AN INVESTIGATION INTO THE EFFECTIVENESS OF CONSTRUCTION SITE MANAGEMENT IN NAIROBI COUNTY

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MASTER OF SCIENCE

(Construction Project Management)

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

2019

An Investigation into the Effectiveness of Construction Site Management in Nairobi County

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A thesis submitted in Partial fulfillment for the Degree of Master of Construction Project Management in the Jomo Kenyatta University of Agriculture and Technology

2019

DECLARATION

This thesis is my original work and has not been submitted for a degree in any other university.

Signature: …………………………………… Date: 18/03/2019………………………

Bonface Maturi Nyabioge

This research thesis has been submitted for examination with our approval as university supervisors;

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JKUAT, Kenya

DEDICATION

With Special appreciation to my Mum, Stellah and my grandparents, Mr. and Mrs. Ogoro whose tireless effort, love, sacrifice and hard work brought me this far and are willing to take me beyond.

To my relatives and friends for instilling in me the discipline that I require to succeed, the humility that opened up my mind and the courage to exceed my limits.

Above all, the Almighty God, whose providence is infinite.

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for his mercies and the provision of strength and resources to carry out this study. This research thesis would never have been completed were it not for the noble guidance of my supervisors, Prof. Stephen Diang'a and Dr. Abednego Gwaya. Their unending inspiration, critical approach and tireless encouragement over the whole process of doing this thesis cannot go unappreciated.

I would also like to acknowledge the Jomo Kenyatta University of Agriculture and Technology for the great opportunity offered to me, the awesome learning experience and the resources to facilitate carrying out this research. The Department of Construction Management whose lecturers and individuals were a great contribution towards this thesis is also appreciated.

Special thanks go to Ms. Nakoli Maloba of the National Construction Authority for making available the list of ongoing commercial/ mixed urban development projects in Westlands constituency which was used as the target population in my study. I am greatly indebted to Mr. Ellis Maturi for his invaluable input during data analysis. On the same note, I express profound gratitude to the industry participants for providing me with the necessary data, their busy schedule notwithstanding.

Last but not least, I would like to extend my humble appreciation to my family and friends who helped me directly and indirectly during the whole process of this research, their views and tips were useful indeed. To all those who prayed for me and wished me well in this academic journey, I thank them and wish them all God's blessing.

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LIST OF ABBREVIATIONS

BIM	Building information modeling
BPS	Board of Postgraduate Studies
CPM	Critical Path Method
DR	Dead reckoning
GPS	Global positioning system
JKUAT	Jomo Kenyatta University of Agriculture and Technology
NACOSTI	National Commission for Science, Technology and Innovation
PERT	Program Evaluation and Review Technique
PCMS	Pro-active construction management system
PMBOK	Project management body of knowledge
RFID	Radio Frequency Identification Device
RTLS	Real-time location system
UAVs	Unmanned aerial vehicles
VCS	Virtual construction simulation system
WSN	Wireless Sensor Network System
WTS	Work Tracking System

ABSTRACT

Construction site management has become more complex than ever since a number of resource flows have to converge simultaneously at the workplace (operatives, information, finance, plant, tools as well as materials) in order to ensure successful completion of construction projects. This research sought to assess the impact of the critical site factors on effective site management in Nairobi County. The selected site aspects that were investigated in relation to effective site management included; material management, labour management, health and safety management, cost management and information management. The study utilized a survey research design and the target population was made up of 45 on-going commercial/ mixed urban development projects worth more than Kshs100 million (Appendix 6) in Westlands constituency. Purposive sampling technique was employed in selecting the 45 projects. The survey achieved 80% response rate from the construction project managers. Data analysis involved cleaning, sorting and coding of raw data collected from the field and processing for purposes of interpretation by use of R software version 3.4.3. The data analysis procedures adopted used both descriptive and inferential (Spearman rank correlation and logistic regression) statistical methods and the results were presented in form of statistical equation models, tables, charts and graphs in a simple and comprehensive manner. The findings indicated that, the selected site factors under equation analysis contributed significantly to the prediction of effective site management. The odds for effective site management are 48.82, 5.89, 23.01, 23.39 & 149.80 times higher when there is proper material, labour, cost, information and health & safety management respectively as compared to poor management of the critical site factors holding all other factors constant. Additionally, the respondents indicated the need for a well-defined site management framework. The study took some steps to show that construction projects need more systematic management than they generally receive. Therefore, a site management framework was recommended to aid construction project managers in managing materials(Use Oracle prime, GPS & DR, UAVs, RFID & WSN), labour (Use Oracle prime, RFID, UAVs & Navisworks), health and safety (Use Oracle prime, RFID, UAVs & Navisworks), cost (Use Oracle prime, Oracle Textura & Navisworks) and information (Use Oracle prime, Oracle Textura, Revit & Skype). Since this study addressed the subject of site management in building construction projects, it would be interesting to study the subject of site management in civil construction projects and compare the results. Also, future studies are required to look into the operation and maintenance stage of the project life cycle as this study only concentrated on the construction phase.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Despite the Project Management Institute (2016) developing the PMBOK Guide that provides generalized project guidance in ten distinct areas (Project integration management, scope management, time management, cost management, quality management, human resource management, communications management, risk management, procurement management and finally stakeholder management), it has also developed the construction extension to the PMBOK Guide that provides construction-specific guidance for the project management practitioner for each of the PMBOK Guide knowledge areas, as well as guidance in the four additional areas not found in the PMBOK Guide.

i. All project resources
ii. Project health, safety, security and environmental management
iii. Project financial management
iv. Management of claims in construction

The construction extension also includes discussion of emerging trends and developments in the construction industry that affect the application of project management to construction projects (Project Management Institute , 2016). Therefore, effective management of any construction project depend largely on the construction project manager's concept on the knowledge areas provided by the Project Management Institute.

This study explores construction site management and to fully understand the concept, it begins with the recognition of what project management is. According to the Project Management Institute (2013), project management is the application of knowledge, skills, tools and techniques to project activities in order to meet project requirements. Hence, Olubunmi *et al* (2014) asserts that, site management involves mobilization and coordination of various aspects of a project as well as creation of an enabling environment for construction activities, for instance, ensuring safety. Mossman (2008) stress that a number of resource flows must converge simultaneously at the workplace – operatives, information, finance as well as materials in order to create value.

Several studies have been conducted focusing on the critical construction site aspects/elements. In Sweden, Golyani and Hon (2010) have discussed the effects of information handling on delivery of construction projects. A study by Lill (2008) conducted in Estonia has given insight on sustainable management of construction labour. In Nigeria, Olubunmi *et al* (2014) contends that material management, health and safety management and cost management are among the critical site elements that needs to be effectively managed. Joro (2015) has looked into material waste management, since it is a major problem in the Ethiopian construction industry.

Kenya is not an exception to research pertaining construction site management. Muiruri and Mulinge (2014) have addressed the health and safety factor, Oloo (2015) has discussed variation orders which is an ingredient of cost management, Mbugua (2014) has given insight on material management by laying emphasis on procurement, Lamka (2015) has looked into the factors that influence construction site labor productivity and finally, Gwaya *et al* (2014) pin pointed information management as one of the key areas requiring the project manager's knowledge and attention.

Despite the extensive literature on construction site management, over 50% of construction projects in Kenya have failed to meet their cost projections, time schedules, quality demands or safety targets (Kimondo *et al*, 2015). Hence, this study decided to consider, discuss and investigate material management, labour management, health and safety management, cost management and information management.

Kasim et al (2005) noted that, late arrival of materials on sites affect the program of works and the overall cost of a project and this may lead to lengthy arbitration and litigation issues during claims. A large quantity of construction materials can be lost due to damage and/or theft as a result of improper storage and/or poor handling. Dey (2001) acknowledged that, receiving materials before they are required causes more inventories cost and chances of deterioration in quality are high due to the fact that these materials lie idle on the site. Therefore, Patel and Vyas (2011) suggested that, the right quality and quantity of materials should be appropriately selected, purchased, delivered and handled on site in a timely manner and at a reasonable cost.

As is the case in any business, people are a construction organization's greatest resource (Muir, 2005). Unsafe work place lead to high mobility of construction workers and irregularity of the workload favors the fluctuation of the personnel (Lill, 2008). Construction by nature is inherently dangerous and the toll of accidents is high in terms of both costs and human suffering (Muir, 2005). Spillane *et al* (2012) observes that, poor co-ordination can cause over-crowding on building sites which can result in operatives sustaining trips and falls in the workplace.

Many disputes have been documented as a result of poor cost management and administration (Oloo, 2015). According to Olubunmi *et al* (2014), cost management covers estimating, valuations, interim payment, variations, day-works, cost-value reconciliation, final accounts and cash flow. Gwaya and Wanyona (2013) asserts that, the most serious source of cost and time risks in building projects during the construction period is "extra work" (technically termed as variations).

Human resources in the field need large amounts of information ranging from project design drawings to personal diaries to support their ongoing works and to make decisions about the process of construction (Chen and Kamara, 2007). Ineffective on-site information management can result in personnel overlooking important issues that require quick response and often cause on-site decisions to be deferred (Singhvi & Terk, 2003).

If projects are to be delivered faster, within budget, with fewer defects and minimized accidents, the critical flows (operatives, information, finance and materials) along with space management (for safe operations) need more systematic management than they generally receive (Mossman, 2008). Almohsen and Ruwanpura (2011) suggested that, new technologies such as mobile-based application can be utilized to increase construction project productivity. In order for construction project managers to better discharge their responsibilities, Chau *et al* (2004) proposes four-dimensional (4D) models for visual representations of the project at different instants, including project progress and the status of site space usage. Maki and Kerosuo (2013) views building information modeling (BIM) as a possible catalyst for fostering the development of construction industry and as a solution to some of the challenges in the industry.

1.2 Statement of the Problem

The continuous demand for improved and efficient project delivery have put pressure to construction project managers, thereby creating a lot of management challenges that require an integrated process to be tackled. On a construction site, components such as operatives, information and materials need be properly managed in order to successfully execute a project. In addition, the risk of accidents should be lowered and a clear process of controlling or administering financial transactions established.

Despite the site management aspects being thoroughly investigated in academia, many projects have failed in the country to meet their primary objectives. Kihoro (2015) confirms that, 48% of construction projects in Nairobi County were still incomplete and 10% of those projects were completely stalled. According to Mose and Moronge (2016), 48% of the building projects in Kenya showed poor performance in terms of completion time, cost overruns and client satisfaction.

Given the consequences of the current site management practices in the construction industry, the importance of investigating the critical site factors (Material, labour, health and safety, cost and information management) cannot be over emphasized. Therefore, this study sought to formulate a framework for effective construction site management.

1.3 Purpose of the Study

The purpose of this study was to investigate the critical site factors and their effect on effective construction site management in Nairobi County, with a view of making recommendations that are geared towards improved on-site management.

1.4 Objectives of the Study

The main objective of this study was to assess the influence of the critical site factors on effective construction site management in Nairobi County. The specific objectives of this study include;

i. To describe the level of effectiveness in construction site management and its explanatory variables.
ii. To establish the relationship between effective construction site management and its explanatory variables.
iii. To formulate a framework for effective construction site management.

1.5 Research Hypothesis

The hypothesis tested was;

Null hypothesis:

The critical site factors have no significant relationship with effective construction site management. The null hypothesis can be statistically stated as;

$$\mathbf{H_0: \beta_1 = \beta_2 = \ldots\ldots \beta_n = 0} \qquad \textbf{(1)}$$

Alternative hypothesis:

At least one of the critical site factors has a significant relationship with effective construction site management. This can be statistically stated as;

$$\mathbf{H_a: \text{At least one } \beta_n \neq 0} \qquad \textbf{(2)}$$

The hypothesis was comprehensively communicated by the following logit model:

$$\boldsymbol{ln\left\{\frac{p}{(1-p)}\right\} = \beta_{1X_1} + \beta_{2X_2} \ldots\ldots\ldots \beta_{nX_n} + \beta_0 + \varepsilon_i} \qquad \textbf{(3)}$$

Whereby;

ln = the natural logarithm, $\log_{exp}$, where exp = 2.71828……

p = the probability that the event Y occurs, p(Y=1)

Y = Outcome variable (effective construction site management)

β = Regression coefficient estimates

$\mathbf{x_{1\ldots n}}$ = Critical site factors (material, labour, health & safety, cost & information)

$\boldsymbol{\varepsilon_i}$ = Error term

1.6 Study Justification

The need for improved construction project delivery has called for an integrated process to be laid in place in order to enhance project productivity. Evidence by Kimondo *et al* (2015) and Gwaya (2015) indicated that over 50% of construction projects in Kenya were failing by not meeting their cost projections, time schedules, quality demands or safety targets. These statistics informed that, high sense of management acumen, capabilities, skills and strategies were required during execution of projects. This study therefore, sought to fill the existing gap by formulating a framework for effective construction site management.

The formulated framework will undoubtedly bring control over the flow of basic resources (personnel, finance and materials) and processes, eased information exchange and increased customer and stakeholder satisfaction (as a result of meeting the project objectives).

1.7 Significance of the Study

The findings from the study are valuable in the construction industry since they can be injected into future projects and offer ways to promote and propagate the use of a site management framework. The study also enlightens construction project managers on how to handle site factors in a broader and more practical context.

From an academic perspective, the findings further contributes to the pool of knowledge available in this area of construction site management and it forms a useful archival material for reference to other researchers and institutional libraries which is vital to the present and future scholars in regard to on-site management.

1.8 Scope and Limitations of the Study

1.8.1 Scope

The study was conducted in Westlands constituency, Nairobi County. The constituency was preferred among other constituencies in the County since it had the largest share of on-going commercial/ mixed urban development projects as per the information obtained on 22nd August 2017 from the National Construction Authority. The research specifically looked into how critical site factors influenced effective construction site management within the County. A survey to investigate these factors was delimited to 45 on-going commercial/ mixed urban development projects worth more than Kshs100 million (Appendix 6). Construction project managers were considered appropriate respondents for the questionnaires

The field work was conducted within twelve weeks after which the data collected was analyzed and then a report compiled. The study examined materials management, labour management, health and safety management, cost management as well as management of information as the independent variables and effective construction site management as the dependent variable. The selection criterion for the variables was arrived at after an exhaustive literature review to determine which factors to consider for this research.

1.8.2 Limitations

The scope of the study for data collection was limited to Westlands constituency, Nairobi County. The study would have covered a wider scope but limited financial resources constrained the study. A budget had been drawn to enable the study to be completed within the estimated budget.

The study realized challenges in accessing construction project managers since one required permission from the head office to access the sites. In most contractor offices, the requests to access their sites were turned down. The administrative assistants made sure that one couldn’t get access to ask for permission from the relevant person in charge. To counter this, the construction project managers from the selected list of on-going projects were friend requested in Linkedln (A professional network), contacts established and permission was requested to do a site survey.

1.9 Assumptions of the Study

This study was based on the following assumptions:

i. The findings of the study can be replicated to other Counties in Kenya.
ii. The critical site factors were not attributed to peripheral pressures such as legal issues, government regulations, socio-political pressures and environmental concerns.

1.10 Definition of Terms.

There are various terms used in the document and whose definition in the context of the study may differ from their everyday definition. Such terms are defined bellow;

a) **Management** - The organizational process that includes strategic planning, setting objectives, managing resources, deploying the human and financial assets needed to achieve objectives and measuring results (Hissom, 2009). The scholar further adds that, management also includes recording and storing facts and information for later use or for others within the organization.

b) **Construction site management** - Refers to the process of mobilizing and coordinating the various resources (materials, finance, people and information) required for construction process, ensuring that the resources are productive, that is, they are in the right place at the right time at the minimum cost and finally creating an enabling environment for construction activities, for example, ensuring safety/security (Guffond and Leconte, 2005).

c) **Effective site management**- The degree of project goal achievement within the stipulated project period, budget, quality and safety targets (Phiri, 2015).

1.11 Research Organization

The study was organized into five chapters and the preliminary pages. The latter includes; declaration, dedication, acknowledgements, table of contents, list of tables, figures, appendices and abbreviations and finally the study abstract.

Chapter One – Introduction

This chapter gave a brief overview of the thesis. It presented the background information on the topic, the problem of the research, the purpose, objectives, research hypothesis and the study justification, significance of the study, the scope and limitations, assumptions of the study, operational terms and finally the study outline.

Chapter Two – Literature Review

The chapter aimed at providing the reader with a contextual background to the subsequent chapters. It encompassed what had already been documented concerning construction site management.

Chapter Three – Research Methodology

This area described the research design and strategy, target population, the sampling techniques and the sources of information. It outlined the procedure adopted in data collection, the eventual analysis and presentation tools. Finally, the chapter looked into operationalization/measurement of variables and ethical issues that guided the study in planning, conducting and reporting the results of the research.

Chapter Four – Analysis and Discussion

This chapter focused on presentation and analysis of data gathered at the survey stage of the research. Analysis of raw data captured by the research instruments was guided by the methodology outlined in chapter three and the findings discussed in line with the research objectives.

Chapter Five – Summary, Conclusions and Recommendations

The chapter summarized the major findings of the study, with the purpose of providing a brief overview of the project outcome. Additionally, conclusions were drawn from chapter four while highlighting contribution of the study to knowledge. Finally, recommendations were stated and areas that were suitable for further research suggested.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presented a review of the research work that was done by various scholars in the field of construction site management. This included; the empirical review, the critical site factors, measurement of effective site management and modern technologies for site management. Finally, the chapter looked into the theoretical and conceptual framework as well as the research gaps.

2.2 Empirical Review

Extensive research has been conducted in the field of construction site management. In the UK, Kasim (2008) investigated material management with the main focus being materials tracking and inventory management processes. A study by Lill (2008) conducted in Estonia gave insight on sustainable management of construction labour. The author aimed to improve management strategies, decrease the mismatch between required and available skilled labour and finally to discuss the consequences of ignoring the interests of craftsmen. Golyani and Hon (2010) have discussed the effects of information handling on delivery of construction projects in Sweden. The study was as a result of the Swedish construction industry being infected by inaccurate and untimely information flow and it was unable to facilitate the value delivery that often results into additional costs and time delays. Chen and Kamara (2007) have also looked into information management in the UK. The scholars specifically investigated the information needs of particular users, the nature of on-site information and the mechanisms of retrieving and transferring information on construction sites.

Cheng and Li (2004) explored construction safety management in China. Their paper presented the views of construction participants on; site safety knowledge, factors affecting site safety and methods for improving project safety management. A study by Muir (2005) conducted in the United States of America highlighted the challenges facing today's construction manager. Some of the challenges pinpointed in his study includes; workforce considerations, safety, time constraints and the changing nature of the work. The need for improved link between the construction site and designers and improved communication between all actors on the construction site resulted into Arnorsson (2012) carrying out research on how to optimize the information flow of construction sites in Denmark. Dao & Follestad (2009) have discussed efficient material delivery and site management in Norway. The authors argue that, failure to allow a continuous flow of materials toward the construction site or poor site management can result in different kind of wastes.

In Nigeria, Olubunmi *et al* (2014) investigated the perception of professionals on construction site management practices. The scholars contends that, labour management, material management, health and safety management and commercial/cost management are among the critical site management elements that needs to be effectively managed. Another study conducted in Nigeria was that of Ayegba (2013) and it specifically looked into material management. The factors investigated includes; the methods of material procurement practice on construction sites, factors affecting material management on building construction site as well as causes of material waste. Chileshe and Berko (2010) have discussed the causes of project cost overruns in the Ghanaian construction sector. The major cost management factors that were found to be significant includes; delays in monthly payments to contractors, variations, inflations and schedule slippage. Joro (2015) has looked into material waste management, since it is a major problem in the Ethiopian construction industry. The study discussed the most significant factors causing construction material waste; site supervision factors, materials handling and storage factors, design and documentation factors, site management and practices factors and operations factors.

In Kenya, Muiruri and Mulinge (2014) have addressed the health and safety issue. The key factors that were investigated in the study include; health and safety measures used on construction sites, the enforcement mechanisms of health and safety regulations and the challenges encountered in the management of health and safety. Oloo (2015) discussed variation orders which is an ingredient of cost management. The main five causes of variation orders were found to be; delay in land acquisition/compensation, differing site conditions, change of plans or scope by client, change of schedule by the client and lack of coordination between overseas and local designers. Mbugua (2014) gave insight on material management by laying emphasis on procurement. Some of the challenges encountered during procurement as discussed by the author include; delayed payment by clients, suppliers default and delayed instructions by the consultants.

Difficult in planning and production estimation on construction sites in Kenya triggered research by Lamka (2015) who specifically looked into the factors that influence construction site labour productivity. Gwaya et al (2014) in their study on development of a benchmarking model for construction projects in Kenya listed knowledge areas that were in line with those of the Project Management Institute (2013) requiring the project manager's attention. The study further acknowledged two areas that needed to be addressed; value engineering and field/site construction project management.

Despite the knowledge acquired from the studies summarized in this section, literature has also shown that many projects in Kenya have failed to meet the primary objectives. Kihoro (2015) reported that, 48% of construction projects in Nairobi County were still incomplete and 10% of those projects were completely stalled. A study conducted by Kimondo *et al* (2015) and Gwaya (2015) indicated that over 50% of construction projects in Kenya were failing by not meeting their cost projections, time schedules or quality demands. According to Mose and Moronge (2016), 48% of the building projects in Kenya showed poor performance in terms of completion time, cost overruns and client satisfaction. This research therefore, decided to consider, discuss and investigate material management, labour management, health and safety management, cost management and information management as the critical factors in site management.

2.3 Construction Site Management Factors

a) Material management

El-Al Kass (2012) defines material management as the process of providing the right materials at the right place at the right time in order to maintain a desired level of production at minimum cost. Dey (2001) and Kasim *et al* (2005) noted that the common issues related to materials management include; incorrect materials take-off from drawing and design documents, damage/loss of items, receiving materials before they are required causes more inventory cost and chances of deterioration of materials' quality are high due to the fact that these materials lie idle on the site.

b) Labour management

Labour account for up to 40% of the direct capital cost of large construction projects (Thiyagu & Dheenadhayalan, 2015). In Kenya, labour costs approximately 25 to 35% of the total project costs (Gichuhi, 2013). Therefore, it is an important resource in construction because it is the one that combines all the other resources such as materials and finance in order to produce the various construction products (EL-Al Kass, 2012). Thiyagu and Dheenadhayalan (2015) pointed out the following management shortcomings which reduce efficiency and productivity of workers: delayed, unclear or inadequate instructions, delays in delivery of materials, provision of poor tools and equipment, unbalanced work gangs, use of wrong methods and lastly, bad advance planning or allocation of work tasks. To coordinate work effectively in a construction site, construction project managers need to know who is doing what, where and whether the work is progressing according to plan (Lopez & Fischer, 2014).

c) Health and safety management

Muiruri and Mulinge (2014) pointed out that, construction sites are considered risky with frequent and high accident rates and ill-health problems to workers, practitioners and end user. Spillane *et al* (2012) acknowledged that, the leading managerial issues in the management of health and safety on construction sites were found to be: difficulty to move materials around site safely; difficulty in ensuring site is tidy and all plant and materials are stored safely; close proximity of individuals to operation of large plant and machinery; difficulty in ensuring proper arrangement and collection of waste materials on-site and lastly difficulty in controlling hazardous materials and equipment on site. Automation can significantly lower the risk of accident by means of three technologies: position tracking of workers and machinery, real-time communication and on-site transportation of materials (Abderrahim *et al*, 2005).

d) Cost management

Cost management has been defined by Lowe and Leiringer (2005) as the process of controlling or administering the financial transactions of an organization with the primary aim of making a profit. According to Olubunmi *et al* (2014), cost management covers estimating, valuations, interim payment, variations, day-works, cost-value reconciliation, final accounts and cash flow. Many disputes have been documented as a result of poor cost management and administration (Oloo, 2015). Variations have been pin pointed as the most serious source of cost and time overruns (Gwaya and Wanyona, 2013).

e) Information management

Accurate information is vitally important in order to accomplish the set objectives. According to Lee (2003), a small change in plan, cost money and time if there is no direct link between the head office and the site office and also when there is no "quick" link between the site office and the construction manager. Chen and Kamara (2007) acknowledged that various construction personnel in the field need large amounts of information to support their ongoing works and to make decisions about the process of construction. Further, Golyani and Hon (2010) commented that, information handling in construction is infected by more wasteful and less value adding activities such as poor information flow (i.e. late information, defective information and unclear information), ineffective management control and poor decision making. The most effective way for construction personnel to manage information on sites is to retrieve or capture information at the point where they are and at the time when they need it (Chen and Kamara, 2007).

2.4 Measurement of Effective Site Management

To successfully deliver a project, a construction project manager requires effective planning and control of the construction site. The extensive literature reviewed indicates that, the subject of measurement of effective site management is debatable with no one agreeable method of measurement. However, effective site management is seen to adopt the performance indicators of a project.

In Singapore, Khosravi and Afshari (2011) have provided a performance measurement model for construction projects and it entails; Time performance, cost performance, quality performance, health, safety and environment and lastly they noted client satisfaction. Gwaya (2015) believes that project performance was determined by the project cost, quality, time, human resource management, scope management and the project process performance management. This study therefore, considered four factors that have been found to be more significant in determining project performance and translated them as the indicators of effective site management: ***meeting the cost projections, time schedules, quality demands and health & safety targets***.

2.5 Modern Technologies for Site Management

Given the short-comings in the current practice of site management in the construction industry, the importance of modern technologies in achieving improved project delivery cannot be over emphasized (Fadiya, 2012). Various attempts have been made in utilization of modern technologies in construction site management.

Fadiya (2012) mentioned that, Wireless Sensor Network System (WSN) can help protect materials from damage by real-time temperature measurement of humidity sensitive materials. Material and equipment loss through theft can be addressed through Radio Frequency Identification Device (RFID) and WSN technologies as highlighted by Carmichael et al (2007). Poon et al (2009) added that, RFID and WSN can improve inventory control through real-time and automatic data retrieval. Lu *et al* (2007) informs that, GPS and DR can help to improve reliability through real-time positioning of delivery vehicles. Fadiya (2012) stressed that, discrete-event simulation can help to optimize resource planning and scheduling.

Chau *et al* (2004) presented a 4D visualization model that enabled: visualized planning; linkage between the 3D geometrical model and the construction schedule data, resource requirement analysis for each activity (labor, material and equipment), material allocation and cost breakdown. Chau *et al* (2004) further asserted that, the model allows bi-directional data exchange between the 3D geometrical model and the project schedule. For instance, if the timing of a certain activity was modified graphically on the screen, synchronized adjustment of that activity will be made automatically to the project schedule and vice versa.

Wong *et al* (2014) provided a 5D BIM model for estimating the possible emissions from construction projects and detecting potential sources of danger to on-site workers in order to prevent fatal accidents caused by falling or being struck by moving objects. A 3D model (Revit-based software) was linked with the construction project schedule (MS Project files) using Autodesk NavisWorks to allow real-time and whole-project simulation. The 5D BIM tool also included a pro-active construction management system (PCMS) which comprised two sub-systems: a real-time location system (RTLS) and a virtual construction simulation system (VCS). Key sub systems elements are explained as follows:

i. A real-time location network is constructed using small hardware devices which serve as tags, which are designed to be mounted onto helmets and moving objects and anchors, which are designed to be fixed in static locations to serve as reference points (Wong *et al*, 2014). It was acknowledged further that; the tags help to alert construction workers by vibrating and/or emitting a specific sound when they are exposed to a particular danger.

ii. The application server (the virtual construction engine) monitors three possible sources of danger, namely, a person falling from a height, striking against or being struck by moving objects and being struck by moving vehicles. Other functions of the application server include synchronizing the user ends to simulate the construction processes and storing and retrieving tag positions to enable the construction processes to be replayed. (Wong *et al*, 2014).

Lopez and Fischer (2014) presented a Work Tracking System (WTS) that manages the information flows between project participants to support better communication about task scope, assignment, status and completion. The system leverages mobile devices and cloud computing to bring the technology to the field. The WTS includes Autodesk Revit software to manipulate the BIM, Autodesk NavisWorks software for the 4D visualization and Asana (a web application that allows teams to share a common task list) to manage work assignments using a mobile app. Lopez and Fischer (2014) further noted that, once a task is created in the WTS and assigned to a specific user, it is automatically added to that person's Asana and once the person marks the task as done in Asana, the change is reflected in the WTS's dashboard. Asana enables users to comment on tasks, giving them the opportunity to add notes, ask questions to other users and attach files (Davison, 2013). A project manager can go around the construction site and register mistakes, take pictures and mark where the mistakes are then the information can be sent to the involved party (in this case Asana can be utilized) for rework (Arnorsson, 2012).

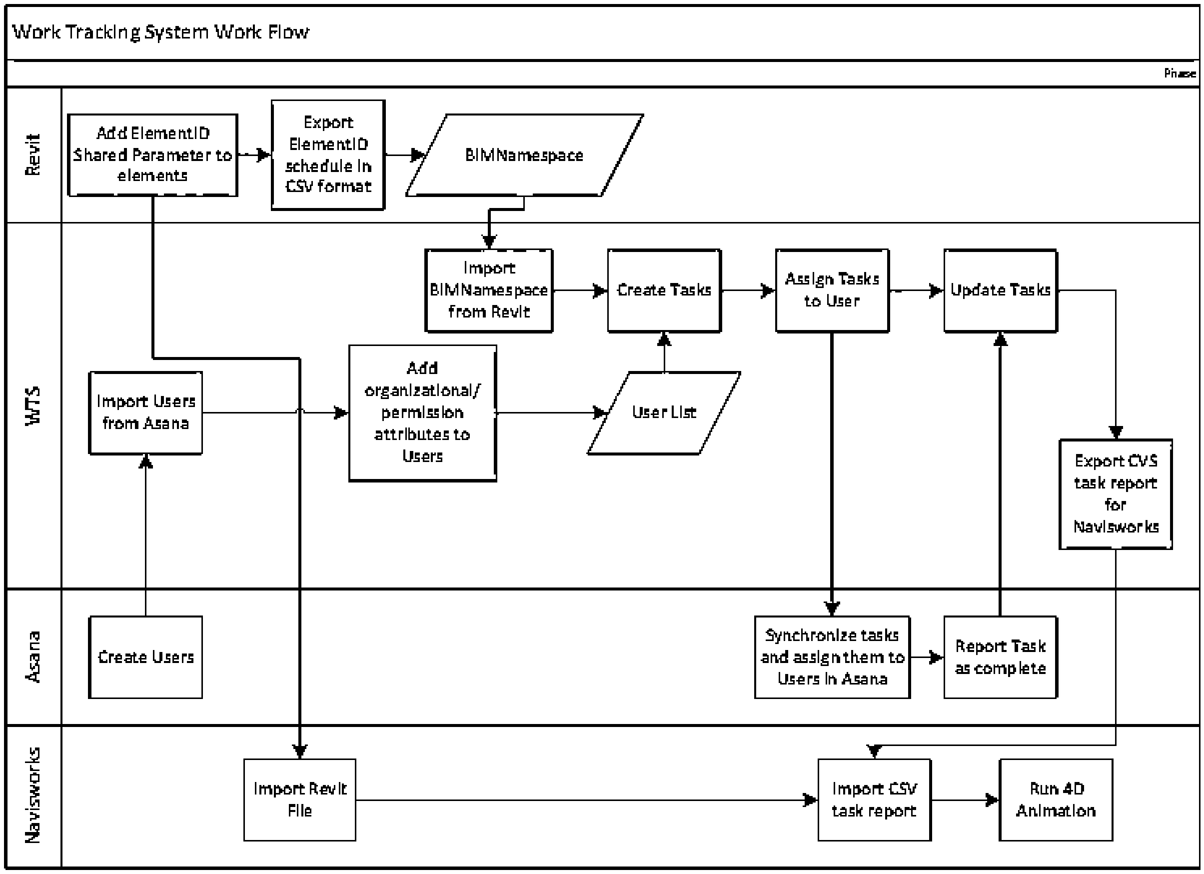

Figure 2.1: Work Tracking System Workflow Integration with Revit, Navisworks and Asana
Source: Lopez and Fischer (2014).

McPartland (2017) explored unmanned aerial vehicles (UAVs) or what is commonly referred to as drones and how the technology is rapidly changing the way the construction industry works. Higgins (2017) pointed out that, drones can be mounted with lightweight HD cameras and other survey equipment. The scholar further highlighted the benefits of drone technology during the construction phase as; they help to track and communicate progress, track and manage materials and assets, reduce theft, improve owner visibility, increase safety, provide valuable information for improving design changes and finally they create a valuable documentation trail in case of problems. Dillow (2016) echoed that, with the right computing tools, builders can turn sensor data into 3D structural models, topographical maps and volumetric measurements (useful for monitoring stockpiles of costly resources like sand and gravel). According to McPartland (2017), it's quick and easy to get a drone into the air meaning the project manager can keep a regular eye on a project with repeat flights allowing for frequent updates.

The real-time visibility into project cost, schedule, risk and performance information delivered through powerful and flexible dashboards and reports in Oracle Prime Projects Cloud Service enables construction project managers and other stakeholders to make the right decisions at the right time (ORACLE, 2017). The discussion capabilities in the cloud platform, allows project teams to communicate and collaborate effectively for more precise project planning, monitoring and execution. ORACLE provides another cloud-based collaboration solution known as Oracle Textura Payment Management Cloud Service that transforms construction payment management processes to increase efficiency, mitigate risk, enhance visibility and improve cash flow (ORACLE, 2016).

Instead of having the project team to come to site for meetings, Skype for business application has been recommended by Anastasia (2014) as a convenient and inexpensive way to communicate. The application has the capability to share screens, take snapshots, send and receive files, make conference calls and leave voice mails.

Gunda *et al* (2013) developed a management model using Geospatial Techniques (GT) for managing earth moving operations (EMO). The model is composed of a Geographical Information System (GIS) and Geographical Positioning system (GPS), programmed in PHP language, hosted on a MYSQL and it uses global system for mobile communication (GSM) to connect to a modem which in turn sends and receive short messages (SMS) to and from a system administrator/ project manager. The summarized advantages of the proposed model include; cost-effectiveness, reliability and accurate tracking. By having detailed information on the whereabouts of all employees and earth moving tools and equipment, the project manager is always in touch with the site operations at any one point in time.

To allow informed decisions to be made with confidence in matters regarding commercial management, Kinuthia (2014) provided Sage 200 construction software for monitoring contract costs and budgets while managing cash flow and relationships. The information extracted from the software can help to keep the construction team up-to-date on the latest invoice and payment status for every change order, track invoice dates, as well as full and partial payment status.

The modern technologies have changed the way the construction industry functions especially during site management. The technologies speed up a variety of processes, like time tracking and resource management. By digitizing the construction sites, communication and response times are made more efficient. Additionally, the ability of creating 4D and 5D simulation has helped in visualizing the project status. With mobile technologies in site management, there is no doubt that the future is bright.

2.6 Theoretical Framework

This study was modeled on the management theory of project management. To fully understand the theory, it begun with the recognition of what project management is. According to Kerzner (2000), project management is the planning, scheduling and controlling of a series of integrated tasks such that the objectives of a project are achieved successfully and in the best interest of the project stakeholders. Chitkara (2012) asserts that, project management as a discipline originated with the development of CPM/PERT planning techniques in the early sixties, when the volume and complexity of tasks increased, especially in construction, aerospace and defense projects.

Koskela & Howell (2002) highlights that; management theory of project management is founded on three theories; planning, execution and control. **The theory of planning** is subdivided into: management-as-planning (creation, revision and implementation of plans) and management-as-organizing (assembly of resources: manpower, materials, time and money). Therefore, this implied that planning is a core task of management.

The theory of execution is conceptualized as one-way communication (orders), within classical communication theory. However, for execution to be effective, the classical communication theory must be complemented with the language/action perspective which emphasizes on two-way communication and commitment (Inuwa, 2014).

Koskela & Howell (2002) states that, **the theory of control** consists of; thermostat model and the scientific experimentation model. The thermostat model conceptualizes that, in the production process, there is a process to control, a unit for performance measurement, a standard of performance and a controlling unit, while the scientific experimental model focused on finding the causes of deviations and acting on those causes.

2.6.1 Implication of the Theories to the Study

i. Material management.

Material management was an independent variable that influenced effective site management within the context of management theory (planning and control theories). A study by Fadiya (2012) revealed that, poor planning and scheduling can result in supply of wrong materials, wrong quantity and wrong timing in delivery. Poon et al (2009), Carmichael *et al* (2007), Dey (2001) and Kasim *et al* (2005) have also discussed common issues related to materials management. The adherence to the project management concept of planning (through management-as-planning and management-as-organizing) and control (through the thermostat model and the scientific experimentation model) can greatly improve project delivery through efficient material management.

ii. **Labour management**

Labour management was an independent variable that influenced effective site management. The construction project manager has a managerial responsibility of planning for labour. This is according to the concept of management-as- organizing where work tasks with the associated responsibilities are defined, positions allocated to them and adequate performers for the positions are selected. The work force needs constant supervision to ensure that there are no deviations and work is progressing according to plan (Lopez & Fischer, 2014). The scientific experimentation model of control is concerned with studying the causes of deviations and how they can be mitigated. Therefore, a better understanding of management theory (planning, execution and control theories) provides a guide to the construction project manager on how to manage the workforce effectively and efficiently.

iii. **Health and safety management**

Health and safety management was an independent variable that affected effective site management and it was conceptualized by the theory of planning **(**management-as-planning) and that of control (through the thermostat model and the scientific experimentation model). Space management (for safe operations) can be addressed in the planning stages of work through discrete-event simulation (Spillane *et al,* 2012). Thermostat model of the theory of control conceptualizes health and safety procedures as a process that is subject to control, which has a unit for performance measurement, a standard of performance and a controlling unit. The scientific experimentation model can be used as a learning process to study the causes of deviations resulting into accidents on construction sites.

iv. Cost management

Cost management forms the basis for project control. According to Oloo (2015), many disputes have been documented as a result of poor cost management and administration. Gwaya and Wanyona (2013) highlighted variations as the most serious source of cost and time overruns. The scientific experimentation model of control is concerned with studying the causes of deviations in the whole process of cost management with the sole aim of identifying causes of deviations (challenges) and how the challenges can be addressed in light of implementing a project successfully. Hence, cost management was an independent variable that influenced effective site management.

v. Information management

Information management was an independent variable that affected effective site management and this was argued using the management theory of execution. Failure to have a clear path of communication can result into personnel overlooking important issues that require quick response and often cause on-site decisions to be deferred (Singhvi & Terk, 2003). Construction personnel on sites should retrieve or capture information at the point where they are and at the time when they need it (Chen and Kamara, 2007). An effective communication system should be accountable and at the same time allow collaboration of project participants to give and receive directions/ instructions. All this is according to the classical communication theory and within the language/action perspective.

vi. Effective site management.

For effective site management, one needs to achieve control over the flow of basic resources (personnel, finance, materials and information) and processes. From a construction project manager's perspective, effective site management is measured by the following four factors: ***meeting the cost projections, time schedules, quality demands and health & safety targets.*** However, with the short-comings in the current practice of site management, a paradigm shift through the use of modern technologies in site management is needed to enable project managers' discharge their duties effectively. All this is as conceptualized by the theory of control (thermostat model and the scientific experimentation model). In addition, effective site management was a dependent variable that affected the explanatory variables.

2.7 Conceptual Framework

Material management, labour management, health & safety management, cost management and information management forms the independent variables while effective site management is visualized as the dependent variable. The constructs and relationships between research variables are illustrated in figure 2.2.

Independent Variables

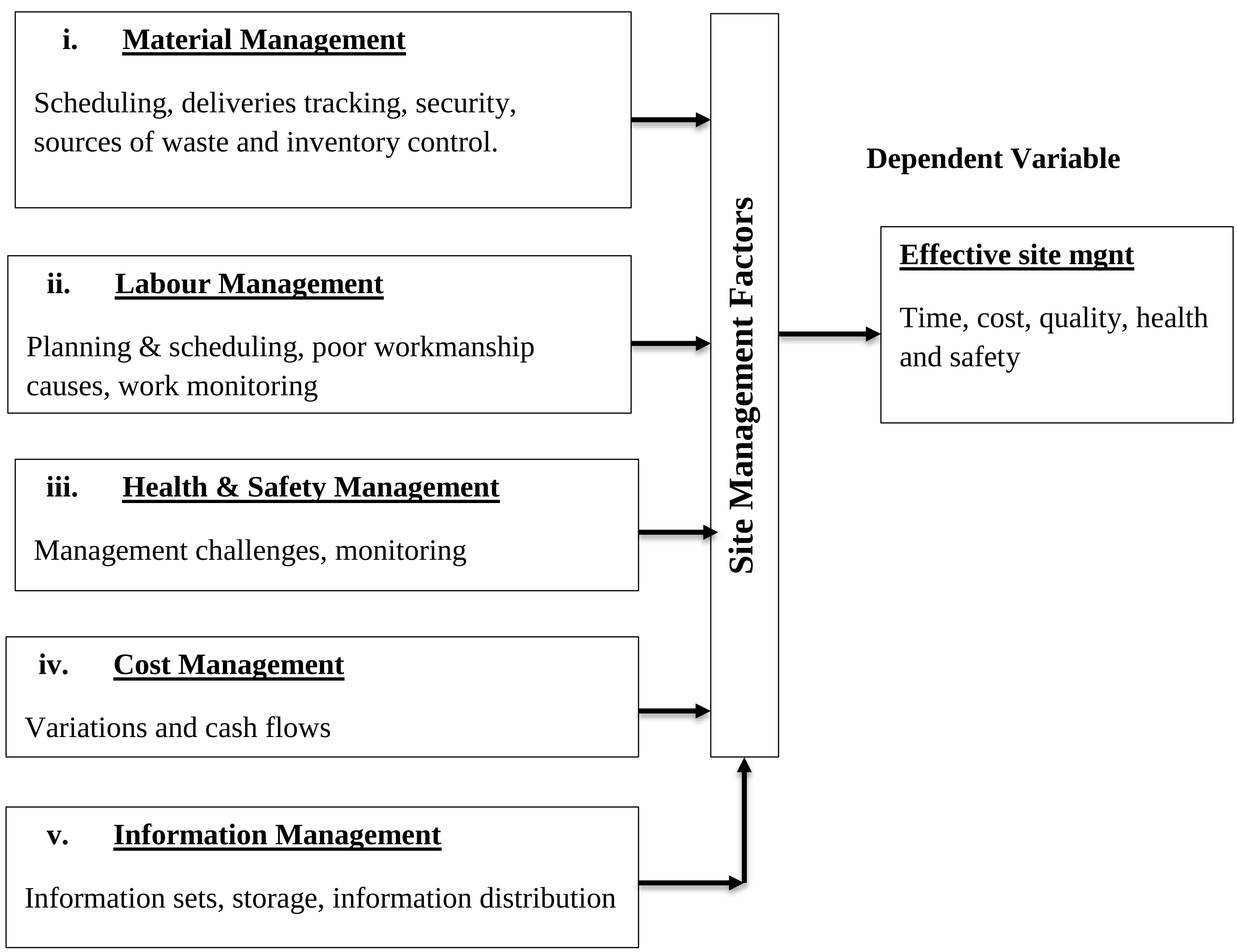

Figure 2.2: Conceptual Framework

Source: Author, 2017

The conceptual model for this study took the form as illustrated below:

$$\mathbf{esmgt = \beta matmgt + \beta lmgt + \beta cmgt + \beta hsmgt + \beta imgt + \beta_0 + \underline{\varepsilon}_i} \quad \mathbf{(4)}$$

Whereby;

esmgt = Effective site management

matmgt = Material management

lmgt = Labour management

cmgt = Cost management

hsmgt = Health & Safety management

imgt = Information management

2.8 Literature Gaps

The Project Management Institute (2016) has developed the PMBOK Guide and a construction extension to the PMBOK Guide that provides construction-specific guidance for the project management practitioner. However, the consequences of the current site management practices have proofed that, the laid down principles are not being followed. Evidence by Kimondo *et al* (2015) and Gwaya (2015) indicated that over 50% of construction projects in Kenya were failing by not meeting their cost projections, time schedules, quality demands or safety targets.

The literature review has revealed that, the local content is scanty and weak especially with respect to the use of a well-defined framework in site management. For example, Kibe (2016) addressed the health and safety issue, Oloo (2015) discussed variation management, Mbugua (2014) gave insight on material management and Lamka (2015) looked into construction site labour productivity. None of this studies synthesized a framework to the factors being investigated. This glaring gaps created the need to look into site management and formulate a framework which will be used by construction project managers to address critical site factors in a more practical context.

2.9 Conclusion

The chapter begun by giving an empirical review of site management with emphasis on the challenges experienced during execution of works and their effects. It also revealed the critical indicators of effective site management plus the various modern technologies that can be harnessed on site, highlighting their benefits. The last part of the chapter explained this study's theoretical and conceptual framework as well as the literature gaps. The theoretical framework was modeled on management theory of project management.

A relationship of the theories to this study was established, hence the basis for the study's conceptual framework. The selected site factors that were investigated in relation to effective site management include; material management, labour management, health & safety management, cost management and information management.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter clarified how the research was carried out from preliminary stages to completion. It intricately described the type of research design adopted, the research strategy, area of study/target population, the sampling techniques, sources of data, approaches and procedures for data collection, data analysis and presentation, operationalization of the variables and finally ethical issues regarding the whole study.

3.2 Research Design

Considering the objectives in this study, a survey design was deemed suitable for this research. The methodology for the study took the form as follows; phase one entailed; designing of the research instruments (questionnaires) and a pilot study was conducted at this stage since this was the surest means for questionnaires to be comprehensible and errors free.

The second phase of the research involved collection of data from 45 on-going commercial/ mixed urban development projects in Westlands constituency. Questionnaires were administered to construction project managers. Phase three focused on data analysis and discussion. R software version 3.4.3 was used to perform the required analysis. Finally, the last phase of the research gave conclusions and recommendations.

3.3 Research Strategy

This study adopted both the qualitative and quantitative research strategies. The two strategies complement each other in covering aspects of the investigation which would not be adequately covered by either of the strategies when used in isolation (Bryman, 2012). Therefore, these strategies were preferred since the aim of the research was to collect information from sampled respondents using questionnaires and later quantitative techniques used in data analysis.

3.4 Area of Study/Target Population

This research was conducted in Nairobi County, Westlands constituency in particular. The constituency was selected from other constituencies in Nairobi County since it was a favorable area of study due to resource constraints especially on finances. The target population was made up of 45 on-going commercial/ mixed urban development projects worth more than Kshs100 million (Appendix 6). Projects worth that amount involve complex site management practices unlike small scale projects. The accessible respondents for the research were the construction project managers.

3.5 Sampling

Purposive sampling technique was employed in this study as only projects worth more than Kshs100 million (Appendix 6) were considered for data collection. Construction project managers were considered appropriate respondents for the questionnaires.

3.6 Nature and Sources of Data

The primary data was obtained directly from respondents through administration of self-completion questionnaires. The primary data provided first-hand information to this study on the critical site factors and their effect on effective construction site management in Nairobi County.

Table 3.1: Nature and Sources of Data

Nature	Method	Techniques	Aspects
Field Research	Questionnaires	Detailed open and closed questions	Information on; ❖ Material management, labour management, health and safety management, cost management and information management. ❖ The emerging trends and developments in site management.

Source: Author, 2017

3.7 Method of Data Collection

This section outlines how the data was collected from the field and how it was recorded. Data collection exercise commenced after being issued with an approval letter from the JKUAT Board of Postgraduate Studies (BPS), an introductory letter from the department of Construction Management in the School of Architecture and Building Science, a research clearance permit by National Commission for Science, Technology and Innovation (NACOSTI) and a cover letter for the questionnaires designed. The cover letter reassured respondents that all the information given was to be treated with extreme confidentiality and no information collected in the study will be used for any other purpose than stated therein. The following instruments were used in collecting the data;

a) Questionnaires

They consisted of both open ended and close ended questions prepared in line with the research variables. The questionnaires captured material management, labour, health & safety, cost, information management and the level of effective site management. The target respondents of the self-completion questionnaires comprised of construction project managers.

3.8 Pilot Study

Finalized questionnaires were tried out in the field for pre-testing since this was the surest means for questionnaires to be comprehensible and errors free (Mugenda & Mugenda, 2003). The research used a convenience sample of four commercial development projects (only projects worth more than Kshs100 million were considered) under construction in Westlands constituency to conduct a pilot survey for purpose of pre-testing the questionnaires. The respondents comprised of 4 construction project managers. The responses obtained led to the final amendments in the draft questionnaires.

3.8.1 Validity of the Questionnaires

To ensure validity, the researcher formulated simple and easy to comprehend questions whose answers had a critical bearing to the variables under investigation so as to guide the study achieve its purpose. Additionally, questionnaires were subjected to people with experience in the field of construction (Construction project managers) to check whether they measured what they were intended to measure.

3.8.2 Reliability Test

To measure the reliability and level of random error of the questionnaires, an internal consistency technique using Cronbach's alpha (α) was applied. The technique allows negative construct to be detected and positive to be accepted ranging from a scale of 0 to 1.0 (Inuwa, 2014). This was done using R software version 3.4.3 to determine how items correlated among themselves

3.9 Method of Data Analysis and Presentation

Firstly, raw data collected from the field was cleaned, sorted and codes ranging from 1 to 5 were assigned to each variable and average scores were computed using R software version 3.4.3 to create latent variables (material management, labour management, cost management, health & safety management, information management and effective site management).

Descriptive statistics analysis was applied in analyzing quantitative data where data was scored by calculating the percentages, mean, median, standard deviation, range, skewness and kurtosis. In addition, a Shapiro-Wilk normality test was used to test the normality of the variables. The descriptive results were presented using tables, bar charts, frequency polygons and quantile - quantile plots.

Inferential statistics was also applied through correlation analysis and the use of logistic regression analysis. Spearman rank correlation was applied in the analysis since the test does not carry any assumptions about the distribution of the data. The correlation coefficient ranges between -1 and 1 hence, the closer you get to 1 (or -1), the stronger the relationship.

- 1 = Perfect positive correlation hence, if one value goes up, so does the other.
- -1 = Perfect inverse correlation hence, as one value goes up, the other goes down.
- 0 = There is no association between the variables.

Latent variables where broken down into two categories by their respective medians (since some of the variables like material management and health & safety were not normally distributed) to be used in logistic regression. The two categories in the variables were poor management coded as 0 and proper management coded as 1. With statistical significance, binary logistic regression analysis was used to estimate the probability of a binary response based on multiple predictor (independent) variables.

The logit model took the form as illustrated below:

$$\boldsymbol{ln}\left\{\frac{\boldsymbol{p}}{(\boldsymbol{1}-\boldsymbol{p})}\right\} = \boldsymbol{\beta}_{\boldsymbol{1}X_1} + \boldsymbol{\beta}_{\boldsymbol{2}X_2} \dots \dots \dots \boldsymbol{\beta}_{\boldsymbol{n}X_n} + \boldsymbol{\beta}_{\boldsymbol{0}} + \boldsymbol{\varepsilon}_{\boldsymbol{i}} \quad \textbf{(5)}$$

Whereby;

ln = the natural logarithm, $\log_{exp}$, where exp = 2.71828……

p = the probability that the event Y occurs, p(Y=1)

Y = Outcome variable (Effective site management)

β = Regression coefficient estimates

$\mathbf{x_{1\dots n}}$ = Site factors (material, labour, health & safety, cost and information)

$\boldsymbol{\varepsilon_i}$ = Error term

Hosmer Lemeshow test was performed on the logistic regression model to test for goodness of fit of the produced.

$\mathbf{H_0}$**:** The model fits the data.

$\mathbf{H_a}$**:** The model does not fit the data

Therefore;

When **p** > **0.05** we fail to reject the $\mathbf{H_0}$

The overall significance of the logistic model was tested using the Likelihood Ratio Test.

$\mathbf{H_0}$**:** The null model is better than the full model.

$\mathbf{H_a}$**:** The full model is better than the null model

Therefore;

When **p** < **0.05** we reject the $\mathbf{H_0}$ in favor of the $\mathbf{H_a}$

The significance of a single coefficient in the model was evaluated using Wald tests.

$\mathbf{H_0}$**:** Some parameters = some value hence, include the variables in the model

$\mathbf{H_a}$**:** Some parameters = zero hence, remove the variables from the model

Qualitative data of respondents expressing their opinions was summarized and the emerging views were noted down.

3.10 Operationalization / Measurement of Variables

Table 3.2: Operationalization of the Research Variables

S/No	Predictor and Outcome Variables	Indicators	Measurement
X1	Material management *(Independent)*	Scheduling, deliveries tracking, protection/security, sources of waste and inventory control.	Ordinal scale with a Likert scale of 1 to 5
X2	Labor management *(Independent)*	Planning & scheduling, causes of poor workmanship/quality, work monitoring	Ordinal scale with a Likert scale of 1 to 5
X3	Health & safety management *(Independent)*	Management challenges, monitoring of health and safety	Ordinal scale with a Likert scale of 1 to 5
X4	Cost management *(Independent)*	Variations and cash flows	Ordinal scale with a Likert scale of 1 to 5
X5	Information management *(Independent)*	Information sets, storage, information distribution	Ordinal scale with a Likert scale of 1 to 5
Y	Effective site management. *(dependent)*	Time, cost, quality, health and safety	Ordinal scale with a Likert scale of 1 to 10

Source: Author, 2017

3.11 Ethical Consideration

This study was guided by research ethics in planning, conducting and reporting the results of the research. A study conducted by McNabb (2009) highlighted the principles to be adhered to in order to ensure that a research meets ethical requirements. The principles are as listed below: truthfulness, thoroughness, objectivity and relevance. This research undertook the following precautions;

Firstly, the research proposal approval and introductory letters were obtained from the JKUAT Board of Postgraduate Studies (BPS) and the Department of Construction Management respectively. Two supervisors were appointed by BPS to facilitate the study. Application for a research clearance permit and authorization letter was made to the National Commission for Science, Technology and Innovation (NACOSTI) and the Nairobi County Government Authorities through the County Commissioner and County Director of Education.

Thirdly, the engaged respondents were informed about the purpose of the study, the benefits of the study to them and the construction industry in general. Collected data was used for the purpose for which the current study was undertaken and therefore, not divulged to unauthorized persons.

Finally, the study was refrained from collecting data that pertains to the identity of the respondents. In addition, the researcher only collected and analyzed data to fulfill the purpose of these research.

3.12 Conclusion

The third chapter provided an explanation on the methodology used in this study. The comprehensive design of the research and the selection of respondents were illustrated. Details regarding collection of data, analysis method and ethical issues were also presented.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

The purpose of this study was to investigate the critical site factors and their effect on effective construction site management in Nairobi County, with a view of making recommendations that are geared towards improved on-site management. Hence, to achieve this, a methodology consisting of a survey of construction sites was employed. This chapter presents the findings of the data analyzed from the research instruments together with their interpretation in line with the study objectives.

4.1.1 Response Rate

Out of the 45 contacts of the construction project managers established, only 36 construction project managers responded to the questionnaires. This represented 80% of the sampled population. Mugenda and Mugenda (2003) as cited by Kibe (2016) recommends that, a response rate of 50% is fairly adequate, therefore a response rate of 80% in this case was considered to be representative of the study population.

4.1.2 Reliability Analysis

Reliability of the data collected was tested using the Cronbach's alpha (α). The minimum acceptable value for Cronbach’s alpha is from 0.5 to 0.6 (Zinbarg, 2005).

Table 4.1: Cronbach’s α Values Interpretation within a Scale of 0 - 1.

Cronbach’s Coefficient Alpha	Internal Consistency Remarks
$\alpha < 0.5$	Unacceptable
$0.5 \leq \alpha < 0.6$	Poor
$0.6 \leq \alpha < 0.7$	Acceptable
$0.7 \leq \alpha < 0.9$	Good
$\alpha \geq 0.9$	Excellent

Source: Oloo (2015)

The questionnaires were constructed basically to capture two broad constructs; demographic profiles and the study variables.

Table 4.2: Questionnaire Factor Categories Cronbach's α Scores

S/N	Factor category	No. of Items	Cronbach's α	Reliability Status
1	Demographic data	4	0.78	Good
2	Material management	24	0.84	Good
3	Labour management	14	0.72	Good
4	Health and safety management	14	0.76	Good
5	Cost management	23	0.75	Good
6	Information management	25	0.76	Good
7	Effective site management	4	0.75	Good

Source: Author, 2017

4.2 Demographic Characteristics of the Respondents

The first section of the questionnaire was mainly designed to provide background information about the respondents. The information was intended to set the framework for the questions in the subsequent sections of the questionnaire relating to construction site management. The results from the study were as presented in figure 4.1, 4.2, 4.3 and table 4.3.

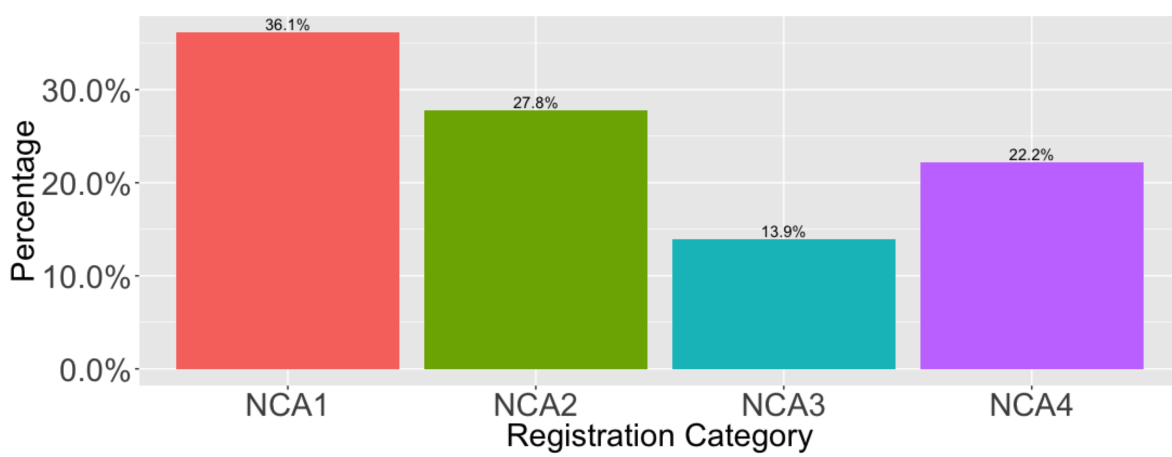

Figure 4.1: Contractors' Registration Category

Source: Field survey, 2017

Figure 4.1 shows the percentage distribution of contractors' registration category according to the National Construction Authority. Virtually 36% of the contractors are registered as large contractors (NCA1) handling projects with unlimited contract value, 28% are NCA2 contractors handling projects that cost Kshs 300 million to Kshs 500million, while the remaining 14% and 22% are NCA3 and NCA4 contractors handling projects costing between Kshs 200-300 million and between Kshs 100-200 million respectively. This results revealed that, the construction project managers' organizations handle large projects which involves site management complexities and as such are more experienced to respond to this study enquiry.

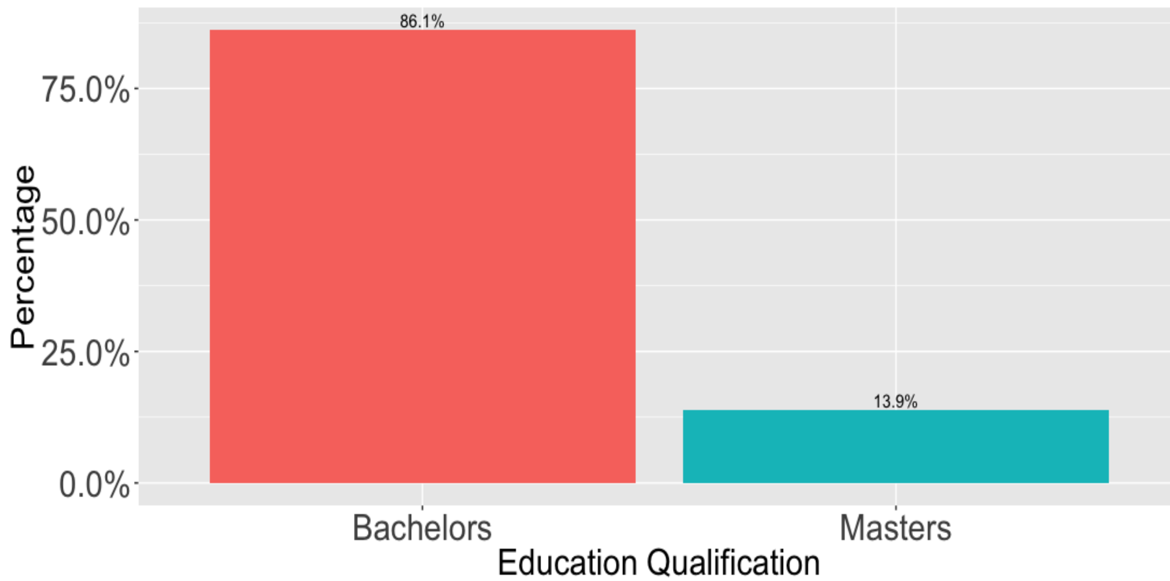

Figure 4.2: Construction Project Managers Educational Qualification

Source: Field survey, 2017

Figure 4.2 is a representation of the construction project managers' highest educational qualification. 86% of the respondents hold Bachelor's degrees while 14% of the project managers hold Master's degrees. This results confirms that most of the construction project managers are knowledgeable and competent enough to manage contractors' project contracts.

Figure 4.3 reveals that, 61% of the respondents specialized in civil engineering, 28% were mechanical engineers while only 11% of the construction project managers specialized in construction management. This informed that, all the construction project managers were educated on core construction courses hence, competent to respond to this study enquiry and this ensured the content validity of the data obtained.

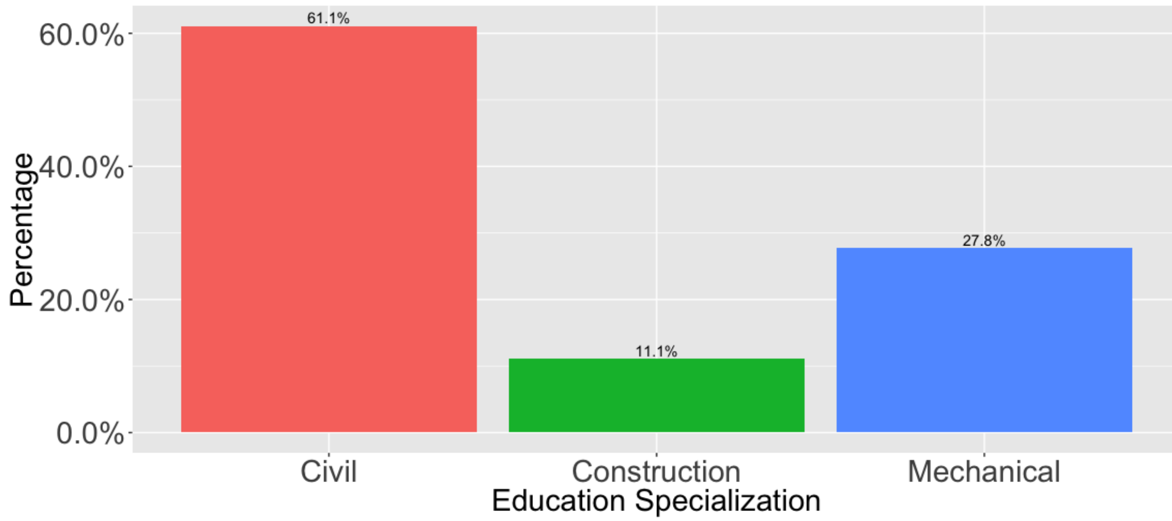

Figure 4.3: Construction Project Managers Educational Specialization

Source: Field survey, 2017

Table 4.3: Construction Project Managers Experience

Experience (yrs.)	Mid value (X)	Frequency(F)	Percentage (%)	FX
Less than 5	2.5	7	19	17.5
5-10	7.5	14	39	105
10-15	12.5	10	28	125
Over 15	15.0	5	14	75
Total		**36**		**322.5**
Mean Years of Experience = ΣFX/ΣF=8.96				

Source: Field survey, 2017

Table 4.3 depicts that, the construction project managers had a mean of 8.96 years of experience. The experience of the respondents supports the belief that, people with long experience are more conscious and conversant with strategies of handling site management challenges. A similar view is held by Kibe (2016) who found out that, working experience is likely to influence health and safety management (this was one of the variable investigated in this study) implementation as workers with long experience are more conscious of health and safety risks associated with construction works.

4.3 Data Analysis for the Research Objectives

4.3.1 Objective 1: To describe the level of effectiveness in construction site management and its explanatory variables.

a) Material Management

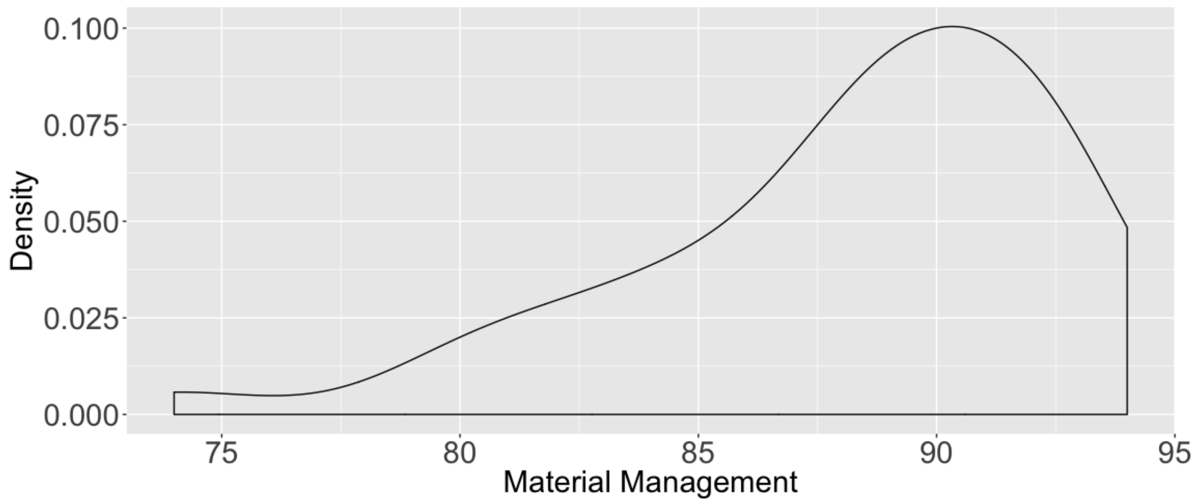

Figure 4.4: Material Management Variable Distribution

Source: Author, 2018

If a distribution is symmetric the left half of the graph (frequency polygon) should be a mirror image of the right half of the graph. If this is not the case the distribution is said to be asymmetric or skewed. The above frequency polygon is left skewed or negatively skewed (-1.2458) since the data lies on the right hand side and it has a long left tail. Furthermore, Daniel (2009) acknowledge that, a distribution will be skewed to the right (positively skewed) if its mean is greater than its median and skewness to the left (negatively skewed) informs that, the mean is less than its median. Hence, a mean of 88.14 is less than the median of 89 with a standard deviation of 4.45 (the small standard deviation shows that the data set is close to the mean of 88.14 with a range of 74-94). The positive kurtosis value (1.6011) convey that the distribution has heavier tails than the normal distribution.

To further ascertain the distribution of the variable, a quantile - quantile plot (Q-Q plot) of theoretical residuals was graphed as illustrated by figure 4.5. A Q-Q plot is a probability plot that is used in determining the nature of a distribution by plotting theoretical quantiles. If a variable is normally distributed the theoretical quantiles should be superimposed on the quantile - quantile line. A negative skew is suggested by the plot since the theoretical quantiles lie above the line with the tails below the line. In addition, a Shapiro-Wilk normality test was used to test the normality of the variable. The observed value of the Shapiro–Wilk statistic is: W = 0.89102 with a p-value = < 0.05. Since the p-value is less than 0.05, we can be 95% certain that the data is not normally distributed.

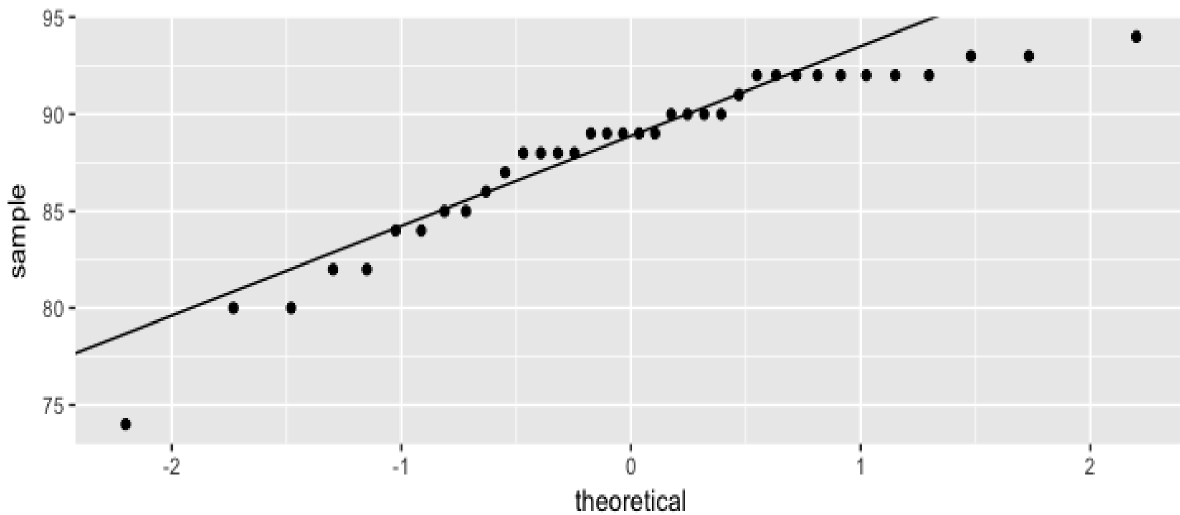

Figure 4.5: Q-Q Plot for Material Management Variable

Source: Author, 2018

b) Labour Management

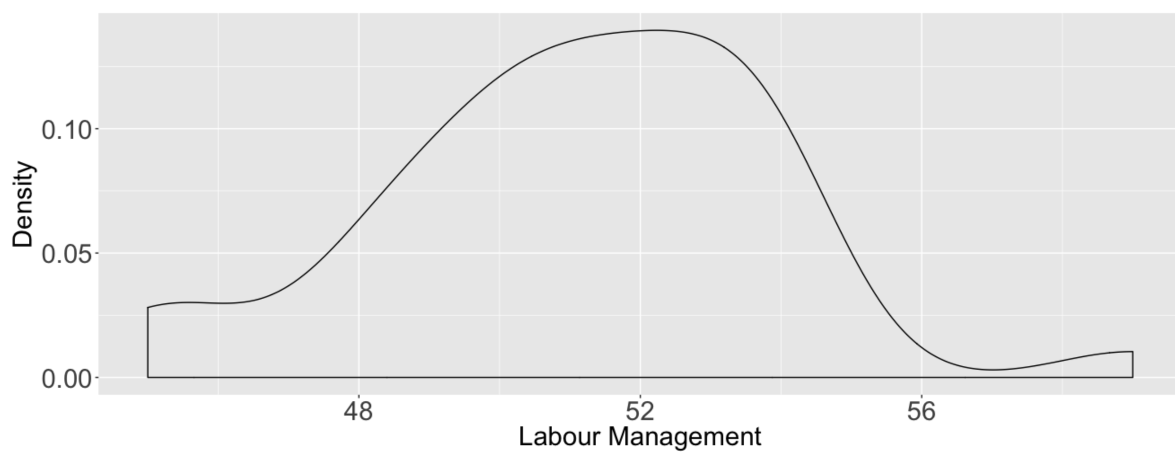

Figure 4.6: Labour Management Variable Distribution

Source: Author, 2018

The above frequency polygon is slightly left skewed or negatively skewed (-0.0558) with a mean of 55.11 and a median of 51. The mean being greater than the median in this case it violates the rule of thumb relating to skewness as conceptualized by Daniel (2009). However

Hippel (2005) highlights exceptions to Daniel (2009) rule by stating that, such scenarios occur when the areas to the right and left of the median are not equal or if one tail is long but the other is heavy. The small standard deviation of 2.85 manifest that the data set is close to the mean of 55.11 with a range of 45-59. The positive kurtosis value (0.9508) convey that the distribution has heavier tails than the normal distribution.

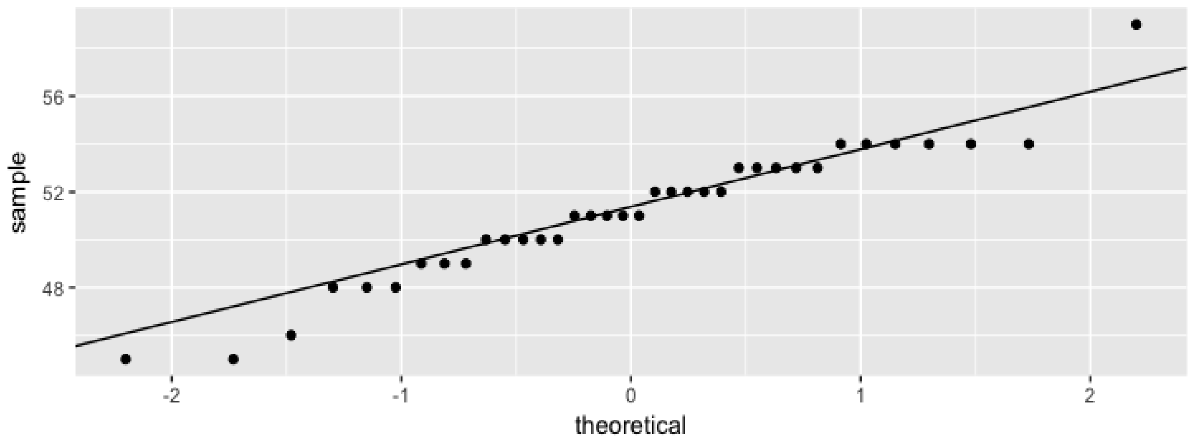

Figure 4.7: Q-Q Plot for Labour Management Variable

Source: Author, 2018

A slight negative skew is suggested by the tails of theoretical quantiles lying below the line. In addition, a Shapiro-Wilk normality test was used to test the normality of the variable. The observed value of the Shapiro–Wilk statistic is: W = 0.95243 with a p-value = > 0.05. Since the p-value is greater than 0.05, we can be 95% certain that the data is normally distributed.

c) Health & Safety Management

Figure 4.8: Health and Safety Management Variable Distribution

Source: Author, 2018

In figure 4.8, the frequency polygon is right skewed or positively skewed (1.5137) since the data lies on the left hand side and it has a long right tail with a mean of 44.25 and a median of 43. The small standard deviation of 5.59 shows that the data set is close to the mean of 44.25 with a range of 37-60. The positive kurtosis value (2.5678) convey that the distribution has heavier tails than the normal distribution.

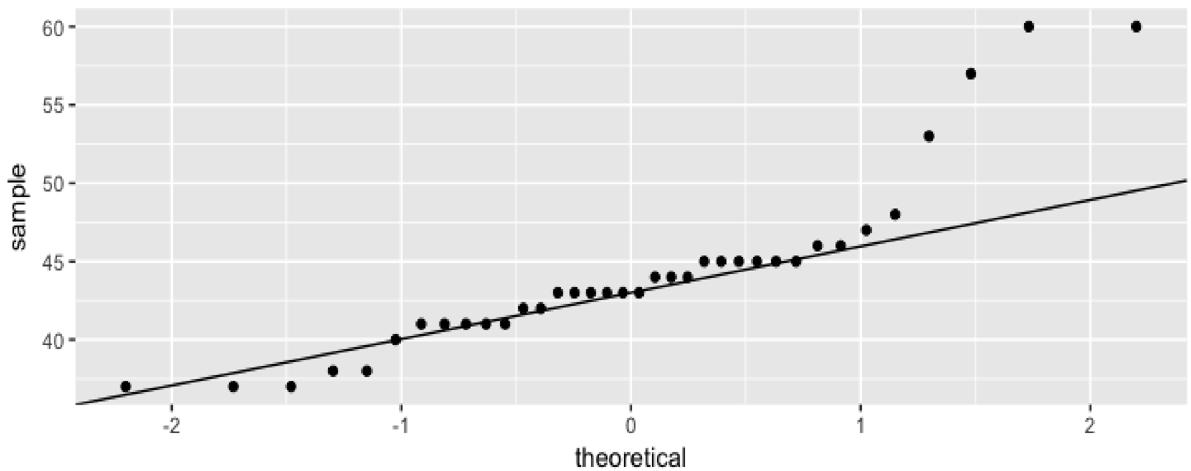

Figure 4.9: Q-Q Plot for Health and Safety Management Variable

Source: Author, 2018

A positive skew is suggested by the tails of theoretical quantiles lying above the Q-Q line. In addition, a Shapiro-Wilk normality test was used to test the normality of the variable. The observed value of the Shapiro–Wilk statistic is: W = 0.83516 with a p-value = < 0.05. Since the p-value is less than 0.05, we can be 95% certain that the data is not normally distributed.

d) Cost Management

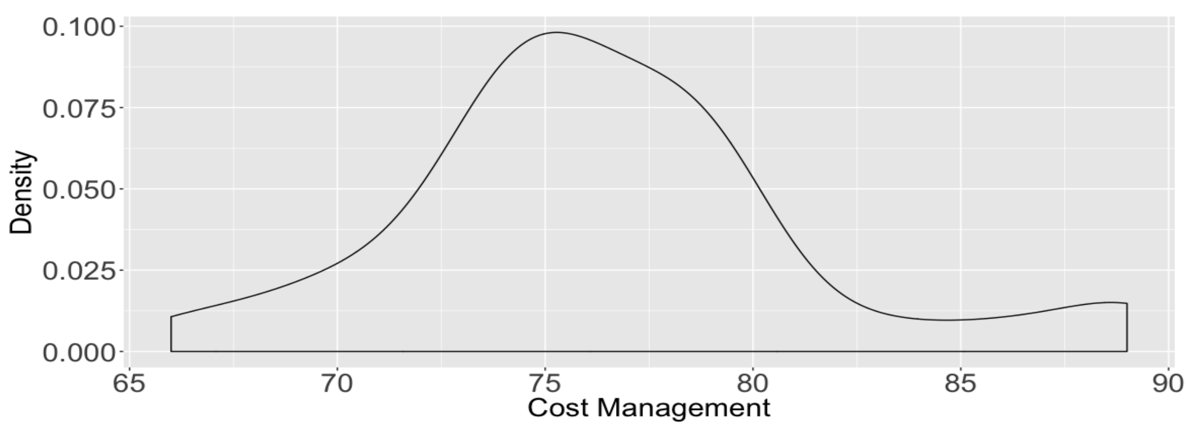

Figure 4.10: Cost Management Variable Distribution

Source: Author, 2018

In figure 4.10, the frequency polygon is slightly right skewed or positively skewed (0.6590) with a mean of 76.44 and a median of 76. The small standard deviation of 4.98 shows that the data set is close to the mean of 76.44 with a range of 66-89. The positive kurtosis value (1.2367) convey that the distribution has heavier tails than the normal distribution.

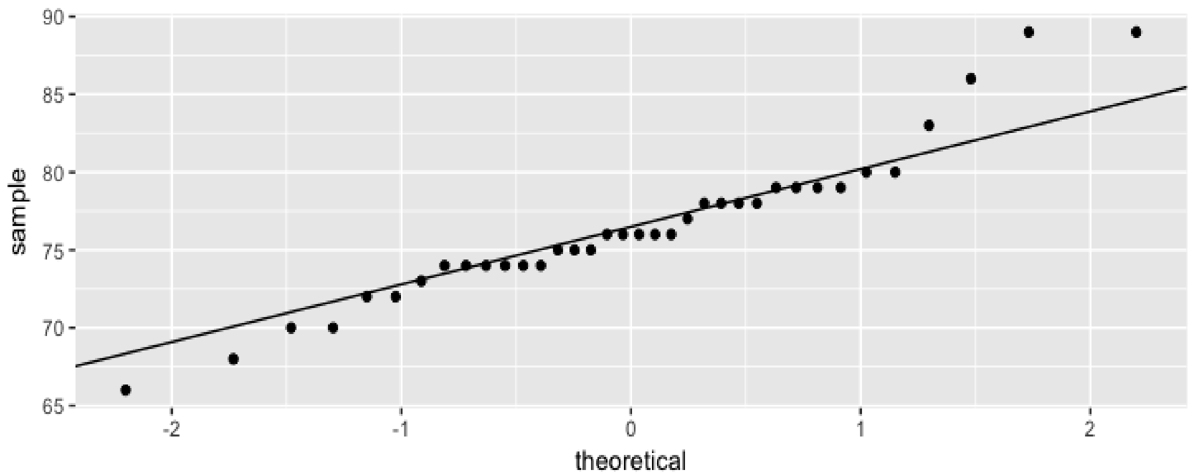

Figure 4.11: Q-Q Plot for Cost Management Variable

Source: Author, 2018

A slight positive skew is suggested by theoretical quantiles lying below the line with the tails of theoretical quantiles lying above the line. In addition, a Shapiro-Wilk normality test was used to test the normality of the variable. The observed value of the Shapiro–Wilk statistic is: W = 0.94195 with a p-value = > 0.05. Since the p-value is greater than 0.05, we can be 95% certain that the data is normally distributed.

e) Information Management

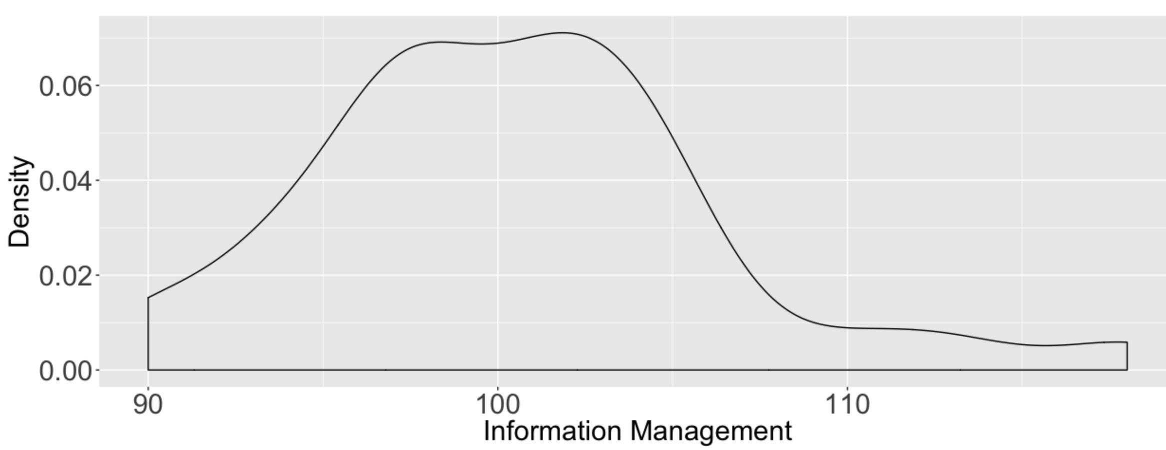

Figure 4.12: Information Management Variable Distribution

Source: Author, 2018

In figure 4.12, the frequency polygon is slightly right skewed or positively skewed (0.7640) with a mean of 100.44 and a median of 100.50. The mean is less than the median and this communicates that the areas to the right and left of the median are not equal or one tail is long but the other is heavy. The small standard deviation of 5.84 manifest that the data set is close to the mean of 100.44 with a range of 90-118. The positive kurtosis value (1.4946) convey that the distribution has heavier tails than the normal distribution.

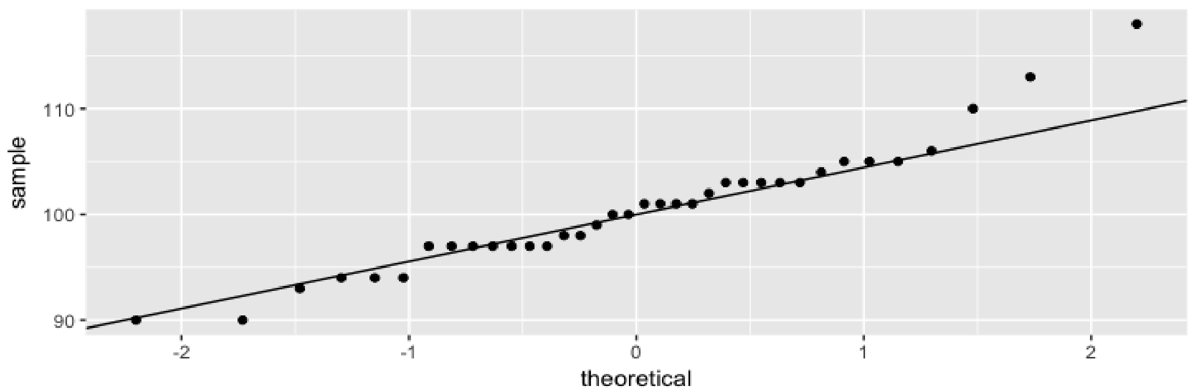

Figure 4.13: Q-Q Plot for Information Management Variable

Source: Author, 2018

A slight positive skew is suggested by theoretical quantiles lying below the line with the tails of theoretical quantiles lying above the line. In addition, a Shapiro-Wilk normality test was used to test the normality of the variable. The observed value of the Shapiro–Wilk statistic is: W = 0.94912 with a p-value = > 0.05. Since the p-value is greater than 0.05, we can be 95% certain that the data is normally distributed.

f) Effective Site Management

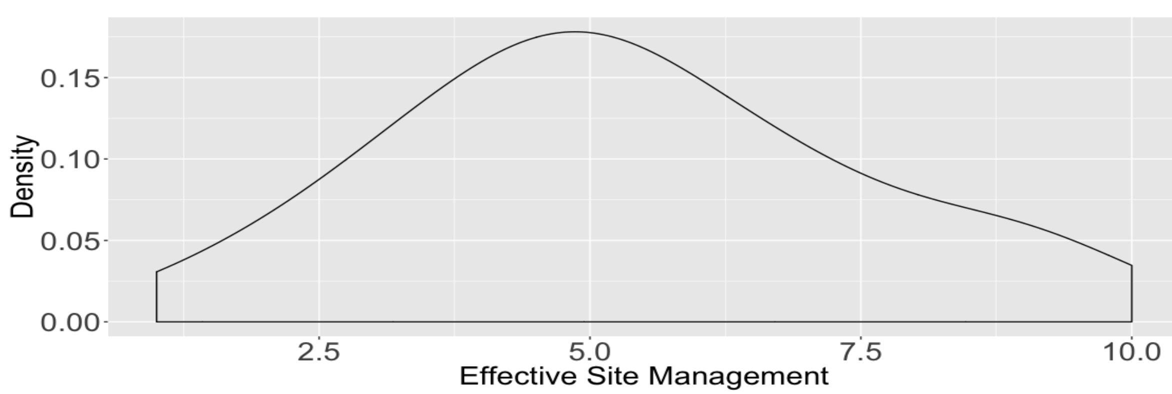

Figure 4.14: Effective Site Management Variable Distribution

Source: Author, 2018

In figure 4.14, the frequency polygon is very slightly right skewed or positively skewed (0.2585) with a mean of 5.33 and a median of 5. The small standard deviation of 2.16 shows that the data set is close to the mean of 5.33 with a range of 1-10. The negative kurtosis value (-0.3607) convey that the distribution has lighter tails than the normal distribution.

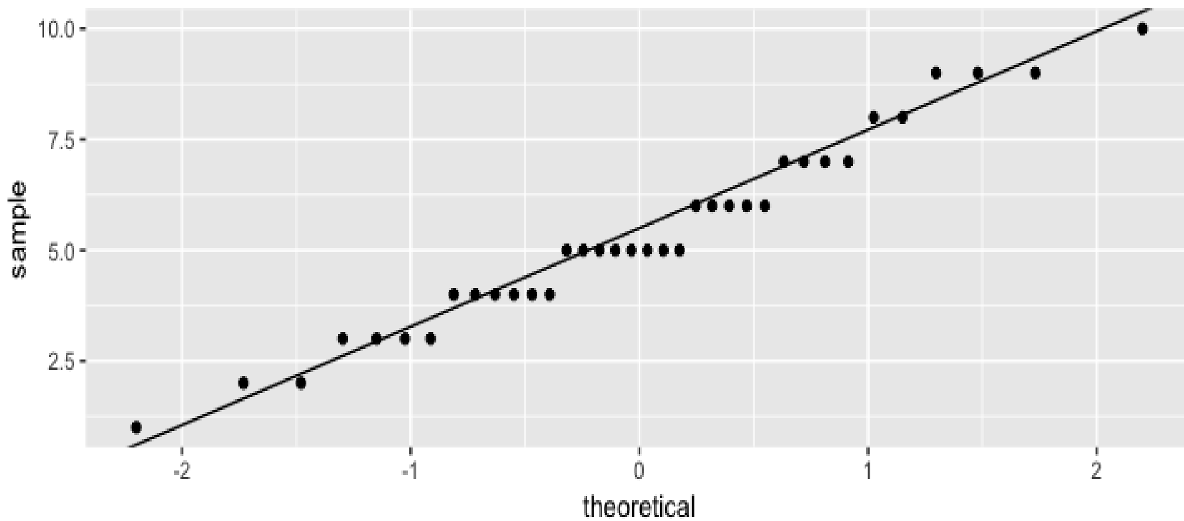

Figure 4.15: Q-Q Plot for Effective Site Management Variable

Source: Author, 2018

A very slight positive skew is suggested by theoretical quantiles lying below the line with the tails of theoretical quantiles lying above the line. In addition, a Shapiro-Wilk normality test was used to test the normality of the variable. The observed value of the Shapiro–Wilk statistic is: W = 0.97002 with a p-value = > 0.05. Since the p-value is greater than 0.05, we can be 95% certain that the data is normally distributed.

Table 4.4**:** Descriptive Statistics Summary

Variable	**Mean**	**Median**	**N**	**Std. Deviation**	**Min**	**Max**	**Skewness**	**Kurtosis**
Material Management	88.14	89	36	4.45	74	94	-1.2458	1.6011
Labour Management	55.11	51	36	2.85	45	59	-0.0558	0.9508
Health & Safety Management	44.25	43	36	5.59	37	60	1.5137	2.5678

Cost Management	76.44	76	36	4.98	66	89	0.6590	1.2367
Information Management	100.44	100.5	36	5.84	90	118	0.7640	1.4946
Effective site Management	5.33	5	36	2.16	1	10	0.2585	-0.3607

Source: Author, 2018

4.3.2 Objective 2: To establish the relationship between effective construction site management and its explanatory variables.

a) Spearman's Rank Correlations

When variables are normally distributed use Pearson's correlation coefficient otherwise use Spearman's correlation coefficient. The Spearman rank correlation test does not carry any assumptions about the distribution of the data and is the appropriate correlation analysis when the variables are measured on a scale that is at least ordinal. In addition, to avoid multi-collinearity, Acquah et al (2018) acknowledge that, the correlation coefficient should not be further than 0.8. From table 4.5, the largest correlation coefficient value (r- value) is 0.422 hence, no multi-collinearity problem detected.

Table 4.5**:** Spearman's Rank Correlations for the Variables

	Effective Site Management	***Material Management***	***Labour Management***	***Health & Safety Management***	***Cost Management***	***Information Management***
Effective Site Management	**1.000**	0.271	0.213	-0.398	-0.275	-0.203
Material Management	0.271	**1.000**	0.367	0.233	0.129	0.185
Labour Management	0.213	0.367	**1.000**	0.422	-0.049	0.390
Health & Safety Management	-0.398	0.233	0.422	**1.000**	-0.017	0.305
Cost Management	-0.275	0.129	-0.049	-0.017	**1.000**	0.201
Information Management	-0.203	0.185	0.390	0.305	0.201	**1.000**

Source: Author, 2018

The correlation between material management and effective site management indicates a positive relationship and so does that of labour management with effective site management. The positive correlation communicates that, a value increase in the predictor variable causes a value increase in the dependent variable.

The correlation between health & safety management and effective site management shows a negative relationship. In addition, the correlation between cost management and effective site management also manifests a negative relationship and so does that of information management with effective site management. The inverse correlation conveys that, a value increase in the predictor variable causes a value decrease in the dependent variable and vice versa.

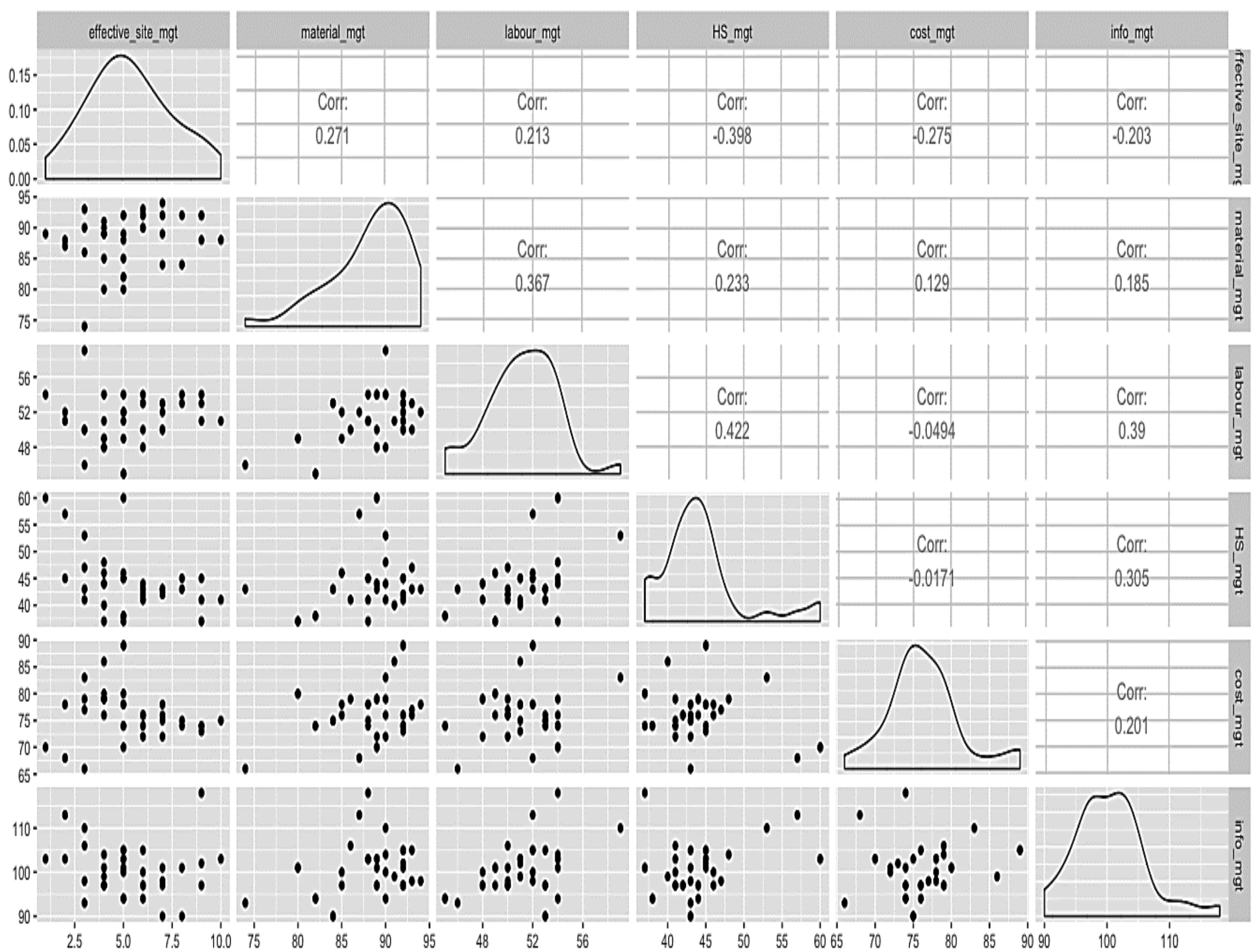

Figure 4.16: Summary of the Descriptive Statistics and Spearman’s Rank Correlations

Source: Author, 2018

b) Binary Logistic Regression

The hypothesis tested was;

Null hypothesis:

Site management factors do not contribute significantly to the model or the critical site factors have no significant relationship with effective construction site management. The null hypothesis can be statistically stated as;

$$\mathbf{H_0: \beta_1 = \beta_2 = \ldots\ldots \beta_n = 0} \qquad \textbf{(6)}$$

Alternative hypothesis:

At least one of the site management factors contributes significantly to the model or at least one of the critical site factors has a significant relationship with effective construction site management. This can be statistically stated as;

$$\mathbf{H_a: \text{At least one } \beta_n \neq 0} \qquad \textbf{(7)}$$

The initial analysis of the logistic regression equation (Model 1) included the site management factors as per the questionnaire and the equation is as shown below;

$$\mathbf{esmgt = \beta matmgt + \beta lmgt + \beta cmgt + \beta hsmgt + \beta imgt + \beta_0 + \underline{\varepsilon}_i} \qquad \textbf{(8)}$$

Whereby;

esmgt	=	Effective Site Management
matmgt	=	Material Management
lmgt	=	Labour Management
cmgt	=	Cost Management
hsmgt	=	Health & Safety Management
imgt	=	Information Management

The initial equation did not provide an overall good fit for the data with a Hosmer Lemeshow goodness of fit test of χ^2 at d.f = 3, 19.78, p-value = 0.0002 ($p<.05$) of which implies that at $\alpha = 0.05$ the model does not fit the data.

However, during analysis it was discovered that the failure of Model 1 to fit the data was due to the exclusion of an important interaction term. This interaction term (interaction health & safety management and information management) was subsequently introduced between into the model. The following logistic regression equation (Model 2) was the final equation used for analysis and it included an interaction term between health & safety management and information management.

esmgt = βmatmgt + βlmgt + βcmgt + βhsmgt + βimgt + hsmgt : imgt + β_0+ $\underline{\varepsilon}_I$ (9)

The above equation fits the data well at $\alpha = 0.05$ with a Hosmer Lemeshow goodness of fit test of χ^2 at d.f = 3, 6.27, p-value = 0.0993 (p>.05). Table 4.6 illustrates the summary of both models.

Table 4.6: Logistic Regression Models

	Model 1				Model 2			
Variables	**β**		**SE**	**OR**	**β**		**SE**	**OR**
Constant	-5.5720	***	1.0377	0.00	-7.6841	***	1.3062	0.00
Material Management	2.3950	***	0.6000	10.97	3.8882	***	0.8133	48.82
Labor Management	1.9623	***	0.5724	7.12	1.7734	**	0.5420	5.89
Commercial/Cost Management	2.3749	***	0.5550	10.75	3.1357	***	0.6549	23.00
Health & Safety Management	1.5750	**	0.5409	4.83	5.0092	***	1.2950	149.80
Information Management	1.6200	**	0.5363	5.05	3.1523	***	0.7430	23.39
Health & Safety Management: Information Management					-4.7638	**	1.4553	0.00
-2LL	31.89				38.70			
χ^2	63.77, df = 5, p<.05.				77.40, df = 6, p<.05.			
Nagelkerke R^2	48.16%				55.97%			
Hosmer Lemeshow test	p = 0.0002				p = 0.0993			

Notes:
**=p<.05; **=p<.01, ***=p<.001.*
SE = Standard Error
OR = Odds Ratio

Source: Author, 2018

From the final logistic regression equation (Model 2), the following interpretation was made regarding the site factors relationship with the outcome variable (Effective site management). The overall significance of the logistic model given by the Likelihood Ratio Test (LRT) was χ^2 at d.f = 6, 77.40, p-value = 0.0000 ($p<.05$) implying that at $\alpha = 0.05$ the site factors contribute significantly to the prediction of effective site management. We therefore concluded that there was a statistical significance for all factors under equation analysis. This was further confirmed using Wald tests that are used to evaluate the significance of a single coefficient in a model. The Wald tests for each of the coefficients in the model were as highlighted in table 4.7.

Table 4.7: The Wald Tests

Coefficients	χ^2	**d.f**	**Wald**		**95% confidence interval**	
Constant	34.6	1	-5.88	***	-10.2443	-5.1240
Material Management	22.9	1	4.78	***	2.2941	5.4823
Labor Management	10.7	1	3.27	***	0.7110	2.8357
Cost Management	22.9	1	4.79	**	1.8522	4.4193
Health & Safety Management	15.0	1	3.87	***	2.4711	7.5474
Information Management	18.0	1	4.24	***	1.6961	4.6085
Health & Safety Management: Information Management	10.7	1	-3.27	**	-7.6160	-1.9115

Notes: **=p<.05; **=p<.01, ***=p<.001*.
Source: Author, 2018

<u>Regression Output Interpretation</u>

The logistic regression coefficients gave the amount of log odds increase in effective site management when site factors are properly managed. The log odds were converted to odds ratio for easy interpretation. Odds ratio represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. The following is an interpretation of the odds ratio for each of the site factors.

1. ***Material management***

Odds of effective site management are 48.82 times higher when there is proper material management compared to poor material management holding all other factors constant.

2. ***Labour management***

Odds of effective site management are 5.89 times higher when there is proper labour management compared to poor labour management holding all other factors constant.

3. ***Cost management***

Odds of effective site management are 23.01 times higher when there is proper cost management compared to poor cost management holding all other factors constant.

4. ***Health and safety management***

Odds of effective site management are 149.80 times higher when there is proper health and safety management as opposed to poor health and safety management holding all other factors constant.

5. ***Information management***

Odds of effective site management are 23.39 times higher when there is proper information management compared to poor information management holding all other factors constant.

6. ***Health and safety management and information management interaction term***

As a result of model 1 failing, the researcher decided to test for confounding in the model. A relationship between the health & safety and information management variables was discovered but it failed to meet the criteria for confounding. An interaction term (interaction between health & safety management and information management) was subsequently introduced into the model.

Interaction occurs when the presence of one factor modifies the effect of another i.e. the effect of one factor differs according to which category of the other factor is being examined. It is an important property of a relationship between two factors and their influence on an outcome variable. When interaction is present, variation between stratum-specific rate ratios is not simply due to chance (as may be in confounding). For instance, there's significant difference in the stratum specific rate ratios beyond what is explainable by chance/random error.

The coefficient for the interaction was the difference in the effect of health & safety management between levels of poor management and proper management of information. So, the effect of moving from poor management level to proper management of health & safety management when we have proper information management is 9.773 (5.0092 - -4.7638) whereas, the effect of moving from poor management level to proper management level of health & safety management when we have poor information management is 5.0092. This means that, the log odds of project performance increases by almost twice when we have proper information management and proper health & safety management in a project in comparison to when you have poor information management and proper health & safety management.

7. ***Intercept***

The intercept (constant) represented the logit of probability of effective site management if all the site factors were absent. Therefore, the coefficient for the intercept represented a decrease in the log odds of effective site management by -7.6841. The Constant is statistically significant since it shows the situation where the factors that predict performance are not present.

4.3.3 Objective 3: To formulate a framework for effective construction site management.

a) **Respondents' Views on the Emerging Trends and Developments in Site Management**

The last part of the questionnaire used for this study sought to elicit information on the emerging trends and developments in site management through an open-ended question. Some of the emerging views were as follows:-

i. That there is need for site managers to embrace project management softwares such as the oracle prime projects cloud service, teamwork projects, BIM 360 and Procore.

ii. That the use of webinars should be encouraged instead of having the project team to come to site for meetings.

iii. That construction project managers should incorporate BIM in project management to make work easier and more efficient. Softwares that enhance collaboration can be utilized. For example, Revit

iv. That site managers should adopt mobile technology. This enables new information to be filled immediately, instead of at the end of the work day.

v. That the use of cloud technology for information management should be encouraged. Hence, installation of Wi-Fi on sites to enable access of cloud information

vi. Use of inventory management software such as clearly inventory.

vii. That construction project managers should incorporate 4D modelling in visualizing the project status. This is made possible by software such as Navisworks.

viii. That site managers should champion for tool-tracking barcode technology. The Equipment module in Autodesk BIM 360 Field has the ability to track physical objects.

ix. Application of sensor-based technology in construction sites as an improvement to safety management. For example, use of RFID.

x. Use of drones to supervise construction sites by taking high resolution photos of the work progress. This keeps project managers constantly informed on the progress of their projects as the drones make repeated flights.

xi. Use of a payment management system to eliminate the disjointed, manual and paper-laden processes.

The theme that stood out from the respondent's views is basically the utilization of modern site management technologies. The interaction of the theme with the critical site factors can be linked to effective site management as illustrated in figure 4.17

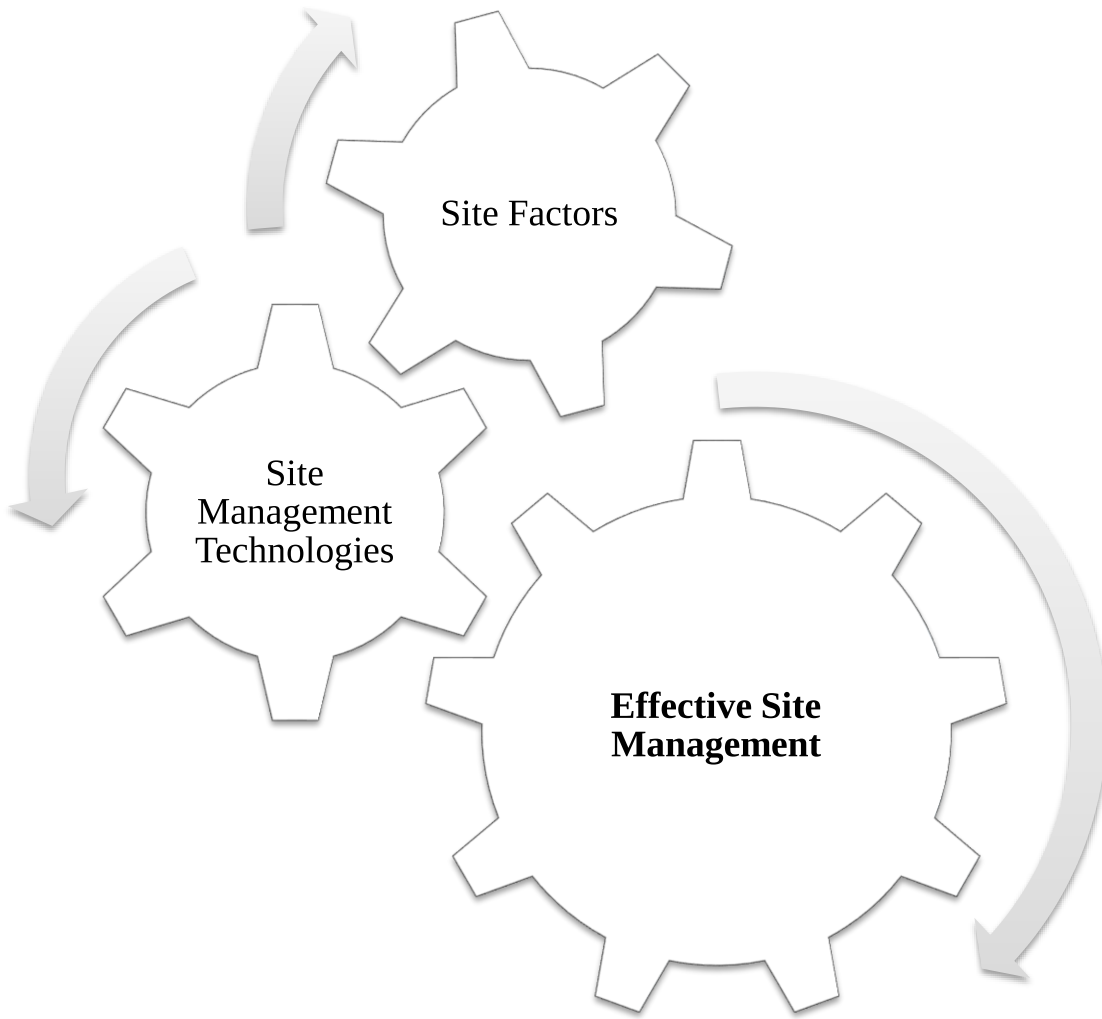

Figure 4.17: Linking modern technologies with site management

Source: Author, 2018

b) Proposed Framework for Construction Site Management.

The information obtained from the field regarding modern site management technologies is utilized to formulate a framework that can link the site factors with effective site management. This section therefore highlights the components of the site management framework and it begins by showing the framework architecture as illustrated by figure 4.18.

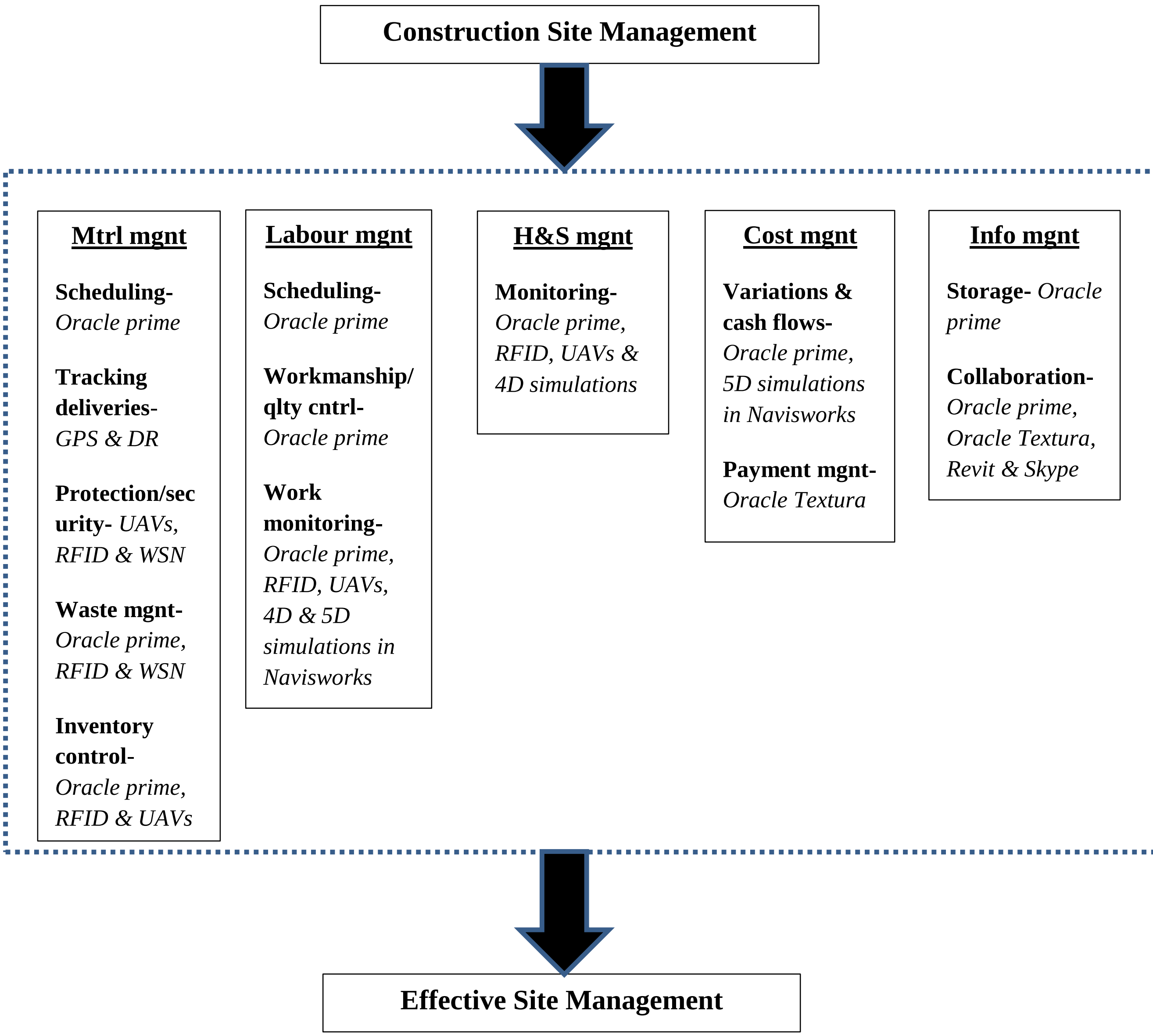

Figure 4.18: Construction Site Management Framework Architecture

Source: Author, 2018

The site factors with the associated technologies are discussed more thoroughly in the subsequent paragraphs.

a) Material Management

The construction project manager can prepare a schedule for materials using Oracle Prime Projects. Oracle Prime Projects is a cloud-based solution that enables construction firms to streamline jobsite processes and it puts the most up-to-date and actionable information at the fingertips of decision-makers in the field. By providing a graphical analysis of resources, Oracle Prime Projects helps project teams to manage resources in a dynamic environment (ORACLE, 2017). Using the analysis page for a project, the project manager can identify resources that are over-allocated or under-allocated and take action to realign and balance the resources.

Tracking of deliveries is made possible through use of global positioning system (GPS) and dead reckoning (DR) technologies. According to Fadiya (2012), use of GPS alone suffers from signal masking and multipath error in dense urban areas, hence a combination of the two technologies (GPS & DR). DR provides location tracking functionality during the outage of GPS by measuring the distance from where GPS becomes unavailable to where GPS is restored based on the speed of the vehicle during the outage and the time of outage (Fadiya, 2012).

In addition to the traditional methods of protecting materials against theft (fencing and use of security guards) and bad weather (building sheds), technologies such as radio frequency identification (RFID), wireless sensors network system (WSN) and unmanned aerial vehicles (UAVs) or what is commonly referred to as drones can be utilized. Using RFID technology, materials can be tagged allowing the construction project manager to see actual products moving on site, view where they were located and receive alerts if anything is not on site when expected or is located in the wrong place. Fadiya (2012) points out that, a wireless sensors network system can help protect materials from damage by real-time temperature measurement of humidity sensitive materials. Drones can be used to monitor and track workers on site by making repeated flights. This ensures maximum productivity and also controls theft of materials.

Construction activities can generate an enormous amount of waste and materials waste has been recognized as a major problem in the construction industry (Kasim et al, 2005). With the right scheduling technology (Oracle Prime Projects) ordering and supplier's error due to inaccurate data can be minimized. Damage due to vandalism and material misplacement on site can be addressed using RFID technology whereas damage of materials due to temperature and humidity is catered by use of a wireless sensors network system.

Inefficient inventory can cause materials running out and delay of construction process (Fadiya, 2012). A construction project manager can leverage RFID technology to view which items are being stored or installed as construction takes place. Drones can be mounted with the right computing tools to carry out volumetric measurements (useful for monitoring stockpiles of costly resources like sand and gravel). Oracle Prime Projects enables users to track resource assignment and proactively perform resource levelling.

b) Labour management

According to Muir (2005) people are a construction organization's greatest resource. Planning and scheduling of labour can be done using Oracle Prime Projects. The cloud solution has the capability of breaking down activities into smaller tasks with role requirements. This enables field workers to decide the best way to execute their work with maximum efficiency and minimal waste (ORACLE, 2017).

While walking the jobsite, construction project managers can use Oracle Prime's area recognition and robust markup tools to create issues directly on a drawing and know exactly where the issue occurred. The project manager can take photos and attach documents for reference and also monitor issue progress. When an issue is resolved, those performing the actions can update the record, snap photos to show completed work and send updates immediately to the project manager.

Interactive Gantt charts in Oracle Prime Projects allows construction project managers to communicate a more accurate and complete graphical representation of a project's schedule in real time. Root causes of delays and incomplete work are easily identifiable while using Oracle Prime Projects as the project team enters/ logs in the reasons for missed commitments for incomplete tasks. Use of drones to supervise construction sites by taking high resolution photos and video footage of the work progress keeps project managers constantly informed on the progress of their projects without having to make regular trips on site. By utilizing RFID technology, construction project managers can capture the identity of each worker entering or leaving a site by means of tags attached to hardhats. 4D simulations using Navisworks software can be embraced for visualized planning (Chau *et al*, 2004).

c) Health and Safety Management

According to Muiruri and Mulinge (2014) construction sites are considered risky with frequent and high accident rates and ill-health problems to workers, practitioners and end user. Inspections and safety reporting are constants at the jobsite but remain highly manual processes (ORACLE, 2017). Oracle Prime Projects cloud service enables users to centralize and automate management of these vital, yet resource-consuming requirements - from scheduling inspections, tracking commissioning steps and managing safety issues to closing out the punch list. The Oracle Prime risk management capabilities provides the necessary tools that develops risk-response plans where post-response scenarios are compared with pre-response results. Additionally, schedules can be linked with risk data to produce histogram curves (Monte Carlo analysis) showing expected time and cost outcomes and the probability of achieving each one.

RFID technology can be used to monitor health and safety on construction sites as it provides information of all workers and their location. Thus, in the event of an emergency, supervisors would know, in real time, who is where for safe evacuation. RFID tags can be mounted onto hardhats of site operatives and anchors fixed in static locations to serve as reference points. The tags help to alert construction workers by vibrating and/or emitting a specific sound when they are exposed to a particular danger. Drones are capable of close-up surveillance of even the tallest and most inaccessible structures and can help site managers to ensure that all work is carried out in compliance with even the most stringent health and safety regulations (Parsons, 2017). Drones can be mounted with survey equipment that can exactly recreate a digital 3D representation of a site, allowing construction teams to preempt health and safety complications and come up with workarounds ahead of time. In addition to health and safety monitoring, 4D simulations using Navisworks software can be used to manage site space for safe operations.

d) Cost management

Many disputes have been documented as a result of poor cost management and administration (Oloo, 2015). Oracle Prime Projects Cloud Service allows project managers to utilize a spreadsheet-like interface to capture budget, perform forecast analysis and predict impending expenses to help reduce the chance of going over budget. Extensive "what if" scenario modeling tools in Oracle Prime, can be used to evaluate and arrive at an optimum portfolio mix for capital plans (ORACLE, 2017). Social features in the cloud service, including discussions and share functionality, enable users to review files, communicate changes and have greater context for more informed decision-making. 5D simulations using Navisworks software can be embraced to visualize the project status (Wong *et al*, 2014).

The need for a payment management system that eliminates the disjointed, manual and paper-laden processes cannot be over emphasized. Oracle Textura Payment Management Cloud Service brings payment process participants, documents and data together in one shared online platform, enabling true collaboration among the many payment stakeholders on construction projects. The solution offers electronic payments to stakeholders eliminating the need to cut and deliver paper checks, providing additional cost and time savings and reducing payment delays. The Oracle Textura Payment Management Cloud Service offers optional early payment to contractors and subcontractors. Oracle has partnered with the financial services company Greensill Capital to promote the technology. Contractors and subcontractors can elect to be paid ahead of normal payment timing in exchange for a fee based on the approved claim amount hence, addressing the cash flow and working capital challenges arising from the industry’s long and inconsistent payment waiting times. In addition, the Oracle solution automates notifications and payment holds for compliance deficiencies, preventing inappropriate disbursement of funds (ORACLE, 2016).

e) Information Management

According to Chen and Kamara (2007), construction personnel on construction sites should capture or retrieve information at the point where they are and at the time when they need it. Oracle Prime mobile app for both iOS and Android enables the project manager to key in new information immediately in the field, instead of at the end of the work day. Therefore, this ability to digitize information and streamline processes ensures that field teams are working with the most accurate and up-to-date project data. The document exchange capability in Oracle Prime Projects Cloud Service provides a robust way for the project team to collaborate. Automated workflows and email notifications keep the team informed about the project progress. Oracle Prime eliminates the obstacles of paper work on the jobsite by enabling project managers and field teams to create and manage project documents in the cloud.

The collaboration tab in Revit software can be used by the project team members to co-author models using the Building Information Modeling (BIM) process. This gives the team members faster access to the most current models thus, improving the flow of communication. Instead of having the project team to come to site for meetings, Skype for business application has been recommended as a convenient and inexpensive way to communicate. The application has the capability to share screens, take snapshots, send and receive files, make conference calls and leave voice mails. Oracle Textura Payment Management Cloud Service enables users to sign and exchange documents electronically. With a single central database, automated notifications alert users to needed actions, including informing contractors and subcontractors when invoice revisions are needed or compliance materials must be updated (ORACLE, 2016).

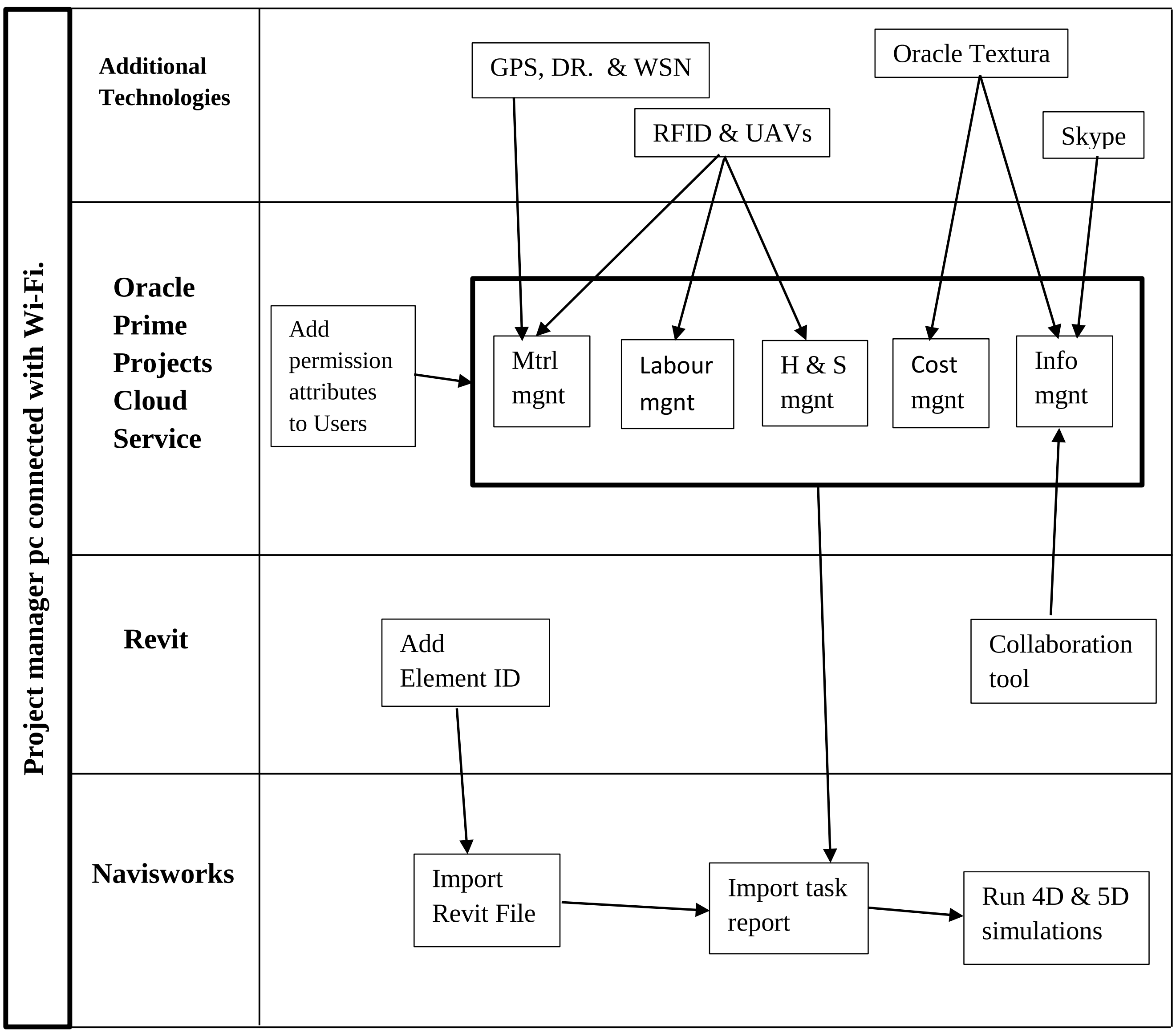

Figure 4.19: Integration of Modern Technologies in Site Management

Source: Author, 2018

4.4 Conclusion

The construction project managers gave a positive response in the research by answering the questionnaires to their best of knowledge. The findings indicated that, health and safety management emerged as the top most factor among those under equation analysis. The results further informed that, there is no well-defined site management system in the Kenyan construction industry and most sites tend to use a combination of technologies/ tools/techniques that complement each other in execution of projects. Finally, the respondents indicated the need of a site management framework hence, the proposed framework in Fig. 4.19 was suggested. The next chapter summarizes the study, draws conclusions, makes recommendations and suggests area(s) for further research.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In the light of the study objectives, this study presents the summary of the study findings, conclusions and addition to knowledge**,** recommendations and future research areas.

5.2 Summary of the Research Findings

In addressing the research objectives, the following was a summary of the findings;

Objective number 1 was to describe the level of effectiveness in construction site management and its explanatory variables. The levels in site management can be deduced from the range, mean and standard deviation summarized in table 5.1

Table 5.1: Levels in construction site management

Variable	Mean	Std. Deviation	Min	Max
Material Management	88.14	4.45	74	94
Labour Management	55.11	2.85	45	59
Health & Safety Management	44.25	5.59	37	60
Cost Management	76.44	4.98	66	89
Information Management	100.44	5.84	90	118
Effective site Management	5.33	2.16	1	10

Source: Author, 2017

Objective number 2 was to establish the relationship between effective construction site management and its explanatory variables. In regard to effective site management, it was found out that, material and labour management had positive correlations while cost, information, health and safety had inverse correlations. The findings also indicates that, the odds for effective site management are 48.82, 5.89, 23.01, 23.39 & 149.80 times higher when there is proper material, labour, cost, information and health & safety management respectively as compared to poor management of the critical site factors holding all other factors constant.

Objective number 3 was to formulate a framework for effective construction site management. The study formulated a site management framework as illustrated in Fig. 4.19 that will aid construction project managers achieve control over the flow of basic resources (personnel, finance and materials) and processes, enhance eased information exchange and increase customer and stakeholder satisfaction. The proposed framework is informed by the data collected from the field.

5.3 Conclusions

The results indicated that, the site factors under equation analysis contribute significantly to the prediction of effective construction site management. The logistic regression output gave the amount of log odds increase in effective construction site management when site management factors are properly managed. The log odds were converted to odds ratio for easy interpretation. To manage materials, labour, cost, information, health and safety effectively, a site management framework was formulated to help construction project managers discharge their duties.

5.3.1 Addition to Knowledge

The study has taken some steps to show that construction projects need more systematic management than they generally receive. The most significant contribution to knowledge is the development of a site management framework that will assist construction project managers to address site constrains more effectively.

This study's findings are also a valuable resource and reference in academia in the teaching and understanding of construction site management (material management, labour management, health and safety management, cost management and information management).

5.4 Recommendations

Based on the findings of this research discussed in chapter four and the main conclusion listed above, the following recommendation in table 5.1 are hereby made with the view of addressing the site factors in a broader and more practical context.

Table 5.2: Recommendations to Improve Site Management

ID	**Findings**	**Recommendations**
1	Proper material management with the odds of 48.82 for effective construction site management	➢ Use of Oracle prime in scheduling ➢ Tracking deliveries done by GPS & DR ➢ Protection from theft and bad weather done using UAVs, RFID & WSN ➢ Waste management catered with Oracle prime, RFID & WSN ➢ Inventory control done by Oracle prime, RFID & UAVs
2	Proper labour management with the odds of 5.89 for effective construction site management	✓ Use of Oracle prime in scheduling, quality control and work monitoring. ✓ Use of RFID, UAVs & 4D simulations to complement Oracle prime in tracking work progress
3	Proper health & safety management with the odds of 149.80 for effective construction site management	➢ A health & safety officer with a diploma as the minimum educational qualification. ➢ Use of Oracle prime, RFID & UAVs to monitor site activities ➢ 4D simulations using Navisworks software to manage site space for safe operations.
4	Proper cost management with the odds of 23.01 for effective construction site management	✓ Variations & cash flows to be managed using Oracle prime Projects cloud service. ✓ 5D simulations using Navisworks software to visualize the project status. ✓ Payment management done using Oracle Textura cloud service

5	Proper information management with the odds of 23.39 for effective construction site management	➢ Use of Oracle prime Projects to store information in the cloud. ➢ Collaboration can be enhanced through use of Oracle prime, Oracle Textura, Revit & Skype

Source: Author, 2018

5.5 Areas for further research

This study recognized from its findings, areas of concern and importance to construction site management that could not be studied appropriately in the course of this work, hence are worthy for further study.

i. Since this study addressed the subject of site management in building construction projects, it would be interesting to study the subject of site management in civil construction projects and compare the results.

ii. Future studies are required to look into the operation and maintenance stage of the project life cycle as this study only concentrated on the construction phase.

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APPENDICES

Appendix I: Questionnaire Cover Letter

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
SCHOOL OF ARCHITECTURE AND BUILDING SCIENCES (SABS)
DEPARTMENT OF CONSTRUCTION MANAGEMENT

September, 2017.

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

I am a Master of Science student in the above addressed institution conducting a research on ***"An Investigation into the Effectiveness of Construction Site Management in Nairobi County''***. The research is for meeting the requirement for a master degree in construction project management at the Jomo Kenyatta University of Agriculture and Technology. The research aims to develop a site management framework that will aid construction project managers in handling site factors in a broader and more practical context.

This questionnaire is purely for academic purposes and the information shall be kept confidential. Kindly fill the questionnaire as per the instructions within two weeks. If you would like to contact the developer of this questionnaire, do not hesitate to use the contacts provided herein.

Thanking you in anticipation of your cooperation.

Sincerely yours,

Nyabioge M Bonface
(Reg No. AB343-3446/2015)
MSc (Construction Project Management) Candidate
(Email: nyabiogebonface@gmail.com) (Tel No: +254711383214)

Appendix II: Questionnaire for the Construction Project Manager

SECTION 1: DEMOGRAPHIC DATA

Kindly put a tick **(**√**)** in the box next to the selected response.

1) Kindly indicate your contractor's registration category

☐ NCA4 (100m -200m) ☐ NCA3 (200m-3000m) ☐ NCA2 (300m -500m)

☐ NCA1 (Unlimited contract value) ☐ others (specify) _

2) Kindly indicate highest level of educational qualification attained

☐ Certificate ☐ Diploma ☐ Bachelor's degree ☐ Masters

☐ Others (specify) _

3) Kindly indicate your educational specialization

☐ Construction Management ☐ Architecture ☐ Civil Engineering

☐ Quantity surveying ☐ other (specify) _

4) Please indicate how long you have worked in the construction industry?

☐ Less than 5years ☐ 5-10years ☐ 10-15years ☐ over 15years

SECTION 2: SITE FACTORS

A: Material Management

1) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** please indicate how you prepare material schedules

S/N	**Scheduling of Materials**	**5**	**4**	**3**	**2**	**1**
1	Expert judgement (Just ordering without preparing the schedules)					
2	Excel					
3	MS Project					
4	Primavera P6					
5	PMWeb					
6	ProContractorMX CPM					
7	Other (specify)					

2) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** kindly indicate how you track deliveries

S/N	**Tracking Deliveries**	**5**	**4**	**3**	**2**	**1**
1	Phone calls					
2	Text messages (normal phone texts and whatsapp)					
3	Global Positioning System (GPS)					
4	Geographical Information System (GIS)					
5	Other (specify)					

3) By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** please indicate the method used in protecting materials from theft and bad weather in your projects.

S/N	**Protection/Security**	**5**	**4**	**3**	**2**	**1**
1	Fencing (theft)					
2	Security guard (theft)					
3	Security dogs (theft)					

4	CCTV cameras (theft)					
5	Bar-code system (theft)					
6	Wireless Sensor Network System (theft and bad weather)					
7	Radio frequency identification system (theft and bad weather)					
	Other (specify)					

4) Please rate the following sources of waste according to the degree of their contribution to construction material waste (**5 being extreme contribution and 1 being no contribution**).

S/N	**Sources of Waste**	**Contribution Rate**				
		Extreme	Great	Moderate	Little	None
		5	**4**	**3**	**2**	**1**
1	Procurement (ordering and supplier's error due to inaccurate data)					
2	Design (Changes and contract docs. errors)					
3	Material handling (transportation, off-loading, on-site distribution, inappropriate storage)					
4	Operation (Tradesperson's errors & equipment malfunction)					
5	Weather (Damage due to temperature and humidity)					
6	Security (Damage due to vandalism)					
7	Material misplacement on site					
8	Residual (Off-cuts for req. length and packaging)					
	Other (specify)					

5) Please rank each of the following inventory control strategies in order of their importance on your projects.

Rank Scale: 5-Very Important; 4-Important; 3-Fairly Important; 2-Least Important; 1-Not Important

S/N	Inventory Control Strategies	5	4	3	2	1
1	Just-In-Time delivery					
2	Use of a construction consolidation centre (a warehouse for storing large quantities of materials until call-off from the site)					
3	Use of on-site logistics specialists (a separate team for materials handling, traffic management, off-loading, storage and distribution)					
4	Use of inventory management optimization software systems (specify) _________________________________.					
5	Economic order quantity (Ordering when supplies reach a specific quantity)					
7	Demand smoothing					
	Other (specify)					

B: Labour Management

1) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** which method/tools do you employ in planning and scheduling labour?

S/N	Methods/tools for planning & scheduling labour	5	4	3	2	1
1	Expert judgement					
2	Excel					
3	MS Project					
4	Primavera P6					
	Other (specify)					

2) What is your level of agreement or disagreement on the causes of poor workmanship/quality?

Rank Scale: 5-Strongly agree, 4-Agree, 3-Neutral, 2-Disagree, 1-strongly Disagree

S/N	**Causes of poor workmanship/quality.**	**5**	**4**	**3**	**2**	**1**
1	Poor supervision by consultants					
2	Defect materials					
3	Coordination challenges between main and sub-contractors					
4	Contract management challenges					
5	Changes in specifications					
	Other (specify)					

3) By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** which techniques/tools are used in tracking work progress in your project?

S/N	**Work monitoring techniques**	**5**	**4**	**3**	**2**	**1**
1	Taking photos and videos					
2	Daily reports					
3	Gantt charts (planned vs. baseline)					
4	Progress curves (also known as S-curves)					
5	Workers position tracking (GPS)					
6	Checklists					
7	4D simulation (specify software used) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _					
	other (specify)					

C: Health and Safety Management

1) Please rank each of the following factors affecting the site health and safety in order of their importance.

Rank Scale: 5-Very Important; 4-Important; 3-Fairly Important; 2-Least Important; 1-Not Important

S/N	Challenges in management of health and safety	5	4	3	2	1
1	Inadequate personal and protective equipment					
2	Inadequate welfare facilities					
3	unawareness of health and safety matters among the workers					
4	Difficulty in controlling hazardous materials and equipment on-site					
5	Difficulty in ensuring proper arrangement and collection of waste materials on-site					
6	Close proximity of individuals to operation of large plant and machinery					
7	Workplace becoming over-crowded					
8	Lack of equipped first aid kits on the construction sites					
9	Lack of top management support in the management of health and safety in construction sites					
	Other (specify)					

2) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** please indicate how you monitor health and safety in your projects

S/N	Monitoring Health and Safety on Site	5	4	3	2	1
1	Regular inspections (identify hazards and assess the remedial action necessary)					
2	Checklist systems					
3	Safety tours					

4	Use of tags & anchors (Tags mounted onto helmets and moving objects vibrate when exposed to a particular danger)					
5	Use of 4D simulation software to manage site space for safe operations (specify software used) _ _ _ _ _ _ _ _ _ _ _ _ _					
	Other (specify)					

D: Cost Management

1) By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** how frequently do you encounter the following causes of variations in your projects?

S/N	**Causes of Variations**	**5**	**4**	**3**	**2**	**1**
1	Change in design by consultant					
2	Errors and omissions in design					
3	Conflict between contract documents					
4	Technology changes					
5	Lack of communication between contracting parties					
6	Change in specifications by consultant/client					
7	Change of plans or scope by client					
8	Change of schedule by client					
9	Client’s financial problems					
10	Lack of contractor’s involvement in design					
11	Unavailability of materials and equipment					
12	Contractor’s financial difficulties					
13	Contractor’s poor procurement process					
14	Complex design and technology					
15	Defective workmanship					
	Other (specify)					

2) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** please indicate how you handle variations in your project

S/N	Variation Management	5	4	3	2	1
1	Communicating changes					
2	Keeping everything documented					
3	Adjustments to budgets and projections					
4	Monitoring contractor behavior					
5	Freezing of design (i.e. no changes after final design)					
6	Knowledge-based decision support system (KBDSS) developed in MS Excel					
	Other (specify)					

3) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** kindly select how you manage cash flows in your project

S/N	Cash Flow Management	5	4	3	2	1
1	Through expert judgement					
2	QuickBooks					
3	Excel spreadsheet					
4	Cushion (a cash flow mgnt tool used to visualize schedule, measure income and track expenses)					
5	Pulse (a multi-platform application used to track income & expenses, monitor cash flow & generate reports)					
6	Sage 200 construction software					
	Other (specify)					

E: Information Management

1) By ranking from 5-Very Important; 4-Important; 3-Fairly Important; 2-Least Important; 1-Not Important, which information sets are critical in your projects

S/N	Information Sets in a Project	5	4	3	2	1
1	Design documents including drawings and specifications					
2	Budgets					
3	Work breakdown structures					
4	Technical documents					
5	Commercial documents					
6	Contracts and regulatory documents					
7	Quality assurance processes/documents					
8	Inspection records					
9	Equipment lists					
10	Punch list					
11	Schedules					
12	Vendor documents					
13	Purchase order documentation					
14	Chronological files of project correspondence and memorandum					
	Other (specify)					

2) By ranking from **5 (extremely frequent), 4 (very frequent), 3 (moderately frequent), 2 (slightly frequent) to 1 (least frequent),** kindly indicate how information is stored in your project

S/N	Storage of Information	5	4	3	2	1
1	Manual filing system					
2	Cloud					
3	Hard drive (including the project management software in the hard drives)					
4	Flask disk					
5	CDs/DVDs					
	Other (specify)					

3) By ranking from **5 (Always), 4 (Often), 3 (Sometimes), 2 (Seldom), to 1 (Never),** please indicate how information is distributed to project stakeholders.

S/N	Information Distribution	5	4	3	2	1
1	Project meetings					
2	Hard-copy document distribution					
3	Phone calls					
4	Text messages					
5	Email					
6	Video and web conferencing					
7	Shared-access electronic databases					
	Other (specify)					

SECTION 3: EFFECTIVE SITE MANAGEMENT

Kindly rate the effectiveness of site management in your project under the following factors in a scale of 1-10

S/N	Effective Site Management	Poor			Fair		Good		Excellent		
		1	2	3	4	5	6	7	8	9	10
1	Meeting the cost projections										
2	Meeting the time schedules										
3	Meeting the quality demands										
4	Meeting the health & safety targets										

SECTION 4: VIEWS ON THE EMERGING TRENDS AND DEVELOPMENTS IN SITE MANAGEMENT.

Please suggest in your opinion the emerging trends and developments that you think will aid construction project managers in managing the site.

____

____

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____

"THANK YOU FOR COMPLETING THIS QUESTIONNAIRE"

Appendix III: Research Authorization Letter from NACOSTI

NATIONAL COMMISSION FORSCIENCE, TECHNOLOGY ANDINNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website:www.nacosti.go.ke
Whenreplying pleasequote

9th Floor, Utalii House
Uhuru Highway
P.O.Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/36446/18183**

Date: **3rd August, 2017**

Bonface Maturi Nyabioge
Jomo Kenyatta University of
Agriculture and Technology
P.O. Box 62000-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Construction site management and its influence on project implementation in Nairobi County,"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for the period ending **3rd August, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.

Appendix IV: Research Permit

THIS IS TO CERTIFY THAT:
MR. BONFACE MATURI NYABIOGE
of JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, 17572-100 Nairobi ,has been permitted to conduct research in *Nairobi County*

on the topic: *CONSTRUCTION SITE MANAGEMENT AND ITS INFLUENCE ON PROJECT IMPLEMENTATION IN NAIROBI COUNTY*

for the period ending:
3rd August,2018

....
Applicant's Signature

Permit No : NACOSTI/P/17/36446/18183
Date Of Issue : 3rd August,2017
Fee Recieved :Ksh 1000

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 15256

CONDITIONS: see back page

Appendix V: List of Registered Ongoing Construction Projects by NCA

	PROJECT NAME	COUNTY	CONSTITUENCY	MAIN CONTRACTOR	PROJECT VALUE (KSH)
1	Commercial Development	Nairobi	Westlands	Seyani Brothers Ltd	3,830,000,000.00
2	Office Development	Nairobi	Westlands	Twiga Construction Ltd	250,068,804.00
3	Office Development	Nairobi	Westlands	Team Construction Ltd	321,522,450.00
4	Commercial Development	Nairobi	Westlands	Wadia Construction Co Ltd	400,000,000.00
5	Office Development	Nairobi	Westlands	Maxhari Construction Ltd	160,954,691.62
6	Commercial Development	Nairobi	Westlands	Kingsley Construction Co Ltd	101,500,000.00
7	Office Development	Nairobi	Westlands	Sentrim Contracts Ltd	1,020,000,000.00
8	Commercial Development	Nairobi	Westlands	Parbat Siyani Construction Ltd	1,035,000,000.00
9	Commercial Development	Nairobi	Westlands	Rosolo Building Co Ltd	380,408,432.20
10	Commercial Development	Nairobi	Westlands	Tridev Builders Co Ltd	284,000,000.00
11	Office Development	Nairobi	Westlands	Vishak Builders	850,533,438.00
12	Office Development	Nairobi	Westlands	Esteel Construction Ltd	805,000,000.00
13	Office Development	Nairobi	Westlands	Zuplex Ltd	228,998,539.00
14	Office Development	Nairobi	Westlands	Jm Developers Ltd	319,302,541.88
15	Commercial Development	Nairobi	Westlands	Core Constructions Ltd	994,810,000.00
16	Hotel Development	Nairobi	Westlands	Lexis International	696,225,607.11
17	Hospital Development	Nairobi	Westlands	Parklane Construction Ltd	622,295,546.00
18	Commercial Development	Nairobi	Westlands	Appropriate Technologies	128,964,000.00
19	Commercial Development	Nairobi	Westlands	China National Aero Technology International Engineering Corporation	8,659,731,388.80
20	Commercial Development	Nairobi	Westlands	China Wu Yi Co Ltd	2,275,183,265.00
21	Building	Nairobi	Westlands	Devshibai And Sons Limited	263,744,000.00
22	Building	Nairobi	Westlands	Thomas And Piron Grands Lacs Ltd	450,168,809.45
23	Building	Nairobi	Westlands	Endeavours Construction Co Ltd	240,000,000.00
24	Building	Nairobi	Westlands	Powerful Ltd	105,000,000.00

25	Building	Nairobi	Westlands	Harree Construction Ltd	779,934,450.00
26	Building	Nairobi	Westlands	Heng Yu International Company Ltd	508,022,050.00
27	Building	Nairobi	Westlands	Mandhir Construction Co Ltd	148,345,062.34
28	Building	Nairobi	Westlands	Bendico Building & Civil Engineering Ltd	127,096,929.00
29	Building	Nairobi	Westlands	Ark Construction Ltd	1,628,345,020.84
30	Building	Nairobi	Westlands	Samar Construction Co Ltd	281,068,099.38
31	Building	Nairobi	Westlands	China Zhongzhing	351,900,782.72
32	Building	Nairobi	Westlands	Visaro Construction Co Ltd	102,376,000.00
33	Building	Nairobi	Westlands	Nirma Construction Ltd	198,500,000.00
34	Building	Nairobi	Westlands	Eagle Realty Ltd	338,825,540.00
35	Building	Nairobi	Westlands	Kabuito Contractors Ltd	419,499,575.00
36	Building	Nairobi	Westlands	Pinnie Agency Ltd	463,563,755.00
37	Building	Nairobi	Westlands	Laxmanbhai Construction Ltd	4,196,267,118.40
38	Building	Nairobi	Westlands	Canaan Developers Ltd	239,761,292.69
39	Building	Nairobi	Westlands	Ataro General Contractors Limited	181,852,132.00
40	Building	Nairobi	Westlands	Swastik Constructionltd	1,396,467,520.00
41	Building	Nairobi	Westlands	Danaff Kenya Company Limited	401,414,250.00
42	Building	Nairobi	Westlands	Rabdiya Construction Co Ltd	568,501,248.74
43	Building	Nairobi	Westlands	Hajar Services Ltd	105,000,000.00
44	Building	Nairobi	Westlands	Aggregate Construction Ltd	1,439,201,057.00
45	Building	Nairobi	Westlands	Superfit Steelcon Ltd	630,000,000.00