INFLUENCE OF LEAN CONSTRUCTION ON THE PERFORMANCE OF HOUSING SCHEME BUILDING PROJECTS IN NAIROBI COUNTY, KENYA

BY

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DECLARATION

This Research Project Report is my original work and has not been submitted for an award in any other University.

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DEDICATION

ledicate this research study to my lovely parents, Dr. and Mrs. Joseph Maina Ayuya for their
eadfast support that has enabled me to come this far.

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ABBREVIATIONS AND ACRONYMS

BRE	- Building Research Establishment
CIRIA	- Construction Industry Research and Information Association
CIWGP	- Construction Industry Working Group on Payment
CMAA	- Construction Managers Association of America
LC	- Lean Construction
LCI	- Lean Construction Institute
LPDS	- Lean Project Delivery System
OECD	- Organization for Economic Cooperation and Development
UNFCCC	- United Nations Framework Convention on Climate Change

ABSTRACT

Lean Construction is a system used in the putting up of housing building units that aims at minimizing waste of materials, time; improve safety and effort in order to generate the maximum possible amount of value for the stakeholders. It is an improvement on the traditional house-building process which focuses on the uniqueness and the singularity of projects characterized by unique choices of technical solutions, a limited use of platforms, uniquely combined teams and scarcely developed logistics and procurement strategies. The main objective is to determine how waste material management influences the performance of housing building projects in Nairobi. The main research question determines to what extent waste material management influences the performance of housing building projects in Nairobi. The study research design is correlation as it sought to analyze the degree of relationship between the variables. The study adopted a mixed-mode approach method whereby quantitative and qualitative techniques are used. The target population was the professionals/experts in the construction industry based within Nairobi County. Study findings indicated that lean construction is a predominantly a rare practice in Kenya. There was no evidence of lean construction guidance notes among the organizations studied. A gender gap exists in the construction industry with most of the players in the sector being male. Parameters describing the overall process of lean construction are considered important determinants of the performance of housing and building projects. Evidence from majority rating on waste management, natural environment, workplace safety, completion time and project cost indicate that players in the sector have to some extent attached some value on the importance of lean construction. A relationship exists between lean construction parameters and performance of housing scheme building projects, though in varying degrees. Waste management showed, a weak relationship with a correlation coefficient of 0.112, natural environment showed a very weak relationship with a correlation coefficient of 0.093, workplace safety showed and projects costs showed a moderately strong relationship with a correlation coefficient of 0.579, while project costs completion time showed a moderate relationship with a correlation coefficient of 0.632. The researcher recommended an adoption of last planners system tool (a subset of lean construction) among the players in the construction industry to increase the level of effectiveness, efficiency, quality, productivity, innovativeness and profitability in the sector. An advocacy on the equal opportunities for both men and women is important in facilitating talent pool in the construction industry and consequently improve on workmanship. As a strategy towards maximising the use of lean construction, it is imperative for organizations to device strategies toward reducing injuries and fatalities in the construction industry. This could be achieved through constant work safety training for employees as well as putting in place strong regulatory framework in the sector. A further study should be undertaken on the effect of lean construction on workplace safety in the construction industry.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Construction is a project-based industry where its unique characteristics are related to the one-of-a-kindness of the project, the production set up, the construction site and the temporary organization (Vrijhoef and Koskela 2005). The residential housing market is heavily affected by general economic conditions, tax laws, and the monetary and fiscal policies of the government. Often, a slight increase in total demand will cause a substantial investment in construction, since many housing projects can be started at different locations by different individuals and developers at the same time. Because of the relative ease of entry, at least at the lower end of the market, many new builders are attracted to the residential housing construction. Hence, this market is highly competitive with potentially high risks as well as high rewards. Hampson K. (1997) believed that construction performance affects productivity across all sectors of the economy.

The scale of a housing scheme is of critical importance to the productivity of an individual construction project. Research by the McKinsey Global Institute (Baily *et al.*, 1997) indicate that a once off house requires almost 33 per cent more hours worked than does a house of equivalent size on a large housing estate. Further, estimates by McKinsey Global Institute (Baily *et al.*, 1997) suggest that productivity is maximized in developing housing projects with at least 50 units. In an ideal construction site, all goods delivered on site should be the right ones, should arrive at the right time and should be placed at the right location, in order to be transformed or assembled at the right place on the site (Ballard and Howell, 2003). Logistics organization on construction sites cannot obviously be introduced without an evolution of the way the works are executed. Traditional methods are inherited from a time when the different corporations such as mason carpenter and plumber worked one after the other. Each of these actors had to adapt his work according to what the previous actor had done.

The term "non value-adding activity" has been widely used by researchers in literature pertaining to lean production. The term non value-adding activity is used to differentiate between physical construction waste found on-site, and other waste, which occurs during the construction process. Non value-adding activities known as waste, detrimentally affect the performance of construction projects (Ballard and Howell, 2003). Analysis of project schedule failures by Ballard and Howell (2003) and Construction Managers Association of America (2006) also indicated that "normally only about 50 percent of the tasks on weekly work plans are completed by the end of the plan week" and that most of these planning failures were possible to mitigate by contractors through an "active management of variability, starting with the structuring of the project - as a temporary production system - and continuing through its operation and improvement." In addition, since the completion of one crew's work usually triggers the start of the next crew's work, this lack of reliability prevents smooth flow and leads to tremendous efficiency losses. However, the key to performance is flow, and the key to flow is removing variability.

According to the Lean Construction Institute (Ballard and Howell, 2003), Lean Construction is now an active force in the United States, United Kingdom, Denmark, Finland, Australia, Brazil, Chile, Peru, Singapore, Indonesia, Venezuela, Ecuador and Colombia.

Considering but one scenario for example; Grana Montero, one of the largest engineering and construction companies in Peru whereby on the first nine projects on which they employed a Lean Construction approach, profit increased by $3 million from $6.2 to $9.2 million. It is not uncommon for projects applying Lean Construction principles to experience performance improvements in productivity and schedule acceleration in ranges of 10 to 20%. However, surveys in the United Kingdom (Common *et al.*, 2000) and the Netherlands (Johansen *et al.*, 2002) strongly suggest that the construction industry has generally been slow in taking up lean concepts.

In Sweden, there are an increasing number of small to medium sized companies that have specialized in multi-storey housing construction by utilizing extensive prefabrication strategies (Björnfot and Sardén 2006). Among the large contractors, who mainly work in a traditional manner, which involves large project organizations, and on-site work, a similar trend in specialization is observable. This specialization does mainly concern an increased use of prefabricated construction products as well as long-term stable client relations. Drivers for this specialization trend according to Björnfot and Sardén (2006), are a demand for reduced construction costs but also a pure business perspective where the higher profitability experienced by specialized companies is sought (10 percent compared to about 2 percent profitability for the large contractors). An Australian analysis of the impact of a 10 percent productivity improvement in various service sectors showed that construction had by far the most impact at 2.8 percent on the gross national product and further 1.2 percent if Domestic Housing was included (Stockel and Quirke, 1992). More specifically the demand for improvement in construction is to provide higher quality in the output and reducing the costs, offer a better process to the client and increase working conditions and safety.

Cement manufacturers in Kenya and Tanzania are currently witnessing a rise in consumption. Data from the Kenya National Bureau of Statistics shows cement consumption in Kenya surged 12 per cent in the nine months to September, hitting 254,000 tonnes from 226,000 tonnes last year, 2011. According to the Economic Survey of Kenya, 2011, cement consumption went up by 16.2 per cent to 3.1million tonnes in 2010 compared to 2.7 million tonnes in 2009, which indicates an increase in construction activity. More so, the total value of reported private building works completed in selected main towns went up significantly from KSh 21.8 billion in 2009 to KSh 37.3 billion in 2010. According to the Construction Business Review (2009), the annual demand for housing stands at 150,000 units against a meager supply of 30,000 units in Nairobi. More so, the Housing Ministry (2009) in a report tabled before Parliament through its Minister in charge noted that the prices of houses in Nairobi have doubled since 2004. This escalation of property prices was attributed to the high cost of land in Nairobi, rising cost of building materials as well as the growing demand for housing in the city.

1.2 Statement of the Problem

The importance of culture and risk should not be understated (Schein, 2004). If the organizational culture, in this case the traditional construction methods, does not allow risk taking, which by definition must include change, then however good the alternative new methods are, they were not be adopted. Schein (2004) further states that the environment in which construction projects are accomplished today often involves completing complex, uncertain projects within tight budget and time constraints. In this environment, change is a defining characteristic and is inevitable. Unfortunately, most traditional housing building projects do not embrace change but instead treat it is an anomaly by trying to specify every possible contingency and assign liability in the event change occurs. The industry as a whole has become much more dynamic as illustrated by its continual fragmentation, which contributes specifically to increased complexity, more parts and interfaces. In the face of these challenging dynamic environments, clients continually attempt to reduce project costs and design/construction time while still demanding high quality final products.

Projects are becoming more complex and customers are requesting that they be built faster, less expensively, and with higher quality standards Koskela (2004). Customers are requesting value. We need to deliver projects that meet, or exceed, the customers' expectations, maximizing value and minimizing waste through strategies and techniques that enhance value. Clients' require overall satisfaction through improved time, cost, quality and whole life/operating cost performance. In addition, they demand that this take place within an innovative, flexible and safe environment. However, these performance improvements also need to be achieved without compromising the supplier's own corporate objectives, which include financial performance, improved market capitalization and penetration into new sectors.

Alarcon et al. (2000) note that the construction industry has developed a number of specialized tools; Critical Path Method (CPM) schedules, Gantt charts, earned value analysis, and various budget-tracking methods to plan and control projects. However, construction projects today are undeniably faster paced and change-prone compared to the relative predictability that characterized projects of the past. The more dynamic tempo of contemporary construction requires more dynamic means of management. Despite the best efforts to refine the means of construction management over the years, the construction industry continues to suffer through cost overruns, missed schedules and unmet expectations. Fortunately, there are tools that can help us take our planning and control capabilities to the next level.

More specifically, the demand for improvement in construction is to provide high quality in the output and reducing the costs, offer a better process to the Client, and increase working conditions and safety (Latham, 1994; Eagan, 1998; Byggepolitisk Task Force, 2000). Construction industry, according to researchers, is a slow progressing industry with frequent problems such as low productivity, insufficient quality, time over-runs, and poor safety, which hinder customer, delivered value (Latham, 1994; Egan, 1998). The study therefore sought to investigate the influence of lean construction on the performance of housing building projects in Nairobi.

1.3 Purpose of the Study

The purpose of this study was to contribute to knowledge and insight about lean construction from the perspective of its influence on the performance of housing scheme building projects in Nairobi County. This will assist the government and private investors to come up with innovative but affordable housing schemes to bridge the glaring gap in the provision of affordable housing to all. The aim of Lean Systems is to design, produce and deliver products/services, which exceed customer expectations in terms of cost, quality, time and performance.

1.4 Objectives

The objectives of this study were to determine:

1.4.1 How waste material management influences the performance of housing scheme building projects in Nairobi County.

1.4.2 How the natural environment influences the performance of housing scheme building projects in Nairobi County.

1.4.3 How workplace safety influences the performance of housing scheme building projects in Nairobi County.

1.4.4 How completion time influences the performance of housing scheme building projects in Nairobi County.

1.4.5 How project cost influences the performance of housing scheme building projects in Nairobi County.

1.5 Research Questions

The research questions were to what extent does:

1.5.1 Waste material management influence the performance of housing scheme building projects in Nairobi County?

1.5.2 The natural environment influences the performance of housing scheme building projects in Nairobi County?

1.5.3 Workplace safety influences the performance of housing scheme building projects in Nairobi County?

1.5.4 Completion time influence the performance of housing scheme building projects in Nairobi County?

1.5.5 Project cost influence the performance of housing scheme building projects in Nairobi County?

1.6 Significance of the Study

Construction activity requires a high degree of flexibility among the actors involved in a building operation whereas the organization of the construction process remains very traditional, from the early design stage to the late utilization phase of the building. With the continuous decline in profit margins and increased competition in construction projects, construction contractors are continuing to search for ways of eliminating waste and increasing profit (Mastroianni and Abdelhamid 2003).

Although numerous approaches have been developed to improve efficiency and effectiveness of construction processes, lean construction techniques offer the promise to minimize, if not completely eliminate, non value-adding work. Koskela (1992) concluded that lean principles should be adapted to construction and he stressed, as a main reason for the transformation, the improved competitiveness that lean manufacturers encountered by eliminating waste. He pointed out that the traditional controlling methods in construction (Critical Path Models, for example) do not address "waste-source" activities in construction (such as waiting, storing, moving, and inspecting) and proposed that actual construction should be broadly perceived as flow processes instead of conversion processes only.

1.7 Delimitation of the Study

The study was based within the precincts of Nairobi County due to the high level of construction activity in the housing sector in comparison to other Counties. Further, Nairobi

County has a well developed road network and transport facilities that greatly enables ease of movement within the County. The study also focused on large-scale housing projects that consist of not less than fifty units per housing scheme. This is because the scale of a housing scheme is of critical importance to the productivity of an individual construction project hence; a large scheme is opportune for this study to be conducted objectively.

1.8 Limitations of the Study

Contractors may not be co-operative during the course of the study due to the secretive nature of the industry and misplaced perceptions towards research studies conducted in this field. However, the researcher negated this by assuring them of confidentiality and willingness to share the merits of the study on its successful completion. This will assist them to conduct their companies more efficiently.

1.9 Assumptions of the Study

The study was based on the assumption that time was sufficient to conduct it successfully and that professionals in the construction industry will be responsive and contribute effectively to the study.

1.10 Definitions of Significant Terms

Construction Projects: process of putting up a number of housing building units, minimum of fifty units, in a piece of land to provide accommodation to people.

Traditional Construction: a system whereby the different trades on a construction project work sequentially hence one trade had to wait for the other to complete the works in order for them to begin.

Lean Construction: a system used in the putting up of housing building units that aims at minimizing waste of materials, time, improve safety and effort in order to generate the maximum possible amount of value for the stakeholders.

Culture: refers to the way contractors and professionals in the housing building industry operate their businesses.

Lean Project Delivery System: a conceptual framework that guides the implementation of lean construction on housing building projects.

Last Planner System: a system that produces reliable workflow and stabilizes the housing building projects. It results in reduced costs, shortened durations, increased quality, and increased safety.

Performance: completion of a construction project efficiently, effectively, timely, innovatively, productively, profitably and achieving quality hence resulting in customer satisfaction.

1.11 Organization of the Study

Chapter one which basically is the introduction to the study covers the following areas: background to the study, statement of the problem, purpose of the study, objectives, research questions, significance of the study, delimitation of the study, limitations of the study, assumptions of the study and definition of significant terms.

Chapter two that is titled literature review delved into what has been done in relation to the topic by exploring further the research objectives and finally identifying the gap in knowledge that exists locally. It covers the following areas: traditional construction, lean construction, learning points on lean construction, lean culture, lean approach in construction, lean construction, waste material management, methods of waste material management, natural environment, sustainable construction, workplace safety, health and safety, safety plans modalities, completion time, project cost, conceptual framework and gap in knowledge.

Chapter three titled the research methodology explores: introduction, research design, target population, sampling procedure, methods of data collection, validity and reliability, operational definition of variables, methods of data analysis and a summary.

Chapter four titled data analysis, presentation and interpretations discussed the study findings based on the study objectives and research questions. Discussions were done in line with each of the study objectives. The chapter was mainly divided into background information and influence of lean construction on the performance of housing building projects in Nairobi County, Kenya.

Chapter five looked at the summary, discussion, conclusion and recommendations. Summary was drawn from the findings in chapter four and was presented based on the research objectives .Conclusion drawn from overall study findings from recommendation and areas of further studies were suggested thereafter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents what previous researchers have found out concerning the Lean Construction system. It contains findings of where the system has actually been used and its outcomes documented. This review is important, as it will enable the researcher find out the existing gap in knowledge within the local context.

The review is organized as follows: traditional construction, lean construction, learning points in lean construction, lean culture, lean approach in construction, lean construction, waste material management, methods of waste material management, natural environment, sustainable construction, workplace safety, health and safety, safety plan modalities, completion time, project cost, the gap in existing local knowledge, summary and conceptual framework.

2.2 Traditional Construction

Based on a comprehensive literature review Thomassen et. al., (2003) suggest that construction is in general perceived to possess a number of organizational characteristics that appear to be of general character and shared by different local or national environments: activities organized in temporary project organizations; trade-based organization of companies and individuals; labor-intensive; fragmentation deriving from the presence of many small and subcontracting firms; separation of design and coordination from production; highly independent activities; poor communication and coordination; 'conservation,' little change, a low level of learning and innovation, and consequently low improvement in productivity; competition on price and price reduction, not on innovativeness or optimization with respect to client values; low levels of trust and high levels of conflicts; a sector troubled by low quality, late delivery and overspending.

The traditional house-building process is not designed with continuity as a foundation, it is rather focused on the uniqueness and the singularity of projects characterized by unique choices of technical solutions, a limited use of platforms, uniquely combined teams and scarcely developed logistics and procurement strategies (Thomassen et. al., 2003). In this context, the need for measurements and knowledge management, the establishment of developed collaboration, introduction of advanced information technology and other long-term activities are difficult and expensive and the conception of their need and usefulness is limited, because of the lack of continuity. The construction industry poses a great challenge as it is essential in generating wealth, improving the quality of life of the citizen through the provision of social and economic infrastructures and it links the whole spectrum of the economy with a multiplier effect that enables other industries to prosper alongside, Noushad A. N., Construction Industry Working Group on Payment, (2007).

2.3 Lean Construction

The concept of lean construction is concerned with the application of lean thinking to the construction industry (Koskela L, 1992). It is about improved delivery of the finished construction project to meet client needs. Lean construction focuses on delivering precisely what the client and end-user want. It must however be noted that Lean is as much a philosophy and culture as a set of principles or approaches. Regardless of whether one takes the perspective of the client/developer, the contractor or the supplier, the end-to-end supply chain must be engaged.

The contractor is in a unique position to be able to co-ordinate downstream activities within the supply chain. In lean construction, owner, designers, general and specialty contractors, and suppliers work together to produce a value-adding, constructible, usable and maintainable facility (Ballard and Howell, 1998).

Koskela L, (1992) suggests that its application requires a fresh approach in thinking about the complete process from design through to construction in order to remove waste, to create 'continuous flow' and to radically enhance value to the customer. The main principles of Lean are according to Koskela L, 1992: specify value from the end customer's perspective, clearly identify the process that delivers customer values and eliminate all non value adding steps, make the remaining value adding steps flow without interruption, let the customer pull - don't make anything until it is needed, then make it quickly, pursue perfection by continuous improvement. Lean is about developing principles that are right for your organization and diligently practicing them to achieve high performance that continues to add value to customers and society. It therefore means being competitive and profitable (Mastroianni and Abdelhamid, 2003).

2.3.1 Learning Points on Lean Construction

Lean is a philosophy, not a set of tools and techniques (Koskela L, 1992). Lean merely provides ideas and principles for organizations to improve operations by using any number of different and innovative tools and techniques. Initiatives and terminology can be intimidating, but it is a simple philosophy that can be clouded by tools and techniques. He further states that Lean involves simple common-sense principles, which can be implemented from the most basic level of operations across the entire organization. Lean thinking can deliver dramatic improvements, particularly attractive to clients. In Lean thinking according to Shen et al. (2001), it should be noted that cost is targeted for reduction, not profit. This needs to be understood by the supply-chain for the principles to be embraced. Relationships of trust between client and suppliers are very important for providing these dramatic savings. Focus on cost, time and quality – measure these and know where it is you are trying to get. The derivative of Lean Construction is Lean Production. Lean production methods have been used and perfected in the world's manufacturing facilities for years. Most see Toyota's "Just-In-Time" production (providing the necessary parts for the car when it is needed rather than storing them) as the monumental achievement of Lean Production (Malloy, 2002). Since the success of Toyota in the manufacturing world, many industries are trying to translate those methods into their own, including construction.

So, what is Lean Construction? A simple, not simplistic, definition is that Lean Construction is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value (Koskela et al. 2002)". Lean is a communication rich and controlled process of construction production that builds on the principles of lean production and operational control found in manufacturing. He goes on to say that, Lean is about achieving a balanced use of materials, people and resources. This allows companies to reduce costs, eliminate wastes and deliver projects on time. Lean construction is a relatively new concept, and it needs to be approached in the right way if it is to be used effectively in the construction industry.

Abdelhamid (2004), defines lean construction as a holistic facility design and delivery philosophy with an overarching aim of maximizing value to all stakeholders through systematic, synergistic, and continuous improvements in the contractual arrangements, the product design, the construction process design and methods selection, the supply chain, and the work flow reliability of site operations.

An important part of the Lean paradigm is the "pull" system, meaning that material replenishment is initiated by consumption and stocks are filled up when needed. No goods or services are produced until a customer downstream asks for it. Salem et al. (2005) noted that Lean Construction practices utilize the knowledge of all field personnel to assist in the planning of projects, especially about the identification and execution of field labor tasks. It integrates the tasks of each trade to create a realistic schedule that is used by the project managers, superintendents, trade foremen, owners, facility maintenance personnel, and facility users that result in increased reliability. Lean Construction practices transform the long-range, master schedule planning tools, into reliable project tasks broken down into weekly, bi-weekly, or six-week look-ahead work plans that clearly identify project tasks, constraints and the people responsible for task completion through the use of a common language and collaboration. This results in an incremental, up-to-date, continuous, effective workflow plan. Its practices should be supplemented by the master schedule, the productivity report, and the budget (Salem et al, 2005).

Lean Construction consists of a search for consistency between the industrial activity and the site activity for the benefit of the building user (Alarcorn et al., 2003). The goal is to build the project while maximizing value, minimizing waste and pursuing perfection—for the benefit of all project stakeholders. Primarily, lean construction aims to reduce the waste caused by unpredictable workflow. Waste is defined in seven categories: defects, delays due to waiting for upstream activities to finish before another job can begin, over processing, overproduction, the construction process design and methods selection, the supply chain, and the workflow reliability of site operations.

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2.3.2 Lean Culture

Culture is a concept that generally refers to "the way things are done around here", and a culture approach is argued to increase the understanding of an organization both from a philosophic and practical viewpoint (Pepper 1995). A more precise definition of culture is that by Schein (2004) who define culture in a development context, meaning that culture is: "a pattern of shared basic assumptions that has been learnt whilst solving problems, that has worked well enough to be considered valid, and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems." It is important to understand that lean is not a technology that comes in a box and can be purchased and used at a site. Instead, it's a culture that has to be imbibed within the organization and practiced by its workers in order to successfully implement lean.

Womack and Jones (2003) mention in their book lean thinking, to be a lean manufacturer requires a way of thinking that focuses on making the product flow through value-adding processes without interruption (one-piece flow), a "pull" system that cascades back from customer demand by replenishing only what the next operation takes away at short intervals, and a culture in which everyone is striving continuously to improve. The concept of lean has developed through the years and is now considered to be valid for structuring and development of organizations.

There is a difference between lean organizations and conventional organizations doing lean things (Veech 2004), why some companies fail in applying lean, and thus fails in approaching a lean culture. The difference lies in the way the company treats its workers. A conventional organization focuses on getting things from the employees, e.g. improved productivity, ideas and work, (Veech 2004), and very similarly Mann (2005) states that: "focus on the people and the results will follow. Focus on the results, and you'll have the same troubles as everyone else – poor follow-up, lack of interest, no ownership of improvements, diminishing productivity." The key message is that it is not enough to just apply a lean principle or tool without a simultaneous strive for a lean culture. What is also needed is a balanced whole system view emphasizing improved performance through a focus on the persons delivering value to customers. Personal focus, involvement and motivation are imperative when applying lean principles and approaching a lean culture. In this respect, lean principles and practices can be seen as facilitators to both individual goals together with improved business performance (Mann, 2005).

2.4 Lean Approach in Construction

Most lean approaches in construction are concentrated in the Lean Construction concept. The academic debate in Lean Construction is to challenge the traditional understanding of projects based on theories of economics, and adopt project management based on theories of production (Koskela and Ballard 2006, Ballard and Howell 2004). Picchi and Granja (2004) have employed an inductive approach analyzing work performed in the Lean Construction field. By summarizing examples of lean tools used on job sites, Picchi and Granja (2004) identified three lean implementation scenarios: fragmented tools application, integrated job site application and lean enterprise application. There are, however, two distinctive points to analyze when accessing the issues related to lean construction: the efforts on identifying and eliminating waste must be in conjunction with cost savings in order to achieve success, and efficiency must be implemented in the whole organization at the same time. Value, as defined in Lean Thinking (Womack and Jones 2003), refers to materials, parts or products – something materialistic which is possible to understand and to specify (Koskela, 2004).

Construction is a process of delivering this value to the client through a temporary production system (Bertelsen and Emmitt, 2005). The client is often an organization representing owners, users and society who value different things at different times during the life of the building, e.g., durability, usefulness, beauty, flexibility and environmental aspects, etc. (Bertelsen & Emmit 2005). The other construction team members also have values to fulfill, but their main concern should be to deliver the best possible value to the client whom otherwise would look elsewhere (Emmitt et al., 2005).

Traditionally, construction projects are first broken into activities, with the activities placed in a logical order, and estimates for time and resources then prepared for each activity, Howell (1999) explains. To reduce overall project costs, contractors try to reduce the cost of each piece in the schedule. Safety, quality, time and cost are measured in terms of negative variance from standards. However, this traditional thinking often ignores the big picture. Instead, lean focuses on how one activity affects the next. Trade workers and other specialists share workloads to maintain a steady workflow and take responsibility for product quality. With the lean method, the project is more about the whole than its pieces. "The aim is to improve the performance of the entire delivery system, rather than reduce the cost of any one activity," Howell (1999) says. Where current project management manages projects as more or less independent activities, lean works first to assure the reliable flow of work between the tasks that make up the scheduled activities. Thus, it requires bringing subcontractors, foremen and superintendents to the planning table because their roles affect the overall project schedule.

2.4.1 Lean Construction System

When the concept of lean was adapted from the manufacturing industry, the concern was in abstracting the first principles that were underlying Lean Production and then tailor them to the Construction Industry. According to Ballard (2000), the challenge was then how to take the Lean Construction principles and make them operational. A new project delivery system was needed that encompasses all the core principles of Lean Construction. This was however, not intended to be a formulaic delivery system, as Lean Construction does not come with a standard set of tools. A lean project delivery system is one that is structured, controlled, and improved in pursuit of maximizing value to owners and workflow reliability on construction sites. The Lean Project Delivery System (LPDS) is a conceptual framework developed by Ballard (2000) to guide the implementation of lean construction on project-based production systems, i.e., the structures we build. The Lean Project Delivery System (LPDS) was developed as a set of interdependent functions (the systems level), rules for decision-making, procedures for execution of functions, and as implementation aids and tools, including software when appropriate.

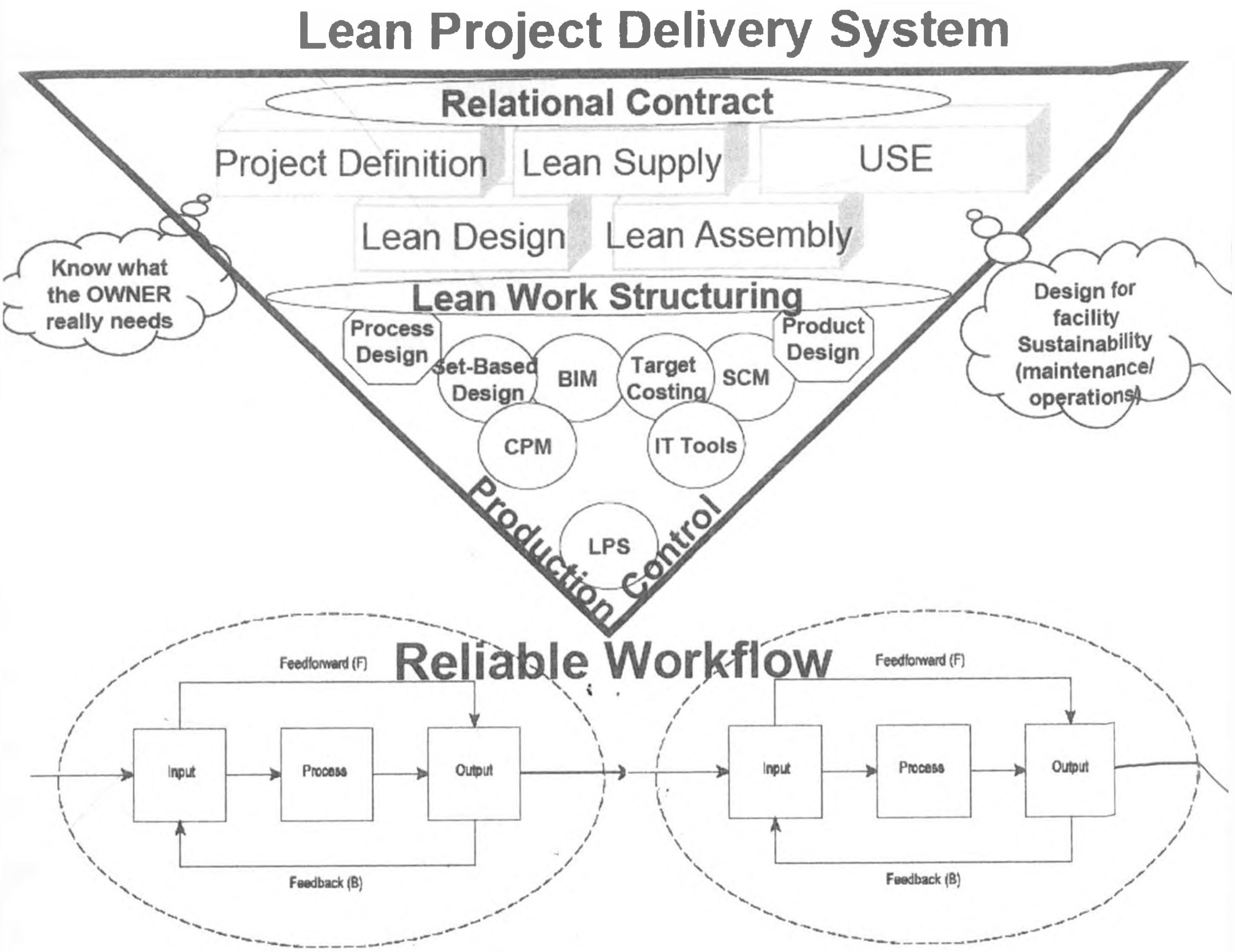

Figure 1 Lean Project Delivery System (Abdelhamid et al., 2008)

The triads and the processes contained within them are as follows: Project Definition phase consists of the modules; Needs and Values Determination, Design Criteria, and Conceptual Design; Lean Design consists of Conceptual Design, Process Design, and Product Design; Lean Supply consists of Product Design, Detailed Engineering, and Fabrication/Logistics; Lean Assembly consists of Fabrication/Logistics, Site Installation, and Testing/Turnover. Essential features of Lean Project Delivery System include (Abdelahamid,et al., 2008): the project is structured and managed as a value generating process; downstream stakeholders are involved in front end planning and design through cross functional teams; project control has the job of execution as opposed to reliance on after-the-fact variance detection; optimization efforts are focused on making work flow reliable as opposed to improving productivity; pull techniques are used to govern the flow of materials and information through networks of cooperating specialists; capacity and inventory buffers are used to absorb variability; feedback loops are incorporated at every level, dedicated to rapid system adjustment; i.e., learning.

Each phase of the project overlaps with the adjacent phases indicating the need to incorporate interests of the subsequent phases. This is the major departure of the Lean Project Delivery System from the traditional project delivery systems, where construction details are thought of only after the project has been bid. The different phases of Lean Project Delivery System provide different areas of improvement within a project delivery system. Although all the phases are crucial for success of a lean project, the heart of the Lean Project Delivery System lies in work structuring and production control (Abdelhamid et al., 2008).

2.5 Waste Material Management

Waste material management is a process of identifying, managing and recycling waste materials on construction projects. Waste material is a detrimental by-product of the building process in the construction industry and waste material management is an important process of identifying and processing waste in order to minimize it (Dunster and Collins, Building Research Establishment, 2003). Waste can be described as any materials by-product of human and industrial activities that has no residual value (Serpell and Alarcon, 1998). The term "non value-adding activity" has been widely used by researchers in literature pertaining to lean production (Koskela, 1992). The term non value-adding activity is used to differentiate between physical construction waste found on-site, and other waste, which occurs during the construction process. A number of definitions of waste are available. In general, Alarcon (1994), Koskela (1992) and Love et al. (1997) argued that all those activities that produce costs, direct or indirect, and take time, resources or require storage but do not add value or progress to the product could be called non value-adding activities or waste.

Mills et al., (2001) noted that prevention of waste must begin the moment the client first decides to go ahead with the project. Waste has been considered to be a major problem in the construction industry. Not only does waste have an impact on the efficiency of the construction industry but also on the overall state of the economy of a country (Koskela, 2000). Contractor firms have began to seek ways of increasing their competitive advantage in global markets by removing all kinds of waste inherent in the construction process by means of implementation of lean construction techniques. Case studies conducted by Koskela (2000) showed that there was a relationship between a reduction of productivity and the incidence of waste in construction. The basic idea of lean construction is eliminating all kinds of waste for fulfillment of customer requirements in a better way (Womack and Fitzpatrick, 1999). Koskela (1992) defined waste as "any inefficiency that results in the use of equipment, material, labor or capital in larger quantities than those considered as necessary in the construction of a building." Waste is that which can eliminated without reducing customer value.

Studies (Trankler et al., 1996) suggest that in the United States of America, Scandinavia and England up to approximately 30 percent of construction is rework, labor is used at only 40-

60 percent of potential efficiency, accidents can account for 3-6 percent of total project costs, and at least 10 per cent of materials are wasted. Furthermore, an Organization for Economic Cooperation and Development study suggests that United Kingdom input costs are generally a third of those of other developed countries but output costs are similar or higher. The message is clear - there is plenty of scope for improving efficiency and quality simply by taking waste out of construction.

Construction and building activities contribute to approximately 30 percent of overall landfill volumes in the States, the United Kingdom adds more than 50 percent and Australia contributes 20-30 percent (Teo and Loosemore, 2001). Research (Kartam, et al. 2004) indicated the construction and demolition waste accounts from about 15-30 percent all solid waste by weight and more than 90 percent of this waste is from landfill in the gulf region, particularly in Kuwait. Poon (2007) pointed out that 20 million tonnes of construction waste was generated in Hong Kong, 12 percent disposed of at landfills and 88 percent at.public fills. Research and study (Trankler, et al., 1996; Peng et al., 1997) concluded that the majority of construction and demolition waste is usually disposed of in landfills and the current trend has been targeted to recycle the construction and demolition waste to recognize its value and potentials of reusing them in future construction project.

Chilean building construction projects experience waste variables such as waiting time, idle time and travelling time (Serpell et al., 1995). Waiting time was caused by over manning, lack of progress, lack of equipment and materials. During the construction process, they normally have more laborers than needed, especially unqualified laborers. The problem related to unskilled laborers was also identified in the Sri Lanka construction industry. Jayawardane and

Gunawardena (1998) indicated in their study that the work force consisted of 51% unskilled workers.

The construction industry in Nigeria has similar productivity problems as Indonesia (Kaming et al., 1997b). Kaming et al. (1997b) identified lack of material, rework/repair, lack of equipment and supervision delays as factors influencing productivity in the construction industry. The study of material management in Malaysia (Abdul-Raman and Alidrisyi, 1994) identified the nature of problems such as delay in the delivery of materials, lack of planning and material variances. Bossink and Brouwers (1996) indicated that in the Brazilian construction industry, 20-30 percent of the purchased materials are not used and end up as waste. Since materials account for 50-60 percent of a construction project's cost, any improvement that avoids material waste results in major cost savings (Wong and Norman, 1997).

The amount of pure waste in traditional construction projects is striking; a Swedish study reports that only about 20 percent of performed work is directly value adding (Josephson and Saukkoriipi 2005). Lean Construction takes on this challenge by striving to better meet customer demands and to improve the construction process as well as its product (Howell 1999). Lean has proved to be a valuable philosophy for construction; Ballard and Howell (2004) and Emmitt *et al* (2005) report on successful implementations. The lean construction philosophy advocates identifying the root causes of waste and removing those causes by means of related tools and techniques, and encourages preventing loss rather than relying solely on reactions attempting to overcome negative effects of loss (Womack and Jones, 1996). Accordingly, contractors should attempt to find out the main causes of waste and eliminate those causes via various tools and techniques proposed by lean construction.

An additional effect of the fragmented construction process is waste during the production phase which in Swedish housing accounts for up to 35 percent of the production costs according to Josephson and Saukkoriipi, (2005). In addition, as noted by Sardén, (2005), adverse participant relations leads to even more waste in a business perspective as prices are continuously negotiated. It seems that a lack of consideration for the value generation process can have dire consequences for all project stakeholders.

Waste in the construction industry includes such delays as time, cost, lack of safety, rework, unnecessary transportation journeys, long distances, improper choice or management of programme or equipments and poor constructability (Lee, et al., 1999). Shen et al., (2004) stated that construction waste are in the form of building debris, rubble, earth, concrete, steel, timber and mixed site clearance materials arising from various construction activities for example, excavation, demolition, pavement work, and refurbishment.

2.5.1 Methods of Waste Material Management

Measures have been made to reduce waste by the use of recyclable materials (Kartam, et al., 2004) to increase the profitability of construction projects. Economic benefits would have been main factors to consider what materials are reused and other factors such as value, recyclability of materials have also played key roles in the decision making, thus materials waste decreased (Hester and Harrison, 1995). According to research conducted by Construction Industry Research and Information Association, Yang and Mitchell (1995, p7), 'it is initially through design that waste minimization, reuse and recycling of construction materials can be encouraged and promoted'. Design has taken a leading role in controlling and handling materials waste on construction sites. (Shen, et al., 2004). Mills et al., (2001) proposed that to provide a cost-effective and successful waste management plan, the project management is required to assess the project materials, standardize alternative waste disposal methods and calculate the economic effect of available disposal methods.

Research and studies by Kartam, et al. (2004); Mills, et al., (2001); Shen, (1999) and Formoso, et al., (1999) attempted at integrating and implementing waste management plan and programme as part of the project management process. The focuses of studies are the cost effectiveness and reductions of waste generated in building and construction site. A proactive analysis of projects should aim at banishing waste before it materializes, through better design, planning, control, procurement and coordination among the construction supply chain actors (Formoso et al. 2002).

Furthermore, waste reduction should not be limited to the upper levels of a supply chain. For example, if a third-tier supplier held considerable inventory to help a second-tier supplier operate just-in-time, the owner will still inadvertently need to pay for the inventory holding costs incurred by the third-tier supplier. Rather, lean project delivery must strive to minimize work-in-progress by achieving continuous workflow from raw materials to installed work (Womack and Jones, 1996).

2.6 Natural Environment

Due to the rising recognition of the environmental impacts, more and more research has been conducted to develop and explain the value of the environment, which is usually referred to as environmental values. More and more researchers started to include the environment as one more pillar of values of the buildings (Ofori, 1992; Huovila and Koskela, 1998; Lapinski et al., 2006). Poon (2007) noted that the construction sector generates enormous amounts of waste by consuming natural resources. The lean concept has proven to be effective in increasing environmental benefits by eliminating waste, preventing pollution and maximizing the owners' value. (Huovila and Koskela, 1998; Riley et al., 2005; Ferng and Price, 2005; Luo et al., 2005; Lapinski et al., 2006). Huovila and Koskela (1998) examined the contribution of the lean construction principles to sustainable development. The contributions include minimization of resource depletion, minimization of pollution and matching business and environmental excellence (Huovila and Koskela, 1998).

Environment Protection Agency (2003) found that lean produces an operational and cultural environment that is highly conducive to waste minimization and pollution prevention, and that lean provides an excellent platform for environmental management tools such as life cycle assessment and design for environment. Luo et al. (2005) applied the lean concept to prefabrication and stated that lean can contribute to improve quality and supply chain and reduce waste. Nahmens (2009) stated that it is a natural extension to apply the lean concept to achieve green production and construction. By applying the lean concept to a production line, 9 to 6.5 people (labor waste), 12 percent space (equipment waste) and 10 percent wallboard (material waste) can be reduced (Nahmens, 2009).

Sustainable development is usually defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, Brudtland report 1987, p.43). Due to the rising recognition of sustainable development, the construction industry is constantly being challenged to reduce its large amount of energy consumption, raw material, and water usage (Low et al., 2009).

According to Klotz et al., (2007), buildings consumed 36 percent of the total energy used, 30 percent of the raw materials used and 12 percent of potable water consumed in the United States of America. Construction companies are encouraged to take environmental considerations into their daily decision making process. Regulatory bodies, both international and national, keep imposing pressures on construction companies to invest in low energy consumption and environment-friendly techniques.

For example, the United Nations Framework Convention on Climate Change was founded in 1992 to deal with the global climate change. The Kyoto Protocol was established to set binding targets for industrialized countries to reduce carbon emissions by the year 2012 (Yates, 2007). For example in Singapore, by acceding to the Kyoto Protocol, the National Climate Change Committee was formed in 2001 to cover climate change in its scope, which has already included energy efficiency and renewable energy. Herrmann et al. (2008) proposed that besides classical economical production objectives (e.g. cost, time and quality), environmental driven objectives (e.g. low carbon dioxide emissions) should be considered in the production process. Due to the rising recognition of global climate change, the term "carbon dioxide emissions" is often used as one environmental sustainability indicator for the products.

2.6.1 Sustainable Construction

Sjöström, C. (1998) suggests that sustainable construction cohesively addresses the triple bottom line – the social, economic and environmental performance of the industry. The quest towards sustainable development in our societies puts the spotlight on the built environment and the construction industry. Construction, buildings and infrastructure are the main consumers of resources, materials and energy.

In the European Union, buildings require more than 40 percent of the total energy consumption and the construction sector is estimated to generate approximately 40 percent of the man-made waste (Sjöström 1998). Environmental burdens caused by construction can be minimized and construction technology can be used to remedy the environment. While traditional design and construction focuses on cost, performance and quality objectives, sustainable design and construction adds to these criteria minimization of resource depletion, minimization of environmental degradation, and creating a healthy built environment (Kibert 1994).

2.7 Workplace Safety

The health and safety record of construction is the second worst of any industry (Howell et al., 2002). Most accidents seem to occur when people are either not properly trained or working out of process. The construction industry is badly reputed for its high accident rate and even strong efforts in the form of regulations, control, education and information campaigns, have had minor effect only (Howell et. al., 2002). Lean advocates minimizing waste and continuously improving. Incidents that disrupt the flow of work or lead to injury are waste, so the relationship between lean and safety is clear.

Lack of safety is one of the chronic problems in construction, as is evident from the high accident rates. Employees in the industrialized housing industry sustain higher rates of reported injuries than their counterparts in the on-site construction industry. In the United States, total injury and illness incidence rates for prefabricated wood manufacturing ranged from 9.5 to 14.3 per 100 workers over the past 5 years, while the residential construction incidence rate is approximately 5 per 100 workers (Bureau of Labor Statistics 2008). Injury rates for both sectors are higher than the national average, 4.2 injuries per 100 workers, which justifies an increased focus on improving safety in all facets of residential construction, whether in industrialized housing plants or in conventional housing onsite. Further, according to the United States Department of Labor's Injuries, Illnesses and Fatalities Program, in 2003 there were 1,131 fatal accidents and 408,300 non fatal injuries and illnesses in the construction industry. Safety is an integral part of every production process, not an afterthought or an add-in, because safety depends on every action, material, and person used (Howell et. al., 2002).

Work processes are inherently safe or hazardous according to the safety hazards present in each step required to complete a process. Safety performance depends on the nature of the job and must be continuously maintained and improved as part of those processes (Koskela 1992). By carefully planning processes to minimize safety risks, work can be less hazardous. Injuries are costly not only in terms of human suffering but also in terms of worker compensation costs, lost time, lost productivity, and higher employee turnover.

Therefore, it is imperative to incorporate safety into process and production plans, in order to achieve projected goals of improved worker health, reduced costs, and increased value. Matilla et al., (1994), note that Lean production practices may affect safety through the use of continuous improvement programs that reduce opportunities for accidents through reduced waste (in materials, motions, and process steps) and therefore reduced safety hazards. It can also include safety initiatives as one category of improvement projects undertaken.

In practice, construction projects with best safety performances are likely to use good scheduling and housekeeping practices, which are main tenets of Lean production (Veteto 1994, Mattila et al. 1994). Using two principles of Lean, reducing waste and increasing efficiency, often result in a reduction of process steps, materials used, and motions required. These reductions in turn will reduce the probability of incurring an accident or coming in contact with hazardous materials. For example, by reducing the number of times a heavy object is lifted and handled, the total time needed to complete a process is reduced (improved efficiency) and the risk of back injury is also reduced.

In construction, the working environment constantly changes among projects, so safety performance is ultimately dependent on the avoidance of unsafe acts by workers (Nishigaki et al. 1992). It is important for all employees to be involved in safety planning. Allowing safety to be considered as an aspect of team work projects and continuous improvement efforts allows employees and managers to discuss and reduce safety hazards as part of continuous improvement opportunities.

2.7.1 Health and Safety

According to Veteto (1994), there are two key issues with regard to health and safety in the construction industry. The first is respecting people's rights to be protected against risks that affect their safety and long-term health. The second is that construction sites that are effectively planned and managed are more productive and profitable as well as being safe. He further states that the starting point for health and safety is effective planning of construction works. This starts at the design stage.

The design process should involve a detailed assessment of the construction process to make sure that no problematic health and safety issues are inherent within the design. Next is the detailed planning and scheduling. This should include clearly identifying processes for the execution of each element of the works. It is also necessary to ensure that the people who are working on the site are: trained and properly competent to do the work safely, properly supervised and given clear instructions, provided with the right tools, equipment and protective clothing, knowledgeable about health and safety issues. Performance against each of these issues needs to be regularly checked and any shortcomings remedied (Veteto 1994).

2.7.2 Safety Plan Modalities

The importance of construction safety to any construction project, whether it's residential or commercial, cannot be gainsaid. Even if it may be an inconvenience, contractors or site managers must accurately identify possible safety risks so as to prepare a construction safety protocol before any construction work begins (Howell et al., 2002). Commonly known as construction safety plan, the safety protocol is simply a document that is created to inform construction workers, clients and the general public about potential dangers in a site.

The document also helps to educate workers on the ways in which they can minimize the risks to both themselves and their workmates. Howell et al., (2002) suggest that to prepare a construction safety plan you need to carefully identify all possible risks around the construction site – including the minor ones that most workers often ignore, such as areas where safety gloves must be used. Once you have identified the risks, define them and then pick out appropriate ways to minimize or combat those risks. For example, if there is an area where workers will be at risk of being hit by falling debris, institute protocol for wearing hard hats.

It is very important for a contractor or site manager to write a safety plan in simple grammar so it can be easily understood by the workers. Remember, the objective of the safety plan document is to get workers informed about construction site safety (Howell et al., 2002).

The next step is to educate your workers and anyone who comes to the site about safety procedures.

In addition, place clear signs near each possible risk area in order to remind your workers and the general public to adhere to the safety protocol. These signs should be very brief and visible, preferably containing an image so that they can put across the message in the shortest time possible. They should use cautionary colors such as yellow, orange and red to capture people's attention. That said it is the responsibility of the site manager to ensure that workers adhere to the site rules and regulations at all times (Howell et al., 2002). The manager must make it clear that the construction safety plan is non-negotiable and must be followed to the dot. Those who fail to follow the guidelines must be disciplined accordingly to send a strong message to the rest of the team. In case of changes in the way risks will be managed, the site manager should amend the plan as required, and he should inform all affected workers of the changes.

2.8 Completion Time

Time is money to owners, builders, and users of the constructed facility. From the owner's perspective there is lost revenue by not receiving return on investment, cash flow crunch, potential alienation and loss of clients/tenants, extended interest payments, and negative marketing impacts. From the users' perspective, there are financial implications similar to owners. The duration of construction tasks consists of process (and reprocess or rework) time, inspection time, move time and wait time (Koskela, 1992).

Some of the major changes that have resulted in shortened construction projects duration include the gradual shift away from traditional bricklaying in favor of pre-cast concrete and steel or timber framed structures (Abdelhamid, 2004). This reduces the need for bricklayers, is more time efficient, and reduces the time needed to plaster, plumb and wire a residential unit. For a process to be Lean, it must shorten the timeline between customer orders and when the customer finally gets that order while still maximizing value (Abdelhamid, 2004). In today's intensely time driven business environment, superior planning, scheduling, and control are vital (Ballard et al., 1998). The Construction Manager is faced with the challenges of completing high volumes of work within tight periods, and generally finite resources. Construction Managers must comprehensively plan construction operations and closely monitor progress.

Critical Path Method schedules and linear schedules are valuable tools that provide several advantages in managing construction operations. Schedule preparation requires managers to think the project through prior to starting the work and provides a structured approach to planning. In addition, Ballard et al., (1998) note that comprehensive schedules provide a means of communicating the work plan to others. Schedules must be an accurate portrayal of the work plan to realize the full value. A good, regularly updated schedule in the hands of a competent Construction Manager is a powerful tool. Good schedules are critical to project success; however, they are only a tool. Schedules do not build things; people build things. Proactive rather than reactive control by the Construction Manager is a key to staying on schedule.

Events or conditions that cause delays and require appropriate action include weather, lower productivity than anticipated, delivery problems, resource constraints, changes in scope, and differing site conditions (Cnudde 1991). The Construction Manager must manage or mitigate these situations in order to deliver a constructed project on time.

Bramble and Callahan (1987) define delay as the time during which some part of the construction project has been extended or not performed due to an unanticipated circumstance. In construction, delay could be defined as time overruns either beyond the completion date stipulated in contract or beyond the agreed date for delivery of a project between the parties (Assaf and Al-Hejji, 2006). Aibinu and Jagbora (2002) describe delay as a circumstance when the contractor and the project owner jointly or severally contribute to the non-completion of the project within the original or the stipulated or agreed contract period. Hence, delay is a situation where the work is being slowed down without stopping it entirely.

Delay is one of the most serious problems in the construction industry and is also an important issue to the completion of a project. According to Shen et al. (2001), majority of the building projects usually cannot be accomplished within the stipulated contract period. Furthermore, according to Alwi (1995), delays in upgrading facilities translate into operating at below optimum efficiency resulting in higher user cost. A delay in constructing or rehabilitating infrastructure negatively affects businesses and the public at-large. Time implications from the constructor's perspective include liquidated damages (negative) and incentive/disincentive payments.

Delays result in extended overhead costs and put a crunch on critical cash flow. Extending project durations limits the constructor's bonding capacity and ability to bid more work (opportunity cost). Inefficient time management results in higher labor and equipment costs. A reputation for late completions is bad for business, especially in negotiated work. Time is of the essence on a construction housing project!

2.9 Project Cost

Poor quality was identified by Koskela (2000) as one of the major factors causing low productivity. Some researchers experienced the high amount of poor quality in construction.

Cnudde (1991) argued that the cost of poor quality (non-conformance), as measured on-site has turned out to be 10-20 percent of the total project cost.

In an American study of several industrial projects, deviation costs averaged 12.4 percent of the total installed project cost (Burati *et al.*, 1992). The causes of these quality problems are attributed to design, 78 percent, and to construction at 17 percent. A study in the Indonesian construction industry (Alwi, 1995) found that poor quality of labor skills contributed 3.2 percent of the total project costs. The information on the notice board should be sufficient and transparent. Two important aspects should be displayed on the notice board, which are waste streams and logistics of daily production (Blumenthal, 2008). By doing so, the lead time can be reduced, thus reducing the costs.

Studies conducted in Sweden (Bertselen and Koskela, 2002) show that one-third of the cost of building materials is not associated with the materials themselves but with packaging, storing, handling, transport, and getting rid of packaged and wasted materials. As costs of transportation accounts for approximately thirty percent of the costs of building materials, which again amounts for two-thirds of the construction costs, there seems to be a great potential for cost reductions in this flow of materials in that in most projects, it is known what will be used but not when (Bertselen, 1993 and 1994).

2.10 Gap in Knowledge

Lean Construction is new to the construction industry in Africa and in Kenya; very few persons are acquainted with it. Studies on Lean Construction system have been well document in other continents but not in Africa and to a large extent, Kenya. The study therefore seeks to show the relevance of Lean Construction system that brings improvement into the local construction industry that is majorly still employing traditional building techniques. According to Abdelhamid et al., 2008, this new system reduces the waste produced locally on and off site, reduced construction periods resulting in savings for both the contractor and professionals on one hand and construction stakeholders on the other hand. The Last Planner System tool, a subset of the Lean Project Delivery System, can be really effective when properly implemented and assist in Lean Construction uptake within the local housing building construction field. The tool is as follows: Last Planner System

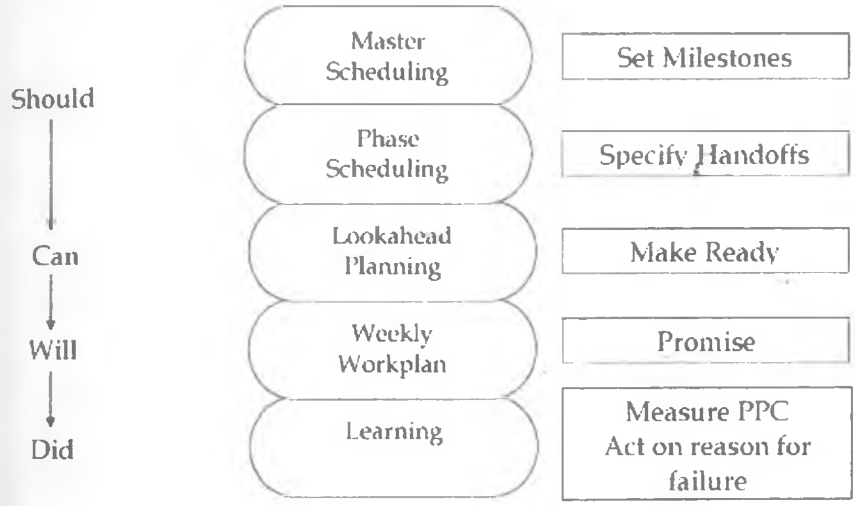

Figure 2 Last Planner System (Abdelhamid et al., 2008)

Proper use of Last Planner System produces reliable work-flow and stabilizes the project. It results in reduced costs, shortened durations, increased quality, and increased safety.

2.11 Conceptual Framework

The conceptual framework depicted on the following page, diagrammatically shows the relationships that exist between the dependent and independent variables under study. The dependent variable is performance of the residential housing building sector whose main indicator is customer satisfaction. The independent variables that will be investigated to establish their level of influence on the dependent variable are: waste material management, natural environment, workplace safety, completion time and project cost. Also shown are the moderating variables and intervening variables.

Conceptual Framework

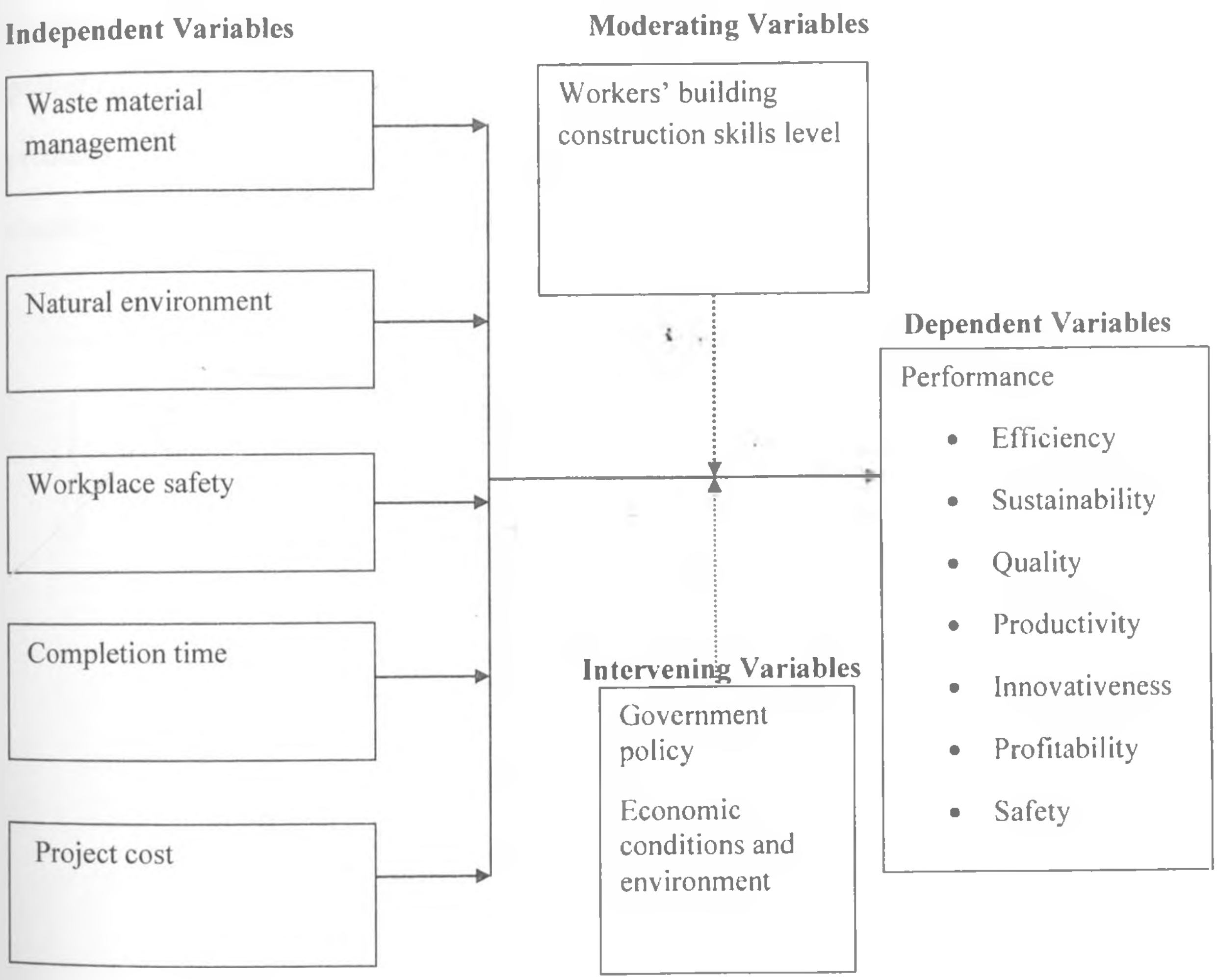

Figure 3 Conceptual Framework

2.12 Summary

This chapter tackled and expounded on the literature review related to Lean Construction system as follows: traditional construction, lean construction, learning points in lean construction, lean culture, lean approach in construction, lean construction, waste material management, methods of waste material management, natural environment, sustainable construction, workplace safety, health and safety, safety plan modalities, completion time, project cost and eventually a gap in existing local knowledge. Proper use of Last Planner System produces reliable work-flow and stabilizes the project. It results in reduced costs, shortened durations, increased quality, and increased safety.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the researcher highlights and details the procedures that assisted in carrying out the study. It encompasses the research design, target population, sample size and sampling procedure, data collection procedure and analysis, instruments validity and reliability and operational definition of variables.

3.2 Research Design

The research design adopted for this study was the correlation research as it sought to analyze the degree of relationship between the variables and to explore their implications for cause and effect (Mugenda and Mugenda, 1999). Correlation research assists to determine whether one or more relationships of some type exist among the variables.

3.3 Target Population

According to Mugenda and Mugenda (1999), population may refer to a set of individuals, events or objects that have a common observable characteristic. The target population for this study was selected on the following criteria; 1. The housing building industry Professionals and Contractors involved in the construction industry within Nairobi County; 2. Professionals and Contractors involved in housing scheme projects with a minimum number of fifty units (houses) and are conversant with Lean Construction. The researcher identified fifty registered Professionals and Contractors. The population was considered ideal because it was based in Nairobi County that had a large number of ongoing housing scheme building projects.

3.4 Sampling Procedure and Sampling Size

The study used non-probability method of purposive sampling procedure. This was largely as a result of the limited number of professionals and contractors in the construction industry who are well versed with the lean construction system that the study is investigating and the housing scheme building projects undertaken. Thirty Professionals and Contractors were therefore handpicked because they had some information on the lean construction system and possessed the required statistics.

Table 3.1 Sample Size

Profession	Number	Percentage	Sample
Quantity Surveyors	5	10	3
Mechanical Engineers	2	4	2
Construction Managers	6	12	4
Environmental Impact Assessment Experts	4	8	2
Project Managers	8	16	6
Structural Engineers	2	4	2
Electrical Engineers	2	4	2
Architects	6	12	3
Foremen	5	10	2
Contractors	10	20	4
Total	**50**	**100**	**30**

3.5 Methods of Data Collection

The data collection methods were of mixed-mode approach. Data was collected using qualitative and quantitative methods such as surveys and observation. To survey according to Mugenda and Mugenda, (1999) was to question people and record their responses for analysis. It enabled the researcher gather abstract information of all types relevant to the study. Survey was also selected as it is appropriate where the respondents are uniquely qualified to provide the requisite information and in this case, pertaining to lean construction system.

The data collection tools used under the survey method included personal interview (face to face or telephone) and questionnaires. Personal interview is more deep and detailed in terms of the information collected and also the interviewer has control and overall guidance of the process. Questionnaires enabled the researcher to obtain important information about the population. In this context, structured questions were employed as the respondents are knowledgeable on the facts involved with lean construction system under study. Observation method involved listening, reading, smelling and touching the problem under study (Mugenda and Mugenda, 1999). Non-behavioral observation was used whereby record analysis of past files was reviewed as well as process activity of the construction site. Files of completed and ongoing housing building scheme projects were perused in order to collect data relevant to this study.

3.6 Instruments Validity and Reliability

Validity refers to the accuracy and meaningfulness of inferences, which are based on the research results (Mugenda and Mugenda, 1999). It is the degree to which results obtained from the analysis of the data actually represent the phenomenon under study. In this study, content validity was used to ascertain the validity of the instruments. Professionals and experts in the construction field were requested to assess and check the instruments measurement capabilities and whether it actually represented the concept under study.

Reliability is the consistency of the results or data obtained when the instrument is subjected to repeated trials. The instruments were subjected to test-retest method that was carried out within a period of two weeks. Further, triangulation was employed whereby after conducting brief interviews on the respondents, a follow-up questionnaire of a similar nature was given to the same respondents to assess and confirm their answers in relation to the interviews.

3.7 Methods of Data Analysis

Data was analyzed as follows:-

3.7.1 Quantitative Data

Quantitative data was analyzed through the use of inferential statistics as follows:-

3.7.1.1 Parametric Statistical Test

It involved measuring the extent of relationships between the variables under study. Interval and ratio data were used with parametric tools in which distributions are predictable and often Normal. The test used on the interval and ration data was Pearson's Product Moment Correlation Coefficient (r).

3.7.1.2 Interpreting Coefficient of Correlation

The coefficient of correlation measures the degree of relationship between the variables under study. The following general rules are given which would help in interpreting the value:

-1	Perfect negative relationship between the variables
-0.10	Almost no relationship
0	No relationship between the variables
0.02-0.09	Very weak relationship
0.10-0.29	Weak relationship

0.30-0.49	Moderately weak relationship
0.50	Moderate relationships
0.50-0.60	Moderately strong relationship
0.70-0.89	Strong relationship
0.98-0.98	Very strong relationship
0.99	Almost perfect relationship
+1	Perfect positive relationship between the variables

3.7.2 Qualitative Data

Qualitative data was analyzed through the use of descriptive statistics method whereby frequencies and percentages were utilized.

The Quantitative and Qualitative methods discussed above were generated with the assistance of computer assisted qualitative data analysis software. For this study, Statistical Package for Social Sciences was used.

3.8 Operational definition of variables

Table 3.2 Operational definition of variables

Objectives	Variables	Indicators	Measurement	Measurement Scale	Study Design	Type of Analysis	Tools of Analysis
To determine to what extent waste material management influences the performance of housing building projects in Nairobi	Waste material management	Debris disposal	Level of debris disposal	Nominal	Correlation	Qualitative	Frequency, Percentage
		Defective works	Number of defective works	Ordinal		Quantitative	Spearman's correlation
		Rework/Repair works	Percentage of rework/repair works	Nominal		Qualitative	Frequency, Percentage
		Demolition	Amount of debris	Ordinal		Qualitative	Frequency, Percentage
		Reuse	Level of reuse	Nominal		Qualitative	Frequency, Percentage
		Material variances	Percentage of material variances	Ordinal		Qualitative	Frequency, Percentage
		Poor constructability	Percentage of incompatible building elements	Ordinal		Qualitative	Frequency, Percentage
	Performance	Customer satisfaction	Confirmation	Nominal	Correlation	Qualitative	Frequency, Percentage

Objectives	Variables	Indicators	Measurement	Measurement Scale	Study Design	Type of Analysis	Tools of Analysis
To determine to what extent the natural environment influences the performance of housing building projects in Nairobi	Natural environment	Water pollution	Level of pollution	Nominal	Correlation	Qualitative	Frequency, Percentage
		Air pollution	Level of pollution	Nominal		Qualitative	Frequency, Percentage
		Noise pollution	Level of pollution	Nominal		Qualitative	Frequency, Percentage
		Logging	Percentage of logging	Ordinal		Qualitative	Frequency, Percentage
		Sand harvesting	Amount of sand harvesting	Ordinal		Qualitative	Frequency, Percentage
		Cement production	Amount of cement production	Ordinal		Qualitative	Frequency, Percentage
		Recycling	Level of recycling	Nominal	Correlation	Qualitative	Frequency, Percentage
	Performance	Customer satisfaction	Confirmation	Nominal	Correlation	Qualitative	Frequency, Percentage

Objectives	**Variables**	**Indicators**	**Measurement**	**Measurement Scale**	**Study Design**	**Type of Analysis**	**Tools of Analysis**
To determine to what extent workplace safety influences the performance of housing building projects in Nairobi	Workplace safety	Accidents	Number of accidents	Interval	Correlation	Quantitative	Pearson's coefficient
		Injuries	Number of injuries	Interval		Quantitative	Pearson's coefficient
		Fatalities	Number of fatalities	Interval		Quantitative	Pearson's coefficient
		Site organization	Level of site organization	Nominal		Qualitative	Frequency, Percentage
		Protective clothing	Percentage of workers in protective clothing	Ordinal		Qualitative	Frequency, Percentage
		Proper tools & equipment	Level of proper tools & equipment usage	Ordinal		Qualitative	Frequency, Percentage
		Adequate signage	Presence of adequate signage	Nominal		Qualitative	Frequency, Percentage
	Performance	Customer satisfaction	Confirmation	Nominal	Correlation	Qualitative	Frequency, Percentage

Objectives	Variables	Indicators	Measurement	Measurement Scale	Study Design	Type of Analysis	Tools of Analysis
To determine to what extent completion time influences the performance of housing building projects in Nairobi	Completion time	Actual duration	Number of weeks	Ratio	Correlation	Quantitative	Pearson's coefficient
		Resource constraints	Availability of resources	Ordinal		Qualitative	Frequency, Percentage
		Site conditions	Level of condition	Nominal		Qualitative	Frequency, Percentage
		Scope change	Percentage of change	Nominal		Qualitative	Frequency, Percentage
		Weather	Condition of weather	Nominal		Qualitative	Frequency, Percentage
		Idle/Waiting time	Number of hours	Ratio		Quantitative	Pearson's coefficient
	Performance	Customer satisfaction	Confirmation	Nominal	Correlation	Qualitative	Frequency, Percentage

Objectives	Variables	Indicators	Measurement	Measurement Scale	Study Design	Type of Analysis	Tools of Analysis
To determine to what extent project cost influences the performance of housing building projects in Nairobi	Project cost	Finishes quality	Level of finishes quality	Nominal	Correlation	Qualitative	Frequency, Percentage
		Price of materials	Percentage increases	Ordinal		Quantitative	Pearson's correlation
		Transportation of materials	Distances covered	Ratio		Quantitative	Pearson's coefficient
		Compensation costs	Percentage of compensation costs	Ordinal		Quantitative	Pearson's correlation
		Disputes	Level of disputes	Nominal		Qualitative	Frequency, Percentage
		Project team involvement	Stage of involvement	Nominal		Qualitative	Frequency, Percentage
	Performance	Customer satisfaction	Confirmation	Nominal	Correlation	Qualitative	Frequency, Percentage

3.9 Summary

This chapter covered the following areas: research design, target population, sample size and sampling procedure, methods of data collection, instruments validity and reliability, operational definition of variables and methods of data analysis.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

In this chapter, the researcher presents the study findings on the influence of lean construction on the performance of housing scheme building projects in Nairobi County. The chapter presents a discussion on the general background of the study, and influence of waste material management, environmental influence, workplace safety, completion time and project costs on performance of housing scheme building projects.

4.2. Background Information

This study was carried out to establish the influence of lean construction on performance of housing scheme building projects in Nairobi County. The study sought to establish how: waste material management, natural environment, workplace safety, completion time and project cost influenced the performance of housing scheme building projects in Nairobi County. The background information provided tabulation on the study response and general experience of respondents in housing scheme building projects. The results as per the finding are presented and discussed below.

4.2.1 Response rate

The study used non-probability method of purposive sampling procedure to select 30 construction professionals and contractors. Out of the 30 sampled respondents, 21 participated in the study while 9 did not. The results are presented on Table 4.1.

Table 4.1: Response rate

Study Participants	Frequency	Percentage
Responded	21	70.0
Did not respond	9	30.0
Total	**30**	**100.0**

The response rate for the study was 70%, indicating above 50% turn out which was adequate to accomplish the study objectives.

4.2.2 Demographic Characteristics of the Respondents in Housing Scheme Building Projects

General information about respondents in the housing sector represented gender and age bracket of the respondents. The results were presented on Table 4.2 and Table 4.3.

Table 4.2: Demographic Characteristics of the Respondents - Gender

Gender of the respondent	Frequency	Percentage
Male	18	85.7
Female	3	14.3
Total	**21**	**100.0**

Table 4.3: Demographic Characteristics of the Respondents – Age

Age bracket of the respondent	Frequency	Percentage
20 - 30 years	8	38.1
31 - 40 years	6	28.6
41 - 50 years	3	14.3
Over 50 years	4	19.0
Total	**21**	**100.0**

The gender representation of the respondents indicated that 85.7% of the respondents who answered this question were males while 14.3 % were females. It shows that construction is basically a male affair.

4.2.3 General Experience of Respondents in Housing Scheme Building Projects

The general experience of respondents in housing scheme building projects was through indicators such as; the role of respondent in the construction sector, presence of any in-house lean construction guidance notes, respondent's years of service in the construction building projects and number of housing scheme building projects the respondent had been involved in. The findings were presented on Table 4.4.

Table 4.4 Indicators of Respondents Experience in Housing Scheme Building Projects

Primary Role	Number	Percentage
Quantity Surveyor	3	14.3
Mechanical Engineer	1	4.8
Construction Manager	4	19.0
EIA Expert	1	4.8
Project Manager	6	28.6
Structural Engineer	1	4.8
Electrical Engineer	1	4.8
Foreman	1	4.8
Architect	1	4.8
Other(please specify)	2	9.5
Total	**21**	**100.0**

Presence of In-House Lean Construction	Number	Percentage
Yes	3	14.3
No	16	76.2
Total	**19**	**90.5**

Experience	Number	Percentage
1 - 5 years	10	47.6
6 - 10 years	3	14.3
11 - 15 years	3	14.3
16 - 20 years	1	4.8
21 years and above	4	19.0
Total	**21**	**100.0**

Number of Housing Schemes Involved in	Number	Percentage
One	4	19.0
Two	3	14.3
Above four	13	61.9
Total	**20**	**95.2**

Majority of respondents who participated in the study were Project Managers representing 28.6%, second majority was Construction Managers representing 19%, while Quantity Surveyors represented 14.3%. According to popular majority (76.2%) of respondents, lean construction guidance / practice notes were not available in their organizations. The respondent's years of experience ranged between 1-5 years to over 21 years. Majority of respondents (47.6%) had worked in their respective organizations for a period of 1-5 years and had been involved in more than four construction projects. There is a considerable level of experience among the respondents with most of them working as project managers for more than four construction projects. It is however evident that lean construction is not a common practice in the construction industry as majority of respondents reveal that there are no criteria to guide the practice. This could imply that the practice is not very popular in the construction industry.

4.3 Influence of Lean Construction on Performance of Housing Scheme Building Projects

Various variables were used to establish the influence of lean construction on the performance of housing scheme building projects. These variables included waste material management, natural environment, workplace safety, completion time, and project cost. On a likert scale 1-5, respondents were asked to rate various indicators under each variable to gauge the overall influence of the variable on the performance of housing scheme building projects. A frequency and percentage as well as a correlation analysis were done for each variable to determine the overall influence on housing scheme building projects. The results are discussed on the following pages.

4.3.1 Influence of Waste Material Management on Performance of Housing Scheme Building Projects

The various indicators that were studied included debris disposal, defective works, rework/repair works, demolition, reuse, material variances and poor constructability.

Table 4.5 Extent of Importance of Waste Management Indicators

Indicators	Level of importance	Frequency	Percentage
	Unimportant	1	4.8
	Of little importance	4	19.0
	Moderately important	6	28.6
Debris disposal	Important	6	28.6
	Very important	3	14.3
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	0	0.0
	Moderately important	5	23.8
Defective works	Important	8	38.1
	Very important	7	33.3
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	4	19.0
Rework/repair works	Important	7	33.3
	Very important	7	33.3
	N/A	1	4.8
	Total	**20**	**96.6**
	Unimportant	0	0.0
	Of little importance	0	0.0
	Moderately important	2	9.5
Demolition	Important	9	42.9
	Very important	9	42.9
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	2	9.5
	Of little importance	5	23.8
	Moderately important	4	19.0
Reuse	Important	6	28.6
	Very important	4	19.0
	N/A	0	0.0
	Total	**21**	**100.0**
	Unimportant	2	9.5
	Of little importance	1	4.8
	Moderately important	5	23.8
Material variances	Important	7	33.3
	Very important	5	23.8
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	2	9.5
Poor constructability	Important	1	4.8
	Very important	14	66.7
	N/A	3	14.3
	Total	**21**	**100.0**

Debris disposal was found to have varying importance among respondents. Majority (28.6%) of respondents indicated moderate and important rating on debris disposal in influencing lean construction.19% indicate that it was of little importance while 14.3% said it was very important. Judging from majority response, debris disposal during waste management can be said to have an influence on performance of housing scheme building projects. Under the influence of defective works, majority (38.1%) of respondents rated important the extent to which defective works affected the performance of housing scheme building projects.

Reworks and repair works attracted an equal majority rating of 33.3% by respondents indicating important and very important. Demolition aspect of waste management was rated very important and important by an equal 42.9% majority of respondents as far as influencing performance of housing scheme projects. Reuse was rated of importance by 28.6% majority of the respondents. Material variances were rated important by 33.3% majority of respondents. Poor constructability was rated very important by 66.7% majority of respondents. Under waste management indicators it can be noted that majority of respondents give an important rating as far as influence on the performance of housing scheme building projects is concerned. A correlation analysis on the extent of relationship was established and results presented on Table 4.6.

Table 4.6 Correlation Analysis of Waste Management Indicators

Indicators	Correlation	Debris disposal	Defective works	Rework/repair works	Demolition	Reuse	Material variances	Poor constructability
Debris disposal	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	21						
Defective works	Pearson Correlation	.243	1					
	Sig. (2-tailed)	.289						
	N	21	21					
Rework/repair works	Pearson Correlation	-.140	.500*	1				
	Sig. (2-tailed)	.557	.025					
	N	20	20	20				
Demolition	Pearson Correlation	.383	.482*	.326	1			
	Sig. (2-tailed)	.086	.027	.160				
	N	21	21	20	21			
Reuse	Pearson Correlation	.674**	-.042	-.119	.044	1		
	Sig. (2-tailed)	.001	.857	.618	.849			
	N	21	21	20	21	21		
Material variances	Pearson Correlation	-.503*	-.475*	-.324	-.278	-.252	1	
	Sig. (2-tailed)	.020	.030	.164	.223	.271		
	N	21	21	20	21	21	21	
Poor constructability	Pearson Correlation	-.316	.055	.196	.144	-.147	.329	1
	Sig. (2-tailed)	.162	.813	.408	.533	.524	.145	
	N	21	21	20	21	21	21	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The results considered correlation coefficient at (0.05) level of significance. From Table 4.6, it can be noted that a moderate relationship 0.5 existed between repair works and defective works on performance of housing scheme projects. Demolition and defective works showed a moderately (0.48) weak relationship on their influence on performance of housing scheme building projects. Debris disposal and material variance indicated a moderately negative relationship of (-0.503). Defective work and material variances indicated a moderately weak relationship with a correlation coefficient of (- 0.475). From the study correlation results it can be noted that the performance of housing scheme construction projects can be to some extent be influenced by waste management practice.

4.2.2 Influence of Natural Environment on Performance of Housing Scheme Building Projects

The various indicators that were studied included water pollution, air pollution, noise pollution, logging, sand harvesting, cement production and recycling.

Table 4.7: Extent of Importance of Natural Environment Indicators

Indicators	Level of Importance	Frequency	Percentage
	Unimportant	0	0.0
	Of little importance	4	19.0
	Moderately important	1	4.8
Water pollution	Important	7	33.3
	Very important	7	33.3
	N/A	2	9.6
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	4	19.0
	Moderately important	5	23.8
Air pollution	Important	3	14.3
	Very important	7	33.3
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	3	14.3
	Moderately important	8	38.1
Noise pollution	Important	4	19.0
	Very important	5	23.8
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	4	19.0
	Moderately important	3	14.3
Logging	Important	5	23.8
	Very important	6	28.6
	N/A	2	9.5
	Total	**20**	**95.2**
	Unimportant	0	0.0
	Of little importance	2	9.5
	Moderately important	0	0.0
Sand harvesting	Important	4	19.0
	Very important	14	66.7
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	1	4.8
	Moderately important	3	14.3
Cement production	Important	6	28.6
	Very important	9	42.9
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	5	23.8
Recycling	Important	5	23.8
	Very important	4	19.0
	N/A	5	23.8
	Total	**20**	**95.2**

Water pollution was rated very important and important by an equal majority 33.3% of the respondents. Air pollution was rated unimportant by 4.8% of the respondents, of little importance by 19% of the respondents, moderately important by 23.8% of the respondents, important by 14.3% of the respondents and very important by 33.3% of respondents. From majority response it can be noted that professionals in construction industry rate the air pollution aspect of natural environment as very important in influencing performance in housing scheme building projects.

Noise pollution was rated moderately important by majority 38.1% of the respondents as far as influencing performance of housing scheme building projects was concerned. Logging was rated very important by 28.6% majority of respondents. Sand harvesting was rated very important by 66.7% of the respondents. Cement production was also a very important factor whereby 42.9% respondents found it to influence performance of housing scheme building projects. Rating on the importance of recycling under natural environment was majorly distributed between moderately important, important, and not applicable. Though overall majority of respondents rated recycling as moderately important or important, there was evidence that the aspect of recycling was in some cases not applicable as far performance of housing scheme building projects were concerned.

Table 4.8 Correlation Analysis of Natural Environment Indicators

Indicators	Correlation	Water pollution	Air pollution	Noise pollution	Logging	Sand harvesting	Cement production	Recycling
Water pollution	Pearson Correlation	1						
	Sig (2-tailed)							
	N	21						
Air pollution	Pearson Correlation	-.048	1					
	Sig. (2-tailed)	836						
	N	21	21					
Noise pollution	Pearson Correlation	-.077	675**	1				
	Sig (2-tailed)	.739	001					
	N	21	21	21				
Logging	Pearson Correlation	054	119	- 009	1			
	Sig (2-tailed)	820	619	.970				
	N	20	20	20	20			
Sand harvesting	Pearson Correlation	077	-.184	044	.302	1		
	Sig (2-tailed)	.740	425	849	195			
	N	21	21	21	20	21		
Cement production	Pearson Correlation	.205	271	181	.334	.269	1	
	Sig. (2-tailed)	374	235	.432	.150	.239		
	N	21	21	21	20	21	21	
Recycling	Pearson Correlation	-.246	078	.213	-.210	-.118	-.401	1
	Sig (2-tailed)	297	.745	366	375	.619	079	
	N	20	20	20	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed)

Environmental factors found to have a relationship in their influence on performance of housing scheme building projects were noise and air pollution whose correlation coefficient was (0.675) representing a moderately strong positive relationship. This would imply that increased in noise pollution is likely to increase air pollution and thus have overall effect of performance of housing scheme building projects.

4.2.3 Influence of Workplace Safety on Performance of Housing Scheme Building Projects

Various indicators of workplace safety deemed to have influence in housing scheme building projects included; Accidents, injuries fatalities, site organization, protective clothing, proper tools and equipments, and adequate signage. Frequency and percentage distribution and their importance in influencing the performance housing scheme building projects have been discussed as follows:

Table 4.9 Extent of Importance of Workplace Safety Indicators

Indicators	Level of importance	Frequency	Percentage
	Unimportant	1	4.8
	Of little importance	1	4.8
	Moderately important	1	4.8
Accidents	Important	4	19.0
	Very important	14	66.7
	N/A	0	0.0
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	1	4.8
	Moderately important	1	4.8
Injuries	Important	7	33.3
	Very important	11	52.4
	N/A	0	0.0
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	0	0.0
	Moderately important	1	4.8
Fatalities	Important	3	14.3
	Very important	15	71.4
	N/A	0	0.0
	Total	**20**	**95.3**
	Unimportant	0	0.0
	Of little importance	0	0.0
	Moderately important	2	9.5
Site organization	Important	8	38.1
	Very important	10	47.6
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	2	9.5
Protective clothing	Important	7	33.3
	Very important	11	52.4
	N/A	0	0.0
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	0	0.0
	Moderately important	1	4.8
Proper tools & equipment	Important	6	28.6
	Very important	14	66.7
	N/A	0	0.0
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	2	9.5
	Moderately important	2	9.5
Adequate signage	Important	9	42.9
	Very important	6	28.6
	N/A	2	9.5
	Total	**21**	**100.0**

Accidents received a very important rating as far as workplace safety influence on performance of housing scheme building projects was concerned. This was evident by 66.7% of majority respondents. Injuries are also considered important in influence performance of housing scheme building projects. 52.4% majority of respondents and 33.3% second majority gave a rating of very important and important respectively. If organizations are therefore to maximize the use of lean construction, it could only be imperative that strategy towards injuries reduction is increased through appropriate work place policies.

Fatalities are also considered very important workplace safety aspects that influence the performance of housing scheme building projects. A very important rating for this aspect was given by 71.4% majority of respondents. Site organization was rated very important by 47.6% of the respondents. 47.6% majority of respondents rated workplace. Use of protective clothing as a safety measures was rated very important by 52.4% majority of respondents. Adequate signage is also an important aspect safety influencing performance of housing scheme building projects.

The correlation analysis Table 4.10 on the following page indicated that accidents and injuries had a strong positive correlation at (0.865). Fatalities are also strongly related to injuries at a correlation coefficient of (0.754). Site organization has a moderate positive relationship with adequate signage, while protective clothing has a moderately weak relationship with adequate signage. Proper tools and equipment exhibit moderately weak relationship with adequate signage with a correlation coefficient of (0.35). From the study findings, not only can it be concluded that different parameters of workplace safety interrelated with one another but also they influence the performance of housing scheme building projects.

Table 4.10: Correlation Analysis of Workplace Safety Indicators

Indicators		Recycling	Accidents	Injuries	Extend fatalities	Site organisation	Protective clothing	Proper tools & equipment	Adequate signage
Accidents	Pearson Correlation	.020	1						
	Sig. (2-tailed)	.933							
	N	20	21						
Injuries	Pearson Correlation	.121	.865**	1					
	Sig. (2-tailed)	.612	.000						
	N	20	21	21					
Fatalities	Pearson Correlation	-.028	.535*	.754**	1				
	Sig. (2-tailed)	.910	.015	.000					
	N	19	20	20	20				
Site organisation	Pearson Correlation	-.112	.131	.160	-.263	1			
	Sig. (2-tailed)	.639	.572	.488	.262				
	N	20	21	21	20	21			
Protective clothing	Pearson Correlation	-.116	-.192	-.036	.043	.286	1		
	Sig. (2-tailed)	.626	.405	.878	.858	.209			
	N	20	21	21	20	21	21		
Proper tools & equipment	Pearson Correlation	-.180	-.072	-.085	.035	.431	.462*	1	
	Sig. (2-tailed)	.447	.755	.714	.883	051	.035		
	N	20	21	21	20	21	21	21	
Adequate signage	Pearson Correlation	-.053	.310	.300	.046	.501*	.469*	.435*	1
	Sig. (2-tailed)	.826	.171	.187	.846	.021	.032	.049	
	N	20	21	21	20	21	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4.2.4 Influence of Completion Time on Performance of Housing Scheme Building Projects

The indicators of completion time examined in this study included, actual duration , resource constraints , site conditions, scope change and idle / waiting time. The results on respondent rating on the extent of importance of completion time indicators were presented on Table 4.11.

Table 4.11: Extent of Importance of Completion Time Indicators

Indicators	Level of importance	Frequency	Percentage
	Unimportant	0	0.0
	Of little importance	0	0.0
	Moderately important	1	4.8
Actual duration	Important	5	23.8
	Very important	14	66.7
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	0	0.0
Resource constraints	Important	8	38.1
	Very important	12	57.1
	N/A	0	0.0
	Total	**21**	**100.0**
	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	3	14.3
Site conditions	Important	6	28.6
	Very important	11	52.4
	N/A	0	0.0%
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	3	14.3
	Moderately important	1	4.8
Scope change	Important	7	33.3
	Very important	8	38.1
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	0	0.0
	Moderately important	4	19.0
Weather	Important	8	38.1
	Very important	7	33.3
	N/A	1	4.8
	Total	**21**	**100.0**
	Unimportant	1	4.8
	Of little importance	3	14.3
	Moderately important	3	14.3
Idle/waiting time	Important	5	23.8
	Very important	6	28.6
	N/A	2	9.5
	Total	**20**	**95.3**

According to the study findings, actual duration was rated a very important indicator of completion time that influenced the performance of housing scheme building projects. Other indicators under completion time as rated by the respondents included resource constraints rated very important by 57.1% of the respondents, site conditions rated very important by 52.4% of majority response, scope change rated very important by 38.1% of the respondents, weather rated very important by 38.1% of the respondents and idle waiting rated very important by 28.6% majority of respondents.

Table 4.12: Correlation Analysis of Completion Time Indicators

Indicators	Correlation	Actual duration	Resource constraints	Site conditions	Scope change	Weather	Idle/waiting time
Actual duration	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	21					
Resource constraints	Pearson Correlation	.192	1				
	Sig. (2-tailed)	.403					
	N	21	21				
Site conditions	Pearson Correlation	.320	.011	1			
	Sig. (2-tailed)	.158	.964				
	N	21	21				
Scope change	Pearson Correlation	.417	.205	.722**	1		
	Sig. (2-tailed)	.060	.374	.000			
	N	21	21	21			
Weather	Pearson Correlation	.254	.431	.530*	.351	1	
	Sig. (2-tailed)	.266	.051	.014	.118		
	N	21	21	21	21	21	
Idle/waiting time	Pearson Correlation	.193	.588**	.471*	.558*	607**	1
	Sig. (2-tailed)	.415	.006	.036	.011	.005	
	N	20	20	20	20	20	

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Scope change and site conditions reveal a strong relationship in the influence of performance of housing scheme building projects as is evident by a correlation coefficient of (0.722). A moderate positive relationship is exhibited between site conditions and weather conditions. Resource constraints were found to positively correlate with site conditions, scope of change and conditions.

4.2.5 Influence of Projects Cost on Housing Scheme Building Projects

The influence of project cost on performance of housing projects was measured through rating the following indicators; finishes quality, workmanship, price of materials, transportation of materials, compensation costs, disputes and project team involvement. The findings were indicated on Table 4.13.

Table 4.13: Extent of Importance of Project Cost Indicators

Indicators	Level of importance	Frequency	Percentage
Finishes quality	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	0	0.0
	Important	4	19.0
	Very important	16	76.2
	N/A	0	0.0
	Total	**21**	**100.0**
Workmanship	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	1	4.8
	Important	1	4.8
	Very important	18	85.7
	N/A	0	0.0
	Total	**21**	**100.0**
Price of materials	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	1	4.8
	Important	5	23.8
	Very important	13	61.9
	N/A	1	4.8
	Total	**21**	**100.0**
Transportation of materials	Unimportant	0	0.0
	Of little importance	2	9.5
	Moderately important	2	9.5
	Important	10	47.6
	Very important	6	28.6
	N/A	1	4.8
	Total	**21**	**100.0**
Compensation costs	Unimportant	0	0.0
	Of little importance	2	9.5
	Moderately important	4	19.0
	Important	10	47.6
	Very important	4	19.0
	N/A	1	4.8
	Total	**21**	**100.0**
Disputes	Unimportant	1	4.8
	Of little importance	1	4.8
	Moderately important	2	9.5
	Important	6	28.6
	Very important	10	47.6
	N/A	1	4.8
	Total	**21**	**100.0**
Project team involvement	Unimportant	0	0.0
	Of little importance	1	4.8
	Moderately important	1	4.8
	Important	4	19.0
	Very important	12	57.1
	N/A	3	14.3
	Total	**21**	**100.0**

Finishes quality was given a very important rating by 76.2% majority of respondents. Likewise workmanship was rated very important by 85.7% majority of respondents. Price of materials was rated as very important by 61.9% of the respondents. Transportation of material was rated important by 47.6% majority of respondents, compensation costs was rated important by 47.6% majority of respondents. The issue of disputes was rated very important by 47.6%

majority of respondents while project team was rated very important as per response of 57.1% majority of respondents. The extent of relationship was further established through correlation analysis and presented in Table 4.14.

Table 4.14: Correlation Analysis of Project Cost Indicators

Indicators	Correlation	Finishing quality	Workmanship	Price of materials	Transportation of materials	Compensation costs	Disputes	Project team Involvement
Finishing quality	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	21						
Workmanship	Pearson Correlation	.699**	1					
	Sig. (2-tailed)	000						
	N	21	21					
Price of materials	Pearson Correlation	472*	178	1				
	Sig. (2-tailed)	031	440					
	N	21	21	21				
Transportation of materials	Pearson Correlation	390	.101	.800**	1			
	Sig. (2-tailed)	.081	.664	000				
	N	21	21	21	21			
Compensation costs	Pearson Correlation	.092	284	.355	666**	1		
	Sig. (2-tailed)	693	212	.115	.001			
	N	21	21	21	21	21		
Disputes	Pearson Correlation	.387	.294	446*	.576**	489*	1	
	Sig. (2-tailed)	.083	196	048	.006	.024		
	N	21	21	21	21	21	21	
Project team involvement	Pearson Correlation	573**	.219	747**	555**	075	418	1
	Sig. (2-tailed)	.007	340	000	.009	746	.059	
	N	21	21	21	21	21	21	21

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

From the correlation results, it can be noted that workmanship and finishing quality have moderately positive strong relationship (0.699) in influencing performance of housing scheme building projects. Price of materials and finishing quality reflect a moderately weak relationship, with a correlation coefficient of (0.472). Transportation of material and price of materials indicate a strong relationship with a correlation coefficient of (0.800). Compensation costs and transportation costs reflect a moderately strong relationship with a correlation coefficient of (0.666). Disputes and transportation of materials have a moderate relationship with a correlation coefficient of (0.576). Disputes and compensation costs show a moderately weak relationship with correlation coefficient of (0.489). Involvement of the project team showed a moderate positive relationship with finishing quality as well as with transportation of materials indicating as positive relationship of (0.555).

Table 4.15 Summary of Correlation Coefficients for Lean Construction Variables

Lean construction parameters	Correlation coefficient	Degree of relationship with performance of housing scheme building projects
Waste management	0.112	Weak relationship
Natural environment	0.093	Very weak relationship
Workplace safety	0.603	Moderately strong relationship
Completion time	0.579	Moderate relationship
Project costs	0.632	Moderately strong relationship

A summary of correlation coefficient was obtained through an aggregate of the coefficients from each indicator of Lean Construction variables under study. The results of the overall coefficients for the independent variables indicated the level of influence as per Table 4.14. The overall correlation results indicate that a weak relationship existed between waste management and performance of housing scheme building projects as well as natural environment. It further indicated that a moderately strong relationship existed between work safety and projects costs. Completion time showed a moderate relationship with performance of housing projects. It can therefore been concluded that work safety , completion time and projects costs have higher influence on performance of housing scheme building projects compared to natural environment and waste management. Further, observations from the findings indicate that all variables of Lean Construction examined in this study have a level of influence on performance of housing scheme building projects in Nairobi County.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this chapter, the researcher presents the summary of findings, discussions, conclusions and recommendations on the study; influence of lean construction on performance of housing scheme building projects in Nairobi County, Kenya. The study sought to answer the questions of the extent to which; waste material management, natural environment, workplace safety, completion time and project cost influenced the performance of housing scheme building projects in Nairobi. Data analysis results generated frequency and percentage distributions on the importance of various indicators under each variable as well as a correlation analysis to determine the extent of relationship between the lean construction indicators under examination.

5.2 Summary of Findings

The summary of findings is discussed in Table 5.1 where the key indicators that were investigated under each independent variable were considered. The variables under study were waste material management, natural environment, workplace safety, completion time and project cost.

Table 5.1: Summary of Research Findings

Objectives	Research Findings	Remarks
i. To determine the extent to which waste material management influences the performance of housing scheme building projects	- The 7 indicators under this variable averaged a correlation value of 0.112 which indicated a weak relationship; - Poor constructability was ranked position 1 by 14 respondents (66.7%); - Repair and defective works had a correlation value of 0.500 that indicated a moderate relation;	- Thus, project poor constructability was viewed as the most important indicator whereas repair and defective works had a significant influence on the performance of housing scheme building projects.
ii. To determine the extent to which the natural environment influences the performance of housing scheme building projects	- The 7 indicators under this variable averaged a correlation value of 0.093 which indicated a very weak relationship; - Sand harvesting was ranked position 1 by 14 respondents (66.7%); - Noise and air pollution had a correlation value of 0.675 that indicated a moderately strong relation;	- Thus, sand harvesting was viewed as the most important indicator whereas noise and air pollution had a significant influence on the performance of housing scheme building projects.
iii. To determine the extent to which workplace safety influences the performance of housing scheme building projects	- The 7 indicators under this variable averaged a correlation value of 0.603 which indicated a moderately strong relation; - Accidents, proper tools and equipment were equally ranked position 1 by 14 respondents (66.7%); - Accidents and injuries had a correlation value of 0.865 that indicated a strong relation;	- Thus, accidents, proper tools and equipment were viewed as the most important indicators whereas accidents and injuries had a significant influence on the performance of housing scheme building projects.

Objectives	Research Findings	Remarks
i. To determine the extent to which waste material management influences the performance of housing scheme building projects	- The 7 indicators under this variable averaged a correlation value of 0.112 which indicated a weak relationship; - Poor constructability was ranked position 1 by 14 respondents (66.7%); - Repair and defective works had a correlation value of 0.500 that indicated a moderate relation;	- Thus, project poor constructability was viewed as the most important indicator whereas repair and defective works had a significant influence on the performance of housing scheme building projects.
ii. To determine the extent to which the natural environment influences the performance of housing scheme building projects	- The 7 indicators under this variable averaged a correlation value of 0.093 which indicated a very weak relationship; - Sand harvesting was ranked position 1 by 14 respondents (66.7%); - Noise and air pollution had a correlation value of 0.675 that indicated a moderately strong relation;	- Thus, sand harvesting was viewed as the most important indicator whereas noise and air pollution had a significant influence on the performance of housing scheme building projects.
iii. To determine the extent to which workplace safety influences the performance of housing scheme building projects	- The 7 indicators under this variable averaged a correlation value of 0.603 which indicated a moderately strong relation; - Accidents, proper tools and equipment were equally ranked position 1 by 14 respondents (66.7%); - Accidents and injuries had a correlation value of 0.865 that indicated a strong relation;	- Thus, accidents, proper tools and equipment were viewed as the most important indicators whereas accidents and injuries had a significant influence on the performance of housing scheme building projects.

Objectives	Research Findings	Remarks
iv. To determine the extent to which completion time influences the performance of housing scheme building projects	- The 6 indicators under this variable averaged a correlation value of 0.579 which indicated a moderate relation; - Actual duration was ranked position 1 by 14 respondents (66.7%); - Scope change and site conditions had a correlation value of 0.722 that indicated a strong relation;	- Thus, actual duration was viewed as the most important indicator whereas scope change and site conditions had a significant influence on the performance of housing scheme building projects.
v. To determine the extent to which project cost influences the performance of housing scheme building projects	- The 6 indicators under this variable averaged a correlation value of 0.632 which indicated a moderately strong relation; - Workmanship was ranked position 1 by 18 respondents (85.7%); - Price and transportation of materials had a correlation value of 0.800 that indicated a strong relation;	- Thus, workmanship was viewed as the most important indicator whereas price and transportation of materials had a significant influence on the performance of housing scheme building projects.

5.3 Discussion of Key Findings

Key findings of the study were compared with the literature review findings under each variable as follows:-

5.3.1 Waste Material Management on the Performance of Housing Scheme Building Projects

The analyzed data showed that waste management in Nairobi County is not given much emphasis attested by the aggregated weak correlation obtained of 0.112. The respondents observed that there was no significant relationship between waste management and performance of housing scheme building projects. However, from the literature review excerpts, waste was generally considered to be a very major problem in the construction industry. According to Koskela (2000), not only does waste have an impact on the efficiency of the construction industry but also on the overall economic state of a country. Case studies conducted by Koskela revealed that there was a significant relationship between a reduction of productivity and the incidence of waste in construction

It was noted by majority of the respondents that poor constructability, defective and repair works contributed a lot to waste production. Studies by Trankler et al., (1996) suggested that in the United States of America, Scandinavia and England, at least 10 per cent of materials are wasted in and this concurs with the study findings. In addition, Kaming et al. (1997b) identified lack of material, rework/repair, and lack of equipment and supervision delays as factors influencing productivity in the construction industry which tallied with the study's findings.

Material variances were noted by the study's findings as having a profound effect on the production of waste whereby wrongly specified materials that were delivered to construction site ended up as waste that lead to increased project cost. Wong and Norman (1997) found out that since materials account for 50-60 percent of a construction project's cost any improvement that avoids material waste results in major cost savings.

5.3.2 Natural Environment on the Performance of Housing Scheme Building Projects

The study findings noted that the environment was a key pillar in the housing building sector and these was seen through the Environmental Impact Assessment regulations that were already in place and the need for statutory approvals from the National Environmental Agency before commencing construction. Literature review also showed that more and more researchers started to include the environment as one more pillar of values of the buildings (Ofori, 1992; Huovila and Koskela, 1998; Lapinski et al., 2006).

Despite this variable having a very weak aggregated correlation value (0.112), the respondents' rated sand harvesting and logging as having a significant impact on the depletion of the environment hence more care needs to be taken. This is seen more so with the increased levels of construction activities that runs hand in hand with the depletion of the natural resources, indiscriminate sand harvesting and logging. Poon (2007) noted that the construction sector generates enormous amounts of waste by consuming natural resources.

Sustainability within the industry is to be critically considered as it was still consuming large amounts of energy, raw materials and water that are ineffectively used without any thoughts of sustainability. Due to the rising recognition of sustainable development, the construction industry is constantly being challenged to reduce its large amount of energy consumption, raw material, and water usage (Low et al., 2009).

5.3.3 Workplace Safety on the Performance of Housing Scheme Building Projects

The study found out that accidents were prevalent in the building sector and efforts to stem them have not borne positive results. Proper tools and equipments were not fully appreciated as observed in some housing scheme building projects. In some instances, some workers did not wear helmets despite their provision by Contractors and instead used them for other purposes. The construction industry is badly reputed for its high accident rate and even strong efforts in the form of regulations, control, education and information campaigns, have had minor effect only (Howell et. al., 2002).

Safety was considered as a very important aspect for the continuity of the construction industry. The Ministry of Labor through the Occupation and Safety Act closely monitored contractors to ensure their workers welfare through proper safety training and adequate compensation in case of accidents. Howell et. al., (2002) also considered safety as an integral part of every production process, not an afterthought or an add-in, because safety depends on every action, material, and person used in a construction activity.

Majority of the respondents considered workplace safety of utmost importance for effective construction production to occur in an ideal setting. Further, in construction, the working environment constantly changes among projects, so safety performance is ultimately dependent on the avoidance of unsafe acts by workers (Nishigaki et al. 1992).Matilla et al., (1994), noted that it was imperative to incorporate safety into process and production plans, in order to achieve projected goals of improved worker health, reduced costs, and increased value. Much emphasis has been put on workplace safety as seen in the literature review.

5.3.4 Completion Time on the Performance of Housing Scheme Building Projects

Idle/waiting time was noted to be a key determinant of the construction process thus any activities that ended up taking productive time were to be omitted or their impact kept to a minimum. The duration of construction tasks consists of process (and reprocess or rework) time, inspection time, move time and wait time (Koskela, 1992).

Most of the respondents rated resource constraints, scope change, weather and diverse site conditions very highly thereby having a direct bearing on the completion time of a housing scheme project. Shen et al. (2001) noted that majority of the building projects usually cannot be accomplished within the stipulated contract period. Similarly, according to Cnudde (1991), events or conditions that caused delays and required appropriate action included weather, lower productivity than anticipated, delivery problems, resource constraints, changes in scope, and differing site conditions.

5.3.5 Projects Cost on the Performance of Housing Scheme Building Projects

In the study, workmanship and finishes quality were key criteria in determining the performance of housing scheme building projects. Thus where these were good, it followed that the productivity was also good. Poor quality was identified by Koskela (2000) as one of the major factors that caused low productivity.

This variable had a moderately strong aggregated correlation value of 0.632 from the correlation analysis. This indicated that the variable had a significant bearing on the performance of housing scheme building projects in Nairobi County. Studies conducted in Sweden by

Bertselen and Koskela (2002), show that one-third of the cost of building materials is not associated with the materials themselves but with packaging, storing, handling, transport, and getting rid of packaged and wasted materials. As costs of transportation accounts for approximately thirty percent of the costs of building materials, which again amounts for two-thirds of the construction costs, there seems to be a great potential for cost reductions in this flow of materials in that in most projects, it is known what will be used but not when, Bertselen (1993 and 1994).

5.4 Conclusions

From the study results, it can be noted that lean construction is a predominantly rare practice in Kenya. Despite many construction professional having reasonable good experience and adequate training, it is noted that the practice of lean construction is not popular among construction organizations, evident by lack of in-house lean construction guidance/ practice notes. This could further be an implication that the construction industry had not considered the practice as an important practice towards performance in the housing scheme building practice.

Workplace safety, completion time and projects costs have higher influence on performance of housing scheme building projects compared to natural environment and waste management. Further, observations from the findings indicate that all variables of lean construction examined in this study have a level of influence on performance of housing scheme building projects in Nairobi.

5.5 Recommendations

On the successful completion of the study influence of lean construction on performance of housing scheme building projects, the researcher recommends:-

1. Adopt proper checks to counter pollution by waste generated from construction activities.
2. More emphasis is given to sustainable construction activity with a view to conserving the environment by all stakeholders involved.
3. Workplace safety is adhered to whereby all involved in the project have adequate skills, training on safety and handling emergencies.
4. Use of the Last Planner System by the project team to counter time variances hence, ensuring projects are completed on time.
5. Adopting Lean Construction practices to reign in waste production and in the process reduce cost.

5.6 Suggestions for Further Research Work

The following areas have been identified for further studies to be undertaken in future:-

1. Create awareness of Lean Construction and its adoption in the construction industry.
2. Depletion of environmental resources and long-term sustainability of the construction industry.
3. Advantages of proper workplace safety practices in the construction industry.
4. Investigation of the scheduling of tasks on construction projects.

5. Factoring of the project cost at the design phase by involvement of the whole project team.

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APPENDICES

Appendix 1: Introduction letter

UNIVERSITY OF NAIROBI
COLLEGE OF EDUCATION AND EXTERNAL STUDIES
SCHOOL OF CONTINUING AND DISTANCE EDUCATION
DEPARTMENT OF EXTRA-MURAL STUDIES
NAIROBI EXTRA-MURAL CENTRE

Your Ref:

Our Ref:

Telephone: 318262 Ext. 120

Main Campus
Gandhi Wing, Ground Floor
P.O. Box 30197
N A I R O B I

8th May 2012

UON/CEES//NEMC/11/082

TO WHOM IT MAY CONCERN

RE: ANDREW ANGAYA AYUYA- REG.NO. L50/64684/2010

This is to confirm that the above named is a student at the University of Nairobi College of Education and External Studies, School of Continuing and Distance Education, Department of Extra- Mural Studies pursuing Master of Arts in Project Planning and Management

He is proceeding for research entitled **"influence of lean construction on the performance of housing scheme building projects in Nairobi County, Kenya".**

Any assistance given to him will be appreciated.

CAREN AWILLY
CENTRE ORGANIZER
NAIROBI EXTRA-MURAL CENTRE

Appendix 2: Letter of transmittal

Andrew A. Ayuya
P.O Box 813-00100,
Nairobi, KENYA
Mobile: 0722-482586
andrewayuya@gmail.com

To whom it may concern,

Ref: Data Collection

The researcher, Mr. Andrew A. Ayuya, is undertaking a project study on "Influence of Lean Construction on the Performance of Housing Scheme Building Projects in Nairobi County, Kenya." This research is being undertaken for the partial fulfillment for the requirements of the award of the degree of Masters of Arts in Project Planning and Management, from the University of Nairobi. The objectives of this study is to explore various ways in which waste material can be managed on site leading to conservation of the natural environment, improved workplace safety, speedy completion of projects and reduced construction costs.

Your participation in this exercise will be very helpful to the researcher in carrying out the study to its successful conclusion. The study aims to create awareness on the potential of lean construction in the housing building sector and the construction industry as a whole.

Thank you in advance for your kind contribution.

Yours faithfully,

Andrew A. Ayuya

Appendix 3: Questionnaire

"INFLUENCE OF LEAN CONSTRUCTION ON THE PERFORMANCE OF HOUSING SCHEME BUILDING PROJECTS IN NAIROBI COUNTY, KENYA"

PERSONAL DETAILS

(These details are required for communication purposes only and will not be disclosed)

NAME:...

POSITION:..

CONTACT DETAILS

TELEPHONE:...

EMAIL:...

This questionnaire has been provided as a word document that can be filled out in soft copy and returned via e-mail; or printed, filled out, and mailed (*this information can be found at the end of the survey*).The questionnaire survey is divided into two self-contained sections (designated as Parts I, and II). Part I asks general questions to learn more about the respondent and their extent of involvement with housing scheme building projects; and Part II aims to establish the influence of lean construction on the housing scheme building projects.

Kindly ensure that the questionnaire is returned to the researcher on or before 25th May, 2012. If additional time or information is needed to complete the questionnaire, please contact the researcher, Mr. Andrew A. Ayuya at 0722-482586 or andrewayuya@gmail.com.

Please indicate if comments are to be:

☐ Kept confidential; or

☐ Raised anonymously during the research report's discussions

Thank you for your assistance.

PART I: GENERAL EXPERIENCE OF RESPONDENTS IN HOUSING SCHEME BUILDING PROJECTS

1. Name of your company:..

2. Level of Education:... 3. Gender:...........

3. Please indicate your age bracket.

[ ] 20-30 years [ ] 31-40 years [ ] 41-50years [ ] over 50 years

1. Please select your primary role below: (You may cross more than one box)

Construction Building Sector		
☐ Developer	☐ Project Manager	☐ Architect
☐ Quantity Surveyor	☐ Structural Engineer	☐ Civil Engineer
☐ Mechanical Engineer	☐ Electrical Engineer	☐ Contractor
☐ Construction Manager	☐ Clerk of Works	☐ Site Agent
☐ EIA Expert	☐ Foreman	☐ Other (Please specify)

2. What do you understand by the term lean construction?

3. Does your organization have any in-house lean construction guidance/practice notes?

☐ Yes

☐ No

☐ Refer to others (Please specify)

4. What indicators do you use to gauge the performance of a housing scheme building project?

5. Kindly list the factors for and against adopting lean construction in housing scheme projects.

Factors for adopting lean construction in housing building projects:

Factors against adopting lean construction in housing building projects:

6. How many years of housing building projects experience do you have?

- [ ] None (**Please move on to Part II**)
- [ ] 1 - 5 years
- [ ] 6 – 10 years
- [ ] 11 – 15 years
- [ ] 16 – 20 years
- [ ] 21 years or above

7. How many housing scheme building projects have you been involved in?

- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] Above 4

PART II: INFLUENCE OF LEAN CONSTRUCTION ON THE PERFORMANCE OF HOUSING SCHEME BUILDING PROJECTS

Please rate each item by placing a cross (X) in the relevant box based on a Likert scale from 1 – 5, where 1 represents the "Unimportant"; 2 represents "Of Little Importance"; 3 represents "Moderately Important"; 4 represents "Important"; 5 represents the "Very Important"; and select "N/A" if you are uncertain in rating a particular statement.

1. To what extent does waste material management influence the performance of housing scheme building projects?

	1	2	3	4	5	N/A
a) Debri disposal	☐	☐	☐	☐	☐	☐
b) Defective works	☐	☐	☐	☐	☐	☐
c) Rework/Repair works	☐	☐	☐	☐	☐	☐
d) Demolition	☐	☐	☐	☐	☐	☐
e) Reuse	☐	☐	☐	☐	☐	☐
f) Material variances	☐	☐	☐	☐	☐	☐
g) Poor constructibiltiy	☐	☐	☐	☐	☐	☐

2. **To what extent does the natural environment influence performance of housing scheme building projects?**

	1	2	3	4	5	N/A
a) Water pollution	☐	☐	☐	☐	☐	☐
b) Air pollution	☐	☐	☐	☐	☐	☐
c) Noise pollution	☐	☐	☐	☐	☐	☐
d) Logging	☐	☐	☐	☐	☐	☐
e) Sand harvesting	☐	☐	☐	☐	☐	☐
f) Cement production	☐	☐	☐	☐	☐	☐
g) Recycling	☐	☐	☐	☐	☐	☐

h) Any additional comments

3. **To what extent does workplace safety influence performance of housing scheme building projects?**

	1	2	3	4	5	N/A
a) Accidents	☐	☐	☐	☐	☐	☐
b) Injuries	☐	☐	☐	☐	☐	☐
c) Fatalities	☐	☐	☐	☐	☐	☐
d) Site organization	☐	☐	☐	☐	☐	☐
e) Protective clothing	☐	☐	☐	☐	☐	☐
f) Proper tools & equipment	☐	☐	☐	☐	☐	☐
g) Adequate signage	☐	☐	☐	☐	☐	☐

h) Any additional comments

4. **To what extent does completion time *influence performance of housing scheme building projects?***

	1	2	3	4	5	N/A
a) Actual duration	☐	☐	☐	☐	☐	☐
b) Resource constraints	☐	☐	☐	☐	☐	☐
c) Site conditions	☐	☐	☐	☐	☐	☐
d) Scope change	☐	☐	☐	☐	☐	☐
e) Weather	☐	☐	☐	☐	☐	☐
f) Idle/Waiting time	☐	☐	☐	☐	☐	☐

g) Any additional comments

5. To what extent project cost influences performance of housing scheme building projects

	1	2	3	4	5	N/A
a) Finishes quality	☐	☐	☐	☐	☐	☐
b) Workmanship	☐	☐	☐	☐	☐	☐
c) Price of materials	☐	☐	☐	☐	☐	☐
d) Transportation of materials	☐	☐	☐	☐	☐	☐
e) Compensation costs	☐	☐	☐	☐	☐	☐
f) Disputes	☐	☐	☐	☐	☐	☐
g) Project team involvement	☐	☐	☐	☐	☐	☐

h) Any additional comments

End of the questionnaire