

IMPROVING PROJECT DELIVERY PROCESS USING
LEAN CONSTRUCTION APPROACH

SAMAILA ADAMU

UNIVERSITI TEKNOLOGI MALAYSIA

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SAMAILA ADAMU

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DEDICATION

This research work is dedicated to late father Alhaji Adamu Dan Malam and my late wife Fatima Mohammed, may Allah SWT grant them *Jannatul Firdaus*

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ABSTRACT

The poor image of the Nigerian construction industry arising from suboptimal performance in project delivery due to colossal wastes is well documented in existing literature. However, effort to proffer solutions to the problems of waste on site has been marginal. After an in-depth literature review it was established that, lean construction approach has been adopted to address waste and non-value adding activities and improved productivity in project delivery. Therefore, this study is aimed at proposing a lean implementation framework (LIF) that will guide the site implementation of lean construction tools to address the waste occurrence menace. Accordingly, action research using mixed-mode approach was adopted, data related to waste occurrences and benefits of lean construction was collected. This was conducted in two phases. The first phase sought to explore the frequency and level of waste and non-value adding activities occurrences in project delivery in Nigerian construction sites. To achieve this aim, data was collected using survey questionnaire administered to 400 experts in construction industry, and tested for internal reliability using Cronbach Alpha. Consequently, the data was analysed using descriptive and inferential statistics and validated using one sample t-test. The results showed the existence of wastes that leads to cost and time overrun. The second phase assessed six lean construction tools via six case study sites. Data was collected through observation, interview, questionnaire and site diary, and analysed thematically using content analysis. The results were validated using methodological triangulation. The results showed that the application of lean construction techniques in Nigerian construction sites could address the problems of waste and non-value adding activities and improve productivity. The study identifies several challenges and barriers that could impede the implementation of lean construction, including lack of knowledge on lean approach, cultural issues, misconception by participants, and lack of involvement of designers in the implementation process. In view of these findings, the study recognises training, enlightenment on benefits of lean, involvement of designers in the implementation process, simplifying the process, trust between the project participants and collaborative planning as strategies for addressing the problems. To facilitate implementation of the suggested solutions to waste occurrences, a lean implementation framework (LIF) was developed to guide the site implementation of lean construction for improving the project delivery process. The LIF was validated using expert opinions by face to face interview, and the result revealed that the framework could be a guide for implementation of lean in construction site.

ABSTRAK

Imej buruk industri pembinaan Nigeria disebabkan oleh prestasi yang kurang memuaskan dalam pelaksanaan projek. Ianya kerana terdapat pembaziran secara berleluasa terhadap bahan binaan di tapak binaan. Namun begitu, usaha untuk menyelesaikan masalah pembaziran sisa di tapak binaan adalah terhad. Setelah kajian literatur yang mendalam dilaksanakan, adalah terbukti bahawa Sistem Pembinaan *Lean* boleh diterima pakai untuk menyelesaikan masalah pembaziran tersebut, menambah nilai aktiviti di tapak serta peningkatan produktiviti dalam pelaksanaan projek. Oleh itu, kajian ini bertujuan untuk mencadangkan rangka pelaksanaan pembinaan *lean* yang boleh digunakan sebagai garis panduan pembinaan di tapak untuk mengatasi gejala pembaziran. Sehubungan dengan itu, pendekatan *mixed mode* digunakan untuk mengenalpasti tahap pembaziran serta kebaikan Sistem Pembinaan *Lean*. Kajian ini dijalankan dalam dua fasa. Fasa pertama adalah untuk memperolehi tahap pembuangan sisa dan aktiviti tidak tambah nilai di tapak. Matlamat ini dicapai menggunakan borang soal selidik yang diedarkan kepada 400 pakar dalam industri pembinaan, data tersebut diuji untuk kebolehpercayaan menggunakan ujian Cronbach Alpha. Data juga dianalisis menggunakan Statistik Diskriptif dan Inferensial. Data disahkan melalui ujian-t. Hasil kajian menunjukkan kewujudan sisa buangan membawa kos dan masa tambahan kepada projek. Fasa kedua pula adalah untuk menilai enam alat pembinaan *lean* yang diuji di enam alat pembinaan sebagai kajian kes. Data dikumpul melalui pemerhatian, temubual, soal selidik dan kajian dairi di tapak. Content analisis digunakan untuk menganalisa data. Hasil kajian disahkan menggunakan metodologi *triangulasi*. Keputusan kajian menunjukkan penggunaan teknik pembinaan *lean* di tapak-tapak binaan di Nigeria boleh menangani masalah sisa pembuangan dan aktiviti tidak tambah nilai serta boleh meningkatkan produktiviti. Kajian ini mengenalpasti beberapa cabaran yang boleh menghalang penggunaan sistem pembinaan *lean* seperti kurang pengetahuan tentang sistem tersebut, isu-isu budaya, kurang penglibatan pihak perunding dalam proses pembinaan projek. Justeru itu, kajian ini mencadangkan latihan, kesedaran tentang sistem pembinaan *lean*, penglibatan perunding berkenaan dalam proses pembinaan *lean*, memudahkan proses pembinaan, kepercayaan antara pasukan projek serta bersama-sama menubuhkan strategi untuk mengatasi masalah. Untuk memudahkan pelaksanaan penyelesaian yang dicadangkan, satu rangka pelaksanaan *lean* dikemukakan sebagai panduan di tapak binaan untuk mempertingkatkan proses pelaksanaan projek. Rangka pelaksanaan pembinaan *lean* ini disahkan menggunakan pendapat para pakar, keputusan yang diperolehi mendedahkan rangka kerja pelaksanaan *lean* di tapak binaan.

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LIST OF ABBREVIATIONS

GDP	-	Gross Domestic Product
NIOB	-	Nigerian Institute of Building
USA	-	United States of America
UK	-	United Kingdom
NBS	-	National Bureau of Statistics
SPSS	-	Statistical Package for Social Science
NIP	-	National Implementation Plan
3Cs	-	Commitment, Consistency and Continuity
3Ps	-	Policies, Projects and Programs
CIDB	-	Construction Industry Development Board
AGM	-	Annual General Meeting
CI	-	Construction Industry
BLDG	-	Building
CAGR	-	Compound Aggregate Growth Rate
PPP	-	Public Private Partnership
DBFT	-	Design, Build, Financed and Transfer
BOO	-	Build, Operate and Own
BOT	-	Build, Operate and Transfer
DBFO	-	Design Build, Finance and Operate
BOOST	-	Build, Own, Operate, Subsidize and Transfer
BOOT	-	Build Operate, Own and Transfer
BLT	-	Build Lease and Transfer
ROT	-	Renovate Operate and Transfer
IFOA	-	Integrated Form of Agreement
BOQ	-	Bill of Quantities
LCI	-	Lean Construction Institute
CII	-	Construction Industry Institute

JIT	-	Just-In-Time
TQM	-	Total Quality Management
TPS	-	Toyota Production System
TFV	-	Transformation, Flow, Value
LPDS	-	Lean Project Delivery System
MS	-	Master Schedule
PS	-	Phase Schedule
RPS	-	Reverse Phase Schedule
LP	-	Lookahead Planning
SWLA	-	Six Week Lookahead
FWLA	-	Four Week Lookahead
WWP	-	Weekly Work Plan
PPC	-	Percentage Plan Completed
FISCA	-	Factors Influencing Scottish Construction Accidents
PDCA	-	Plan, Do, Check & Act
5S	-	Seiri, Seiton, Seiso, Seiketsu Shitsuke
LIP	-	Lean Implementation Programme
CE	-	Construction Excellence
BRE	-	British Research Establishment
CPM	-	Critical Path Method
IGLC	-	International Group for Lean Construction
LPS	-	Last Planner System
WBS	-	Work Breakdown Structures
TQC	-	Total Quality Control
LEA	-	Lean Enterprise Architecture
QFD	-	Quality Function Deployment
KIVP	-	Knowledge Innovation Visible Planning
EME	-	Extended Manufacturing Enterprise
FA	-	Factor Analysis
NGO	-	Non-Governmental Organisation
N	-	Number
WOLI	-	Waste Occurrences Level Indicator
WSM	-	Material Waste
WST	-	Time Waste

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CHAPTER 1

INTRODUCTION

1.0 Introduction

The motivation behind the study was based on the call by the federal government of Nigeria for the transformation of the key sectors of the economy through its transformational agenda 2011 to 2015 programs. The Nigerian construction industry is one of the key sectors of the Nigerian economy; it contributes about 3.74% of gross domestic product (GDP) in 2011 (Statistics, 2012). A challenge was thrown to professionals in the construction industry by Hon. Minister of Housing to come up with a holistic solution of addressing the current problems in the construction industry for sustainable development (42nd National Conference/AGM NIOB, 2012). This study will look at the possibility of applying lean construction tools in construction sites in Nigeria, and assess its suitability in managing and controlling activities in the project delivery process for the minimization or possibly elimination of waste and non-value adding activities, for improving the construction process and the creation of value to the owner, by improving productivity.

1.1 Background of the Research

The Nigerian construction industry is characterised with high cost of production, time overrun, uncompleted projects, poor quality of work, accidents and

so on (Abdulhameed *et al.*, 2012; Oyewobi *et al.*, 2011). The industry is also facing continues decrease in profit margin which lead to claims for variations (Adamu and Howell, 2012; Adamu *et al.*, 2012). All these ensuing from poor project planning (Olusegun and Machael, 2011; Oke and Ogunsemi, 2011; Adamu and Abdulhamid, 2012), uncompleted design during the project delivery (Aina and Wahab, 2011; Windapo and Matins 2010), waste generation due to bureaucracy, delay from material suppliers, variations and poor site management (Dlakwa and Culpin, 1990; Oke and Ogunsemi, 2011; Adeagbo, 2014), and unethical behaviours in some government works in form of fraudulence practice and kickback (Mansfield *et al.*, 1994; Olomolaye *et al.*, 1987). All these problems are peculiar to the Nigerian construction industry which attribute to its low productivity, high cost and time overrun, poor quality of the products produced.

The Nigerian construction industry as a major sector of the economy requires attention for the transformation agenda to be successful. Nigeria, just like any other developing country in line with her Vision 20:2020 and indeed its Transformation Agenda 2015, recognized the need to use infrastructural development as a means of firing the Nigerian economy and uplifting the wellbeing of its citizenry. The need for the use of best practice in the provision of these infrastructures is necessary. In this respect, it was recognised by extant that lean construction has made a colossal impact within the construction industry of developed nations. Such as USA, UK, Denmark, Chile, Finland, Brazil are so on. Also, some developing countries have recorded improvements in their project delivery process after the application of lean construction approach (Ballard and Howell, 2003). Application of lean construction tools was investigated by (Salem *et al.*, 2005; Gonzalez *et al.*, 2010; Ballard *et al.*, 2009; Loong *et al.*, 2010; Al Sehaimi *et al.*, 2009; Yu *et al.*, 2009; Adamu and Howell, 2012; Adamu *et al.*, 2012), the result has shown a substantial improvement in the project performance of the projects in the countries applied.

1.1.1 Lean Construction

Lean Construction was developed based on production management method of project delivery, is a new technique of project delivery that can be adopted to any type of construction, mainly suitable for quick, uncertain and complex project (Howell, 1999). Lean Construction is just as the current practice has objective of better meeting customers need while using of minimum or smaller amount of everything, but different from the current practice because production management philosophy is the basis of lean construction. It is a “physics” of construction. “Physics” is the word borrowed from production philosophy, which means “factory of physics” an exceptional wording on production management (Hopp and Spearman, 1996). Lean management in production has made a great revolution to the manufacturing industry, from design stage, supply chain and assembling. When adapted from manufacturing to construction, it changes the method of the work right through the project delivery process. The lean management approach differs from traditional management approach, as lean pull concept of scheduling opposes to traditional push concept. Lean construction emerges from the objectives of lean production systems, i.e. minimization of waste and maximization of end value to users using specific approaches by applying them in the new concept of project delivery (Howell, 1999). Because of these changes:

- The delivery process of a facility and the definition of the facility were designed collectively to better meet the user’s expectation and support client purposes. Negative iterations are reduced in the process while positive iterations are allowed and supported.
- Work is planned all through the process to reduce waste and increase value at the project delivery level.
- Effort for improvement of performance and its’ management are targeted towards improving general project performance. As it is better than to increase the speed of an activity or reduction of cost.
- “Control” is redefined from “results monitored” to “make effects to occur”. The planning and control of the systems performance were measured and improved.

1.2 The Problem Statement

The current yield of the Nigerian construction industry suffers continuous decrease, as its contribution to GDP continues to fluctuate up and down every year as per report of the National Bureau of Statistics (2012). The average GDP contribution of Building and Construction sector for ten years after the independence records shows that, from 1971-1980 was 8.3%, 1981-1990 was 2.3%, 1991-2000 was 1.8%, 2001-2010 was 1.8% and for 2011 was 1.79%. While in the last quarter of 2012 it records 1.14%. As per records of NBS (2015), the average GDP contribution of the construction sector for 2012 maintained 1.79% and dropped to 1.62% in 2013. In 2014, the contribution made in 2013 dropped down by 0.46%. Currently, the record from NBS shows that the construction sector recorded GDP contribution of 11.24% in 2015 and dropped to 7.47% in 2016 (NBS, 2016) with all the efforts of investment in the sector by public and private sectors. The industry is also characterized with continued decrease of profit margin, increase in defects and rework, cost and time overrun, abandoned and uncompleted project due to poor project definition, control and management of the project delivery process, unnecessary waste generation and non-value adding activity (Olusegun and Machael, 2011; Oke and Ogunsemi, 2011). Even so, it was demonstrated that lack of proper application of innovative approaches is among the many contributing factors associated with the recorded failure in the GDP contribution and a poor image of the industry (Adamu and Howell, 2012; Adamu *et al.*, 2012; Adeagbo, 2014). Accordingly, waste generation and non-value adding activities were also found to be attributing factors in the poor project delivery (Oke and Ogunsemi, 1991; Dlakwa and Culpin, 1990; Adeagbo, 2014; Ahiakwo *et al.*, 2012; Ahiakwo *et al.*, 2014). All this research identified these problems without offering solutions to solve them. The success of any project is largely dependent upon proper tools of planning, control, management, and elimination of waste and non-value activities in the industry, (Sacks and Goldin, 2007; Memon *et al.*, 2013) as enunciated by the extant.

However, recently the lean construction community outlined that research should be centred on developing practical solutions to explicitly solve problems not only to identify them (Alschaimi and Koskela, 2008). Accordingly, to solve the prevailing problems within the Nigerian construction industry, a novel research

approach that can go beyond the normal traditional research of descriptive or explanatory research should be adopted to address the persistent practical construction management problems, and contribute to construction management knowledge. An action research, constructive research and design science research are suggested to be the best suitable research model for this situation (Aken, 2005; Jarvinen, 2007; Azhar, *et al.*, 2010; Koskela, 2008; Alsehaimi *et al.*, 2009; Voordijk, 2009; Jang *et al.*, 2010).

Challenging the traditional construction approach, lean construction approach is a production-based management philosophy that stresses the removal of waste and non-value adding activities in the project delivery process. Starting from the project design stage to delivery processes of a construction project using lean ideologies advocated by Ohno (Fewings, 2013). It is a continuous process for the elimination of material and time wastages, with determination of meeting or exceeding client's requirements, at the same time focusing on the value stream and pursuing continuous perfection in the project delivery process (Koskela *et al.* 2002; Salem and Zimmer 2004).

It was enunciated by extant that adopting lean construction approach in project delivery on sites could address the problem of waste and non-value adding activities occurrences (Houvila and Koskela, 1998; Howell and Ballard, 1999; Saurin *et al.*, 2002; Thomas *et al.*, 2005; Salem *et al.* 2007; Schafer *et al.*, 2008; Mossman 2009). The lean construction concept has been adopted by some developed nations in their construction industry at the project sites, and remarkable benefits were achieved at the projects levels (Nahmens and Ikuma, 2009; Koranda *et al.*, 2012). Lean construction tools have been used in many countries to improve co-ordination, planning, control, productivity, communication, collaboration, teamwork, learning and project performance success in projects (Alarcon, 1997; Tommelein and Ballard, 1997; Fiallo and Revelo, 2002; Ballard *et al.*, 2009; Gonzalez *et al.*, 2010; Mossman, 2012). Nevertheless, there is no any empirical evidence that relays the implementation of lean construction concepts in the Nigerian construction sites.

After assessing the peculiar problems of waste and non-value adding activities occurrences in Nigerian construction sites, and the benefits of addressing these menaces associated with lean construction approach, this research gap was identified.

1.3 Research Gap

After enlightening the economic role, the construction industry played in Nigerian, and its ugly status in terms of waste generation and non-value adding activities occurrences in the project delivery process. Consequently, with recognition of the effect of waste and non-value adding activities, which leads to cost and time overrun, and decrease in productivity and profit margin, there is no comprehensive data on frequency and level of waste and non-value adding activities occurrence in the project delivery process. Similarly, there is scarce information on how to address these menaces in the construction site. Subsequently, there is little attempt to use lean construction to improve the project delivery process in terms of waste and non-value adding activities occurrences in the construction site. Based on this gap, this research come with this aims. To develop a framework for the implementation of the lean construction in Nigerian construction site to improve the project delivery process. To achieve the research, aim the following research questions were raised.

1.4 Research Question

- 1 *What is the frequency and level waste generation and non-value adding activity occurrence in the current project delivery of Nigerian construction sites?* This question is aimed at exploring the literature to generate a survey questionnaire using expert opinion to establish the frequency and level of waste and non-value adding activities occurrence in the current project delivery process in the Nigerian construction industry.
- 2 *Can the adoption of lean construction approach in Nigerian construction sites eliminate waste and non-value adding activities in the project delivery process?* This question is aimed at broadening our knowledge to understand the benefits of applying lean construction approach in Nigeria construction sites, through assessing the implementation of lean tools in the case study sites.
- 3 *How can lean construction approach be implemented in Nigerian construction sites to improve the project delivery process?* This question aims

to propose a detail framework for the implementation of lean construction in the construction sites to address the problems of colossal waste and non-value adding activities occurrences in project delivery process of Nigeria.

To answer the research questions and pursuance to achieving the main aim of the research, the following objectives were developed.

1.5 Objective of the Research

1. To determines the frequency and level of waste and non-value adding activities occurrences in the current projects delivery process in Nigerian construction sites.
2. To assess the implementation of lean construction techniques in Nigeria construction sites, and established its contribution towards the elimination of waste and non-value adding activities.
3. To develop and propose a framework for the implementation of lean construction in Nigerian construction site.

1.6 Significance of the Research

The poor image of Nigerian construction industry in terms of waste and non-value adding activities occurrence is well documented in literature. Similarly, the application of lean construction to address the problem of waste and non-value adding activities has been established by many researches. Therefore, this research will contribute to the body of knowledge by revealing.

- ❖ The frequency and level of waste generation and non-value adding activities occurrences in Nigerian project delivery processes.

- ❖ A clear picture for the benefits of lean construction implementation in the Nigerian construction site to address the problems of waste and non-value adding activities.
- ❖ Remarkably, the study has come up with lean construction implementation framework to guide the government and organizations to implement lean construction on sites to eliminate waste and non-value adding activities. This will be presented as a gizmo of project delivery process improvement.

To guide the research and pursuant to these objectives, the study was design to be conducted within certain parameters.

1.7 Focus and Scope of the Research

The Nigerian construction industry is very broad; therefore, the scope of this research is to establish the frequency and level of waste and non-value adding activities in the project delivery process, and assess the implementation of six lean construction tools within six construction sites in Nigeria. This study cannot pretend to address all problems in Nigerian construction industry; therefore, it is necessary to specify the boundary of knowledge behind the study. The research will focus on project delivery process at construction sites only. This will involve the planning, control and management of the construction process, because of its impact to cost, quality, safety and time. Looking at the percentage of the projects being carried out by government, medium and small contractors, lean construction approach will be applied in medium and small projects executed by government and the private sector. The projects may be handled by contracts and direct labour. The research will be conducted using building construction in academics' environment and residential in three different cities and locations. However, issue discussed will be equally relevant to other complex project in term of the lean construction implementation process.

1.8 Research Methodology

This study adopted an action research model, using mixed mode for data collection. Action Research Model is a method use to facilitate change by participating or being involve in the system's operation in a diagnostic, active learning, problem finding and problem solving process (Jarvinen, 2007). Action research is either research initiated to solve an immediate problem or a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems (John and Sons, 2010). There ten features why using action research, these will be discussed in detail in Methodology chapter.

The study relies on a literature review to develop the survey questionnaire for the realisation of the first objective. The survey was undertaken within the professional in the construction industry, which includes architect's engineers, project managers, builders, quantity surveyors and others. The quantitative data collected will be analysed using descriptive and inferential statistics using the Statistical Package For Social Science (SPSS) software to explore the frequency and level of material and time waste occurrences in current project delivery process. Cronbach Alpha will be used to test the internal reliability of the questionnaire.

The second research question will be addressed using established data from case studies sites and empirical data from the survey and semi structured interview. The research will adopt mixed mode model using pragmatic approach, based on the principles of phenomenology combining both quantitative and qualitative data. Phenomenological approach commonly used in construction environment for inquiry offers an opportunity for a brood description of a phenomenon of everyday experience to achieve an understanding of its essential structure (Malagon-Maldonado, 2014). The action research via case studies experiments conducted will answer the second research question. Literature of previous research on implementation of lean construction will be reviewed to understand how the tools will be implemented in the site. Site diary, minutes of meeting, interview, pictures, questionnaire survey and documentations are the instruments of data collection. Data collected will be analysed

thematically using classical content analysis for the interview, descriptive and inferential statistic for the questionnaire. The lean projects are compared with non-lean implemented projects to identify the benefit of the lean construction implementation. The data collected and analysed will be synthesised to develop a lean implementation framework. The framework will show how lean construction approach will improve the project delivery process in construction site in terms of waste and non-value adding activities. Detail methodology will be described in chapter 4 including the sampling method adopted.

1.9 Limitations of the Research

This research was conducted in Nigerian construction sites, using the site and the practitioners in the construction industry as unit of analysis. Lean construction is not yet implemented in construction site in Nigeria, therefore, there are limited practitioners with knowledge on lean construction implementations. The data collection procedure was limited to the case study sites only, and people involved in training conducted and the lean projects execution.

Due to this limitation, the research was conducted in the projects that were managed using lean construction approach only, and validations were made with expert that have experience in lean construction practice.

1.10 Structure of Thesis

The thesis will be consisting of seven chapters organised in logical and systematic manner to accomplish the research aim and objectives, through addressing the research questions. The detail flow chart is presented in Figure 1.1.

The first chapter gives an introduction of the research, by highlighting the background of the research, and how the studies was conducted from literature review to development of the research problem and research gap. Furthermore, the research goal was defined by stating the aim of the study. Subsequently, the research questions and objectives were stated and clearly outlined. The significance of the research was outlined, and the scope and focus of the study was identified And the methodology adopted for the research was outlined, followed by the research limitations. And finally, the structure of the thesis was presented in Figure 1.1.

The second chapter reviews literature on Nigerians transformational agenda and the theory on the Nigerian construction industry in term of investment and output and the problems of traditional project delivery. Comprehensive literature review on waste and non-value adding activity that exist and efforts in addressing the problems were discussed in this chapter.

The third chapter entails an in-depth review of literature and on theoretical background of lean construction, and outline the benefits achieved by the adoption of lean construction approach by developed nations and emerging economy. Different lean frameworks developed from previous studies were reviewed and conceptual framework was developed in this chapter.

The fourth chapter will outline the research methodology used for the study. It presents in detail the philosophical paradigm, theories, strategies and methods adopted during the research. It gives details of how the research was conducted in responds to the research problem and question. That is describing different research models and research designs and reason for selecting action research using mixed mode model. It will demonstrate how quantitative and qualitative data are collected and analysed to address the objective of the research.

The fifth chapter presents data analysis, discussions and findings for quantitative data. Subsequently, synthesised the results and generates an analytical outcome to present the frequency and level of waste and non-value adding activities existing in current project delivery process of Nigerian construction industry.

The sixth chapter presents the lean construction implementation reports, how data was collected and analysed. Then, presents the findings for both quantitative and qualitative data. Subsequently, synthesised the results and generates an analytical outcome to present the framework. The framework and its relevance are also presented. The validation of the framework process and its result are also presented in this chapter.

The seventh chapter will summarise the finding and draw conclusion of the research, and make recommendations for practice as well as area for further research.

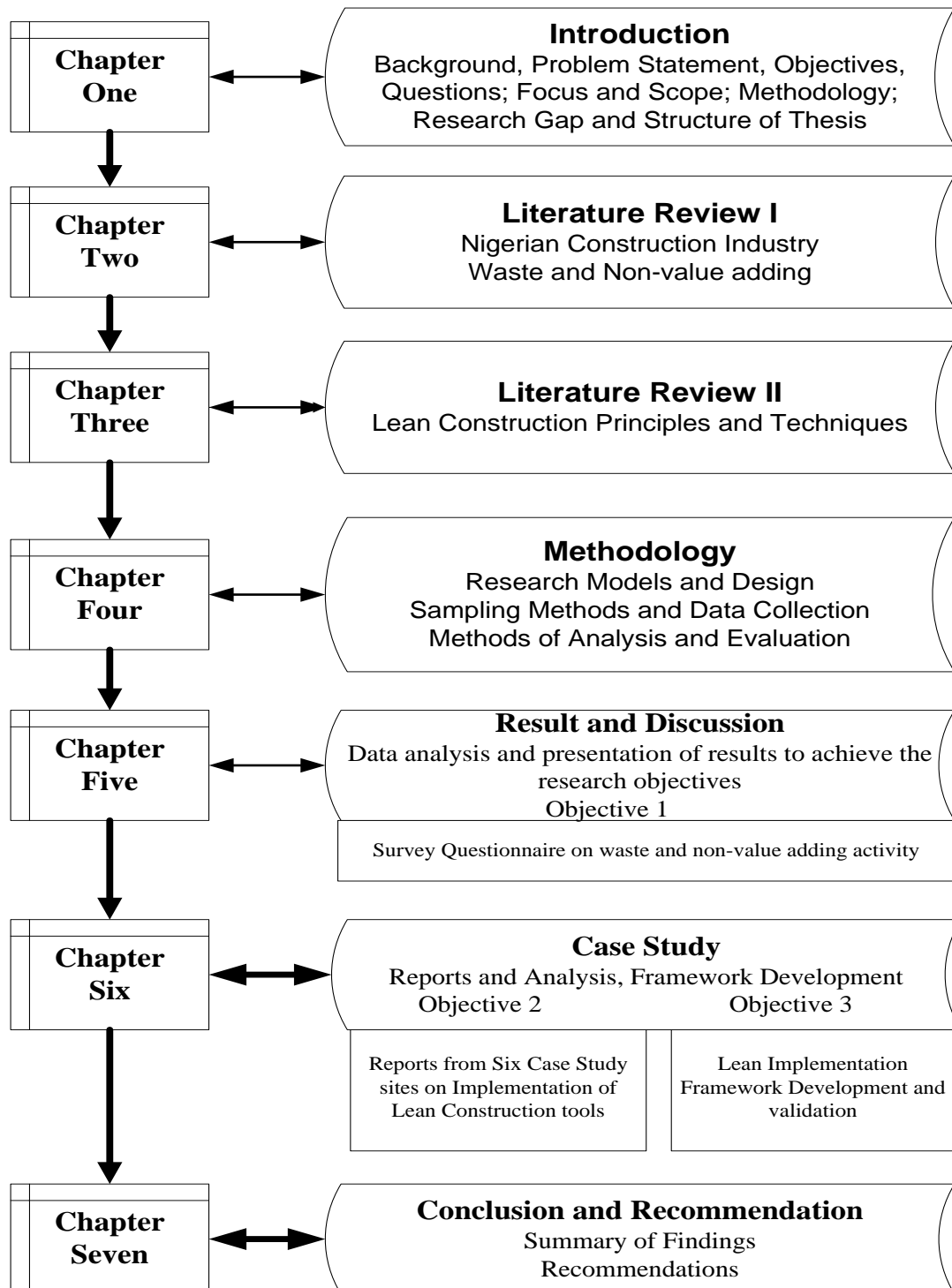


Figure 1.1 : Research structure

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