (Mahashabde, 2016). Lean construction can be examined through the essential elements, and it undergoes a continuous process by identifying: - Understanding the waste, Lean thinking, Lean techniques, and Lean implementation.

According to Sami and Harish (2016), generally, the lean principles includes:-

- Establishing good terms within the team comprising of owners, architects, contractors, subcontractors, and suppliers.
- Emphasizing the process design, and thus combining project design.
- Stopping production rather than spoiling the construction process.
- Enhancing the participation of all the team members in a project, thus decentralizing decision-making.

2.4 Practices and Techniques of Lean Construction

In the construction industry, the implementation and adoption of Lean Construction Practices are poor compared to other sectors like manufacturing industries. It is different from the traditional construction process, and thus it is an advanced way to improve the construction industry's performance in meeting the demands of contemporary society (Babalola et al., 2018). The lean construction techniques in practice include the last planner system, reduce variability, increase transparency, flow variability, continuous improvement, just in time, and seek perfection techniques (Sholanke et al., 2019). Different studies show that certain lean tools and principles in the design phase of construction projects are unknown how they maximize the value of construction projects' design products. Therefore, there is no systematic review that bridges some best design practices to the principles of lean construction. Consequently, no evaluation tool is available, allowing the assessment of the level of using certain practices in a specific project (Herrera et al., 2019).

2.4.1 The Practice of Lean Construction in the Construction Industry

Lean practices are referred to as tools, approaches, strategies, or techniques used to achieve lean construction objectives (Babalola et al., 2018). Lean Construction Practices have developed quite well in many different countries worldwide, bringing in continuous improvement, broad culture, and improved certainty levels in projects. It is influenced by many easy aspects, such as the site's culture and the organization, planning and engineering expertise available, commitment, and support from top management and site management (Raghavan et al.,2014).

Babalola et al. (2018) discovered that 32 Lean Construction Practices had been implemented or adapted to different kinds of buildings and infrastructure projects in various countries. There is no conclusion on the general pattern of adoption of lean practices globally. These practices are used to meet customers' demands of increasingly demanding quality products, better performance, and lower costs (Primayuda et al., 2019).

Much of surveys and empirical studies up to now have reported that the most adapted practices to be implemented in the construction field are: just-in-time (JIT), Kanban system, the 5S process, increased visualization, standardization, prefabrication, LPS, value stream mapping (VSM), waste elimination, continuous improvement, first-run studies (plan, do, check, act), total quality management (TQM), error proofing (Poka-Yoke), Ishikawa diagram, party analysis, FMECA

(failure modes, effects, and criticality analysis) and five why's (Bajjou and Chafi, 2018). Practical approaches to simplification include: shortening the flows by consolidating activities, reducing the part count of products through design changes or prefabricated parts, standardizing parts, materials, tools, etc., decoupling linkages, and minimizing the amount of control information needed (El-Kourd, 2009).

In another way, lean construction management is different from typical contemporary practice because it (1) has a clear set of objectives for the delivery process; (2) is aimed at maximizing performance for the customer at the project level; (3) designs product and process concurrently; and (4) applies production control throughout the life of the project (Ayalew et al., 2016).

2.4.2 Techniques of Lean Construction

The Lean Construction Techniques are the pillar of LC and have evolved since its adoption in the construction industry. Lean Construction Techniques as procedures, structures, conceptions, models, methodologies, and products, when implemented to assist firms in applying lean across the workplace (Akinradewo et al., 2018). The Lean techniques are used in the manufacturing and construction industry to eliminate waste, improve productivity, and save time and cost by adding values to the product. Identification and elimination of activities with no added-value are primordial in Lean Construction philosophy; indeed, removing no value-added activities helps to get closer to customer expectations (Tejas and Ashwini, 2018). There are various Lean construction techniques in practice in the construction industry are the last planner system, concurrent engineering, the Percent Plan Complete measurement, resources managing, standardization, immediate problem detection, detection of incompatibility and discrepancy, use of visual indicators, team integration, reduce variability, increase transparency, flow variability, continuous improvement, just in time, and seek perfection techniques (Sholanke et al., 2019) and (Akinradewo et al., 2018). Various lean techniques have been analyzed and adopted throughout the construction research field are:- Process mapping technique, 5s techniques, last planner technique, increased visualization, fail for safe quality, daily huddle meeting first run studies, and many more lean techniques are available (Ramasamy et al., 2016).

Implementing lean techniques in the construction industry will help increase the project's profit and quality in a reasonable time (More et al ., 2016).

2.5 Tools of Lean Construction

The lean construction tools' effectiveness is evaluated through the lean implementation measurement standard and performance criteria (Remya et al., 2019). Lean Construction tools like the Last Planner System, Just in Time, Total Quality Management, and Continuous Improvement has received a lot of attention in developing nations. (Mahashabde, 2016) According to (El-Kourd, 2009) revealed that the lean construction tools, which can be applied to the construction projects, are:

1) Just in Time (JIT): - is a production cost system in the specified time for certain products within the project; productivity that leads to its development and reduce its costs.
2) Last Planner System: - is the person or group accountable for operational planning, that is, the structuring of product design to facilitate improved workflow and production unit control, that is, the completion of individual assignments at the operational level.
3) Master Schedule: -The master schedule is an overall project schedule, with milestones that are usually generated for use in the bid package. RPS is produced based on this master schedule.
4) Reverse Phase Scheduling (RPS): A pull technique is used to develop a schedule that works backward from the team planning completion date.
5) Six-Week Look Ahead (SWLA): indicated that the tool for workflow control looks ahead to schedules. SWLA shows what kinds of work are supposed to be done in the future.
6) Weekly Work Plan (WWP): - is produced based on SWLA, the actual schedule, and the field condition before the weekly meeting.
7) Percent Plan Complete (PPC): - The Last Planner's measurement metric is the Percent Plan Complete (PPC) values. It is calculated as the number of activities that are completed as planned divided by the total number of planned activities.
8) Increased Visualization: - The increased lean visualization tool is about communicating key information effectively to the workforce by posting various signs and labels around the construction site.
9) First Run Studies: - The studies commonly use video files, photos, or graphics to show the process or illustrate the work instruction.

10) Daily Huddle Meetings (Tool-box Meetings): - This tool is similar to the lean manufacturing concept of employee involvement, which ensures rapid response to problems through workers' empowerment and continuous open communication through the toolbox meetings.
11) Others such as; The 5s Process (Visual Work Place), Fail-Safe for Quality, Productivity Standardization, and The Five Why's:

Therefore, several lean tools can be used in the lean design, such as Target Value Design (TVD), set-based design (SBD), Building Information Modeling (BIM), Choosing by Advantage (CBA), and Last Planner System (LPS), among others. Accordingly, no evaluation tool is available, allowing the assessment of the level of using certain practices in a specific project (Herrera et al., 2019). Implementing such lean tools and techniques had significantly reduced waste and improved performance in construction projects (Abdelrazig, 2015).

2.6 Implementation of Lean Construction on Construction Projects

The implementation of Lean Construction in the construction projects stabilized by modifying the planning system, reducing variation in the flow; that improves the downstream operations (Dineshet al.,2017). Lean thinking practical in construction can be waste elimination; Improving reliability; Creating continuous flow in a pull system; Meet the customer's need; Involvement of workers at every level; Involvement of supplier and client in the project process; Built-in quality; Continuous improvement; Knowledge sharing (Locatelli et al., 2013).

In building design, several studies consider applying some of these principles, such as using lean tools and techniques to achieve value delivery, integration, and waste reduction in the process. (Picchi et al., 2016) .

Though the implementation of lean practices is not yet well established in the construction industry compared to other sectors like the manufacturing industry. Lean Construction is a departure from the traditional construction process because it seeks to deliver the best value for money by adopting strategies that ensure efficiency and enhanced productivity in the entire lifecycle of projects (Babalola et al., 2018).

2.7 Waste in Construction Industry by Lean Concepts

In the Lean concept, wastes are not limited to construction material; they include all sorts of inefficient use of labor force, equipment, and other resources in the project (Tafazzoli et al., 2020).

Waste is assumed to be the only physical waste by construction professionals; however, there have been records of noticeable wastes in the construction industry generated through what is known as "non-value-adding activities"(Oguntona et al., 2019).

Construction Waste is any wastefulness that results in the use of equipment, material, capital, or labor in more quantities than those expected as necessary in the production of a building (Mohammed, 2016). Construction waste could result from errors in design, modifications, redoing of work, defects, and the use of excess materials (Oguntona et al., 2019).

According to (Elhaj et al., 2018); (Mohammed 2016), and (Ragnhild, 2019) there are seven kinds of pure waste in the construction industry in lean concepts, which are described as follows.

i. **Overproduction: -** it means making too much, too early, or just in case or completing more work before it is needed. When the material is fabricated too early, or stock material is in the warehouse or at the job site. Printing more blueprints or making more copies of a report than needed is an overproduction (Ragnhild, 2019), and (Mahashabde, 2016).
ii. **Waiting for waste**:- it implies that time is not used effectively, and it creates delay to value-adding activities like plant breakdowns, material shortages (late deliveries), material not being used, labor shortages, tool setups (power failures), and poor planning or coordination (Mohammed, 2016).
iii. **Transportation waste:-** which comes from the movement of components and materials around a site in different ways such as distances traveled to the site and on-site, material handling, delivery to stock or storage, and empty returns from delivery lorries (Ragnhild, 2019).
iv. **Unnecessary Inventory**:- like early deliveries, storage space, safety shocks or over-ordering and shortages due to damage of goods stored for a too long time or raw material, work in progress, or finished goods which are not having value added to it (Ragnhild, 2019). It includes uncut materials, work-in-process, and finished fabrications. Some contractors claim that they have no inventory because they job-cost all material. While this may work for accounting, if the material is not yet installed and is still not being used by the customer, it is still a 'Waste' which includes spare parts, unused tools, consumables, forms and copies, employee stashes, and personal stockpiles (Mahashabde, 2016).

v. **Over-processing: -** Doing more than needed by the customer. This 'Waste' includes over-engineering requiring additional signatures on a requisition, multiple handling of timesheets, duplicate entries on forms, and getting the estimates multiple times from the suppliers (Mohammed, 2016).

vi. **Unnecessary Movement:-** such as machine watching, stretching to reach goods or materials, searching for materials, drawings, walking to fetch materials, drawings, bending, lifting, and congestion due to poor work coordination (Ragnhild, 2019).

vii. **Defect Waste: -**transportation like damage, paperwork errors, lost goods, stock loss or damage, and rework, which can cost money, time, and reputation. Other than that, defects, inappropriate processes, and overproduction waste are construction material waste (Mohammed, 2016). It includes incorrect installations, defects in fabrication, and errors in punch lists. Not meeting the required code is an additional 'Waste.' Also, rework in construction is rarely measured (Mahashabde, 2016).

The project managers hardly recognize waste, which is the major cause of loss of efficiency and productivity (Sami and Harish, 2016). Generally, Construction waste can be classified in figure 2.2. below:

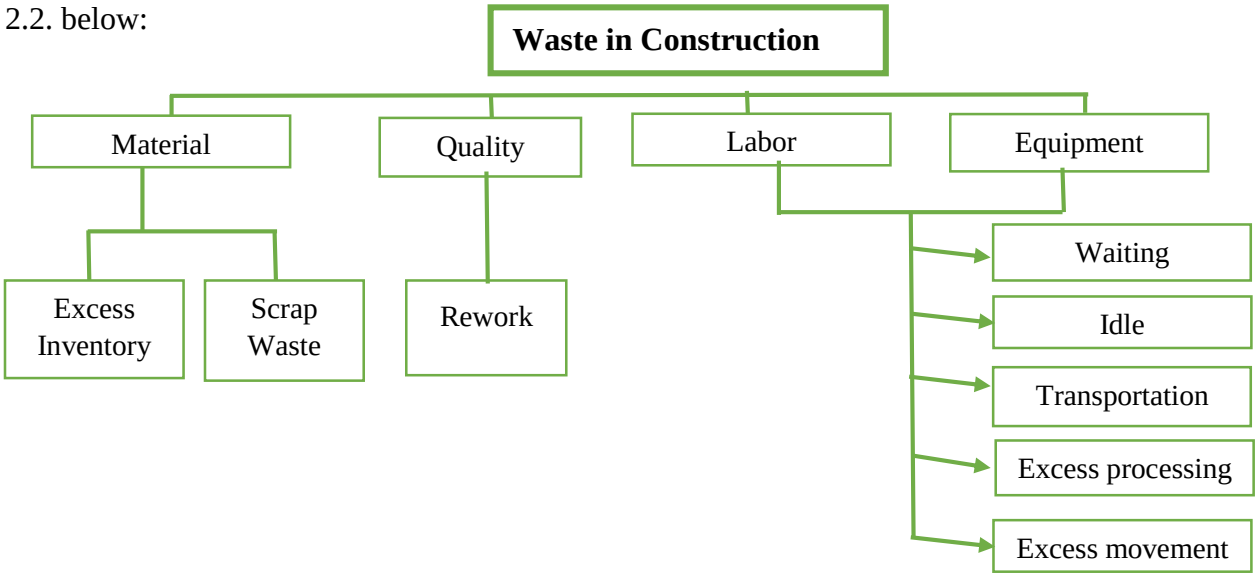

Figure 2.2 Construction Waste Classification (Mohammed, 2016).

In implementing 'Waste' elimination solutions at the operation level, construction simulation and 3-D visualization tools were implemented. One of the main reasons for wastage at the construction site was the lack of communication and coordination (Mahashabde, 2016). Construction waste is generally assumed as residual material or tools that are not used after construction is completed. Still, every construction activity that raises costs but does not benefit directly or indirectly is also a waste (Primayuda et al., 2019).

2.8 Benefits of Lean Construction Practices on Building Construction Projects

Implementing Lean Construction in the construction industries will lead to improved project delivery methods, delivery of products, or services that enable clients to accomplish their goals with satisfaction. Besides, productivity gains, minimization of risks and maximization of opportunities, greater predictability, shorter construction periods/ reduced project time, injection of reliability, accountability, certainty, and honesty into the project environment, improved design are some advantages of lean construction practices (Adegbembo et al., 2016). The Implementation of Lean Construction practices includes culture, plans, tools, and ideas to maximize value while minimizing all waste varieties (Primayuda et al., 2019). Studies strongly support the multiple advantages of applying lean in construction projects (Tafazzoli et al., 2020).

According to the findings (Remya et al., 2019), the six benefits of implementing LC practices are:- Waste reduction, effective administration of materials on-site, improved lifecycle cost, good project coordination, improved safety on-site, and greater productivity.

Akinradewo et al. (2018) stated that by eliminating waste in the Construction, LC encourages Minimize double handling and movement of equipment and workers, Balance team, coordinate flows, Takeoff material constraints, Minimize variance in input, Minimize changeovers and difficult setups and Reduce interpersonal dynamics.

According to Dinesh et al. (2017) and Tejas & Ashwini (2018) identified that the general advantages while applying Lean Construction Principles are reducing the share of non-value adding activities and Delivering projects on time or, in some cases, ahead of schedule, precisely specify a value from the perspective of the ultimate customer, increasing the output value to meet the customer's requirements and identify the process that delivers customer values, to reduce cycle times, minimizing the steps to simplify, to reduce process variability, to increase the output flexibility, focusing on the completion of the process, to increase transparency, pursue perfection

by continuous improvement, balance flow improvement, benchmarking, improving the project cost, quality, and time, and increases profit and market share.

Therefore, Lean practices (LPs) ' economic benefits cover the cost, time, and quality advantages of LPs adoption. Some of the benefits in this category include project time reduction, project cost reduction, project quality improvement, continuous improvement in the project process, better control of inventory, minimization of risk, among several others (Babalola et al., 2019). In brief, Lean construction has been increasingly adopted to make the projects more profitable, enhance quality, and improve customer satisfaction (Tafazzoli et al., 2020).

Waste reduction, effective administration of materials on-site, improved lifecycle cost, good project coordination, improved safety on-site, and greater productivity as the six benefits of implementing LC practices (Albert, 2020).

2.9 Barriers to the Implementation of Lean Construction Practices

Adegbembo et al. (2016) stated that the barriers to the implementation of Lean Construction Practices are classified into different categories based on a thorough and critical review of international literature relating to the take up of lean practice. These include; lack of training, lack of interest from the client, waste accepted as inevitable, delay in material delivery, etc. Moreover, these meetings had to be held regularly and took up too much time when poorly managed. There are many barriers to lean construction implementation: time, training, organization, low understanding of the concept, self-criticism, and lack of integration (Dinesh et al., 2017). The main obstacle for Lean Construction is that the project manager or the contractor may question the use of the Lean principles at an early stage of implementation of Lean at any new project site (Mahashabde, 2016).

Ayalew et al. (2016) identified that lack of knowledge, lack of industry support, lack of sufficient support among project team, employee's resistance, and lack of standards as the most influential barriers that will hinder the implementation of Lean Construction in the Ethiopian construction industry. These barriers affect the application process of LC and hinder the project performance if not properly managed. Suppose they do not understand the factors that affect the successful implementation of LC. In that case, organizations will not know what improvement efforts need to be made and where these efforts should be focused, or which efforts could obtain the best results (Albert, 2020).

According to Mohd et al. (2013), the barriers to implementing Lean construction are described in Figure 2.3 below. Therefore, these barriers are timely delivery of materials to the site, organizing training employees on a lean concept, and companies being client-focused (Adegbembo et al., 2016).

Figure 2.3 Barriers to the Implementation of Lean Construction (Mohd et al., 2013).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Area

This study was conducted in Jimma City, located in the Oromia National Region State, Southwestern Ethiopia, 352 Km from the Addis Ababa capital City of Ethiopia. It is the capital and administration center of the Jimma zone.

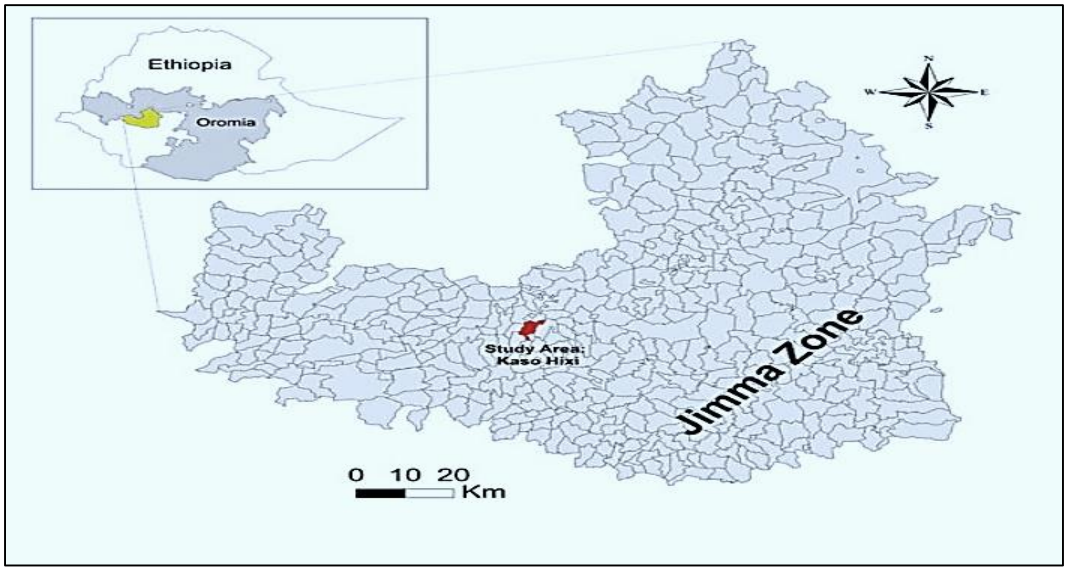

Figure 3.1 Location of the Study Area *(Source: Google earth, 2020)*.

3.2 Research Design

The research is a descriptive type of research that is an appropriate method to assess Lean Construction Practices on building construction projects. It also includes the principles, techniques, tools, and implementation of Lean Construction Practices on Building Construction Projects and stakeholders' awareness about these practices in Jimma City. In this research, few data collection methods were used, including observation, interviews, and questionnaire survey. The questionnaire and interviews were designed and distributed for consultants and contractors involved in building construction projects and site observations were also conducted. Two types of research strategies were used during studies, quantitative and qualitative research. A quantitative approach was used to gather factual data and study relationships between facts and how such facts and relationships according to theories and any research findings were executed

previously. The qualitative approach seeks to gain insights and understand the perception of different parties involved in the project.

3.3 Study Variables

- **Dependent variable**
  - ✓ Lean Construction Practices
- **Independent variable**
  - ✓ Awareness of Lean Construction
  - ✓ Implementation of Lean Construction
  - ✓ Lean Construction Principles
  - ✓ Lean Construction Techniques
  - ✓ Lean Construction Tools

3.4 Study Population

The targeted population of this study was limited to Building Construction Projects in Jimma City, Ethiopia.

3.5 Sample Size and Sampling Procedure

Sampling is the process of selecting representative units of a population for the study in research investigation. Sample is a small proportion of a population selected for observation and analysis. Sampling was introduced to make the research findings economical and accurate. The respondents of this study were contractors and consultants who are involved in the Building Construction Projects within Jimma City. This study's sampling method was non-probability sampling, representing a group of sampling techniques and a free distribution that helps researchers select a unit sample from a population. And also, the sample of this study was selected by using a non-probability sampling technique, which is the purposive sampling method. The contractors and consultants in building construction projects are selected from 12 building construction projects under construction in Jimma City based on the study objective. These building construction projects are constructed by GC1, and the others are constructed by GC2 to GC7. The contractors and consultants who are actively involved in these building construction projects are purposively selected. For this study, samples were 40 respondents from the contractors' firms and 20 from the

consultant's firms selected for questionnaires from Twelve (12) Building construction project sites. A total of 60 respondents were involved in this study.

3.6 Sources of Data

This study used both primary and secondary data sources. The primary sources were conducted with structured questionnaires, observations and interviews. The secondary sources were collected from various published and unpublished sources, books, journals, and research reports.

3.7 Data Collection Procedure

In this study, both quantitative and qualitative methods were used: in step one, the qualitative data were identified from the literature and interview and in step two, quantitative data were collected from questionnaires, site observation, and interviews.

3.7.1 Questionnaire Distributions

The respondents that were selected purposively in the research studies are Consultants and Contractors in the Building Construction Projects of Jimma City. Questionnaires were distributed to these respondents in twelve (12) Building Construction projects actively under construction in the different project sites and which are selected and identified based on objective of study; they are well organized, functional, have good workmanship in Jimma City. These projects were constructed and consulted by GC1 to GC7 Contractors and Consultants and some of them are consulted by academician of Jimma University which were implementing Lean Construction Practices and which have the Lean Concepts and Cultures to use in their Projects.

From the above building construction projects, eight (8) projects are constructing by GC1, and the others are constructing by GC2 to GC7. The research study questionnaire is compiled for a sample size of the Building Construction project sites only. Totally 60 questionnaires, 40 questionnaires to contractors, and 20 for consultants were distributed to the project sites. Besides, Six Respondents; Three Project Managers, Two Office Engineers, and One Site Engineer working in GC1 Contractors and Consultants Firms were conducted face-to-face interviews to obtain more data or information for the objective study.

3.8 Data Presentation and Analysis

The data was collected through a pre-tested structured questionnaire. Interviews were categorized and analyzed according to their targeted objectives and then analyzed by applying the relative

importance index (RII) method. The data were organized, tabulated, analyzed, and interpreted using an Excel spreading sheet.

The five-point Likert scale was converted to a Relative Importance Index (RII) for each factor using the following formula (Abhiram et al., 2016) ; (Hatkar et al., 2016) ;(Gunduz et al.,2013) , and (Damtewet and Enday, 2019). The data received in the second questionnaire were analyzed by the Relative Importance Index (RII) method.

$$RII = \Sigma W \div (H * N) \quad \text{..... Equation (3.1)}$$

Relative Importance Index (RII) method; Where W is the total weight given to each factor by the respondents, which ranges from 1 to 5 and is calculated by adding the various weightings given to a factor by the entire respondent, H is the highest-ranking available (i.e., 5 in this case). N is the total number of respondents that have answered the question. The analyzed data output was also presented using tables, graphs, charts, and a simple percentage for further interpretation and discussion.

3.9 Data Measurement

The data measurement to assess the lean construction practices on building construction projects, ordinal scale was selected. An ordinal scale is a ranking or a rating data normally using integers in ascending and descending order, as shown in Table 3.1. different for different sections of questionnaires as objectives of the study.

Table 3.1 Ordinal scale used for data measurement

S/NO	Ordinal scale		**1**	**2**	**3**	**4**	**5**
1	Items	III	Very low	low	Medium	High	Very high
2		IV	Very Low Extent	Low Extent	Neutral	Extent	Very High Extent
3		V&VII	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.10 Data Validity and Reliability

The projects were assessed, and data were collected from respondents through a questionnaire survey. In order to check the reliability of data, Cronbach's Alpha coefficient was used; Cronbach's Alpha values were in the range from 0.9 to 1. This range is considered excellent; since the result ensures reliability of response of each project. The average Cronbach's Alpha of all items of questions equals 0.912 for the entire project, indicating excellent responses as the whole data. The Pearson correlation coefficient and Spearman correlation coefficient were used to checking data validity, which estimates a relationship between two interval variables and has an excellent correlation between variables. The correlations between the projects are measured by Pearson correlation coefficient and Spearman correlation coefficient, and some have an excellent correlation between projects. Most correlations between the projects fall within the excellent range, while few fail in an acceptable and good range.

Cronbach's alpha tests to see if multiple-question Likert scale surveys are reliable. These questions measure latent variables hidden or unobservable variables like a person's conscientiousness, neurosis, or openness. These are very difficult to measure in real life. Cronbach's alpha will tell you if the test you have designed is accurately measuring the variable of interest. The formula for Cronbach's alpha is**:**

$$\alpha = N/(N-1)) * (1- S\bar{v}/ T\bar{v}) \quad \text{..... Equation (3.2)}$$

Equation of formula for Cronbach's alpha Where N=the number of items.

$S\bar{v}$ = sum of the item variances.

$T\bar{v}$ = variances of total scores.

Table 3.2 Cronbach's Alpha Formula with Consistency

S/No	Cronbach's alpha	Internal Consistency
1	$\alpha \geq 0.9$	excellent
2	$0.9 > \alpha \geq 0.8$	good
3	$0.8 > \alpha \geq 0.7$	acceptable
4	$0.7 > \alpha \geq 0.6$	questionable
5	$0.6 > \alpha \geq 0.5$	poor
6	$0.5 > \alpha$	Unacceptable

According to studies, the Alpha was developed by Lee Cronbach's in 1951 to provide a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. Internal consistency describes the extent to which all the items in a test measure the same concept or construct, and hence it is the method to compute the correlation of each test item with the total score test; items with low correlations (approaching zero) are deleted. If alpha is too high, it may suggest that some items are redundant as they are testing the same question but in a different guise. A maximum alpha value of 0.90 has been recommended (Mohsen and Reg, 2011).

Therefore, the average Cronbach's Alpha of all items of questions this study was equals 0.912 for the entire project, indicating excellent responses as the whole data and it was recommended.

3.11 Ethical Considerations

After getting the approval and permission letter from Jimma University, Jimma Institution of Technology postgraduates research and publication director office for continuing the study, and the Department of Construction Engineering and Management, the data collection process was conducted. The researcher first informed participants about the nature of the research and requested their consent to participate. Only those organizations and personnel who voluntarily participated in the study were approached for an interview and comment. The researcher also committed to reporting the research findings completely and honestly, without misleading others about the findings' nature. Under no circumstance, the researcher fabricated data to support a particular conclusion. Finally, the researcher took appropriate measures to ensure the research would cause no physical or psychological harm to research participants. As a general rule, therefore, the study did not raise any ethical concerns.

3.12 Data Quality Assurance

- The quality of the data was assured by using a validated structured questioner.
- Data collectors were trained intensively on the study, the study's objective, the confidentiality of the information, informed consent, and interview technique.
- The data collectors were work under the researcher's close supervision to ensure adherence to correct data collection procedures and review the filled questioner at the end of data collection every day for completeness.

CHAPTER 4

RESULTS AND DISCUSSIONS

This part deals with the results and discussions of the results obtained from the study. It also describes the results and discussion of a questionnaire survey, observations, and interviews concerning the assessment of Lean Construction Practices on Building Construction Projects in Jimma City and viewpoints of Contractors and Consultants' sampled from Building construction projects. The consideration was on the statement of the problem, objective and scope of the study. The formulated questionnaires, surveys, interviews with respondents, and the problem of statement helped the researcher obtain data; and finally, the implementation of Lean Construction Practices on Building Construction Projects, including its benefits, barriers on building construction industry in Jimma City.

4.1 Response Rate

The results from 60 questionnaires were distributed for contractors and consultants involved in building construction projects in Jimma City 52 were received as shown in Table 4.1 below ; It shows that a total of 40 questionnaires were distributed for contractors, and from these 36 questionnaires were returned, which means 90% of respondents of contractors were responded and 20 questionnaires distributed for consultants from this 16 questionnaires were returned which means 80% of respondents of consultants were responded from contractors and consultants organizations and totally from 60 respondents 52 were answered in questionnaire survey which means 87% of response rate. Besides, six respondents, three project managers, two office engineers, and one site engineer working in GC1 contractors and consultants were conducted face-to-face interviews to obtain more information on the study's objective.

Table 4.1 Response rate

Types of respondents Organization	Questionnaires Distributed	Questionnaires Received	Response Rate in percentage (%)
Contractor	40	36	90%
Consultants	20	16	80%
Total	**60**	**52**	**87%**

4.2 General information and profiles of Respondents

This part mainly designed to provide general information about the respondents in terms of the organization's name, state of the respondent's organization or company type, position and experience, educational status, and a contact person who are participated in this study population.

4.2.1 Specialization of Respondents

Table 4.2 below; shows that from the respondents,69% are civil engineers, 10% are Architects, and 21% are others. So most of the participants or respondents were Civil Engineers in the questionnaire survey of this study. They are aware and implement Lean Construction Practice in the Building Construction Projects as their profession, which they are required.

Table 4.2 Specialization respondents

Specialization of respondents	Number of respondents	Percentage (%)
Civil engineer	36	69%
Architect	5	10%
Other	11	21%
TOTAL	**52**	**100%**

4.2.2 Education Level of Respondents

Figure 4.1 shows that from the total of 52 respondents, five (10%) with Diploma, 29 (55%) were Bachelor Degree, 17 (33%) were Master's Degree and one (2%) with a Doctorate Degree. So most of the respondents have Master and Bachelor Degree. The more advanced in the program, the higher the level of education, so they have good ideas or concepts about lean construction and implement properly in building projects. Hence in this study, about 88% of respondents have Bachelor's and Master's Degrees involved in the questionnaire survey. The respondents' education level was strongly supported to get data to identify the Lean Construction Practices implemented on Building Construction Projects based on this study's objectives.

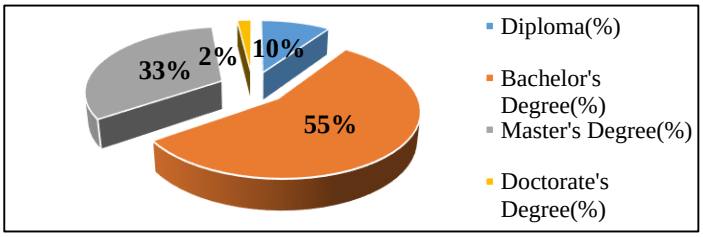

Figure 4.1 Education level of respondents

4.2.3 Experience of Respondents

Figure 4.2 shows that from total 60 respondents, 24 (46%) respondents have experienced between 0 to 5years, 17 (33%) respondents have experienced between 5 to10 years, 7(13%) respondents have experienced from 10 to15 years, 4 (8%) respondents have experience more than 15 years. Based on these results, the respondents' experiences helped get full information for this study to achieve its objectives. The experiences of respondents on building and other construction projects help understand lean construction concepts and implement Lean Construction Practices on Building Construction Projects.

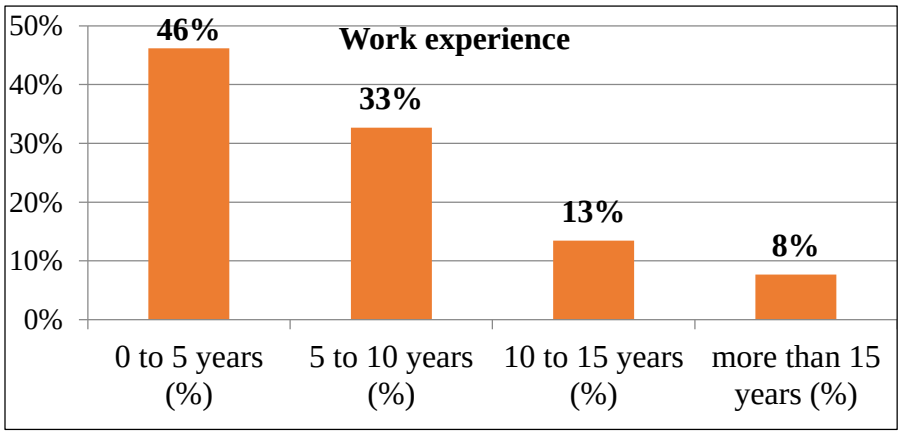

Figure 4.2 Experiences of respondents

4.2.4 Position of Respondents

Figure 4.3 shows that 17 (33%) are site engineers, 16 (31%) are office engineers, eight (15%) are project managers, and 11(21%) are others. Therefore, most of the respondents are site engineers and office engineers. It means that they hold a supervisor role to make sure things are happening as they should be throughout the projects.

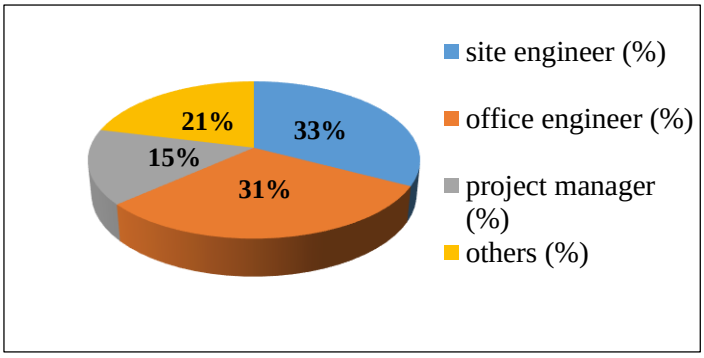

Figure 4.3 Position of respondents

4.2.5 Respondents Firms

Figure 4.4 shows that 36 (69%) respondents are contractors, and 16 (31%) are consultants. Therefore, most of the respondent's organizations are contractor's firms, which are participated in this study. Based on this, the concepts and implementation of Lean Construction Practices are different according to their firms.

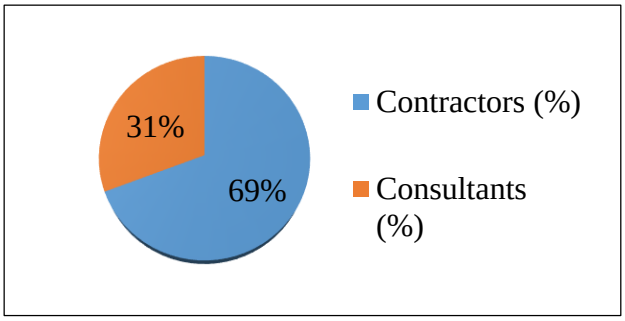

Figure 4.4 Respondents firms

4.3 Lean Construction Practices Implemented on Building Construction Projects in Jimma City

The Lean Construction Practices implemented in Jimma City by the respondents on building construction projects are shown in Figure 4.5 below. It shows that site workers' regular performance measurement has a high implementation level with a relative importance index of 0.746. In contrast, identification of client needs, projects needing immediate attention given more importance, Strict criteria for the selection of a subcontractor, Involvement of project participants in the making of schedules were ranked 2nd,3rd,4th, and 5th with a Relative Importance Index of 0.715, 0.708, 0.704 and 0.700 respectively. The others like Percent Plan Complete, Personnel responsible for procurement, Continuous improvement, Look–ahead of schedule (a program of work), Weekly meetings, All parties involved in the design (involvement of construction professionals right from the inception), Using computer software for estimating, Direct involvement of foremen in decision making, Training of employee, Just-in-Time (JIT) delivery (timely delivery of construction materials to the site), Uninterrupted workflow and daily Site meetings are ranked from average to very low with their relative importance index was implemented in building construction projects in Jimma City.

From the above lean construction practices, Regular performance measurement of site workers, Identification of client needs, Project needing immediate attention given more importance, Strict

criteria for the selection of a subcontractor and Involvement of project participants in the making of schedules are highly implemented on building construction projects in Jimma City.

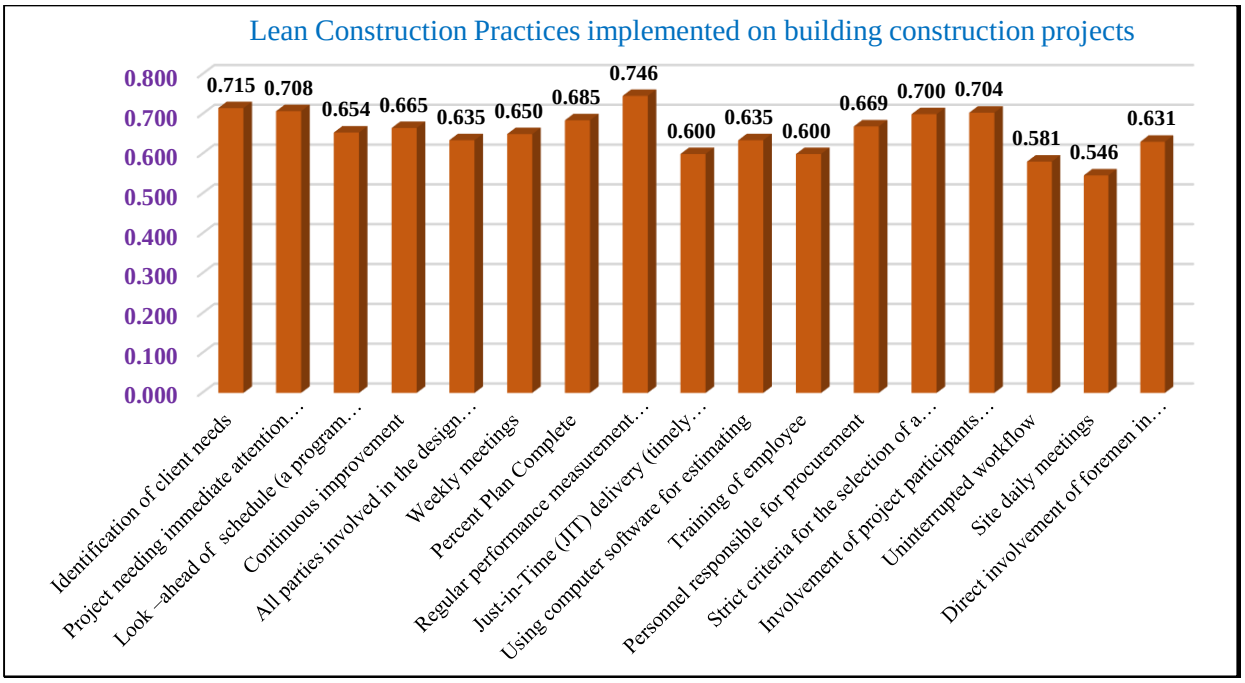

Figure 4.5 Lean construction practices which are implemented on building construction projects

4.4 Lean Construction Techniques and Tools Implemented by the Firms On Building Construction Projects in Jimma City

The Lean Construction Techniques and Tools implemented by Firms On Building Construction Projects in Jimma City as shown in table 4.3; firstly, very high extent implemented are on-site management and integrated project delivery method, 5S (sort, set, shine, standardize and sustain), Value-based management and Health and safety improvement: which were ranked 1st, 2nd,3rd,4th and 5th with relative importance index 0.731, 0.700, 0.696, 0.692 and 0.688 respectively. Secondly, Team/partnering, Target Value Design, Pull Scheduling, Visualization tools (signpost and board for instruction on-site), Fail-Safe for Quality, Design structure matrix, Concurrent management, and Standardization are implemented extent or averagely and they were in order with relative importance index. The others' low extent implemented in ranking order are Detailed briefing, Location-based management, Benchmarking, First Run Study, Error proofing, Visual Design Construction(3D/BIM), 6 Sigma, and the last planner system, Just-in-time, and Kaizen the low extent implemented are Kanban System and Daily clustering.

Based on these findings, the construction firms are implementing some of the lean construction techniques and tools like the very high extent implemented are on-site management and integrated project delivery method, 5S (sort, set, shine, standardize and sustain), Value-based management, and Health, and safety improvement are highly on building construction projects in Jimma City. Therefore, the Lean Construction tools and techniques are implemented to minimize construction waste and increase project values on building construction projects in Jimma City.

Table 4.3 Lean Construction Techniques and Tools implemented by the Firms on Building Construction Projects

S/NO	Lean Construction Techniques and Tools	RII	Rank
1	6 Sigma	**0.608**	**20**
2	Benchmarking	**0.654**	**14**
3	Concurrent management	**0.658**	**12**
4	Daily clustering	**0.588**	**25**
5	Design structure matrix	**0.666**	**10**
6	Detailed briefing	**0.654**	**14**
7	Error proofing	**0.638**	**18**
8	Fail-safe for quality	**0.665**	**11**
9	First, run the study	**0.642**	**17**
10	Health and safety improvement	**0.688**	**5**
11	Integrated project delivery	**0.700**	**2**
12	Just-in-time	**0.600**	**22**
13	Kaizen	**0.596**	**23**
14	Kanban System	**0.592**	**24**
15	Last planner system	**0.608**	**20**
16	Location-based management	**0.653**	**15**
17	On-site management	**0.731**	**1**
18	Pull scheduling	**0.677**	**7**
19	Standardization	**0.658**	**12**
20	Target value design	**0.677**	**7**
21	Team/partnering	**0.681**	**6**
22	Value-based management	**0.692**	**4**
23	Visual Design Construction(3D/BIM)	**0.638**	**18**
24	Visualization tools (signpost and board for instruction on site)	**0.669**	**9**
25	5S (sort, set ,shine, standardize and sustain)	**0.696**	**3**

4.5 Level of awareness of Lean Construction Practices among firms in the Building Construction Projects

The result in Figure 4.6 below shows that Level of Awareness of Lean Construction Practices among firms in the building construction projects in Jimma City. The result reveals that Involvement of project participants in the making of schedules has a very high level of awareness among construction professional with a relative importance index of 0.731 while Strict criteria for the selection of a subcontractor, regular performance measurement of site workers are ranked 2nd with a relative importance index of 0.727, continuous improvement ranked 4th with relative importance index of 0.712, identification of client needs ranked 5th with relative importance index of 0.708, while the others; Site daily site meetings, Personnel responsible for procurement, weekly meetings, look –ahead of schedule (a program of work), project needing immediate attention given more importance, just-in-time (jit), percent plan complete, uninterrupted workflow, direct involvement of foremen in decision making, all parties involved in the design (involvement of construction professionals right from the inception), training of employee and using computer software for estimating are aware by construction firms as ranking order from average to very low.

So, from these practices, mostly involvement of project participants in the making of schedules, strict criteria for the selection of a subcontractor, regular performance measurement of site workers, continuous improvement, identification of client needs, site daily meetings, and personnel responsible for procurement are understood by consultants and contractors in building construction projects in Jimma City.

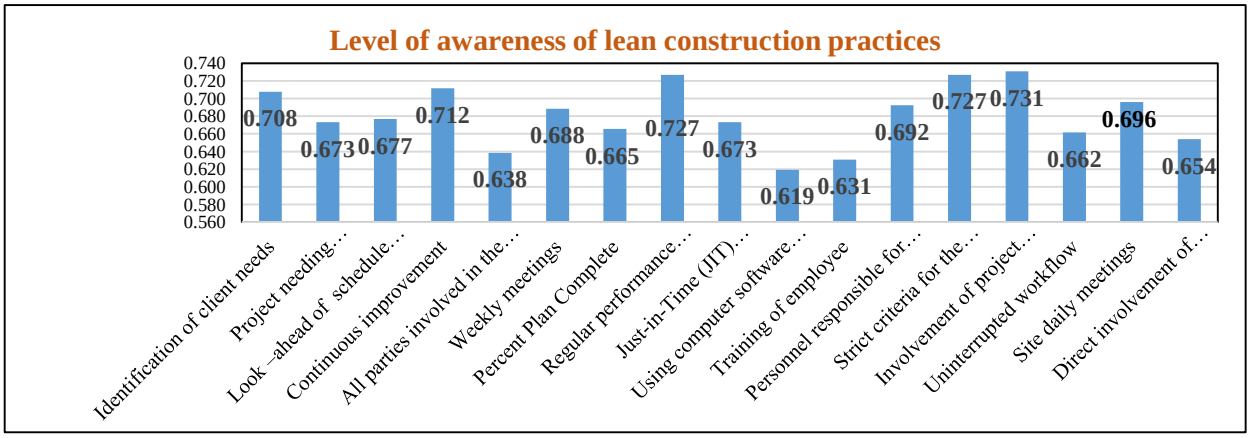

Figure 4. 6 Level of awareness of Lean Construction Practices on building construction projects

4.6 Factors for Level of Awareness of the Lean Construction Practices on Building Construction Projects in Jimma City

Based on interview and questionnaire survey the factors Awareness of Lean Construction Practices on Building Construction Projects, shown in Figure 4.7 below, 19.23% of respondents said unavailable researches in lean construction in Jimma City, 26.92% of respondents said resistant to change, 19.23% of respondents said top-level managements satisfied on status of traditional project management approaches,17.31% of respondents said ignorance of the concept lean construction and 17.31% of respondents said the absence of knowledge of Lean Construction Practices. Therefore, based on the results, most of these factors that affect awareness of lean construction practices in Jimma City are resistant to change, unavailable research in lean construction in Jimma City, and top-level management satisfied traditional project management approaches. The resistance to change is high affects the awareness and implementation of Lean Construction Practices.

Based on the survey's results and interviews about the building construction projects sustainability, the cost of implementation, site conditions, and complexity of projects affect the level of awareness of lean construction practices on building construction projects in Jimma City.

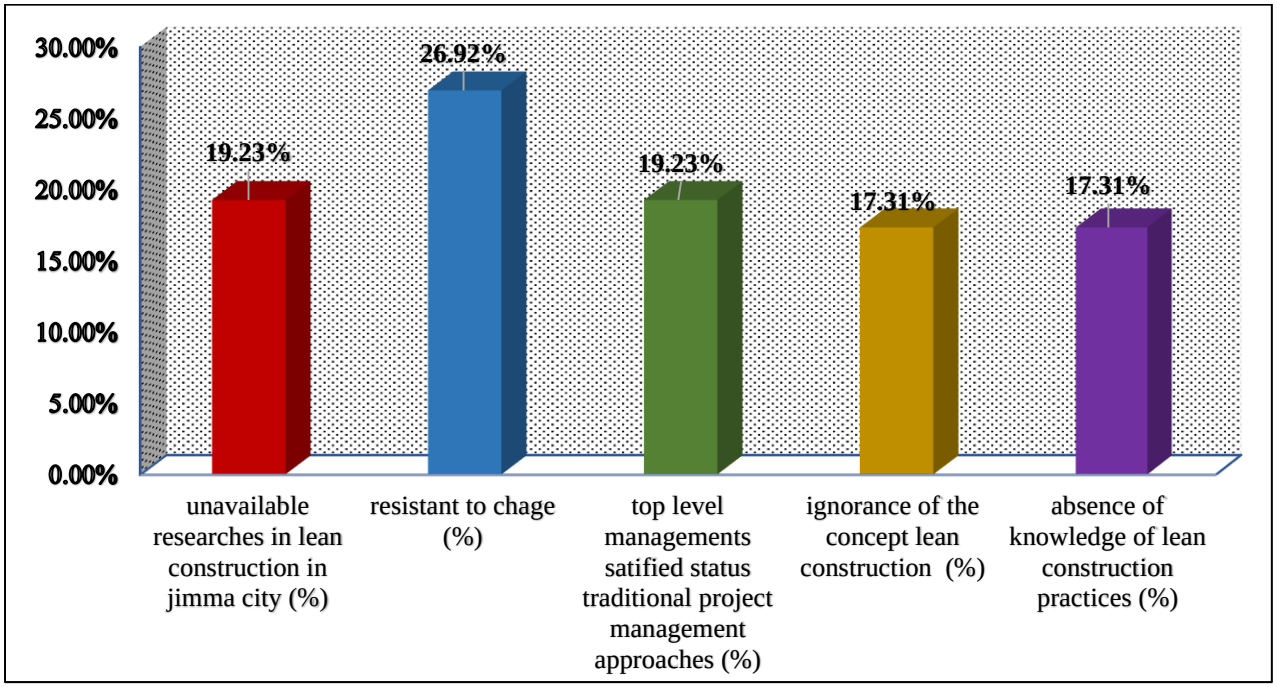

Figure 4.7 Factors for the Level of awareness of the Lean Construction Practices on building construction projects

4.7 Efficiency of the Level of Awareness of the Lean construction practices among firms in the building construction Projects

The efficiency of awareness of the concepts of lean construction practices on building construction projects in Jimma City is the average based on respondents' perspectives, which is shown in Figure 4.8 below. It shows that 10% of respondents have very low concepts of lean construction practices, 15% of respondents have low concepts of lean construction practices, 50% of respondents have concepts of lean construction practices averagely, 25% of respondents have high concepts of lean construction practices, 0% of respondents have very high concepts of lean construction practices. Therefore **50%** of respondents have efficiently understood a construction theory developed from lean production theory from the manufacturing industry or Toyota Company. Consequently, based on interviews and questionnaires, level of awareness of the Lean Construction Practices among stakeholders on the building is average. The firms are partially understanding about the concepts of Lean Construction Practices in Building Construction Projects in Jimma City.

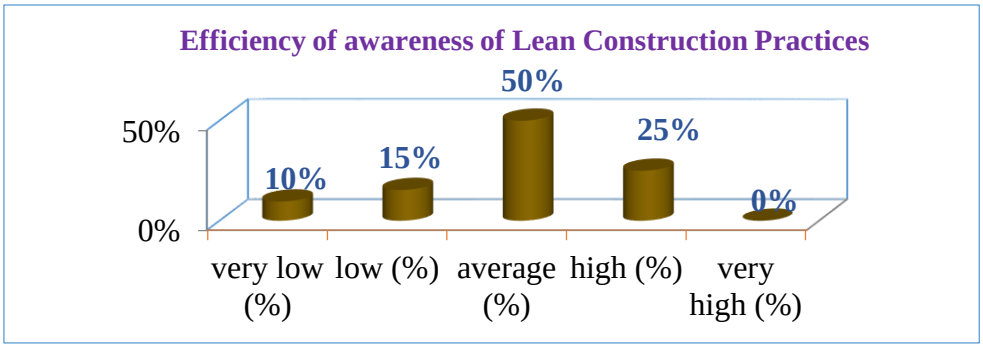

Figure 4.8 Efficiency of awareness of Lean construction Practices on building construction projects

4.8 The Efficiency of Implementation of the Lean Construction Practice on Building Construction Projects

Based on results, the level of efficiency of Implementation of the Lean Construction Practices On Building Construction Projects as shown in Figure 4.9, 10 % of respondents have a very high level, 46% of respondents have a high level, 25% of respondents have efficiency an average level, 11 % of respondents have a low level, and 8% of respondents have very low efficiency of Implementation of the Lean Construction Practices. So, on building construction in Jimma City,

most construction firms have sufficient level on efficiency of Implementing the lean construction practices to minimize the construction wastes and increase the value of projects.

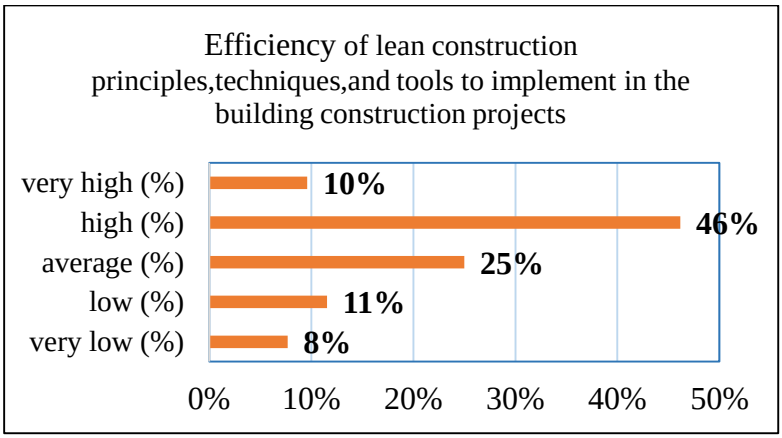

Figure 4. 9 Efficiency s to implement Lean Construction practices on building construction projects

4.9 Efficiency on Suitability of Implementation of Lean Construction Practices on Building Construction projects

Based on the result of findings, Figure 4.10 shows that 86 % of the respondents are agreed the efficiency on the implementation of lean construction practice are suitable for building construction projects in Jimma City to add or maximize value for projects and to minimize construction wastages, and 14% of the respondents do not agreed on the efficiency of suitability implementation of Lean Construction Practices on building construction projects in Jimma city. Their views are the efficiency of implementing the lean construction practices not fully efficiently suitable for building construction projects in Jimma City. Therefore, based on results, the lean construction practices to some extent efficiently increase the values for building construction projects, reducing all waste varieties in Jimma City.

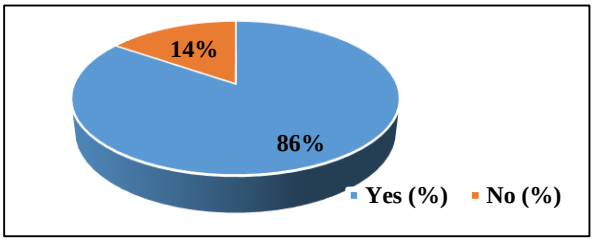

Figure 4.10 Efficiency on suitability of lean construction practices for building construction projects

4.10 Benefits of Efficient Implementation of Lean Construction Practices on Building Construction Projects

Figure 4.11 reveal the respondent's view of the benefits of efficiently implementing the Lean Construction Practices on Building Construction Projects in Jimma City. Increased productivity was ranked to a very high extent having the relative importance index of 0.839. In contrast, efficient communication among the client and construction team and improved quality are ranked 2nd and 3rd with a relative importance index of 0.831 and 0.792, respectively.

Both the Reduced project timetable and to increase transparency were ranked 4th with a relative importance index of 0.785; these have high extent advantages, Minimization of risk, Improved safety, Improved risk management, Reduced waste, Efficient administration of materials, Better control of inventory, Balance flow improvement, Effective system with less cost, Improved customer satisfaction, Focusing on the completion of the process, Minimizing the steps to simplify and Improved whole-life cost are the extent benefits of the efficiency of implementing lean construction practices on building construction projects in Jimma City were ranked as in descending order by their relative importance index. Therefore, these benefits show the efficient implementation of Lean Construction Practices on Building Construction Projects in Jimma City, and the firms are adopting and use some extent the lean concept or thinking to minimize the construction wastes and increase the value of projects.

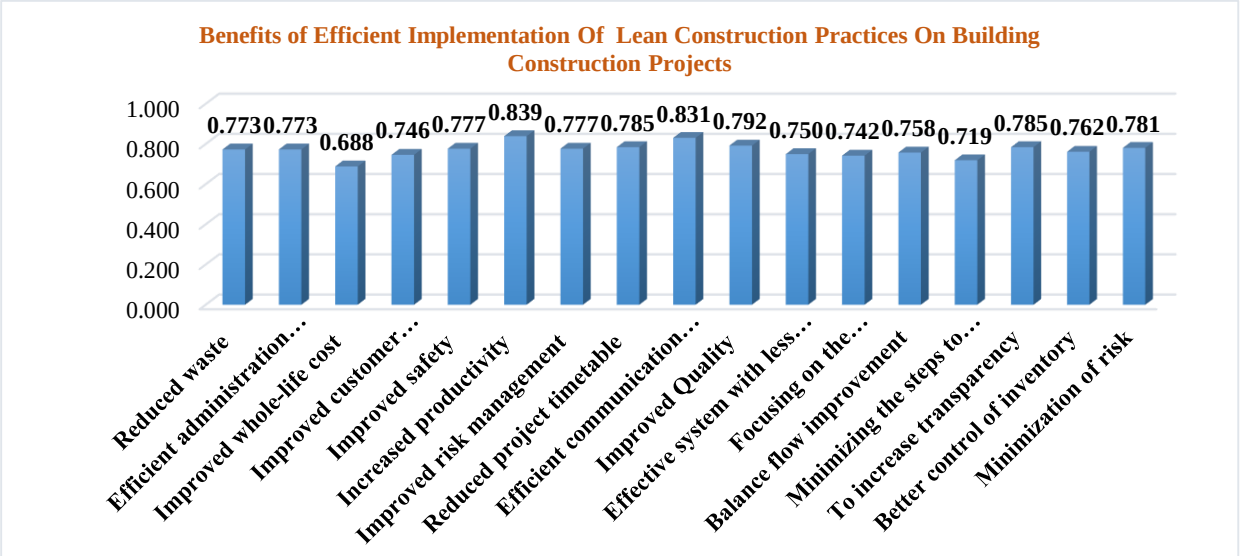

Figure 4.11 Benefits of efficient implementation of lean construction practices on building construction projects

4.11 Barriers to Efficient Implementation of Lean Construction Practices on Building Construction Projects

The result in Figure 4.12 shows the various barriers to implementing Lean Construction practices: Misconceptions about Lean, Lack of Lean knowledge, cost of implementation, High expectations from management, and Lack of long term forecast and investment. These are ranked 1st,2nd,3rd,4th, and 5th with relative importance index 0.723, 0.715, 0.712, 0.704, and 0.692, respectively, and they have a very high barrier. Respondents strongly agree these barriers are highly affecting implementing lean construction practices on building construction projects in Jimma City. Changing employees' working culture, Lack of incentives, Low effort to learn, Complexity, Lack of cooperation from employees, and Long implementation time are ranked from 6th to 11th with their relative importance order. These are high to very low effect on implementing lean construction practices in respondents' view, and respondents agree to disagree strongly. These are barriers to the efficiency on the implementation of Lean Construction Practices on Building Construction Projects.

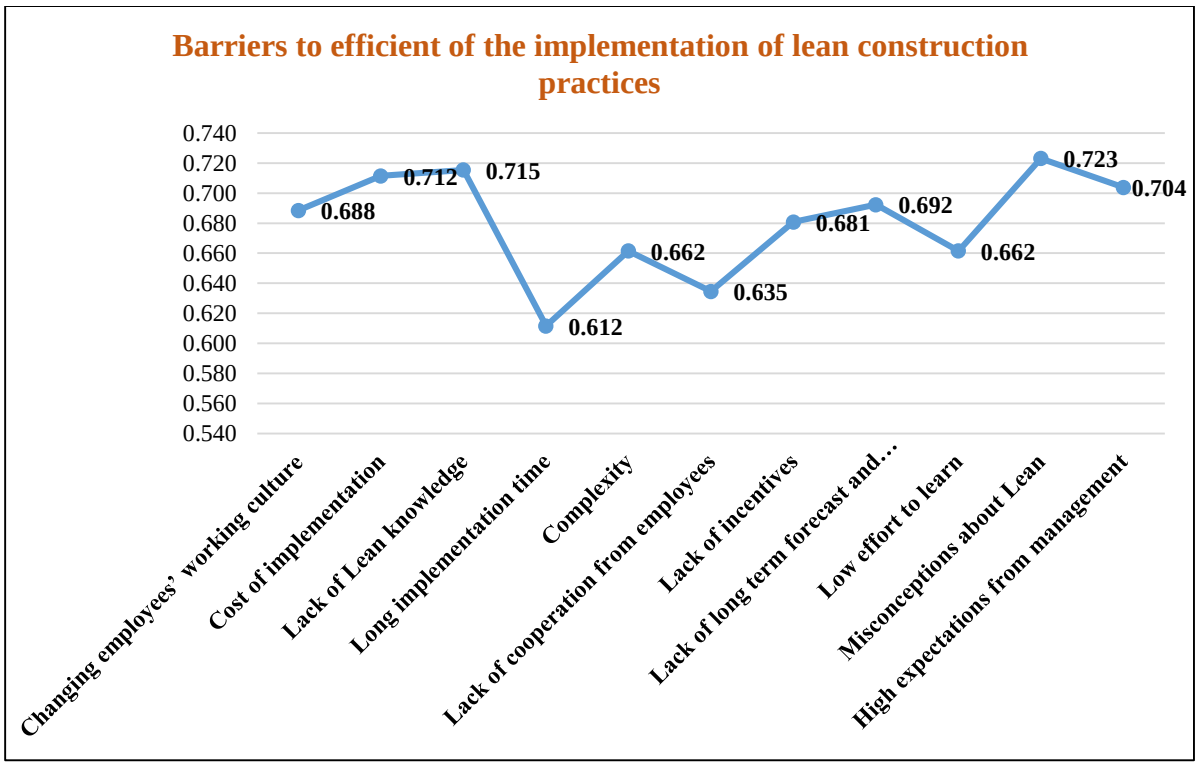

Figure 4.12 Barriers to the efficiency on the implementation of lean construction practices

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study assessed Lean Construction practices on building construction projects in the case of Jimma City, which subsequently reveals based on results the following conclusions;

- Based on the findings or results of the study identified that the Lean Construction Practices which are highly implemented on Building construction projects in Jimma City are regular performance measurement of site workers, Identification of client needs, Project needing immediate attention given more importance, Strict criteria for the selection of a subcontractor and Involvement of project participants in the making of schedules as their Relative Importance Index (RII) order. And also the Lean Construction Techniques and Tools which are high extent implemented by firms on Building Construction Projects in Jimma City based on their Relative Importance Index (RII) order are; On-site management, Integrated Project delivery Method, 5S, Value-based management, Health, and safety improvement, and Team/partnering. So, the study found that implementation of Lean Construction Practices on Building Construction Projects in Jimma city is not high because all Lean Construction Practices not fully adopted or implemented to add value and minimize wastage of resources for the Building Construction Projects.
- As findings of this study determined, 50% of respondents have average level of awareness of Lean Construction Practices on Building Construction Projects. This shows that the firms in building construction projects has sufficient level of awareness about the concepts and theory of lean production which developed from the manufacturing industry or from Toyota Company to implement its practices including tools and techniques on building construction projects. So, the level of awareness of Lean Construction Practices among firms on Building Construction Projects determined was average level of the Lean Construction Practices in Jimma City.
- The study evaluated that based on the results the efficiency of the implementation of Lean Construction Practices among stakeholders on Building Construction Projects good which means 46% of respondents were said that the efficient implementation of Lean Construction Practices on building construction projects in Jimma city. Approximately Average number of respondents were in Jimma city efficiently implement Lean Construction Practices On

Building Construction Projects to minimize construction waste and increase projects' value. The benefits which are highly get from adopting the efficient implementation of Lean Construction Practices on Building Construction Projects in Jimma city are; Increased productivity, Efficient communication among the client and construction team, Improved Quality, Reduced project timetable, and Transparency. These benefits show the efficiency of implementing Lean Construction Practices on Building Construction Projects in Jimma City, and the firms are adopting and using to some extent the lean concept or thinking to minimize the construction wastes and increase the value of projects. The major barriers to efficient implementation of the Lean Construction Practices on Building Construction Projects in the Jimma City are; Misconceptions about Lean, Lack of Lean knowledge, cost of implementation, High expectations from management, and Lack of long term forecast and investment.

Therefore, based on above conclusions of the results; the study identified that some of the Lean Construction Practices including its tools and techniques are implemented to add values and minimize construction wastes on building construction projects. The level of awareness of Lean Construction Practices among firms on Building Construction Projects is average and they understood the concepts and theory of lean construction practices. There is partially sufficient efficiency of implementing Lean Construction Practices on building construction projects in Jimma City and to some extent the firms are adopting and using the lean concept to minimize the construction wastes and increase the value of projects.

5.2 Recommendation

Based on the results of this study; the recommendation of this study that Lean Construction practices are moderately implemented on Building Construction Projects and to implement fully or highly on building construction projects in Jimma city; LC should be given to construction firms and professionals as training and workshop to develop the concept of lean thinking or lean construction and to acquire a better knowledge of it and can easily build on the foundational knowledge to implement Lean Construction practices in Building Construction Projects in Jimma City to minimizes construction wastes and maximize the value projects.

Lean Construction practices should be given through the systematic training and actions research on LC practices and collaboration among construction companies to increase the level of awareness on LC Practices among firms in the building construction projects. Lean Construction

practices should also be organized as a curriculum for students in construction fields, which help increase awareness moving lean thinking faster into the mainstream of construction education.

The efficient implementation of Lean Construction practices in Building Construction Projects in Jimma city is moderately or partially sufficient. So to increase level of implementation LC Practices on Building Construction Projects, it should be given for firms as current trend of practices or approach of project designing and managing through training and workshop to get high implementation of LC practices.

For the further studies, the researcher assesses Lean Construction practice implementation in the building construction industry and other Construction Projects by changing scope in Jimma City. Research conducted on the standard procedure of LC key concepts is scarce; hence there is a need for research to be undertaken on this potential area on Building Construction Projects and to have a wider study area of Lean Construction Practices including its principles, tools, and techniques that are not addressed in this study researcher will be study other locations in Ethiopia. A similar area will be conducted on construction organizations that have implemented the LC concept by observing their construction projects' practices.

REFERENCES

Ahmed. M. Mohd, J. Aini ,A. B. Nor Azmi and Z. Mardhiah.(2013). Sustainability through Lean Construction Approach: A literature review. Procedia - Social and Behavioral Sciences, Volume 101, p. 90 – 99.

Abdelrazig, Y. E. (2015). Using Lean Techniques To Reduce Waste And Improve Performance In Municipal Construction Project Delivery, Arlington: The University Of Texas At Arlington.

Abhiram,P.,Asadi,S.S. and Prasad,A.V.S.(2016). Implementation Of Lean Methodology In Indian Construction. International Journal of Civil Engineering and Technology (IJCIET), 7(6), pp. 641-649.

Abubakar,B. Muhammad, (2013). A Framework For Utilising Lean Construction Strategies To Promote Safety On Construction Sites, Wolverhampton: A thesis submitted to the School of Technology University of Wolverhampton in partial fulfilment of the requirements for the Degree of Doctor of Philosophy.

Adamu, S.(2017). Improving Project Delivery Process Using Lean Construction Approach, s.l.: Faculty of Built Environment Universiti Teknologi Malaysia.

Adegbembo, Taiwo Fadeke; Bamisaye, Olorunfemi Paul2 & Aghimien, Douglas Omoregie, (2016). Assessment of Lean Construction Practice in the Nigerian Construction Industry. Procs. of the Joint International Conference (JIC) on 21st Century Human Habitat:Issues, Sustainability and Development, pp. 756-764.

Akinradewo,O.,Oke,A.,Aigbavboa,C., Ndalamba,M.(2018). Benefits of Adopting Lean Construction Technique in the South African Construction Industry. Proceedings of the International Conference on Industrial Engineering and Operations Management, pp. 1271-1277.

Albert, I.(2020). A Lean Production Approach To Materials Management In The Nigerian Construction Industry. A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Construction Management in the Department of Construction Management, Nelson Mandela University, Port Elizabeth, South Africa, pp. 43-47.

Aslam, M. H. , Assel, B. and Jong Ryeol Kim.(2019). Investigation of Wasteful Activities Using Lean Methodology: In Perspective of Kazakhstan's Construction Industry. Buildings, 9(113), pp. 1-14.

Ayalew,T..M., Zakaria, D., and Zoubeir, L., (2016). The Future of Lean Construction in Ethiopian Construction Industry. International Journal of Engineering Research & Technology (IJERT), 5(02), pp. 107-113.

Babalola,O., Ibem, E.O. and Ezema, I.C.(2018). Assessment of Awareness and Adoption of Lean Practices in the Nigerian Building Industry. International Journal of Civil Engineering and Technology (IJCIET), 9(13), pp. 1626-1640.

Babalola,O., Ibem, E.O. and Ezema, I.C.(2019). Lean construction: an approach to achieving sustainable built environment in Nigeria. Journal of Physics: Conference Series, 1299(012007), pp. 1-10.

Bajjou, M.S. and Chafi,A.(2018). Lean construction implementation in the Moroccan construction industry: Awareness, benefits and barriers. Journal of Engineering, Design and Technology, 16(4), pp. 533-556.

Bajjou,M.S. and Chafi, A.(2018). A Conceptual Model Of Lean Construction:A Theoretical Framework. Malaysian Construction Research Journal, 26(3), pp. 67-86.

Bhargav,D. Pekka,H.J. Sergio,K., and Lauri,K.(2015).Suggestions To Improve Lean Construction Planning. Proceedings of the 23rd Annual Conference of the International Group for Lean Construction, 29-31 July .pp. 193-202.

Brun, P. M., Ricardo, R. M., and Thaís da C. L. Alves. (2008). Implementing Lean Construction Concepts In A Residential Project. ResearchGate, pp. 1-6.

Damtew Yirgalem and Enday Abdulkadir. (2019). Assessment of building construction defect causes in North Shoa zone, Ethiopia. Journal of Civil Engineering and Construction Technology, 10(1), pp. 1-10.

Dawit, Y. (2019). Challenges Confronting Project Management Processes for the Success of Hydropower Projects: A case study of Ethiopian Electric Power (EEP), Addis Ababa : Addis Ababa University.

Dinesh,S., Sethuraman,R. & Sivaprakasam,S.(2017). The Review On Lean Construction An Effective Approach In Construction Industry. International Journal of Engineering Research and Modern Education, Issue Special Issue, pp. 119-123.

Elhaj, A.M., Ahmed,M. and Sing, W. L.(2018). Assessment of Lean Construction Practice at Selected Construction Sites in Klang Valley. International Journal of Engineering & Technology, 7((4.35)), pp. 125-130.

El-Kourd, R. M. (2009). A Study of Lean Construction Practices in Gaza Strip, Gaza Strip: The Islamic University of Gaza ,Deanery of Higher Studies,Faculty of Engineering,Civil Engineering Department, Construction Management.

El-Kourd, R. M. (2009). A Study of Lean Construction Practices in Gaza Strip, Gaza Strip: The Islamic University of Gaza ,Deanery of Higher Studies,Faculty of Engineering,Civil Engineering Department, Construction Management.

Ethiopian Economic Association(EEA), E. E., Volume VI 2006/07.(2008). The Current State Of The Construction Industry, Addis Ababa, Ethiopia: Ethiopian Economic Association(EEA).

Gebrehiweta, T. and Luob,H., (2017). Analysis of Delay Impact on Construction Project Based on RII and Correlation Coefficient: Empirical Study. Procedia Engineering, Volume 196, p. 366 – 374.

Gunduz, M., Nielsen Y. and Ozdemir, M. (2013). Quantification of Delay Factors Using the Relative Importance Index Method for Construction Projects in Turkey. Journal of Management in Engineering, Volume 29, pp. 133-139.

Hatkar K. B . and Hedaoo N .A.(2016). Delay Analysis By Using Relative Importance Index Method In Infrastructure Projects. International Journal of Civil Engineering and Concrete Structures, 1(3), pp. 10-20.

Herrera, R. F., Mourgues ,C., Fernando, A.L. and Pellicer,E., 2019. An Assessment of Lean Design Management Practices in Construction Projects. Sustainability, 12(19), pp. 1-19.

Locatelli,G. , Mancini,M., Gastaldo,G. and Mazza,F.(2013). Improving Projects Performance With Lean Construction: State Of The Art, Applicability And Impacts. organization, technoloy and management in construction.An international journal. 6(2), pp. 775 - 783.

Mohd,S. Bajjou, A. Chafi, and A. En-Nadi.(2017). A Comparative Study between Lean Construction and the Traditional Production System. Int. J. Eng. Res. Africa, Volume 29, p. 118–132.

Mahashabde, V. (2016). Comparison Of Lean Construction In India And United States Of America, Bowling Green, Kentucky: Top Scholar® Masters Theses & Specialist.

Mahashabde, V. (2016). Comparison Of Lean Construction In India And United States Of America, Bowling Green, Kentucky: TopSCHOLAR® Masters Theses & Specialist.

Marwa, S. (2013). Improving Project Performance Using Lean Construction in Egypt :A Proposed Framework, Cairo: The American University in Cairo.

Mohammed, O. I. (2016). Applying Lean Construction Concepts to Construction Industry in Sudan, Sudan: Sudan University of Science and Technology College of Graduate Studies.

Mohsen Tavakol, Reg Dennick .(2011). Making sense of Cronbach's alpha. International Journal of Medical Education, Volume 1, pp. 1-3.

More,V.D., Dr.Charhate,S. and Sinha,M. (2016). Lean Construction Techniques in Indian Construction Industry: Some Analysis. International Journal of Civil Engineering Research, 7(1), pp. 59-65.

Oguntona, O.A.,Aigbavboa,C.O. and Mulongo,G.N. (2019). An Assessment of Lean Construction Practices in the Construction Industry. Sustainable Human Settlement and Construction Research Centre, pp. 524-534.

Picchi, J., Franco,V. and Flávio, A. (2016). Lean design in building projects: guiding principles and exploratory collection of good practices. In: Proc. 24th Ann. Conf. of the Int'l. Group for Lean Construction, Issue 4, p. 113–122.

Primayuda, V. D. H. a. H. (2019). Exploring Lean Construction for Housing Projects: A Literature Review. IOP Conf. Series: Earth and Environmental Science 366 012006, pp. 1-9.

Radhika ,R., and Sukumar,S. (2017). An Overview Of The Concept Of Lean Construction And The Barriers In Its Implementation. International Journal of Engineering Technologies and Management Research, 4(3), pp. 13-26.

Raghavan, N., Kalidindi, S., Mahalingam, A., Varghese, K. and Ayesha, A. (2014). Implementing Lean Concepts On Indian Construction Sites: Organisational Aspects And Lessons Learned. Proceedings IGLC-22, pp. 1181-1190.

Ragnhild, M. D. G. (2019). Implementation of Lean and Last Planner System® in the construction industry in Norway. Master of Science in Engineering Structures and Materials, University of Stavanger.

Ramasamy, U. , Kumar,V. And Ganapathy. (2016). A Critical Study Of Various Lean Techniques In Practice And Developing A Framework For Different Construction Building Projects. Int. J. Chem. Sci.: 14(S1), pp. 175-187.

Remya, R., Bipin Das, M., Kaveri ,M. and Krishnan ,G.H. (2019). A Review Paper on Lean Management in Construction Sites. International Research Journal of Engineering and Technology (IRJET), 6(5), pp. 5446-5449.

Richard, H. A., Shahryar, S. and Shariman, B. M. (2016). Lean Construction: An Effective Approach For Project Management. ARPN Journal of Engineering and Applied Sciences, 11(3), pp. 1607-1612.

Sami, Md S. P. and Harish ,Naik, B. (2016). An Analysis of Lean Construction Practices in Tamilnadu Construction Industry Engineering and Technology. International Journal of Innovative Research in Science,, 5(9), pp. 16391-16398.

Sarhan,J. G., Bo Xia, Fawzia,S., Azharul, K.(2017). Lean Construction Implementation in the Saudi Arabian Construction Industry. Construction Economics and Buildings, 17(1), pp. 46-69.

Sarhan ,S., Pasquire, C. , Elnokaly, A. and Pretlove, S. (2019). Lean and Sustainable Construction: A Systematic Critical Review of 25 Years of IGLC Research. Lean Construction Journal 2019, pp. 1-20.

Saygili, M.E., Kemal, Y. and Behzat, T.O. (2019). Research Development of Lean Construction Journal: A Bibliometric Analysis. Lean Construction Journal 2019, pp. 47-63.

Shaik Md Sami Pasha and B.Harish Naik. (2016). An Analysis of Lean Construction Practices in Tamilnadu Construction Industry. International Journal of Innovative Research in Science, Engineering and Technology, 5(9), pp. 16391-16398.

Sholanke, A. B. , Chen, S. J., Newo, A. A. and Nwabufo, C. B.(2019). Prospects and Challenges of Lean Construction Practice In The Building Industry In Nigeria: Architects' Perspective. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8(8), pp. 667-673.

Tafazzoli , M., Mousavi,E., and Kermanshachi ,S. (2020). Opportunities and Challenges of Green-Lean: An Integrated System for Sustainable Construction. Sustainability , 12 (4460), pp. 1-20.

Tejas Vidhate and Ashwini salunkhe (2018). General overview of Lean Management in Construction Industry. International Research Journal of Engineering and Technology (IRJET), 5(7), pp. 1999-2004.

Zhang, X. (2019). Integrating Lean Construction, BIM and Quality: A New Paradigm for the Improvement of Chinese Construction Quality, s.l.: A thesis submitted for the degree of Doctor of Philosophy University of Bath Department of Architecture & Civil Engineering.

APPENDIXES

Appendix I: Questionnaire

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

Questionnaires Survey

Date: _____

Subject:- Request to respond to a questionnaire for MSc thesis work

Dear Respondents

This questionnaire is designed and attached to this letter is to study the title "**Assessment of Lean Construction Practices On Building Construction Projects: A Case of Jimma City**." as part of Partial Fulfillment of the Requirement for the Degree of Masters of Science in Construction Engineering and Management. The information obtained will be used for academic purposes only; all information and feedback will be kept strictly confidential. Your experience and educational background in the construction industry will significantly contribute to the success of my study, and I believe this kind of study will be an input for the development of lean construction practices on building construction in Jimma City and also the Ethiopian construction industry. Your response to each questionnaire is highly valuable and contributory to the outcome of the study. So, I am kindly requesting you to respond to each question.

Thank you.

Wondimagegn Gebeyehu Ganebo

Tel: +251 966091918 (Ethiopia)

Email: wondegebeyehu8@gmail.com

Advisor: Eng. Bien Maunahan (Assistant Prof.)

Co-Advisor: Eng. Mebratu Abera (MSc.)

TITLE: - ASSESSMENT OF LEAN CONSTRUCTION PRACTICES ON BUILDING CONSTRUCTION PROJECTS: A CASE OF JIMMA CITY

Objective of the Study

General Objective

The main objective is to assess lean construction practices on building construction projects in the case of Jimma City.

Specific Objectives

The Specific Objectives of this research can be listed as follows:

1. To identify the Lean Construction Practices implemented on Building Construction Projects in Jimma City.
2. To determine the level of awareness of Lean Construction Practices among firms on Building Construction Projects in Jimma City.
3. To evaluate the Efficiency of Implementing Lean Construction Practices on Building Construction Projects in Jimma City.

The Questionnaire is to be used to Collect the data for assessment of Lean Construction Practices on Building Construction Projects in the case of Jimma City. This questionnaire prepared for data collection contains Seven parts: -

Part I: Personal and organizational profile of respondent

Please choose the appropriate choice by putting (√)

(1) What is your specialty?

□ Civil Engineer □ Architect □ Other……..

(2) What is your education level?

□ Diploma □ Bachelor's Degree □ Master's Degree □ Doctorate's Degree

(3) How many years have you dealt with construction projects?

□ 0-5 □ 5-10 □ 10-15 □ More than 15

(4) what is your position in the project?

□ project manager □ site engineer □ office engineer □ others

(5) What your firm's role in the project?

□ Contractor □ Consultant

Part II: General Introduction about awareness of Lean Construction Practices

Lean construction is an implementation of lean production techniques which has been developed in Toyota motor company. Lean construction is to manage and improve the construction process to deliver what the customer needs ideally. Lean construction is a continuous process that applies through design, planning, and construction. It is an integrated process in which clients, designers, contractors, suppliers, etc. must be committed to working together. Lean construction aims to improve communication, eliminating all variety of waste and errors, and enhancing the value or performance of projects on the worksite environment. The Lean concept is all about getting the right things to the right place at the right time, in the right quantity while minimizing waste, and being open and responsive to change. Lean thinking practical in construction can be waste elimination; Improving reliability; Creating continuous flow in a pull system; Meet the customer's need; Involvement of workers at every level; Involvement of supplier and client in the project process; Built-in quality; Continuous improvement and knowledge sharing.

Please choose the appropriate choice by putting (√)

1) To what extent do you know about lean construction?
   □ Very Low □ Low □ Average □ High □ Very High
2) To what level do you have effectively implement Lean Construction Practices in a construction Projects including its principles, techniques, and tools?
   □ Very Low □ Low □ Average □ High □ Very High
3) What do you think the motive behind not fully implementing of lean construction practices on building construction projects in Jimma City?
   □ Unavailable researches in lean construction in Jimma City
   □ Resistant to change
   □ Top-level management satisfied with Status traditional projects management approach
   □ Ignorance of the concept Lean construction
   □ Absence of knowledge of lean construction Practices
4) Lean construction practices effiecntly suitable for building construction projects to minimize waste and maximize the value of projects?
   □ Yes □ No
   If yes, please specify----------

Part III: Lean construction practices which are implemented and its level of awareness among firms on Building construction projects

Please choose the appropriate choice by putting (√). The level of agreement is represented by **1. Very Low 2. Low 3 Average 4. High 5. Very High**

S/NO –	Lean Construction Practices	Level of awareness among firms					Implementation on Building construction projects among firms				
		1	2	3	4	5	1	2	3	4	5
1	Identification of client needs										
2	Project needing immediate attention given more importance										
3	Look –ahead of schedule (a program of work)										
4	Continuous improvement										
5	All parties involved in the design (involvement of construction professionals right from the inception)										
6	Weekly meetings										
7	Percent Plan Complete										
8	Regular performance measurement of site workers										
9	Just-in-Time (JIT) delivery (timely delivery of construction materials to the site)										
10	Using computer software for estimating										
11	Training of employee										
12	Personnel responsible for procurement										
13	Strict criteria for the selection of a subcontractor										
14	Involvement of project participants in the making of schedules										
15	Uninterrupted workflow										
16	Site daily meetings										
17	Direct involvement of foremen in decision making										

Part IV: Lean Construction Techniques and Tools Implemented by the Firms on Building Construction Projects a case of Jimma City

Please choose the appropriate choice by putting (√) The level of agreement is represented by **1. Very Low Extent 2. Low Extent 3 Neutral 4. Extent 5. Very High Extent**

S/NO –	Lean techniques and tools	Implementation on building construction projects				
		1	2	3	4	5
1	6 Sigma					
2	Benchmarking					
3	Concurrent management					
4	Daily clustering					
5	Design structure matrix					
6	Detailed briefing					
7	Error proofing					
8	Fail-safe for quality					
9	First, run study					
10	Health and safety improvement					
11	Integrated project delivery					
12	Just-in-time					
13	Kaizen					
14	Kanban System					
15	Last planner system					
16	Location-based management					
17	On-site management					
18	Pull scheduling					
19	Standardization					
20	Target value design					
21	Team/partnering					
22	Value-based management					
23	Visual Design Construction (3D/BIM)					
24	Visualization tools (signpost and board for instruction on site)					
25	5S (sort, set ,shine, standardize and sustain)					

Part V: Benefits of Efficient implementation of the Lean Construction Practices on Building Construction Projects

Please tick appropriately according to the level of agreement on each specified Benefits of Efficient implementation of the lean construction practices

The level of agreement is represented by:

Strongly disagree = 1, disagree =2, neutral =3, agree =4 and **strongly agree = 5**

S/NO_	Benefits of Efficient implementation of the Lean Construction practices	1	2	3	4	5
1	Reduced waste					
2	Efficient administration of materials					
3	Improved whole-life cost					
4	Improved customer satisfaction					
5	Improved safety					
6	Increased productivity					
7	Improved risk management					
8	Reduced project timetable					
9	Efficient communication among the client and construction team					
10	Improved Quality					
11	Effective system with less cost					
12	Focusing on the completion of the process					
13	Balance flow improvement					
14	Minimizing the steps to simplify					
15	To increase transparency					
16	Better control of inventory					
17	Minimization of risk					

Part VI: Barriers to Efficient Implementation of Lean Construction Practices

Please tick appropriately according to the level of agreement on each specified barriers to efficient implementation of Lean Construction practice in the Jimma City.

The level of agreement is represented by:

Strongly disagree = 1, disagree =2, neutral =3, agree =4 and **strongly agree = 5**

S/NO_	Barriers to Efficient Implementation of Lean Construction Practices	1	2	3	4	5
1	Changing employees' working culture					
2	Cost of implementation					
3	Lack of Lean knowledge					
4	Long implementation time					
5	Complexity					
6	Lack of cooperation from employees					
7	Lack of incentives					
8	Lack of long term forecast and investment					
9	Low effort to learn					
10	Misconceptions about Lean					
11	High expectations from management					

Appendix II: Interview Questions

Project Name: _____
Name of the organization: _____
Respondent's Name (optional): _____

Position/role: _____

Date and time: _____

The interviewee is a member of the organizations and previously involved or still involved in the project.

Introduction

Good morning/Good afternoon Mr./Ms. (Name of respondent) my name is Wondimagegn Gebeyehu. Before starting my question, I would like to thank you for your voluntary participation in this research. The interview was divided into two sections and will last approximately 30 to 40 minutes. This semi-closed interview, which is forwarded to the contractor and consultants who are involved in the building construction project, is part of this academic research that aims **to assess Lean Construction Practices on Building Construction Projects in the case of Jimma City**. With this survey, I would like to assess lean construction practices on building construction projects in Jimma City in order to determine the effectiveness of the implementation of lean construction practice on building construction projects. In the long term, this research helps the stakeholders to reduce project time, to reduce project cost, to reduce all wastes of construction projects and maximize the value of projects. All information you provide will be kept in strict confidentiality and only used for academic research. Please feel free to answer the questions with what you know and what you think in your mind. I value your participation and thank you for the commitment of time, energy, and effort.

Recording Confidentiality

I would like to ask your permission to record our conversation. The reason why I want to record the conversation, in order to get full details about this interview, which will help me for the analysis phase. Other than that, it will also be more comfortable for us to discuss because I can focus much more on the conversation, not on writing too much about the details of our conversation.

The content of this interview is confidential. It will not be disclosed to anyone without your permission. After the research, everything (recordings, notes, etc.) will be discarded.

Additionally, my supervisor will be the only to access to the analyzed information.

The following questions are about lean construction including its principles, tools and techniques and implementation of lean construction practices that are adopted from various kind of literature.

1. For how long have you been practicing Lean Construction? _____
2. How integrated Lean Construction principles implemented in your organization as part of the strategic plan? _____

   _____
3. How your organization demonstrate a long-term plan for adopting the implementation of an effective Lean Construction practices on your projects?

   _____

   _____

   _____
4. Does the organization implement lean construction practices for eliminating waste? if Yes, How?

   _____

   _____
5. What are the Lean Construction principles, techniques and tools effectively implemented on your project?

   _____

   _____
6. Does the organization understand the benefits of implementing the Lean Construction method? If yes, List it_____

   _____
7. What are the barriers hindering the effectiveness of implementation of Lean Construction in your Projects? _____

   _____

Appendix III: Results of Likert Five Point Scale Data and Its Relative Importance Index of Respondents

Assessment of Lean Construction Practices On Building Construction Projects: A Case of Jimma City

Implementation of Lean Construction Practices On Building Construction Projects by Respondents

The level of agreement is represented by 1. Very Low 2. Low 3 Average 4. High 5. Very High

S/NO_	Lean construction practices	1	2	3	4	5	ΣW	N	H*N	RII=ΣW/ (H * N)	Rank
1	Identification of client needs	2	6	18	12	14	**186**	**52**	**260**	**0.715**	2
2	Project needing immediate attention given more importance	1	6	15	24	6	**184**	**52**	**260**	**0.708**	3
3	Look –ahead of schedule (a program of work)	5	9	13	17	8	**170**	**52**	**260**	**0.654**	9
4	Continuous improvement	4	6	16	21	5	**173**	**52**	**260**	**0.665**	8
5	All parties involved in the design (involvement of construction professionals right from the inception)	7	9	13	14	9	**165**	**52**	**260**	**0.635**	11
6	Weekly meetings	3	11	15	16	7	**169**	**52**	**260**	**0.650**	10
7	Percent Plan Complete	4	4	15	24	5	**178**	**52**	**260**	**0.685**	6
8	Regular performance measurement of site workers	1	2	21	14	14	**194**	**52**	**260**	**0.746**	1
9	Just-in-Time (JIT) delivery (timely delivery of construction materials to the site)	7	9	20	9	7	**156**	**52**	**260**	**0.600**	15
10	Using computer software for estimating	7	9	12	16	8	**165**	**52**	**260**	**0.634**	12
11	Training of employee	7	11	16	11	7	**156**	**52**	**260**	**0.601**	14
12	Personnel responsible for procurement	2	9	18	15	8	**174**	**52**	**260**	**0.669**	7
13	Strict criteria for the selection of a subcontractor	2	8	15	16	11	**182**	**52**	**260**	**0.700**	5
14	Involvement of project participants in the making of schedules	2	8	13	19	10	**183**	**52**	**260**	**0.704**	4
15	Uninterrupted workflow	5	15	16	12	4	**151**	**52**	**260**	**0.581**	16
16	Site daily meetings	13	12	12	6	9	**142**	**52**	**260**	**0.546**	17
17	Direct involvement of foremen in decision making	4	12	19	6	11	**164**	**52**	**260**	**0.631**	13

Level of Awareness of Lean Construction Practices by respondents

The level of agreement is represented by 1. Very Low 2. Low 3 Average 4. High 5. Very High

S/NO_	Lean construction practices	1	2	3	4	5	ΣW	N	H*N	RII=ΣW/ (H * N)	Rank
1	Identification of client needs	2	10	13	12	15	184	52	260	**0.708**	**5**
2	Project needing immediate attention given more importance	6	2	15	25	4	175	52	260	**0.673**	**10**
3	Look –ahead of schedule (a program of work)	6	4	13	22	7	176	52	260	**0.677**	**9**
4	Continuous improvement	1	7	13	24	7	185	52	260	**0.712**	**4**
5	All parties involved in the design (involvement of construction professionals right from the inception)	2	11	21	11	7	166	52	260	**0.638**	**15**
6	Weekly meetings	1	10	17	13	11	179	52	260	**0.688**	**8**
7	Percent Plan Complete	5	6	17	15	9	173	52	260	**0.665**	**12**
8	Regular performance measurement of site workers	3	5	12	20	12	189	52	260	**0.727**	**2**
9	Just-in-Time (JIT) delivery (timely delivery of construction materials to the site)	1	13	12	18	8	175	52	260	**0.673**	**10**
10	Using computer software for estimating	4	10	19	15	4	161	52	260	**0.619**	**17**
11	Training of employee	4	8	20	16	4	164	52	260	**0.631**	**16**
12	Personnel responsible for procurement	4	4	20	12	12	180	52	260	**0.692**	**7**
13	Strict criteria for the selection of a subcontractor	2	9	11	14	16	189	52	260	**0.727**	**2**
14	Involvement of project participants in the making of schedules	1	8	14	14	15	190	52	260	**0.731**	**1**
15	Uninterrupted workflow	1	9	24	9	9	172	52	260	**0.662**	**13**
16	Site daily meetings	2	12	12	11	15	181	52	260	**0.696**	**6**
17	Direct involvement of foremen in decision making	4	6	23	10	9	170	52	260	**0.654**	**14**

Lean Construction Techniques and Tools Implemented by the Firms On Building Construction Projects a case of Jimma City by respondents

Scale **:** very low = 1, low extent =2, neutral =3, extent =4 and very high extent = 5

S/NO_	Lean construction techniques and tools	1	2	3	4	5	∑W	N	H*N	RII	Rank
1	6 Sigma	9	3	21	15	4	158	52	260	0.608	20
2	Benchmarking	4	10	16	12	10	170	52	260	0.654	14
3	Concurrent management	1	14	14	15	8	171	52	260	0.658	12
4	Daily clustering	7	11	17	12	5	153	52	260	0.588	25
5	Design structure matrix	3	7	19	16	7	173	52	260	0.666	10
6	Detailed briefing	6	10	10	16	10	170	52	260	0.654	14
7	Error proofing	9	7	13	11	12	166	52	260	0.638	18
8	Fail-safe for quality	2	10	17	15	8	173	52	260	0.665	11
9	First, run study	3	13	15	12	9	167	52	260	0.642	17
10	Health and safety improvement	4	3	18	20	7	179	52	260	0.688	5
11	Integrated project delivery	3	7	11	23	8	182	52	260	0.700	2
12	Just-in-time	6	13	15	11	7	156	52	260	0.600	22
13	Kaizen	5	8	24	13	2	155	52	260	0.596	23
14	Kanban System	3	11	24	13	1	154	52	260	0.592	24
15	Last planner system	3	17	13	13	6	158	52	260	0.608	20
16	Location-based management	2	12	13	20	5	170	52	260	0.653	15
17	On-site management	4	2	12	24	10	190	52	260	0.731	1
18	Pull scheduling	3	8	13	22	6	176	52	260	0.677	7
19	Standardization	2	6	23	17	4	171	52	260	0.658	12
20	Target value design	2	7	16	23	4	176	52	260	0.677	7
21	Team/partnering	4	5	16	20	7	177	52	260	0.681	6
22	Value-based management	4	5	15	19	9	180	52	260	0.692	4
23	Visual Design Construction (3D/BIM)	10	3	14	17	8	166	52	260	0.638	18
24	Visualization tools (signpost and board for instruction on site)	3	10	16	12	11	174	52	260	0.669	9
25	5S (sort ,shine , standardize and sustain)	2	8	14	19	9	181	52	260	0.696	3

Benefits of Efficient Implementation of Lean Construction Practices On Building Construction Projects by Respondents

Scale: Strongly disagree = 1, disagree =2, neutral =3, agree =4 and strongly agree = 5

S/ NO_	Benefits of Efficient Implementation of the Lean Construction practices	1	2	3	4	5	∑W	N	H*N	RII	Rank
1	Reduced waste	3	5	9	14	21	**201**	**52**	**260**	**0.773**	**9**
2	Efficient administration of materials	2	3	8	26	13	**201**	**52**	**260**	**0.773**	**9**
3	Improved whole-life cost	7	6	6	23	10	**179**	**52**	**260**	**0.688**	**17**
4	Improved customer satisfaction	1	5	15	17	14	**194**	**52**	**260**	**0.746**	**14**
5	Improved safety	1	7	7	19	18	**202**	**52**	**260**	**0.777**	**7**
6	Increased productivity	2	2	5	17	25	**214**	**51**	**255**	**0.839**	**1**
7	Improved risk management	2	4	10	18	18	**202**	**52**	**260**	**0.777**	**7**
8	Reduced project timetable	1	6	10	14	21	**204**	**52**	**260**	**0.785**	**4**
9	Efficient communication among the client and construction team	0	3	4	27	18	**216**	**52**	**260**	**0.831**	**2**
10	Improved Quality	1	4	8	22	17	**206**	**52**	**260**	**0.792**	**3**
11	Effective system with less cost	3	4	9	23	13	**195**	**52**	**260**	**0.750**	**13**
12	Focusing on the completion of the process	1	6	9	27	9	**193**	**52**	**260**	**0.742**	**15**
13	Balance flow improvement	1	3	16	18	14	**197**	**52**	**260**	**0.758**	**12**
14	Minimizing the steps to simplify	3	6	8	27	8	**187**	**52**	**260**	**0.719**	**16**
15	To increase transparency	0	4	10	24	14	**204**	**52**	**260**	**0.785**	**4**
16	Better control of inventory	0	5	14	19	14	**198**	**52**	**260**	**0.762**	**11**
17	Minimization of risk	0	5	9	24	14	**203**	**52**	**260**	**0.781**	**6**

Barriers to Efficient Implementation of Lean Construction Practices On Building Construction Projects in Jimma City by Respondents

Level of Agreements: Strongly disagree = 1, disagree =2, neutral =3, agree = 4 and strongly agree = 5

S-NO_	Barriers to efficient implementation of lean construction practices	1	2	3	4	5	∑W	N	H*N	RII	Rank
1	Changing employees' working culture	1	10	13	21	7	**179**	52	**260**	**0.688**	**6**
2	Cost of implementation	1	9	12	20	10	**185**	52	**260**	**0.712**	**3**
3	Lack of Lean knowledge	2	8	13	16	13	**186**	52	**260**	**0.715**	**2**
4	Long implementation time	3	15	16	12	6	**159**	52	**260**	**0.612**	**11**
5	Complexity	3	8	16	20	5	**172**	52	**260**	**0.662**	**8**
6	Lack of cooperation from employees	6	9	14	16	7	**165**	52	**260**	**0.635**	**10**
7	Lack of incentives	2	8	17	17	8	**177**	52	**260**	**0.681**	**7**
8	Lack of long term forecast and investment	3	11	9	17	12	**180**	52	**260**	**0.692**	**5**
9	Low effort to learn	4	9	9	27	3	**172**	52	**260**	**0.662**	**8**
10	Misconceptions about Lean	3	4	8	32	5	**188**	52	**260**	**0.723**	**1**
11	High expectations from management	1	10	12	19	10	**183**	52	**260**	**0.704**	**4**

Appendix IV: Reliability test by Cronbach's Alpha Coefficient using Microsoft Excel sheet

Reliability Test For Part III

Reliability Test by Cronbach's Alpha coefficient

Respondents	Questions																	
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	TOTAL
R1	3	2	2	3	1	3	4	3	3	2	3	2	3	2	3	1	3	43
R2	4	3	2	4	4	2	3	3	3	4	4	4	3	4	2	3	2	54
R 3	3	5	5	4	1	2	1	5	3	1	3	4	2	4	1	1	2	47
R4	2	3	3	3	2	1	3	2	3	4	2	3	2	4	3	5	3	48
R 5	1	2	1	4	4	2	1	3	1	3	3	3	2	3	1	4	2	40
R 6	2	1	3	1	3	4	1	3	5	4	4	2	3	5	2	3	1	47
R 7	4	5	4	4	4	5	5	5	4	4	4	5	5	5	5	3	4	75
R 8	3	4	4	4	4	3	4	3	4	4	4	3	4	4	4	2	4	62
R 9	2	2	1	2	2	1	1	3	3	2	2	3	1	3	2	1	2	33
R 10	4	4	3	3	2	3	4	4	1	3	1	5	5	5	1	1	3	52
R 11	3	3	3	3	3	2	3	3	2	3	2	3	3	4	3	2	2	47
R 12	4	4	4	4	4	4	5	5	3	3	3	4	5	4	4	4	5	69
R 13	3	4	2	3	2	5	4	5	1	1	1	2	3	4	4	1	2	47
R 14	3	4	2	3	2	4	4	4	1	1	1	1	3	4	4	1	2	44
R 15	3	4	2	3	2	3	3	3	1	1	1	1	3	4	4	1	2	41
R 16	3	4	4	3	4	4	4	3	3	4	3	3	4	3	3	3	3	58
R 17	3	4	4	2	1	4	4	3	2	2	2	3	3	3	3	2	3	48
R 18	3	3	2	2	1	1	3	2	2	2	3	3	2	2	2	1	2	36
R 19	3	3	5	5	4	3	4	5	4	3	3	4	5	4	4	3	3	65
R 20	3	3	3	3	1	3	3	3	2	2	2	2	2	1	2	1	1	37
R 21	5	3	4	3	5	3	4	3	5	3	3	5	5	4	4	3	5	67
R 22	2	3	3	3	1	4	2	4	2	1	1	2	2	1	2	4	3	40
R 23	4	2	4	3	2	2	2	5	3	3	4	4	4	2	2	1	3	50
R 24	5	4	4	4	5	4	5	4	3	5	5	4	4	5	3	5	5	74
R 25	5	4	4	4	5	4	5	4	3	5	5	4	4	5	3	5	5	74
R 26	4	4	4	4	4	2	4	4	5	5	3	5	5	3	5	3	5	69
R 27	5	4	5	4	4	3	4	5	4	4	3	4	5	5	3	1	3	66
R 28	5	4	5	4	5	3	4	5	4	4	3	4	5	5	3	2	3	68
R 29	4	3	3	2	2	2	3	4	2	4	2	4	2	2	3	3	3	48
R 30	1	2	1	1	1	2	2	1	1	1	1	2	1	2	1	2	1	23
R 31	3	3	2	2	3	2	4	3	3	3	2	3	4	2	2	2	2	45
R 32	3	3	1	1	3	3	3	3	2	2	3	3	3	3	2	2	3	43
R 33	5	4	5	3	3	3	4	5	3	3	3	3	3	3	3	3	3	59
R 34	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	84
R 35	4	4	4	4	4	4	4	3	4	5	5	4	4	4	4	4	4	69
R 36	4	4	3	4	4	3	3	3	3	5	5	5	4	4	1	1	5	61
R 37	5	4	3	3	3	3	3	5	3	3	3	3	3	3	3	3	3	56
R 38	5	4	5	4	4	4	4	4	4	4	4	4	5	5	5	5	5	75
R 39	3	4	4	4	3	4	4	4	4	4	4	4	4	4	2	4	3	63
R 40	2	2	3	3	3	4	4	3	3	4	4	3	4	3	4	3	4	56
R 41	5	5	4	5	5	5	4	4	3	5	5	5	3	4	3	3	3	71
R 42	4	5	5	5	5	4	3	4	4	4	4	4	4	4	4	5	5	73
R 43	5	5	4	5	5	5	4	4	3	5	5	5	2	3	2	2	5	69
R 44	2	4	3	4	4	5	3	3	5	4	2	3	3	3	3	2	1	54
R 45	5	3	4	4	4	3	3	5	5	4	4	2	5	3	2	5	5	66
R 46	5	4	3	4	5	5	2	5	5	3	2	2	4	4	3	2	3	61
R 47	5	4	4	4	3	2	3	4	2	2	4	4	4	5	3	5	4	62
R 48	4	4	4	4	3	4	4	3	3	2	3	3	4	4	4	4	4	61
R 49	4	3	3	4	3	4	4	4	3	4	2	3	4	2	2	5	3	57
R 50	3	4	2	3	2	5	4	5	1	1	1	2	3	4	4	1	2	47
R 51	3	3	2	2	3	2	4	3	3	3	2	3	4	2	2	2	2	45
R 52	3	3	1	1	3	3	3	3	2	2	3	3	3	3	2	2	3	43
Variances of items	1.2	0.8	1.4	1.1	1.6	1.2	1.1	0.9	1.4	1.6	1.5	1.1	1.2	1.2	1.2	2	1.5	168.4
																		variances of total scores

number of item	17
sum of the item var	22.12
variances of total s	168.43
cronbach's α	**0.92**

Reliability Test for Part IV

	Reability Test by using Cronbach Alpha Coefficient																											
Respondents	Questions																											
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	TOTAL		
R1	2	3	2	3	2	2	3	3	3	3	3	2	2	2	2	3	2	3	2	2	2	2	1	3	2	59	number of item	25
R2	1	1	2	3	2	2	1	2	3	3	2	1	2	1	2	2	1	2	3	2	3	2	2	3	2	50	sum of the item variances	21.43
R 3	4	5	3	2	3	5	1	5	2	3	3	5	2	1	3	4	4	5	1	3	4	5	5	4	4	86	variances of total scores	361.28
R4	3	2	4	2	3	4	2	4	1	3	5	4	2	3	5	4	3	4	2	3	1	3	4	2	3	76	cronbach's α	**0.98**
R 5	1	2	4	1	3	2	5	4	3	2	4	2	1	4	5	2	3	1	3	3	4	2	3	2	4	70		
R 6	1	2	3	2	3	2	4	2	3	1	4	5	3	4	2	3	1	3	5	4	2	3	5	2	4	73		
R 7	4	4	4	5	4	3	4	4	3	4	5	5	4	4	5	4	5	4	4	3	3	3	3	4	4	99		
R 8	3	4	4	2	3	2	3	3	4	4	3	2	3	3	4	4	4	4	3	4	3	4	4	2	4	83		
R 9	3	3	2	2	2	1	3	2	2	3	3	2	1	3	2	4	3	3	3	2	3	2	3	3	2	62		
R 10	1	3	2	2	5	4	5	5	5	5	5	5	3	2	2	5	5	3	3	3	5	5	5	5	3	96		
R 11	2	2	3	2	3	3	3	3	3	3	2	1	2	2	2	2	3	2	2	2	2	3	3	3	3	61		
R 12	3	5	5	4	5	5	5	4	5	4	4	4	3	3	3	3	4	3	3	4	4	3	4	4	4	98		
R 13	4	2	2	1	3	1	1	4	2	4	4	2	4	3	2	2	4	4	3	4	4	4	4	5	5	78		
R 14	4	2	2	1	3	1	1	4	2	4	4	2	4	3	2	2	4	4	3	4	4	4	4	5	5	78		
R 15	4	2	2	1	3	1	1	4	2	4	4	2	4	3	2	2	4	4	3	4	4	4	4	5	5	78		
R 16	3	5	4	3	3	4	5	3	3	2	3	4	3	3	3	3	4	4	4	4	4	3	3	3	3	86		
R 17	1	2	2	3	2	2	3	3	2	3	2	2	3	2	2	3	4	2	3	2	4	4	1	2	2	61		
R 18	3	4	3	3	2	2	2	3	3	3	3	3	4	4	4	4	2	2	3	3	3	1	3	2	2	71		
R 19	4	4	5	4	4	4	5	4	4	5	5	3	4	3	3	3	5	3	3	3	4	4	3	3	4	96		
R 20	1	1	2	2	2	3	2	2	1	3	2	2	3	2	1	2	3	3	2	2	3	3	1	2	2	52		
R 21	3	4	4	4	4	2	2	2	2	2	3	3	3	3	3	4	4	4	4	3	3	3	3	4	4	80		
R 22	1	1	2	2	1	2	3	3	2	3	2	2	3	2	1	2	4	4	3	3	3	3	1	3	2	58		
R 23	4	3	4	4	5	5	4	4	5	4	3	2	3	2	2	4	5	5	4	5	5	5	4	4	4	99		
R 24	5	5	5	3	4	5	5	5	4	5	5	4	5	4	5	5	5	5	4	4	5	5	5	5	5	117		
R 25	5	5	5	3	4	5	5	5	4	5	5	4	5	5	5	5	4	4	5	5	5	5	5	5	5	118		
R 26	3	5	4	4	4	4	4	5	5	4	4	4	4	3	3	4	5	4	4	4	4	4	4	4	4	101		
R 27	3	5	5	4	4	5	5	3	4	4	4	4	4	4	4	3	3	4	4	4	3	4	4	5	4	100		
R 28	3	5	5	4	4	5	5	3	4	4	4	5	4	4	4	4	4	2	4	4	3	4	4	5	4	101		
R 29	1	2	2	2	4	3	3	3	3	1	1	1	2	3	2	4	3	2	3	2	3	2	3	2	3	60		
R 30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25		
R 31	2	3	2	3	3	3	2	2	2	3	2	1	1	2	2	2	3	2	2	3	1	3	1	2	3	55		
R 32	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	75		
R 33	3	3	3	3	3	4	4	2	3	4	4	3	3	3	3	3	3	3	4	4	2	4	1	3	5	80		
R 34	5	5	5	5	5	5	5	4	5	5	5	5	3	3	3	3	5	5	5	5	5	5	5	5	5	116		
R 35	3	3	3	3	2	2	5	5	5	3	4	2	2	2	4	5	5	4	4	4	4	4	4	3	3	88		
R 36	3	3	3	2	5	4	1	2	2	3	3	3	3	4	4	1	1	1	3	1	2	1	1	1	1	58		
R 37	3	3	3	4	4	4	4	4	4	1	1	3	3	4	5	4	4	4	3	3	3	1	1	1	2	76		
R 38	4	4	4	5	5	4	5	5	5	5	4	5	4	4	4	4	4	5	4	4	5	5	5	4	5	112		
R 39	4	4	3	5	3	5	4	4	4	4	5	3	3	3	2	2	4	4	4	4	4	4	4	4	4	94		
R 40	4	3	4	3	4	3	3	3	4	4	4	3	4	3	3	4	4	3	4	4	4	4	4	4	4	91		
R 41	4	4	5	5	4	4	2	2	4	4	4	3	2	4	4	5	5	5	4	4	4	4	5	5	4	100		
R 42	3	3	3	3	4	4	4	4	4	3	4	4	4	4	3	4	4	4	3	4	4	4	4	4	3	92		
R 43	3	4	4	4	4	4	3	4	4	4	4	3	3	3	4	4	4	3	5	5	5	5	4	3	4	97		
R 44	3	3	4	3	3	3	1	1	2	4	4	3	3	3	4	4	4	4	4	4	4	4	4	4	4	84		
R 45	5	5	4	4	4	4	4	5	5	5	4	3	3	4	4	3	5	4	3	3	4	5	2	3	4	99		
R 46	2	3	3	1	1	4	4	3	5	4	4	3	3	2	2	4	4	4	4	3	3	3	2	4	4	79		
R 47	3	4	3	4	5	5	3	3	3	3	4	4	3	3	4	4	4	3	3	4	4	4	3	3	3	89		
R 48	4	4	4	3	4	4	4	3	3	4	4	4	3	3	3	3	4	4	3	4	3	3	3	3	3	87		
R 49	3	4	4	4	3	4	3	3	3	4	4	4	3	3	4	4	4	4	4	4	4	4	3	3	3	90		
R 50	4	2	2	1	3	1	1	4	2	4	4	2	4	3	2	2	4	4	3	4	4	4	4	5	5	78		
R 51	4	3	2	3	3	3	2	2	2	3	2	1	1	2	2	2	3	2	2	3	1	3	1	2	3	57		
R 52	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	75		
variance of items	1.3	1.4	1.2	1.4	1.1	1.7	1.9	1.1	1.4	1.1	1.2	1.5	0.9	0.8	1.3	1.1	1.1	1.1	0.8	0.9	1.2	1.2	1.7	1.4	1.1	361.28	variances of total scores	

Reliability Test for Part V

			Reability Test by using Cronbach Alpha coefficient																	
Respondents	**Questions**																			
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**TOTAL**	number of item	17
R1	5	3	2	2	2	4	4	3	4	3	3	3	4	4	4	4	4	**58**	sum of the item variances	24.63
R2	5	4	4	5	5	5	2	5	5	4	4	4	5	5	5	4	5	**76**	variances of total scores	151.96
R 3	3	2	1	3	2	4	2	3	4	1	4	2	2	1	4	2	3	**43**	cronbach's α	**0.89**
R4	1	2	1	2	3	4	2	3	3	4	2	2	4	2	3	4	2	**44**		
R 5	2	1	2	3	2	1	3	2	4	2	4	3	3	4	2	3	2	**43**		
R 6	2	3	1	3	4	2	4	3	2	4	2	4	3	1	3	5	2	**48**		
R 7	5	5	4	4	4	5	4	4	4	5	4	4	4	4	3	3	3	**69**		
R 8	5	4	5	5	4	4	4	5	4	4	3	5	4	4	5	4	4	**73**		
R 9	4	4	4	3	3	5	3	5	4	3	4	3	3	3	4	4	3	**62**		
R 10	5	5	5	5	5	5	5	5	5	5	2	2	3	5	5	3	3	**73**		
R 11	4	4	4	5	4	5	4	5	4	4	5	4	5	4	5	5	5	**76**		
R 12	5	4	4	4	4	5	4	5	5	5	5	5	5	4	5	5	5	**79**		
R 13	4	4	4	3	5	5	5	4	5	5	5	4	5	4	4	4	4	**74**		
R 14	4	4	4	3	5	5	5	4	5	5	5	4	5	4	4	4	4	**74**		
R 15	4	4	4	3	5	5	5	4	5	5	5	4	5	4	4	4	4	**74**		
R 16	5	4	4	5	5	5	5	5	4	5	4	4	4	4	4	4	4	**75**		
R 17	5	5	5	5	5	5	5	5	5	5	4	4	4	4	5	5	4	**80**		
R 18	5	5	5	5	4	5	3	5	5	3	4	3	4	4	5	5	3	**73**		
R 19	5	5	4	3	3	5	5	3	4	3	4	3	4	3	5	5	4	**68**		
R 20	4	4	4	4	4	4	4	3	4	3	3	3	3	4	4	4	4	**63**		
R 21	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	**84**		
R 22	4	4	3	3	4	4	4	4	4	4	3	4	3	4	4	3	4	**63**		
R 23	3	4	4	3	2	23	3	4	4	3	3	4	2	3	4	3	4	**76**		
R 24	3	4	3	5	5	4	3	2	4	4	1	2	3	2	3	3	5	**56**		
R 25	3	4	3	5	5	4	3	2	4	4	2	2	3	2	3	3	5	**57**		
R 26	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**85**		
R 27	5	4	4	4	4	5	5	4	5	4	4	4	4	4	4	4	5	**73**		
R 28	5	4	4	4	4	5	5	4	5	4	4	4	4	4	4	4	5	**73**		
R 29	1	3	2	3	2	2	1	2	2	2	1	2	3	1	2	3	2	**34**		
R 30	5	4	4	5	4	5	4	5	4	5	5	5	4	3	3	3	4	**72**		
R 31	5	5	5	4	4	5	4	5	4	4	4	5	4	4	5	5	4	**76**		
R 32	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	**68**		
R 33	2	3	2	2	2	3	3	3	3	4	4	4	3	3	3	2	5	**51**		
R 34	3	4	3	4	3	3	4	4	5	5	3	3	3	4	4	5	5	**65**		
R 35	4	3	3	1	1	1	1	1	3	3	3	1	1	5	5	3	3	**42**		
R 36	3	1	1	3	3	3	4	5	4	4	4	4	2	2	2	3	3	**51**		
R 37	2	3	2	2	2	3	3	3	3	4	4	4	3	3	3	2	2	**48**		
R 38	5	5	5	4	4	4	4	4	4	4	4	4	5	5	5	4	4	**74**		
R 39	4	4	4	3	5	4	4	5	5	3	5	4	5	5	4	3	4	**71**		
R 40	3	3	2	2	3	3	2	2	2	2	3	3	3	2	2	2	3	**42**		
R 41	1	5	1	5	5	5	5	5	5	4	1	4	4	4	4	4	4	**66**		
R 42	4	4	4	3	4	4	4	3	4	4	4	4	5	4	4	5	4	**68**		
R 43	4	4	4	4	5	5	5	5	4	5	5	4	4	4	3	5	4	**74**		
R 44	3	4	3	4	3	4	3	2	4	2	5	3	4	4	4	4	5	**61**		
R 45	3	2	1	4	5	5	5	3	5	5	5	5	3	2	3	3	3	**62**		
R 46	2	3	1	4	4	4	3	4	4	4	3	4	3	3	4	2	5	**57**		
R 47	5	5	5	4	5	4	5	5	4	4	4	4	5	5	4	4	4	**76**		
R 48	5	4	4	4	4	4	5	5	4	5	4	4	3	3	4	3	5	**70**		
R 49	5	5	4	5	5	5	5	5	5	5	4	5	5	4	4	5	5	**81**		
R 50	4	4	4	3	5	5	5	4	5	5	5	4	5	4	4	4	4	**74**		
R 51	5	5	5	4	4	5	4	5	4	4	4	5	4	4	5	5	4	**76**		
R 52	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	**68**		
variance of items	**1.5**	**1**	**1.7**	**1**	**1.2**	**7.7**	**1.2**	**1.2**	**0.6**	**1**	**1.2**	**0.9**	**0.9**	**1.1**	**0.8**	**0.9**	**0.8**	**151.96**	variances of total scores	

Reliability Test For Part VI

			Reability Test by using Cronbach Alpha coefficient												
Respondents	**Questions**														
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**TOTAL**		number of item	11
R1	4	3	4	3	3	4	4	4	4	5	4	**42**		sum of the item variances	12.88
R2	3	2	5	2	4	4	4	3	4	4	2	**37**		variances of total scores	55.86
R 3	3	2	3	1	4	1	3	2	2	4	2	**27**		cronbach's α	**0.85**
R4	2	3	4	3	2	3	2	4	2	3	4	**32**			
R 5	2	3	2	3	2	3	2	1	3	4	2	**27**			
R 6	1	2	3	2	4	2	4	3	1	4	3	**29**			
R 7	3	4	2	4	4	3	3	4	4	3	5	**39**			
R 8	4	4	4	3	3	4	4	4	3	4	4	**41**			
R 9	4	3	5	1	2	5	3	5	4	4	3	**39**			
R 10	2	2	2	2	3	1	1	2	2	2	2	**21**			
R 11	3	4	4	4	3	5	4	4	4	3	4	**42**			
R 12	4	5	4	5	4	4	4	5	4	4	4	**47**			
R 13	4	4	3	2	4	2	4	2	4	4	4	**37**			
R 14	4	4	3	2	4	2	4	2	4	4	4	**37**			
R 15	4	4	3	2	4	2	4	2	4	4	4	**37**			
R 16	4	4	4	3	3	3	2	4	3	4	3	**37**			
R 17	4	3	5	4	3	4	4	4	4	4	5	**44**			
R 18	3	3	5	3	4	5	5	5	4	4	1	**42**			
R 19	2	3	5	4	4	5	5	4	4	4	4	**44**			
R 20	4	4	5	3	3	4	3	4	4	5	4	**43**			
R 21	4	5	4	4	4	4	4	4	4	4	4	**45**			
R 22	4	4	5	4	4	4	3	4	4	4	3	**43**			
R 23	4	4	3	5	5	4	4	3	4	4	5	**45**			
R 24	2	2	2	2	2	2	2	2	2	2	3	**23**			
R 25	2	2	2	2	2	2	2	2	2	2	2	**22**			
R 26	4	5	1	5	5	1	3	1	1	1	3	**30**			
R 27	2	5	4	3	3	3	3	4	4	4	5	**40**			
R 28	2	5	4	3	3	3	3	4	4	4	5	**40**			
R 29	2	1	3	2	3	1	2	3	2	3	3	**25**			
R 30	3	2	5	4	2	4	3	5	4	4	2	**38**			
R 31	5	5	5	2	1	4	5	5	4	4	3	**43**			
R 32	3	4	3	3	4	3	3	5	3	4	3	**38**			
R 33	4	3	4	2	4	4	4	4	4	2	2	**37**			
R 34	5	4	5	5	2	3	5	5	5	5	5	**49**			
R 35	2	5	2	1	1	3	3	3	5	4	2	**31**			
R 36	3	3	3	3	3	2	2	2	2	5	5	**33**			
R 37	4	4	4	5	5	5	5	5	4	4	4	**49**			
R 38	4	4	4	4	4	5	4	5	5	5	5	**49**			
R 39	4	4	4	4	3	3	4	4	4	4	4	**42**			
R 40	3	2	2	3	3	2	3	2	3	3	2	**28**			
R 41	4	4	5	4	4	4	4	5	1	1	5	**41**			
R 42	3	3	3	3	3	3	2	2	2	3	4	**31**			
R 43	3	2	2	2	2	1	1	1	2	1	2	**19**			
R 44	5	4	3	4	5	4	5	4	3	4	5	**46**			
R 45	5	5	1	3	5	1	3	3	1	3	3	**33**			
R 46	3	3	4	2	4	4	3	3	4	4	4	**38**			
R 47	5	5	4	4	3	3	3	3	3	4	4	**41**			
R 48	4	4	4	5	3	3	3	3	3	3	4	**39**			
R 49	5	3	5	3	4	5	5	4	4	4	4	**46**			
R 50	4	4	3	2	4	2	4	2	4	4	4	**37**			
R 51	5	5	5	2	1	4	5	5	4	4	3	**43**			
R 52	3	4	3	3	4	3	3	5	3	4	3	**38**			
Variance of items	**1.02**	**1.09**	**1.28**	**1.21**	**1.06**	**1.45**	**1.09**	**1.48**	**1.14**	**0.93**	**1.13**	**55.86**		**variances of total scores**	