

The Future of Lean Construction in Ethiopian Construction Industry

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Abstract— The concept of Lean Construction has been observed as a useful means of performance improvement in developed and emerging countries. This study assessed the level of awareness, potential benefits & barriers on lean construction in Ethiopia. The study identified that there is some level of awareness upon professionals about lean construction even though lean construction is not yet practiced in Ethiopian construction industry. The results has also pointed out that the potential benefits expected from the implementation of lean construction are greater productivity, improved sustainability/waste reduction, greater customer satisfaction, and reduced project schedule and high quality construction. In addition, most influential expected barriers to implement Lean Construction are lack of knowledge, lack of industry support, lack of sufficient support among project team, employee's resistance and lack of standards.

Keywords— Lean Construction, Construction Industry, Awareness, Ethiopia

I. INTRODUCTION

A. The importance of Lean Construction in a globalized world.

Historical records asserted that industrial revolution has started with the Victorian industrial revolution in the 19th century, when factory production was introduced in predominantly a farming economy in England. The second industrial revolution, which took place in the middle of the 1800s all the way up to World War I, mass production took root, by the introduction of steel and electricity to power up manufacturing plants. In the middle of the 1900s, digital technology started to make its presence felt, slowly replacing the old (analog and mechanical) way of doing things [1]–[3]. Industry 4.0 is the mane for the “fourth Industrial Revolution” which is a new approach in manufacturing that makes use of the latest technological inventions and innovations, particularly in information and communication technology which involves the use of advancements in communication and information technology to increase the degree of automation and digitization of production, manufacturing and industrial processes [2]. Of the central importance of industry 4.0 is its interface with other smart infrastructure which includes smart logistics and smart homes and buildings [2], [3]. This indicates that construction industry is still a driver for other industries in providing infrastructure for the success of this transformation particularly in developing countries which lacks the basic infrastructure even to transform to the earlier industrial revolution phases. In order to cope with such a rapid and advanced transformation of manufacturing industry in their respective transformation stages both developed and

developing world needs an efficient construction industry with better performance.

The concept of Lean Construction has been observed as a useful means of performance improvement by improving workflow reliability, planning and control, particularly in developed and emerging countries like UK, US, Australia, Brazil, Finland, Singapore, Peru, Chile and Denmark. [4], [5]. They further described that, some other developing countries like Singapore, Ecuador, Indonesia and Columbia has also recorded improvements after implementation. [6] also pointed out that lean construction which results from the application of a new form of production management is one approach for improving performance of construction industry.

II. LITERATURE REVIEW

A. The Context of Ethiopian Construction Industry

Ethiopia is one of the developing countries in the horn of Africa bordered by Eritrea to the north and northeast, Djibouti and Somalia to the east, Sudan and South Sudan to the west, and Kenya to the south. The country is the second populous country in Africa next to Nigeria, with over 90 million inhabitants, it occupies a total area of 1,100,000 square kilometers (420,000 sq mi), and its capital and largest city is Addis Ababa [7], [8].

Based on [9], the Ethiopian construction industry can be viewed in six distinct periods for its evolution. The following table summarizes these distinct periods and their feature.

Table 1. Summary of Ethiopian construction industry six distinct periods (Adapted from: (Mengesha 2004).

Period	Designation	The Feature of Each Periods
Pre 1968	Foreign Company Domination	This was a period where almost all construction activities in the country were undertaken by international construction companies
1968-1982	Emergence of small scale domestic construction companies	A period that encourages private sector development which results in establishment of small scale domestic construction companies in the country.
1982-1987	Parastatal Companies domination	This period was known as parastatal company domination period since the private construction company which was established earlier has been taken by the government and almost all construction activities were undertaken by those state owned construction firms.
1987-1991	Fragmentation of Phases	During this period design services and construction phases was introduced as a separate phase to Ethiopian construction industry.
1991-2001	Era for Re-emergency of	The year 1989 brings another change in government with completely different

privatization		policies that re-emerge private sector development. As a result of this a number of private construction companies were established in the country and started taking parts in many construction activities.
Since 2001	Emergency of Integration and capacity building	Realizing the performance and capacity limitation of domestic firms which begins to be involved in some projects, the government has introduced the concept of integration and capacity building in 2001.

From 2001 onwards, the construction industry in Ethiopia is developing tremendously. Recent studies by [7] indicated that the GDP contribution of the industry has been raised to 5.6% and approaches to the sub Saharan average (6%). Meanwhile, the Gross Domestic Capital Formation (GDCF) which was about 60 percent in 1996/97 has reached nearly 75 percent in 2002/03. Beyond its contribution to the nation, the industry is also the 6th major contributor of the content infrastructure stock following South Africa, Egypt, Morocco, Algeria and Nigeria (Construction Sector Report on Africa 2013).

Since then, the country has been implementing significant number of programs/projects which include the university capacity building program (UCBP), the housing development program and the road sector programs among others. The following table summarizes the major construction undertakings during this period;

Table 2. Summary of Major Construction Projects in Ethiopia during this period

Sector	Program/Projects	Description
Building	University capacity building Program	It was a program with an objective of constructing 13 university projects together with capacity development of domestic construction and consulting firms. The program was designed and implemented with involvement of GTZ IS as a project implementing agent.
	Housing development Program	This was a program that aims to construct 450,000 housing units in 5 years in the capital and creating employment opportunity for small and medium scale enterprises.
Road and Transport	Road Sector Development Program I - III	A 13 years program that was planned to implement 38,080 Km of road together with capacity building of domestic construction and consulting firms. At the end of the 13 years the program was succeeded to accomplish 105% of its target (39,965km).
	Railway	In addition to road infrastructure the country has also identified potential rail way corridors to connect the capital with major cities. Currently there are two active rail way projects in Ethiopia: The Light Railway Transit in the capital and the Addis Ababa- Djibouti rail way that connects the capital to the port of Djibouti.
Energy	Gilgel Gibe I-III, Tekeze and Beles	These are hydropower projects constructed for the last two decades to generate 3,230 MW of electricity. Except Gilegel Gibe III all of these projects are completed some years back and started functioning.
	The Great Renaissance Dam (GRD)	Besides the above hydropower projects, the country is also undertaking the construction of the great renaissance dam (GRD) which is expected to generate 600GW

Geo-Thermal Project	This is also one of the mega and largest Geo-thermal plant in Africa launched at a cost of 4Billion USD recently.
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Despite its prominent role, the industry like others construction industry in developing countries is facing many performance challenges in implementing construction project. A study by SMEC an international company based in Australia in 1999, 2001 and 2002 cited in [11] indicated that the industry performance in general is very low and characterize its deficiency as; Inadequate capital base, old and limited number of equipment, deficiency in human resources with technical and managerial skills and very limited experiences and participation in private sector. In agreement with the above findings [9] has also pointed out that the performance of Ethiopian construction industry with respect to the three constraints (time, cost and quality) to be low. His finding revealed that the time, cost and quality performance for the two case study projects that he studied was 182%, 37.6% and 44% from the planned schedule and budgeted cost and predetermined requirements for quality.

A recent study by (Yimam 2014) on Project Management Maturity in developing country (Ethiopia) also revealed that, the construction process management maturity level in Ethiopian construction industry is a very low. According to this study, the average for processes maturity is 1.3 and that of the practice dimension is 0.99 which indicates that the processes and practice maturity levels are at informal and basic level respectively. These facts demonstrate that the performance of Ethiopian construction industry is characterized as poor in meeting project requirements such as cost, time and quality.

Realizing this situation and the significant benefits of lean construction in improving performance of construction industry, the objective of this research study is therefore to assess the level of awareness on lean construction and its future perspective in Ethiopian construction industry.

B. Lean Construction

Lean principles were developed during post-World War II in Japan by the Toyota Motor Company to make a paradigm shift in the way the company was managed. The principle was considered to be an innovation that transform the company into pragmatic problem solving way of management which was known as the Toyota Production System [13] cited in [14]. In the beginning of the 1990s, the new production philosophy was known by several different names such as (1) world class manufacturing; (2) lean production; and (3) new production system [6].

In the subsequent years the principle was adapted by the manufacturing industry and resulted in significant progress in increasing productivity and product quality. Some of the improvements in manufacturing processes as a result of applying "lean production" principles include reducing the amount of human effort, space and inventory required in the factory and increasing the quality and variety of products and the flexibility of manufacturing operations [14].

Following these remarkable achievements in manufacturing and the declining performance of construction industry for the past 40 years, the construction industry has also look in to lean production as an option to improve the situation [6]. In 1992,

Koskela has reported the adaptation of lean production concepts in the construction industry and presented a production management paradigm where production was conceptualized in three complementary ways, which is known as Transformation; Flow; and Value generation (TFV) theory of production. This tripartite view of production has led to the birth of lean construction as a discipline that subsumes the transformation-dominated contemporary construction management [15].

Lean is a philosophy that requires a continuous improvement effort which is focused on a value stream defined in terms of the need of customers [14]. These include eliminating the waste that occurs between activities in order to increase the overall process efficiency. According to this philosophy eliminating or minimizing a waste is achieved through reduction of non-value added activity. Because improving the efficiency of individual activities within a project does not necessarily improve the efficiency of an overall process [16].

C. What Makes Lean Construction Different from Traditional Construction Practices

Traditional project management is derived from an activity-centered (scheduled activities) approach, which aims to optimize the project activities and define the assignment and objectives of project participants by assuming customer value is already identified in a design phase [17]. As a result of this stakeholders in traditional construction processes interact each other with an objective of optimizing various activities and resources from their own perspective or interest. This local optimization of resources, however leads to an overall reduction in productivity, risk to schedule performance, and higher costs [18]. In agreement with [18], [19] also characterized the current practice as that makes the coordination & controlling between organizations or crews primarily from a central plan that establishes sequence and determines when an activity will start. Similarly [15] had critiqued construction project management in its approach of modeling construction as a series of conversion (value-adding) activities and he strongly recommends the construction industry to adopt the new production philosophy that improves competitiveness by identifying and eliminating waste (non-value-adding) activities.

Lean project management differs from traditional project management not only in the goals it pursues, but also in the structure of its phases, the relationship between phases and the participants in each phase [5]. They further describe projects as temporary production systems which can be structured to deliver product while maximizing value and minimizing waste. In agreement with [5], [20] further states, every production system as integrates designing and making a product and he further argue that production (and hence project) management is understood in terms of designing, operating and improving production systems.

According to [21] this production system has two aspects; conversions and flows. Conversion activities are activities which add value because they take material, information, or other input and transform into a product and Flow activities are non-value adding and consist of activities such as inspections, waiting, or moving. [15] also argue the same, although all activities expend cost and consume time, Lean

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. To the contrary, traditional construction management emphasizes on the conversion only and does not give attention to the design of systems and processes to manage work flow. In other words current project management views a project as the combination of activities, whereas lean thinking views the entire project in production system terms, that is, as if the project were one large operation [19], [22]. Lean thinking therefore forces attention on how value is generated rather than how any one activity is managed [19]. [6] on the other hand stated that managing construction under lean 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 concurrently product and process; and (4) applies production control throughout the life of the project.

Generally, three features distinguish lean construction from conventional construction management practice [17], [23]. First, it focuses on reducing waste that may exist in any form in the construction process, such as inspection, transportation, waiting and unnecessary motion. Second, it aims to reduce variability and irregularity so that materials and information can flow without interruption. Third, construction material is expected to be on site only when it is needed.

D. Implementation of Lean Construction

According to [24] there are four roots of Lean Construction approach: success of the Toyota Production System, dissatisfaction with project performance, efforts to establish project management on a theoretical foundation, and the discovery of facts called “anomalous” which is difficult to explain from the perspective of traditional thinking and practice. [24] also identified that Lean construction comes from recognizing the limitations of current project management and applying new production management called “lean production” to the construction industry. [25] in his critical evaluation of previous studies on construction delay also reported that poor project management was a dominant and common reason for delay in construction projects. The implementation of lean construction is therefore mainly an attempt to improve the poor performance of construction projects to minimize dissatisfaction with project performance. As a result of this a number of companies have implemented lean for the last two decades. Nowadays, many of these companies and researchers in the field have reported satisfactory results from their implementation [26]. Accordingly, Lean Construction is now an active force in the United States, United Kingdom, Denmark, Finland, Australia, Brazil, Chile, and Peru. Implementation also has begun in Singapore, Indonesia, Ecuador, and Colombia [5].

E. Benefits and barriers of Lean Construction

When lean construction is implemented and the work environment is stabilized through modifying the planning system, it becomes possible to reduce variation in flows that improve the downstream operations [27]. [28] in their critical literature review on implementation of lean construction has identified several benefits when applying lean principles in construction which include; reduce sharing of non-value

adding activities, increase the output value through systematic construction of customer requirement, reduce process variability, reduce cycle times, Simplify by minimizing the number of steps parts and linkages, increase output flexibility, increase process transparency, focus on complete process, build continuous implement into the process and balance flow improvement with conversion improvement and benchmarking.

[26]however revealed that there are barriers in implementation of lean construction. According to [26] these barriers are; lack of time for implementing new practices in the projects, lack of training, challenge to create organizational elements, lack of self-criticism to learn from errors, respond to some deficiencies, low understanding of the concepts, low use of different elements, inadequate administration, weak communication and transparency and lack of integration of the construction chain.

III. RESEARCH METHODOLOGY

The study approach involves both literature search and the use of structured questionnaires which was considered to be the most appropriate tool to reach the population of the study with limited time and from a distance at a time. The literature review was conducted to extract the variables for the assessment and to have a conceptual bases on the subject matter. Accordingly the survey was designed based on variables extracted from literatures and organized in four parts which include question related to respondent profiles, basic principles of lean construction, potential benefits of lean construction and the barriers for implementation.

The designed survey were then sent to 135 professionals selected through stratified random sampling from academic institution, owner's origination, implementing agencies, construction and consulting firms in the following proportions in Addis Ababa in order to reach majority of the companies and more experienced professionals: 21 to client; 38 to consultants; and 46 to contractors, 15 to academician and 15 to others. Out of the 135 questionnaire distributed, 81 were received and only 69 were duly completed and found suitable for analysis, representing a responses rate of 51.11%.

The data obtained from the survey was analyzed using mean score together with standard deviation in order to rank the level of awareness on lean construction and to identify the potential benefits and barriers to implement lean construction in Ethiopian construction industry. The output of the analyzed data is then presented using tables, graphs and simple percentage for further interpretation and discussion.

IV. RESULTS AND DISCUSSION

A. Respondent Background

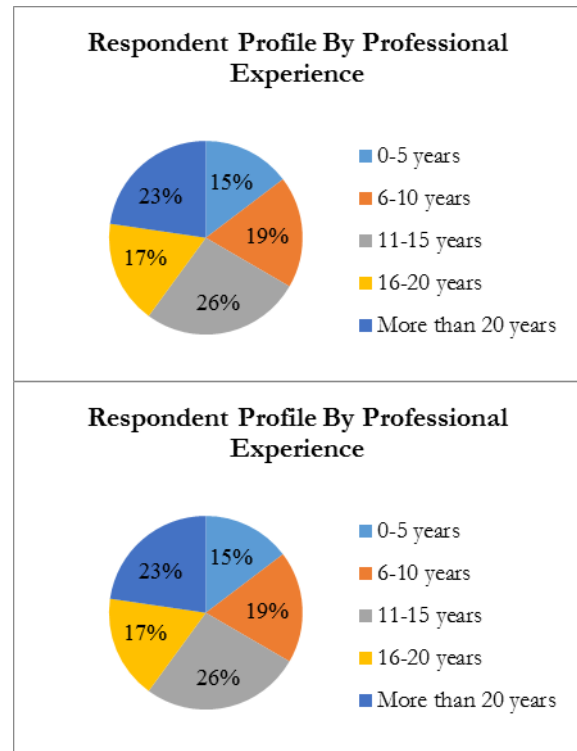


Fig 3. Respondent Profile by type of firm and professional experience.

As it can be observed from Figure 3, the distribution of the response is 70% from contractor and consults (35% each), 18% from academicians and implementing agents (which is 9% each) and 11% from client. In terms of experience, more than 66% of the respondent has more than 10 years' professional experiences in the industry.

B. Awareness and Familiarity with Lean Concept

According to the survey, 48% of the respondents are familiar with the concept of Lean Construction. However the answers on most of other lean construction related concepts doesn't reflect the same. As it is indicated on Figure 4, the response of majority of the respondents demonstrate that professionals in the industry are not familiar with most of the lean related concepts such as; big room (only 92%), Takt time (89%), Last Planner System (85%), Value Stream Mapping (78%) and Toyota Way (77%).

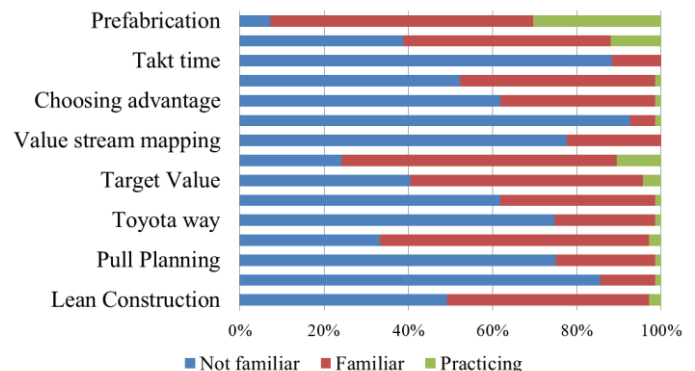


Fig 4. Professional Awareness on Lean Related Concepts

The result agrees with findings of other researchers such [29] which pointed out that there is low level of familiarity and application of Lean Construction among practitioners in the Ghanaian construction industry. [4] and [30] also identified that the level of awareness about Lean Construction in Nigeria is very low.[31] who studied the Lean Construction practice in Abu Dhabi construction industry identified that only 32% of the assessed companies were familiar with the concept of Lean Construction in Abu Dhabi.

The result on the other hand revealed that most professionals have a better awareness on the concept of prefabrication (61% familiar and 31% practicing), multiple contracts (64% familiar and 10%). Just In Time (65% familiar and 2% practicing), modular construction (50% familiar and 13% practicing) and target value (56% familiar and 3% practicing).

Their awareness on prefabrication and modular construction is expected since many of the building construction specially the housing sector and university construction are using on site prefabricated beams for the concrete slab. However, professional awareness on Target Value Design, Just-In-Time and multiple contracts concepts may not be well understood from Lean Construction perspective.

C. Understanding on Project Specific Elements that Define Lean Construction

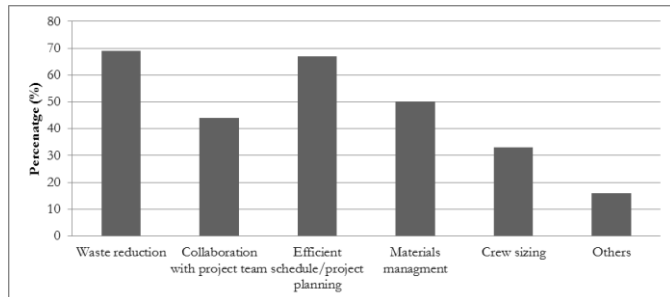


Fig 1. Project specific Elements which define Lean Construction

Following the assessment of professionals awareness on Lean Construction and other related concepts, respondent were asked to identify some project specific Lean elements that best describe Lean Construction to their understanding (Figure 5). Accordingly, majority of the respondents believe that waste reduction (69%), efficient schedule (68%) and materials management (50%) as project specific elements that define Lean Construction to their understanding.

This result agrees with the finding of [32]; a study conducted by McGraw Hill Construction on assessment of Lean Construction Practice. According to this study, those who are practicing Lean Construction mention waste reduction, collaboration or project team and efficient schedule respectively and those who are not implementing Lean Construction suggested materials management, crew sizing and project planning as a project specific elements that defines Lean Construction.

D. Application of Lean Construction concepts

The next phase investigated the application of Lean Construction concepts. Respondents were asked the following question: “Did you practice/adapt any of the

following concepts to improve efficiency in any project?” Figure 6 reveals the obtained answers to this question.

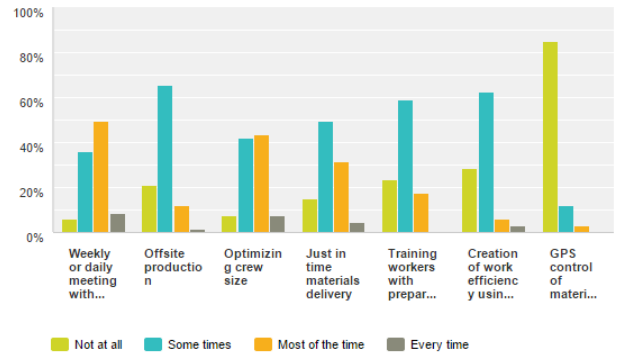


Fig 2. Application of different concepts related to Lean Construction by respondents

The mean and standard deviation resp. are as follow (1 being to “Not at all): Weekly or daily meeting with workers (2.61, 0.73), Offsite production (1.94, 0.62), optimizing crew size (2.51, 0.74), Just In Time materials delivery (2.25, 0.76), Training workers with preparatory tools/Methods (1.94, 0.76), Creation of work efficiency using studies of workers activities – Workflow (1.84, 0.66), GPS control of materials, tools, equipment – technology (1.18, 0.45).

According to the obtained figure, many practices aren’t established in the Ethiopian Construction industry. For instance, GPS Control which is related to technology use, is rare. “Creation of work efficiency using studies of workers activities”, which is related to workflow, is rare as well. There are, however, some notions established like “Weekly or daily meetings with worker” and Optimizing crew size”. This means that the level of appropriation is very low.

Following this question, we asked respondents their view on the implementation of Lean Construction in Ethiopia. The question was formulated as follow: “Do you think Lean Construction will be implemented in the near future in Ethiopian construction industry?”

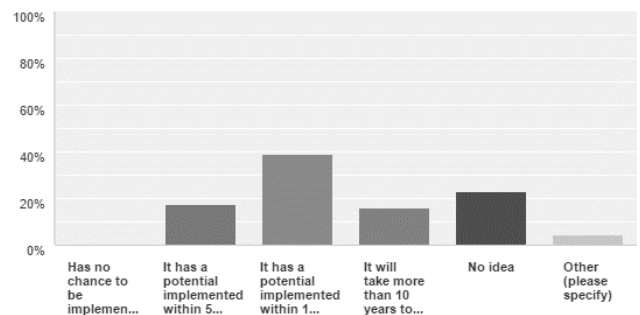


Fig 7. Implementation of Lean Construction in the Ethiopian Construction Industry

Figure 7 describes the timeframe of Lean Construction of implementation in the Ethiopian Construction Industry according to respondents.

The majority of respondents think that Lean Construction will be implemented (100%). 17.39% think that it will be implemented in the Ethiopian Construction Industry within 5 years, 39.13% within 10 years and 15.94% voted for more than 10 years. 23.19% have no idea. Statistically speaking, the mean is 3.58 and the standard deviation is 1.15. It means that, overall, the introduction of Lean Construction in the

Ethiopian Construction industry is expected to be in 5-10 years, according to the respondents view.

E. Expected Benefits

Anticipating the implementation of Lean Construction in Ethiopia, respondents were asked to rate the expected benefits and potential barriers as a result of implementing Lean Construction in Ethiopian construction industry.

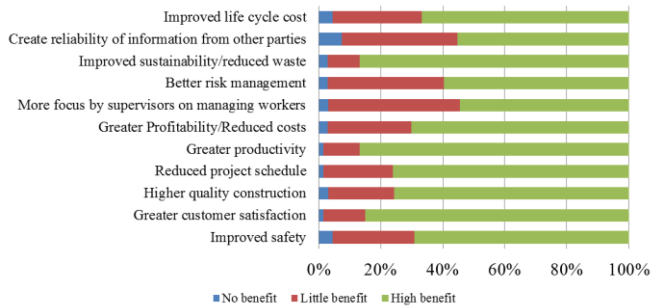


Fig 8. Potential benefits through Implementation of Lean Construction in Ethiopia

The response in Figure 8 revealed that greater productivity (89%), improved sustainability/reduced waste (87%), great customer satisfaction (85%), reduced project schedule (77%) and high quality construction (75%) are the top five expected benefits that Ethiopian Construction industry will be benefited by implementing Lean Construction.

This result also agreed with finding of many researchers; [33] on his study of assessing the impact of implementing Lean Construction identified improved productivity and reduction project cost as a major benefits realized in the projects he studied. [34] has also reported that; increase productivity, increase quality, increase sustainable values, provides better value to the customer and reduced human effort as a key benefits obtained through applying Lean Construction principles. Another study on assessment of Lean Construction maturity by [35] also revealed that high quality of construction, greater customer satisfaction, greater productivity, improved safety, reduced project schedule, better risk management and improved profit as a benefit resulted in applying Lean Construction. In agreement with the above studies [36] also pointed out that client satisfaction, reduced project cost and reduction in project time by 25% as benefit achieved by implementing Lean Construction principles.

F. Expected barriers

With respect to barriers, respondents were asked to rate the expected barriers that will affect the implementation of Lean Construction in Ethiopian construction industry among the thirteen potential barriers identified from literature (Figure 9). The result indicates that lack of knowledge and skill (74%), lack of industry support/understanding of lean (66%) and lack of sufficient support across project team (63%), employee’s resistance (57%) and lack of standard (56%) are the top five most influential barriers to implement Lean Construction in Ethiopian construction industry.

This finding also agrees with findings of many other research on Lean Construction barriers; [37] has summarized the main barriers in implementing Lean Construction as managerial,

technical, human attitude, the process of LC, educational, government and financial. [38] and [39] on their part pointed out that lack of knowledge and skills and lack of organizational culture that support team work as the most challenging barrier to implement lean in Libyan and Ugandan construction industry. Similarly [40] identified that lack of adequate understanding on lean, culture & human attitudes and lack of management commitments as an important barrier that need to be addressed for successful implementation of Lean Construction in the UK construction industry. The result from [41] on the other hand revealed that cultural issues and resistance to change as the most challenging barriers among others such lengthy approvals, poor supervision and sub-contractors involvement.[4] on the other hand identified that shortage of technical, skilled and professional workers, pitiable wages and salaries, client uncertainty and inconsistency, poor organizational structure and management, poor government control and enforcement of regulations as the major barriers.

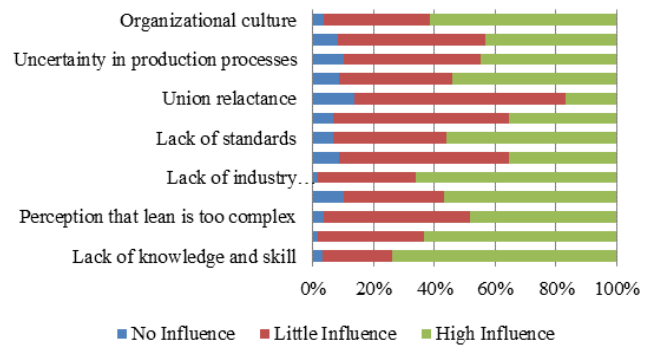


Fig 9. Potential barriers to Implementing Lean Construction in Ethiopian Construction Industry

VI. CONCLUSION

The study indicated that professional in Ethiopian construction industry are somehow aware about Lean Construction but their awareness towards other lean related concepts such as big room, takt time, last planner system, value stream mapping and Toyota way is very low. The result on the other hand indicated that the level of awareness on prefabrication, modular construction, multiple contracts, just in time and target value is good as compared to the above lean related concepts. From these facts it can be conclude that at least there is some level of awareness upon professionals about Lean Construction even though Lean Construction is not yet practiced in Ethiopian construction industry.

The study has also identified that the potential benefits expected from the implementation of Lean Construction and the expected barriers. Accordingly, greater productivity, improved sustainability/waste reduction, greater customer satisfaction, reduced project schedule and high quality construction are identified to be as a potential benefits. In agreement with expected benefits, the response on professional understanding towards project specific lean concepts also revealed that Lean Construction is described as a means of waste reduction, efficient construction and materials management.

Finally the study has 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 Ethiopian construction industry.

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