AN ASSESSMENT OF THE LEVEL OF ADOPTION OF INFORMATION COMMUNICATION TECHNOLOGY BY LOCAL BUILDING CONTRACTORS DURING PROJECT IMPLEMENTATION (A CASE FOR KENYA)

ELIAS NYAGA NELSON

MASTER OF SCIENCE

(Construction Project Management)

JOMO KENYATTA UNIVERSITY OF

AGRICULTURE AND TECHNOLOGY.

2016

An Assessment of the Level of Adoption of Information Communication Technology by Local Building Contractors During Project Implementation (A Case for Kenya)

Elias Nyaga Nelson

A thesis submitted in partial fulfillment for the degree of Master of Science in Construction Project Management in the Jomo Kenyatta University of Agriculture and Technology.

2016

DECLARATION

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

Signature …… Date ……

Elias Nyaga Nelson

This thesis has been submitted for examination with our approval as University supervisors.

Signature …… Date ……

Dr. Ahmad Omar Alkizim

JKUAT, Kenya

Signature …… Date ……

Dr. Kiplimo Mutai

JKUAT, Kenya

DEDICATION

To my loving wife Harriet whose constant support and encouragement continued to give me morale to continue even when the going was rough; to our children Murugi, Muthomi and Mukiri who kept me going by constantly enquiring of the progress was and still is a source of inspiration. Some of the time spent doing this work was meant to be spent with you but you understood and sacrificed that this work may be completed. I dedicate this research to you, for you are part of it.

Elias Nyaga Nelson

ACKNOWLEDGEMENT

I am very grateful to my supervisors, Dr. Ahmad Omar Alkizim and Dr. Kiplimo Mutai for their assistance, encouragement, and guidance throughout the course of this work. All the advice and constructive criticism are much appreciated and have been very helpful. I am also grateful to my classmates, lecturers and workers at JKUAT for their assistance and cooperation throughout the period of putting together this work. My special regards goes to all those who spared their time to fill my questionnaires and attend my interviews for without them this work would not have been completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEC	Architectural engineering and construction
BIM	Building information modeling
BQ	Bill of Quantities
COW	Clerk of works
ERP	Enterprise resource planning
GPS	Geographic Positioning System
ICT	Information and communication technology
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KPDA	Kenya Private Developers Association
L.A	Local authority
MS	Microsoft
NCA	National construction authority
OPM	On-Line Project Management
QS	Quantity surveyor
RFI	Request for information
RFID	Radio Frequency Identification
SPSS	Statistical Packages for social Sciences

WPMS Web Based Project Management Systems

WWW World Wide Web

ABSTRACT

In the competitive market of the construction industry, construction firms attempt to implement projects within the least cost and time, and the highest quality. One of the factors that has been established to affect these parameters is the utilization of ICT. Many ICT platforms have been developed to help in execution of projects. Kenyan construction firms have attempted to utilize several of them; however, the level to which this has been achieved in the Kenyan context is not clear. This research explored the opportunities that exist and the level of adoption of ICT in Kenya. This was achieved by first exploring how construction industries in developed countries have adopted ICT in their construction project performance as a basis for ICT potential. A thorough study was carried out through literature review which established that there are varieties of ICT platforms available for use by Kenyan building contractors during construction project implementation and the main ones include. Personal Digital Assistant (PDA), Pocket PCs, Desk top PCs, PDA- based mobile computing system, Laptops, RFID-based(Radio frequency identification), Smart phone application, Telematics digital work bench, iPhone –based "construction equipment finder", Mobile collaboration tool and Mobile phone- based graphical user interface. Eighty construction firms were then selected mainly in class NCA1 and NCA2 through sampling. Questionnaires were distributed to different professionals, supervisors and workers engaged by firm owners and who are directly involved with these projects. The responses were analyzed and a narrative interpretation developed which established that there is low level of ICT adoption especially in the area of cost control, site security, planning and scheduling. Factors hindering higher levels of adoption were also established and the main ones are rapid changes in ICT technologies, high cost of employing ICT professionals and high cost of employing ICT professionals in that order. A secondary questionnaire was developed whose analyzed results were used to develop a model that can be used to increase levels of ICT adoption by Kenyan building contractors during project implementation. The study recommended that Construction firms should be motivated by the direct benefits of ICT and draw deliberate policies that provide some proportion

of their internal budget for ICT investments and that financial institutions can assist building contractors in Kenya to finance their ICT investment by offering flexible credit facilities to firms seeking to invest in ICT. Construction client may support contractors upon request, to procure ICT facilities for their contracts as a means to support efficiency and collaboration on their projects. This will be deducted on installments from their progress payments. ICT skill acquisition should also be incorporated in construction courses as a supplement to technical knowledge and expertise in various fields of construction study. There should also be a closer cooperation between ICT technology developers and contractors to train professional and also develop ICT systems that will address the specific operational needs of Kenyan contractors. Construction customers/clients should also take into account the contractors ICT technological capabilities as a criterion for selection. Clients could often mandate the use of specific ICT technologies on their project, for instance, tendering on-line, specifying project control technologies such as scheduling tools, cost control systems, and communication systems such as email and project webs. This could boost the potential for competitive advantage through the use of ICT technology in the building firms and to an extent compel construction firms to work towards higher ICT adoption to remain competitive and relevant

Keywords: Construction Industry, Construction Projects, ICT, Kenya

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The construction industry is the means through which physical development is achieved, and is a main driver of the national economy. The more resources, engineering, labor, materials, equipment, capital, and market exchange are provided from within the national economy, the higher the factor of the extent of self-reliance. The increasing complexity of infrastructure projects and the environment within which they are constructed place greater demand on construction managers to deliver projects on time, within the planned budget and with high quality (Enshassi *et al.,* 2003).

Construction projects require fluent communication and information exchange between on-site inspectors and schedulers in charge of progress control. Unnecessary project delays and rework are often caused by missing or outdated information. Easily available, accurate and up-to-date information on project status can improve work efficiency and quality. Information and communication technology acts well to bridge this gap. (Tsai, 2009).

In my view the level of this adoption and the areas requiring intensity of adoption in the construction industry is little known and this makes it difficult for the operators to know which areas to target in the adoption for best results. a project is termed successfully performed if it passes four success test criteria i.e. the time criterion – completed on time; the cost or money criterion – completed within budget; the effectiveness criterion – completed in accordance with the original set performance and quality standards; and client's satisfaction criterion – accepted by the intended users or clients whether the client is internal or from outside the organization.

The above success criteria call for successful project implementation by the utilization of proven management techniques of planning, organizing, directing and control. The issues on life cycle management, time management, conflict resolution and management, networking, contracts management, project choice and project quality are the key factors that contribute to project success. Effective project choice, for example, which results in a good project selection, greatly improves the probability of project success especially when the project is executed in accordance with project management implementation guidelines.

In the recent past however a new dimension has emerged that has a high likely hood of having an impact on Construction Project success that is a shift from the traditional factors that has prevailed over the years and that is the application of information and communication technology.

Information and communication technology is defined as a collective reference to the integration of computing technology and information processing and comprises a wide range of technical approaches to a variety of problems in construction industry (El-Ghandour & Al-Hussein, 2004)

ICT can also be defined as the application of decision support tools, which uses electronic machines and programs for processing, storage, analysis, control, transfer and presentation of construction information data during the whole life cycle of a construction project (El-Ghandour & Al-Hussein, 2004)

ICT development has influenced construction industry in the recent decades. New technologies have enabled construction organizations to process and store their information easily and huge amount of data can be transferred quickly. A variety of technology-based approaches have been recently proposed to improve the monitoring of construction materials (Tsai, 2009).

Calculations are possible in little time and with high accuracy. Communication technology has provided fast communication tools for construction firms and the time and costs have been saved by emerging of new ICT tools.

The construction industry is faced with the ongoing challenge of changing and improving current work practices in order to become more client-orientated; more competitive as well as productive through adoption of ICT as an integral part of the construction process (Weippert *et al*., 2003).

Today large building and construction companies use ICT to the same extent as companies in other industries in order to co-ordinate and manage their internal information flows (Molnár *et al.*, 2007). However, in construction projects the use of ICT for intra- and inter-organizational coordination and information exchange in the planning-, design- and production processes has been limited even if it is claimed to be a recognized potential (Wikforss & Löfgren, 2007). Among the explanations for the limited adoption and use of ICT are: fragmentation of the industry and lack of integration between design and production process (Dainty *et al.,* 2006)

There are many different disciplines with discipline-specific software applications that are required to build and maintain a building or a network. For example, in the case of a building, disciplines involved include land developers, architects, heating and ventilation specialists, plumbers, telephone companies and utilities, and road departments of local governments to name a few. The software applications they use include architectural design, structural engineering, civil engineering, land development, geospatial, and surveying applications. Traditionally each discipline has been isolated from the other and each has maintained its own island of technology or silo of design and engineering information.

Disciplines such as architecture, structural engineering, construction, civil engineering, and GIS are classic information silos. Each maintains its own information island

comprised of design applications and data. This has created a nightmare for operations and maintenance, emergency planners and responders, urban planners, and others who require seamless access to urban terrain including building interiors and exteriors, roads and highways, and above ground and underground utilities. The biggest challenge is not typically data, because the data that would help these folks already exists because much if it is created when buildings and infrastructure were designed. The biggest challenge is that islands of information and technology make it difficult to integrate existing data in a seamless view. For example emergency responders need immediate and seamless access to information about the building where an emergency is occurring, including interior, surrounding buildings and access roads, and telecommunications and utilities, aerial as well as underground. At the present time they would need to have been trained in many applications from a multitude of vendors to be able to access all of the different design and geospatial files that would help them deal with an emergency.

By drawing on the rich body of literature on organizational and managerial aspects of ICT, the crucial point of departure is to understand adoption and use of ICT as an emergent change process embedded in an organizational and societal context (Kling, 1980; Markus & Robey, 1988; Orlikowski, 1992). In order to analyze the processual and emergent nature of ICT adoption and use, the interrelationships between contextual elements, actors' frames of reference and the role of the ICT itself need to be analyzed (Constantinides & Barrett, 2006).

Mechanization of intellectual work by means of computers started in the 1960s (Grierson, 1998). Computers are now widely used for automating and supporting various tasks in construction. Increasingly, computers are also used for supporting and automating the information flows that integrate these tasks. However, as yet no real computer-integrated construction has evolved (Laitinen, 1998).

Much effort has been spent to improve the efficiency and quality of construction projects with the help of information and communication technologies. These technologies

support traditional tasks, ease communications, speed up processes, and manage information. Unfortunately, the construction industry remains behind other industries and is still relatively in the early stages of adapting to these technologies (Klinc *et al*., 2010).

Even though the utilization of information and communication technologies in the preconstruction planning process has made great advances through the use of systems such as Building Information Modeling (BIM), the use of information and communication technologies in on-site information management has been limited. Part of the lower productivity on construction sites can partly be explained by the fact that information and communication needs in the construction phase are not adequately met.

On-site information management is critical because it is the fundamental element of successful project management (Tsai, 2009). In order to stay within schedule and budget limits, construction projects require fluent communication and information exchange between on-site inspectors and schedulers in charge of progress control. Unnecessary project delays and rework are often caused by missing or outdated information. Easily available, accurate and up-to-date information on project status can improve work efficiency and quality.

Internet acts as an important data base and communication channel. Electronic archive can reduce paper works and improve accuracy and accessibility. However construction organizations face numerous barriers during ICT implementation in their companies.

This research aims to assess the level of adoption and opportunities that the Kenyan construction industry has in ICT adoption.

1.2 Statement of the problem

High competition has forced contractors to bid projects with minimum profits in order to stay in business, this coupled with the high level of expectation from more informed

clients and building end users and the increasing complexity of construction projects and turbulent economic environment within which they are operated has led to a great need to obtain a thorough understanding of the underlying conditions that contribute to success in performance of these projects and the exact impact any factors are likely to have on that success in order to make informed decisions on how to mitigate them.

Over the years the construction industry has been accused of being slow in adopting newer methods of performing the various activities that constitute construction one of them being the incorporation of information and communication technology. The general manufacturing industry is said to have embraced information and communication technology to a large extent and this has many times been explained as the reason behind the development of more reliable efficient products.

The construction industry is faced with the ongoing challenge of changing and improving current work practices in order to become more client-orientated; more competitive as well as productive through adoption of ICT as an integral part of the construction process (Weippert *et al*., 2003).

From literature review there is no clear evidence that enough has been done to establish the level of adoption of ICT by Kenyan contractors during project implementation in order to establish the gaps which if addressed would increase the level of project success

1.3 Purpose of the study

The purpose of this study is to assist Kenyan building contractors to identify gaps that may exist in the methods used in project performance with a view to improve it especially through ICT adoption for it has been proven in other sectors that its adoption is an effective tool in enhancing performance.

One argument for adopting ICT is that a company can remain, or be more competitive, by for example reducing costs, or improving the perceived quality of goods and services

delivered. In this context, application of ICT in the construction industry helps to address these areas and hence improve competitiveness. Understanding the level of the ICT adoption is key to understanding gaps that if addressed would make construction firms more competitive.

1.4 significance of the study

It is now widely accepted that ICT has had important and positive implications for both productivity and output growth. Yet most of that literature is concerned with the developed economies. The extent of the ICT adoption in developing countries remains largely unknown and this makes it difficult for the operators to know which areas to target in the adoption for best results. This study is significant for it aims to assess the level of adoption and opportunities that the Kenyan construction industry has in ICT adoption in order to be able to take full advantage of the ICT benefits and hence improve project success

The contribution of this research work is also significant for it contributes to the general body of knowledge Since it sets out to investigate the level of adoption and utilization of ICT within the construction industry, its findings are aimed at providing a deeper understanding of issues associated with the adoption and utilization of ICT in a developing country such as kenya. In order words, the research contributes to knowledge by developing an evidence based report that describes the level of ICT adoption in Kenyan construction industry.

1.5 Objectives of the study

The objectives of this study are:

i. To identify areas of potential application of information and communication technology (ICT) in construction project performance by building contractors

ii. To examine the extent of adoption of ICT by Kenyan local contractors in the construction project performance
iii. To determine the significant factors hindering Kenyan building contractors from achieving higher levels of adoption of ICT during construction project performance
iv. To develop a model for adoption of ICT by Kenyan building contractors

1.6 Research questions

To be able to address the above research objectives, four research questions were addressed which are:

1. What ICT platforms exist for application by Kenyan building contractors?
2. To what extent is ICT being used by Kenyan building contractors during construction project implementation?
3. What factors hinder Kenyan building contractors from achieving higher levels of ICT adoption during construction project performance?
4. Which model can the Kenyan building contractors adopt in order to increase the level of adoption of ICT during construction project implementation?

1.7 Scope of the study

Because this study is an assessment of the level of adoption of information and communication technology on construction project performance and since the term construction project performance is a broad definition its definition shall be taken to mean the sum total of construction project activities within the constraints of time, cost and quality only.

These factors of Time, cost and quality are also influenced by different factors with each factor having different rates of occurrences and their impact on the final project success also varies.

To try to follow the serial impacts and counter impacts would render the study too complex for any meaningful and usable conclusions to be drawn Therefore, single line effect has been used which has its own limitations when it comes to total causal analysis.

1.8 Limitation of the study

However, research work is not usually without its problems and limitations encountered in the process of its preparation.

There is also the limitation of unavailability of adequate documented information in the field of the study, and the reluctance of some stakeholders in the construction industry to provide information related to causal factors due to the fact that construction firms make their money by doing construction work and not filling questionnaires and therefore any activity outside their core business would naturally be met with reluctance.

To be realistic and to be able to achieve some relatively reliable outcomes this research will focus on eighty construction projects in Nairobi County only which will be sampled using methods stated in the research methodology which in itself is a limitation for other projects outside this scope may have information that may have enriched this study.

1.9 Assumptions of the study

This study assumed that records on ICT adoption are well kept by the contractors and will be sufficiently availed when asked for and that respondents will have adequate capacity to give this information as required. It also assumed that the selected area of coverage is a fair representation of most scenarios in Kenya. To ensure validity and reliability of responses, specific questions were set in the questionnaire to establish existence of ICT capacity or existence of specific specialists to handle ICT and ICT records

1.10 Definition of terms

1.10.1 Construction Project Performance

It is the eventual completion of a project within the originally set contract period, budget and specifications.

1.10.2 Project

Is a non-routine undertaking with a definite time, budget and specifications which is temporary in nature and is undertaken to create a unique product or service. This study on its part defines project as simply as a form of investment or development which entails the injection of scarce resources and other materials including land with the aim of realizing its latent potential in form of yield or for satisfying other social or economic benefits

1.10.3 ICT adoption

Defined as an emergent change process embedded in an organizational and societal context (Kling, 1980; Markus & Robey, 1988; Orlikowski, 1992)

1.10.4 Information and communication technology

Defined as the application of decision support tools, which uses electronic machines and programs for processing, storage, analysis, control, transfer and presentation of construction information data during the whole life cycle of a construction project (El-Ghandour & Al-Hussein, 2004)

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The main aim of this chapter is to analyze several discussions by various researchers regarding the application of information and communication technology in construction projects. The first area is the background of the research themes where the issues related to the Kenyan construction industry and the need of Information and Communication Technology to address these issues, are discussed. The common challenges associated to the industry such as fragmented nature, low productivity rate, and quality, and time and cost overrun are discussed.

This chapter is important with respect to the framework as it provides the secondary data for the development of a theoretical framework. The theoretical framework was used in the research to guide the research inquiry and to develop interview questions

Today, information and communication technology (ICT) has become the driver of most operations and the construction industry has adopted in most of construction processes from information being generated, transmitted and interpreted to enabling the project to be built, maintained, reused and eventually recycled. This has totally transformed construction processes. According to Sun and Howard (2004)

The construction industry is faced with the ongoing challenge of changing and improving current work practices in order to become more client-orientated; more competitive as well as productive through adoption of ICT as an integral part of the construction process (Weippert *et al.*, 2003).

Today large building and construction companies use ICT to the same extent as companies in other industries in order to co-ordinate and manage their internal

information flows Molnár *et al*, (2007). However, in construction projects the use of ICT for intra- and inter-organizational coordination and information exchange in the planning-, design- and production processes has been limited even if it is claimed to be a recognized potential (Wikforss & Löfgren, 2007). Among the explanations for the limited adoption and use of ICT are: fragmentation of the industry and lack of integration between design and production process (Dainty *et al.,* 2006)

2.2 The background of Kenya

Kenya gained its independence from the British in 1963. It has a total land mass of 580,367 square kilometers with a Population of approximately 39 million people (Kenya bureau of statistics August, 2010.)

According to Muriithi, Petronilla and Muthoni (2014) after independence, Kenya promoted rapid economic growth through public investment, encouragement of smallholder agricultural production, and incentives for private industrial investment. Gross domestic product (GDP) grew at an annual average of 6.6% from 1963 to 1973. Agricultural production grew by 4.7% annually during the same period, stimulated by redistributing estates, diffusing new crop strains, and opening new areas to cultivation. After experiencing moderately high growth rates during the 1960s and 1970s, Kenya's economic performance during the 1980s and 1990s was far below its potential. Kenya

Muriithi, Petronilla and Muthoni (2014) also asserts that the economy grew by an annual average of only 1.5% between 1997 and 2002, which was below the population growth estimated at 2.5% per annum, leading to a decline in per capita incomes. Muriithi continues to state that the decline in economic performance was largely due to inappropriate agricultural, land, and industrial policies compounded by poor international terms of trade and governance weaknesses. Increased government intrusion into the private sector and import substitution policies made the manufacturing sector uncompetitive.

According to the Kenya economic survey 2014, the policy environment, along with tight import controls and foreign exchange controls, made the domestic environment for investment unattractive. From 1991 to 1993, Kenya had its worst economic performance since independence. Growth in GDP stagnated, and agricultural production shrank at an annual rate of 3.9%. Inflation reached a record 100% in August 1993. In the mid-1990s, the government implemented economic reform measures to stabilize the economy and restore sustainable growth, including lifting nearly all administrative controls on producer and retail prices, imports, foreign exchange, and grain marketing. In spite of the economic reform measures, the Kenyan Government's failure to meet commitments related to governance led to a stop-start relationship with the International Monetary Fund (IMF) and World Bank, both of which suspended support in 1997 and again in 2001. According to Kenya economic survey 2014, Economic growth began to recover in this period, with real GDP growth registering 2.8% in 2003, 4.3% in 2004, 5.8% in 2005, 6.1% in 2006, and 7.0% in 2007. However, the economic effects of the violence that broke out after the December 27, 2007 general election, compounded by drought and the global financial crisis, brought growth down to less than 2% in 2008. In 2009 there was modest improvement with 2.6% growth. In May 2009, the IMF Board approved a disbursement of approximately $200 million under its Exogenous Shock Facility (ESF), which is designed to provide policy support and financial assistance to low-income countries facing exogenous but temporary shocks. The ESF resources were meant to help Kenya recover from the negative impact of higher food and international fuel and fertilizer costs, and the slowdown in external demand associated with the global financial crisis. From then on the Kenyan economy has gradually been improving despite various slowdowns associated with political landscape and unfavorable agricultural climatic conditions coupled with poor fiscal policies. (Kenya economic survey, 2014)

2.3 The background of Kenyan construction industry

Construction industry in Kenya is one of the key drivers of economic growth for the last five years. The Kenyan construction industry contributes 7% to the country's GDP and employs more than one million people. According to report by Kenya National Bureau of Statistics (KNBS). Economy of Kenya grew by 4.9% in the first quarter of 2011 mainly due to improved productivity in the construction industry. The industry added KES 12.6 billion to the country's GDP in Q1 2011. Growth was also reflected in cement consumption which rose to 779.3 million tonnes up from 667.1 million tonnes consumed in Q1 2010. Rapidly expanding population has further fuelled increase in investments in the construction industry to capitalize on the demand for decent housing. Opportunities for investment are immense particularly in the manufacture and supply of construction materials and components, construction of middle and lower income housing as well as in the upgrading of informal settlements.

However, the Kenyan economy slowed down in 2012 adversely affecting the growth of the construction sector. According to Kenya National Bureau of Statistics, real estate and construction witnessed slowdown in growth compared to the same period in 2011. The construction sector only grew by 1.4% in 2011, as compared to 5.1% during the same period in 2012. However, the sector grew faster towards the end of the year as commercial banks continue to lower lending rates. − According to the Financial Stability report for 2011 released by the Central Bank of Kenya, during the year ended 31st December 2011, the real estate sector had 23, 157 loan accounts with gross loans to the sector totaling KES146.4 billion. The building and construction sector had 11, 580 loan accounts and loans of up to KES 41.2 billion.

The table 2.1 provides at a glance, a comprehensive picture of Kenya's economy in all aspects of the Building and construction industry as well as reflecting on the various trends over a three year period, the statistical analysis were carried out in 2011, from Kenya national bureau of statistics.

Table 2.1: Kenya's economy in all aspects of the Building and construction industry

	Unit	**2008**	**2009**	**2010**	**2011**
Key indicator (output)	**Ksh. (millions)**	**223,175.9**	**265,755.5**	**288,937.8**	**319,631**
Gross domestic product as an activity (at market prices)	Ksh. Mn)	80,407 36%	97,445 36.6%	109,146 47.6%	125,046 39.1%
Gross domestic product as an activity (at constant 2001 prices)		43,735 19.6%	49,270 18.5%	51,486 17.8%	53,715 16.8%
Growth rates of GDP as an industry		8.2	12.7	4.5	4.3
Sources of GDP growth, 2008-2011		16.3	14.9	2.8	3.5
Percentage contributions to GDP by activity(current prices)		3.8	4.1	4.3	4.1
Employment as an industry 2008-2011		84.8	93.4	101.3	109.0

Source*: Kenya* National Bureau of Statistics (KNBS) report August 2010

It is coming out Cleary that despite the challenges facing the building and Construction Industry, the industry is still resilient. Innovation has been cited as one of the factors hampering growth of the industry , maybe the introduction of Alternative building technology may allow contractors, developers and home owners a new bliss, alternative building technology promises significant reduction in cost which, significantly reduces the cost of capital. Adoption of Alternative building technology may see the market grow significantly because a lot of financial challenges related to constructing building will be overcome.

2.4 Challenges Facing the Construction Industry Worldwide

The construction industry is highly competitive, and firms must continually improve their productivity to remain competitive. This challenge of continual productivity improvement has reached crisis proportions in the US where statistics published by US Bureau of Labor Statistics show that the productivity of the construction industry has actually declined in the last 40 years while non-farm productivity has increased by over 200% in the same period as indicated by figure 2.1

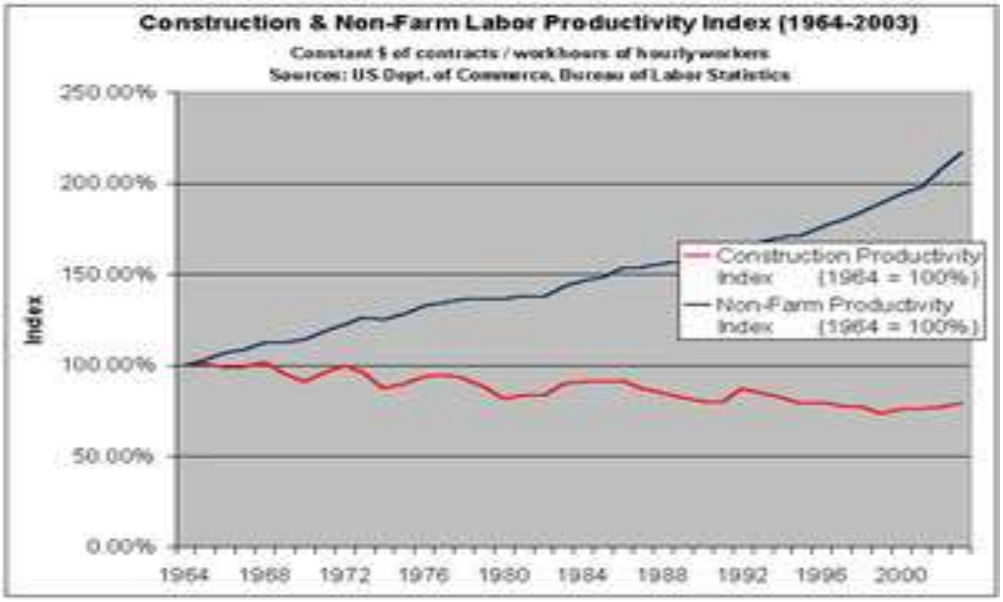


Figure 2.1: Comparison between |Construction and non –farm Labor Productivity

Source: US Bureau of Labor Statistics report 2013

The traditional facility lifecycle involves planning, designing, construction, operations and maintenance, and decommissioning. Facilities include buildings, highways and roads, network infrastructure such as telecommunications, power, water, wastewater, and gas networks. There are many different disciplines with discipline-specific software applications that are required to build and maintain a building or a network. Large building and construction companies use ICT to the same extent as companies in other

industries in order to co-ordinate and manage their internal information flows (Molnár *et al*, 2007). However, in construction projects the use of ICT for intra- and inter-organizational coordination and information exchange in the planning-, design- and production processes has been limited even if it is claimed to be a recognized potential (Wikforss & Löfgren, 2007). Disciplines such as architecture, structural engineering, construction, civil engineering, and GIS are classic information silos. Each maintains its own information island comprised of design applications and data. This has created a nightmare for operations and maintenance, emergency planners and responders, urban planners, and others who require seamless access to urban terrain including building interiors and exteriors, roads and highways, and above ground and underground utilities. Among the explanations for the limited adoption and use of ICT are: fragmentation of the industry and lack of integration between design and production process (Dainty *et al*, 2006); a focus on solving technical problems, at the same time as the organizational context is overlooked, as well as problems of existing ICT solutions to incorporate interests of varying professional groups (Wikforss & Löfgren, 2007); which in turn is grounded in a varying set of principles, rules, knowledge domains in professional groups leading to difficulties in co-operating.

By drawing on the rich body of literature on organizational and managerial aspects of ICT, the crucial point of departure is to understand adoption and use of ICT as an emergent change process embedded in an organizational and societal context (Kling, 1980; Markus & Robey, 1988; Orlikowski, 1992). In order to analyze the processual and emergent nature of ICT adoption and use, the interrelationships between contextual elements, actors' frames of reference and the role of the ICT itself need to be analysed (Constantinides & Barrett, 2006). The biggest challenge is not typically data, because the data that would help these folks already exists because much if it is created when buildings and infrastructure were designed. The biggest challenge is that islands of information and technology make it difficult to integrate existing data in a seamless view. For example emergency responders need immediate and seamless access to information about the building where an emergency is occurring, including interior,

surrounding buildings and access roads, and telecommunications and utilities, aerial as well as underground. At the present time they would need to have been trained in many applications from a multitude of vendors to be able to access all of the different design and geospatial files that would help them deal with an emergency.

The importance of taking the organization and its context into consideration when ICT adoption and use is studied has in IS-research been recognized by for example Lucas (1975). He stated that one reason for failures of ICT implementations was a focus on the technology, whereas it was neglected that a new ICT should be integrated in an organization where people would be affected by the new technology. This view was further developed in the seminal articles by Kling (1980) and Markus and Robey (1988) who challenged the views on change, tending to overemphasize the rationality of managers directing change and the capability of ICT to create predictable changes of organizational processes. Instead they suggested that research should analyze the processual and emergent nature of ICT-mediated change. The process of ICT adoption and use can be described as social process involving a wide array of actors.

This social process is linked to intra organizational and broader contexts, so called multi-layered contexts, emerging from a series of historical, organizational and economic circumstances (Walsham, 1993). The context can be understood as broader socio-political structure in which the adoption and use unfolds, including industry characteristics, political agendas and power relations (Pettigrew, 1985). Further the context is also understood as an organization's cultural characteristics including particular formal and informal rules of behavior enacted by organizational members (Martin, 1992). When changes triggered by the adoption and use of a new ICT it is very likely that programs of action inscribed in the ICT challenge existing cultures, structures and power relations in the organization (Orlikowski, 1992; 2000).

For example, in the case of a building, disciplines involved include land developers, architects, heating and ventilation specialists, plumbers, telephone companies and

utilities, and road departments of local governments to name a few. The software applications they use include architectural design, structural engineering, civil engineering, land development, geospatial, and surveying applications. Traditionally each discipline has been isolated from the other and each has maintained its own island of technology or silo of design and engineering information.

As a concrete example, all of the world's utilities and telecommunications firms manage infrastructure in essentially the same way and are facing similar challenges. In analyzing the information flow in these organizations, the most striking problem is islands of information. The engineering group uses CAD applications, construction uses large format paper, the records or network documentation group may use GIS tools, and operations uses paper or a handheld viewer. The information flow between these groups is more often than not paper. The result is a very inefficient process characterized by data redundancy, redundant processes, and poor data quality including poor communication as may be shown in figure 2.2

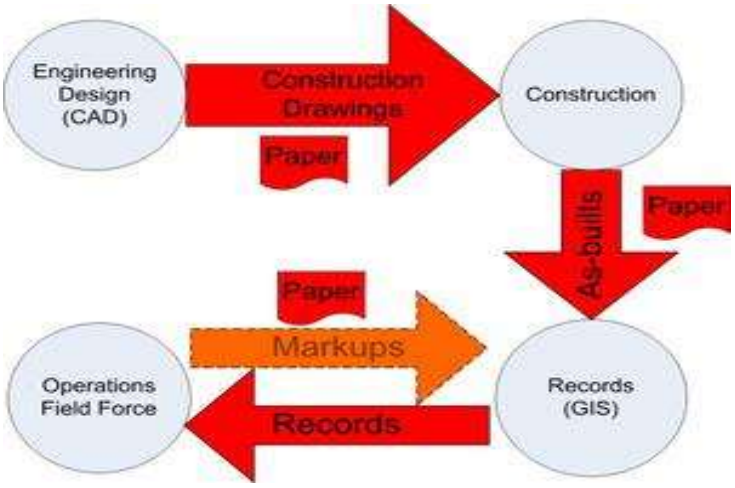


Figure 2.2: Information Islands between different Disciplines in the Construction Industry

Source: Colwell (2008)

2.5 challenges facing Kenya's construction industry

Kenya as a developing country is faced with myriad challenges especially in the building and construction sector. However, according to the statistics derived from the Kenya National Bureau of Statistics' website, it is adept to reiterate that the building and construction sector in Kenya contributes to 7% of the country's gross domestic product (GDP). Among the challenges facing the building and construction industry in the country is Capital. Dr. Laila Macharia, the chairperson (KPDA) Kenya Private Development Association restated that capital is a major challenge that most of the entrepreneurs in the construction sector encounter together with dissatisfaction as the constructors tend to settle for whatever little they have attained. She adds that in Kenya, building and construction sector has limited capacity and the corresponding gains that the contractors count on are reaped by corruption

2.6 ICT adoption in the general industry

By drawing on the rich body of literature on organizational and managerial aspects of ICT, the crucial point of departure is to understand adoption and use of ICT as an emergent change process embedded in an organizational and societal context (Kling, 1980; Markus & Robey, 1988; Orlikowski, 1992). In order to analyze the processual and emergent nature of ICT adoption and use, the interrelationships between contextual elements, actors' frames of reference and the role of the ICT itself need to be analyzed (Constantinides & Barrett, 2006).

The importance of taking the organization and its context into consideration when ICT adoption and use is studied has in IS-research been recognized by for example Lucas (1975). He stated that one reason for failures of ICT implementations was a focus on the technology, whereas it was neglected that a new ICT should be integrated in an organization where people would be affected by the new technology. This view was further developed in the seminal articles by Kling (1980) and Markus and Robey (1988)

who challenged the views on change, tending to over emphasize the rationality of managers directing change and the capability of ICT to create predictable changes of organizational processes. Instead they suggested that research should analyse the processual and emergent nature of ICT-mediated change. The process of ICT adoption and use can be described as social process involving a wide array of actors (Newman & Robey, 1992; Robey & Bourdreau, 1999). This social process is linked to intra organizational and broader contexts, so called multi-layered contexts, emerging from a series of historical, organizational and economic circumstances (Walsham, 1993). The context can be understood as broader socio-political structure in which the adoption and use unfolds, including industry characteristics, political agendas and power relations (Pettigrew, 1985). Further the context is also understood as an organization's cultural characteristics including particular formal and informal rules of behavior enacted by organizational members (Martin, 1992). When changes triggered by the adoption and use of a new ICT it is very likely that programs of action inscribed in the ICT challenge existing cultures, structures and power relations in the organization (Orlikowski, 1992; 2000).

2.7 ICT Adoption in the Construction Industry Globally

Mechanization of intellectual work by means of computers started in the 1960s (Grierson, 1998). Computers are now widely used for automating and supporting various tasks in construction. Increasingly, computers are also used for supporting and automating the information flows that integrate these tasks. However, as yet no real computer-integrated construction has evolved (Laitinen, 1998). This stems from the reality that the construction business in general involves the temporary convergence of core competencies from different players to deliver a unique product, the building. Each individual player uses his/her specific IT tools to facilitate his/her specific work objective. Consequently information sharing through IT between different players is in essence a nightmare (Kazi *et al.*, 2001).

A study in India showed that IT infrastructure at project sites and IT capability of site staff are important factors and need improvement in Indian construction industry (Ahuja, Yang & Shankar, 2009).

Also connectivity through internet is poor in remote project sites and down time is very high. Training and education of construction students and executive is important. Hard copy storage of data and documents in organizations is substantial even if electronic copies are also kept as a backup. It was found that personal meetings are still preferred by construction professionals over teleconferences and other e-meeting solutions for managing building construction projects (Ahuja, Yang & Shankar, 2009.)

Responses were collected from 152 U.S. and 31 Korean firms. It was found that; overall, the strongest interest among the responding contractors is in document and content management applications. The data indicate that the use of information technology by contractors is generally higher in Korea than in the United States. The most important barrier to the use of Web-Based IT is the reluctance by project participants to share data and information in US. Additional important barriers are needed training and high cost and little return on investment

Much effort has been spent to improve the efficiency and quality of construction projects with the help of information and communication technologies. These technologies support traditional tasks, ease communications, speed up processes, and manage information. Unfortunately, the construction industry remains behind other industries and is still relatively in the early stages of adapting to these technologies (Klinc *et al.*, 2010).

A vast amount of information is generated in all phases of a project. This information ranges from drawings produced in the design phase to different project reports prepared during the construction phase. Thus, the efficiency of information management is crucial to the construction industry and has been recognized as an important competitive

advantage by construction companies (Chen & Kamara, 2008). Even though the utilization of information and communication technologies in the preconstruction planning process has made great advances through the use of systems such as Building Information Modeling (BIM), the use of information and communication technologies in on-site information management has been limited. Part of the lower productivity on construction sites can partly be explained by the fact that information and communication needs in the construction phase are not adequately met.

On-site information management is critical because it is the fundamental element of successful project management (Tsai, 2009). In order to stay within schedule and budget limits, construction projects require fluent communication and information exchange between on-site inspectors and schedulers in charge of progress control. Unnecessary project delays and rework are often caused by missing or outdated information. Easily available, accurate and up-to-date information on project status can improve work efficiency and quality.

However, the construction industry has not found appropriate solutions for the problem of information communication and exchange on construction sites.

Traditionally, the main type of information that on-site construction personnel receive and transfer is paper-based files, which include documents such as drawings, data collection forms, correspondence, progress information and specifications (Bowden *et al.*, 2004). Coordination of activities and management of operations on a construction site raises numerous queries and requires numerous interactions between project participants, which need to be handled quickly and efficiently to avoid downtime, rework, waste, and cost overruns (Miah *et al.*, 1998).

In recent years, with rapid change in mobile technology and Internet communication, research activity in this field proliferated. Since the early 1990's, the academic and industrial sectors have been investigating the use of hand-held devices for developing

applications used in field data collection. A sample of these developments is presented here in chronological order. McCullouch and Gunn (1993) studied the possible automation of construction data collection with pen-based computers. Their study covered employee timekeeping, materials purchasing functions, and a daily report form. McCullouch (1997) also demonstrated the benefits of using pen-based computers in road maintenance operations. Nathawani *et al.* (1995) designed a PDA-based (Personal Digital Assistant) data collection application for maintenance inspection, and Repass *et al.* (2000) developed an application for a Palm handheld device that gives users access to schedule information and enables users to record schedule information electronically once they return to the office. Cox *et al.* (2002) described an application that automates the collection, recording, processing, and distribution of field inspection data relative to quality compliance using Pocket PCs. Kimoto *et al.* (2005) developed a PDA-based mobile computing system that lets construction managers record inspection reports, access drawings and specifications, check the position of structural members, and monitor progress. Wang *et al.* (2007) presented an RFID-based (Radio Frequency Identification) supply chain control system for the construction industry that allows engineers to collect data using PDAs, providing dynamic operation control and management. Dong *et al.* (2009) telematic digital workbench captures digital images of a defect with a note regarding the defect, defines the location of the defect, and sends the information to an off-site database. Irizarry and Gill's (2009) iPhone-based "Construction Equipment Finder" application finds the equipment rental location closest to the jobsite, whereas their "Be Safe" application provides access to safety-related information. Haas *et al.* (2002) conducted an extensive literature review covering a wide range of topics dealing with the implementation of mobile devices in construction, primarily on project management, schedule management, facility inspection, and field reporting applications. Haas *et al.* (2002) found that mobile devices have potential benefits in terms of time savings and improved information accuracy. However, achieving those benefits depends on a proper implementation strategy. Haas *et al.* (2002) study also showed a lack of interest in mobile devices on construction managers' part

and a lack of interest in developing applications for the construction industry compared to other industries. Since 2002, i.e, since Haas *et al*. (2002) study, various researchers started experimenting with mobile devices on the jobsite for processing CAD/BIM, inspecting field activities, monitoring progress, eliminating defects, improving quality, setting up the site layout, and locating construction

As Hore (2006) hinted, Information and Communication Technology (ICT) should support the entire construction process of construction from inception through to the operational maintenance of the building asset. This involves using ICT tools and technology to create, communicate and exchange information and data among the various participants in the project team. Again project models that supports improved co-ordination and management of information throughout the project life cycle has gained increased recognition and that, contractors among the building team can also use ICT throughout the entire process of their operations (Sarshar, 2003).

According to Harris and McCaffer (2001), the most significant impact that ICT has had on management of information resources in construction is perhaps in the area of communication.

Computers and web-based technology has offered the potential for great advances in transferring information accurately and quickly, and in some instances, approaching the goal of real time information flows according to McCaffer (2001), this has made the use of the Internet and computer-aided communication very essential for closer collaboration among construction project partners and that traditional forms of communication in organizations are carried out through face-to-face interaction; paper-based drawings, letters and graphics; through telephone calls.

According to engsbo *et al* (2007), the advantages of using electronic communication includes decrease in the cost of communication as compared to traditional means (e. g. distribution of paper copies vs. attaching a file to an email), rapid increase in the speed

of communication (e. g. time for an electronic message to arrive compared to a snail mail delivery), and the technologies involved in bringing e-communications are becoming ever more versatile (e. g. both video-conferencing and textual communication simultaneously). However, some disadvantages such as lacking interpersonal exchange and legal implications (e. g. validity of a signed paper compared to one sent by e-mail) are still issues with electronic communication.

2.8 ICT Adoption in the Construction Industry in Kenya

According to the Kenya National Bureau of Statistics, the Kenyan construction industry contributes 7% of the Gross Domestic Product (GDP).

The Kenya Private Developers Association (KPDA) asserts in the Kenya Private Developers Association report 2014 that capital is one of the main challenges faced by entrepreneurs in the construction industry together with the complacence existing among the contractors as they lean towards settling for what they have achieved instead of exploring other frontiers like ICT application in order to enhance their project performance

The KPDA report further asserts that the players in the sector have limited capacity and the benefits the construction contractors could have counted on are reaped by corruption. Innovation is not honored and merit is thrown out through the window.

Professionals in the sector have a tendency of inclining to a conservative perspective and therefore prefer working for clients with similar thinking patterns. This in turn affects the choices they make with respect to building materials, research and investments and innovation including ICT adoption

2.8.1 ICT Modelling in the Construction Industry

Researchers have highlighted the requirement to align 'Information strategy plan' supported by 'Strategic adoption of ICT' with the business strategy of the organization (Leuven & Voordijk, 2001; Retik & Langford, 2001, p.125-144). This can best be achieved through a well thought framework. A well-developed model helps in estimating cost of the new IT systems and includes cost of hardware, software and support .It also helps business managers to gain a greater understanding of the potential of ICT and helps to improve their understanding of the organization's business requirements by the IT staff, thus enhancing the efficiency of the system.

It also ensures adequate consideration of those areas where technology itself may be an underlying change agent (Purba *et al.* 1995). Consequently, it supports and shapes an organization's competitive strategy

Construction organizations have different departments or engineering groups and researchers have highlighted that departmentally isolated approaches to the technology implementation in construction organizations have often led to "islands of automation" or "functional silos" in many of the present organizations (Back & Moreau 2000). In such a scenario the users may be satisfied with their individual Information Strategy Plan.

ICT can be adopted strategically, if the organizations and industries can find ways of applying it to either improve individual activities, or alter the linkages between them to make the overall value chain or value system more efficient. Full efficiency will not be achieved through the adoption of well-designed but incompatible systems handling differing requirements and purposes of each user (McDonagh 1995).

In the construction projects, data generated at each stage of the project is utilized at all the successive stages up to the facilities management stage. Researchers have highlighted the requirement to bridge the gap between design and planning stages of projects.

Effective and seamless transfer of information between all the stages and between project team agencies requires strategic adoption of mutually compatible software, hardware and communication capabilities. It is more relevant in the present scenario, since many of the technologies today are dependent on the use and proper functioning of other technologies. For example, the potential of an expert system is limited by the breadth and accuracy of the database from which it draws information (Back & Moreau 2000).

In the context of the construction industry where inter-organization communication is important, strategic ICT adoption is required at the industry level and organizational strategies are required to be aligned with the industry wide strategy.

The project level strategies are required to be aligned with the organization level strategy of the clients and the project management agencies. Industry wide strategic ICT adoption would require the understanding, participation and support of all the concerned professions, enterprises and government agencies. Implementation of IT adoption and enabled networks and to make it possible to manage the information flows during the entire life cycle of the buildings, so that the project team members share project data instead of paper documents.

The CRC CI initiative is a research and development program initiated by Cooperative Research Center for Construction Innovation' in Australia. Its vision is to lead the Australian property and construction industry in collaboration and innovation, with the three objectives of (Brewer *et al.* 2003) enhancing the contribution of long term scientific and technological research and innovation to Australia's sustainable economic

and social development. Enhancing the collaboration between researchers, industry and government, and improving efficiency in the use of intellectual and research resources creating and commercially exploiting tools, technologies and management systems to deliver innovative and sustainable constructed assets to further the financial, environmental and social benefit to the construction industry and the community.

Under this initiative, the research projects measuring ICT adoption in the construction industry and studying factors for the effective adoption of ICT are being undertaken (Brewer *et al.* 2003).

All these initiatives are industry led initiatives undertaken to combine research and practice and aim to enhance sustained and effective adoption of ICT in the construction industry.

Rogers (1962) defines that the diffusion process occurs within a society as a group process whereas the adoption process pertains to an individual. To achieve ICT diffusion at the industry level, strategic adoption of ICT is required at the organization level and also strategic initiatives are required at the industry level.

Standardization of information transfer is very important at the national as well as international levels and can also be achieved by the industry level initiatives.

Effective adoption of ICT would be achieved if appropriate ICT tools and technologies are adopted and work processes are adapted for use of the technology.

Thus following factors are required to be considered strategically at the organization level for effective adoption of ICT:

ICT development in an organization should be business driven and should play a part in and be integral with construction activities and business processes of the organization. Thus a construction organization's 'Strategy for ICT adoption' should be aligned with its business objectives (Rogers, 1962).

2.9 Information and Ccommunication Requirements in Construction

Typically, the construction sector is considered one of the most information-dependent industries. For instance, a construction project chain may involve large numbers of skilled professionals and companies with, quite often, much repetition of activities and accumulation of paperwork. Majority of these participants require access to the regular project information at one time or another (Murray *et al.*, 2001).

This means that, timely and accurate access to information is therefore important for all project participants as it forms the basis on which decisions are made and physical progress is achieved. Currently, several construction documents such as drawings, specifications, bills of quantities, correspondence, schedules, and programmes produced on construction projects are currently exchanged on paper bases and face to face communication between practitioners in industry (Hore & West, 2005).

Admittedly, effective collaboration between all the role players during construction is not only important but also necessary for the successful completion of a construction project. With so many interested parties, effective communication and information sharing among them is vital. Not only must the formal structures and networks be examined to understand the level of information sharing that is happening on a formal basis, but the informal relationships among parties will depend on how and when information is shared and how and when information is flowing (Perreira & Soares, 2007).

2.10 Communication need in Construction

Effective communication is vital in construction due to the large number of project participants, the separation of design and construction disciplines and the geographically dispersed nature of the projects (Barrie & Paulson, 1992). Therefore, the improvement of communication in the construction industry has been a target of practitioners and researchers for many years. In order to function effectively, a construction company must have communication systems of different types to cover inter-personal, inter-departmental, and inter-organizational communications (Guevara & Boyer, 1981).

2.11 Role of ICT in the Construction process

The benefits offered by ICT include among others improved access to richer information to aid decision making, quicker information, improved information flow, greater management control and getting geographically dispersed group to work together (Peansupap, 2004).

2.12 Measure of ICT application in Construction process

An IT barometer was developed at KTH, Stockholm in 1997 by Samuelson (Samuelson 1998) to try and measure level of ICT application and targeted a representative sample of companies in the Swedish construction industry spread throughout the country and in this study the barometer has been used as a basis for areas of adoption and it covered the following areas

2.12.1 Type of Company

This includes building owners and managers, architects, engineers, contractors, materials suppliers and craftspeople, number of staff, location of offices, types of work, and position of respondent. In Denmark questions on annual turnover and the % spent on IT were added. (Samuelson, 1998)

2.12.2 Types and numbers of Computers

Proportion of usage of different operating systems, past and future change in IT investment, types of general application such as office suites, planning, technical calculations and administration. (Samuelson, 1998)

2.12.3 Soft wares

Types of software and number of licenses, applications for building and use of GIS, proportion of drawings produced with CAD, types of data structures used. (Samuelson, 1998)

2.12.4 Level of use of IT

Proportion of tasks carried out by each application, types of document transferred digitally, numbers of staff having computers and training, levels of computer competence by different types of staff. (Samuelson, 1998)

2.12.5 Communications

Use of local area and wide area networks, proportion of employees with access to communications, time spent on IT, WWW home pages and Intranets

2.12.6 Role of IT in the |Company

IT department, managers, handbook and strategy, attitudes of staff to IT, reasons for investment, changes resulting from IT use, productivity, future investment

2.12.7 ICT Barometer Results

When the ICT barometer was tested on three countries namely Denmark, Finland and Sweden, it was established that building contractors can achieve a high level of ICT adoption during contract implementation as almost equal to other players in the

construction industry such as architects, engineers and construction managers (Samuelson, 1998)

2.12.7.1 Electronic Communication and Data exchange systems

According to Harris and McCaffer (2001), the most significant impact that ICT has had on management of information resources in construction is perhaps in the area of communication.

Computers and web-based technology has offered the potential for great advances in transferring information accurately and quickly, indeed, this has made the use of the Internet and computer-aided communication very essential for closer collaboration among construction project partners.

Electronic communication (e-communication) is a system used as a means of sending or retrieving messages through computers or Internet connections. Nowadays, this includes a multitude of communication tools, ranging from simple forms such as e-mails to more complex forms, such as electronic document management (EDM) systems, enterprise resource planning (ERP) systems and project planning systems (ensgbo & Sandhu, 2007).

Other applications and interface with external parties also comes in the forms of Extranets, Electronic Data Interchange (EDI), e-commerce, electronic document management systems (EDMs) provides support for procurement and collaboration.

According to Engsbo *et al.* (2007), the advantages of using electronic communication includes decrease in the cost of communication as compared to traditional means (e. g. distribution of paper copies vs. attaching a file to an email), rapid increase in the speed of communication (e. g. time for an electronic message to arrive compared to a snail mail delivery), and the technologies involved in bringing e-communications are becoming ever more versatile (e. g. both video-conferencing and textual communication

simultaneously). However, some disadvantages such as lacking interpersonal exchange and legal implications (e. g. validity of a signed paper compared to one sent by e-mail) are still issues with electronic communication.

2.12.7.2 Project Extranets or Project Specific Web Sites

Project extranets or Project Specific Web Sites are web based applications for providing collaboration through ICT platform to perform typical project management tasks such as storing and managing project information (Becerik, 2004). It is a network that uses Internet protocols and public telecommunication system for communicating both privately and selectively with the contractor's client and business partners. Other terms and acronyms used to describe the same collaboration platform include Web Based Project Management Systems (WPMS) and On-Line Project Management (OPM) (Colwell, 2008). Project owners, designers, contractors and suppliers can share information and in so doing improving communication, coordination and collaboration. The technology may also allow for instance, contractors to securely share part of its company information resources with suppliers, subcontractors, project partners, clients or other companies (Bowden *et al.*, 2005). Typical features include document control (including version control), task automation, file and workflow tracking, electronic design review and file viewing capabilities. Typical documents include drawings, specifications, reports and schedules. Up to date information is available to everyone on the team. Portal access by contractors, subcontractors and suppliers will reduce costs through access to information (Colwell, 2008)

2.13 Theoretical Framework

While ICT technologies might help to improve information and communication in construction firms through reduction of numerous paper copies of documents and drawings, better document management and archiving and faster, cheaper and more accurate communication flows, its widespread usage is yet to fully gain grounds in the

construction industry as compared to many other sectors of the economy (Egbu & Botterill, 2002). This is largely due to the fact that the construction industry is characterized by activities which are discontinuous, dispersed, diverse and distinct. Obviously, this could make the implementation of ICT in the construction industry more difficult than other industries. This theoretical framework dwells on time tested theories that embody the findings of numerous investigations on how phenomena occur and most of it is informed by a thorough look at work done by previous researchers on ICT adoption in construction and its potential in enhancing construction project performance which clearly indicates that as project phases progress from feasibility to operation and maintenance, the level of ICT application continues to reduce as evidenced by the summary Possible ICT applications at different construction project phases on table 2.1 This in essence will imply that by the time the contractor breaks ground to commence practical construction; the ICT application is quite low and can be clearly demonstrated by the figure 2.3

2.14 Conceptual Framework

The construction project implementation arrangements currently in use in developing countries have been inherited from Western countries which have a different history, culture, collective experience and breadth of construction expertise.

These arrangements determine the documentation, procedures and practices in the industry, and specify the roles of the participants and the relationships among them, and hence the networks of power and authority. They stress formality and the following of set channels of communication. This kind of arrangement sets the people doing the actual job of construction as the lowest in the ladder. These are the people who have little formal training and therefore technology transfer or even ICT application is expected to be low which in essence imply that ICT application will continue to lower as you approach actual implementation as indicated in figure 2.3

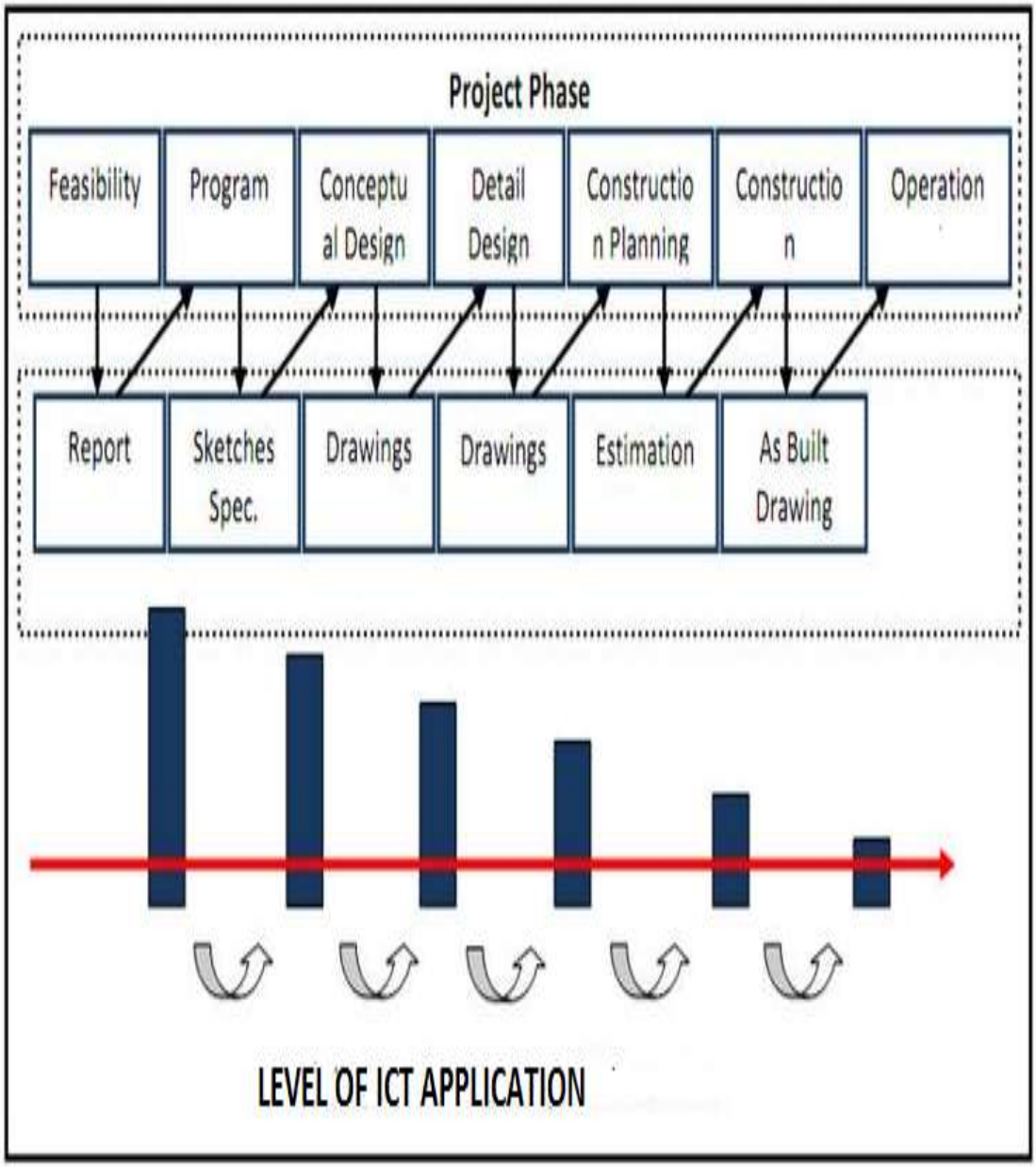


Figure 2.3: Level of ICT Application during Construction Project Implementation

Source: Haron (2013)

In each project phase stated, different researchers have documented possible ICT applications and which have been summarized in table 2.2

Table 2.2: Possible ICT Applications at different construction Project Phases

	Project phase	**Deliverable output**	**Possible ICT application**	**Information source**
1	Feasibility	Feasibility study report	Microsoft office suite Spread sheets Word processing Electronic document management software(EDMS)	Samuelsson (2002) Hore(2006)
2	Conceptual design	Drawings, sketches	Micro station MiniCAD FastCAD AutoCAD Building Information Modelling (BIM)	Howard (1998)
3	Detailed design	Drawings	Micro station ArchiCAD MiniCAD FastCAD AutoCAD Revitt Building Information Modelling (BIM) Architectural Desktop Autodesk Building Systems	Howard(1998) Ozumba And Shakantu(2008) Wang et al (2007). Hore (2006)
4	Construction planning	Work Schedules, cash flow charts	Enterprise Resource Planning (ERP)	Hore and West (2005)

	Project phase	Deliverable output	Possible ICT application	Information source
			Esti-mate Manifest Resource cost Sheet WinSmesta Buildsoft Masterbill Manifest CATOPro WinQS Snape Vector	Oladapo (2005)
5	construction	As built drawings, constructed facility	Microsoft Project Primavera Power Project, PMSystems	Colwel, 2008 Moniem, 2000
6	Operation and maintenance	Maintenance schedules	Auto-I Barcodes Radio Frequency Identification(RFI) tags optical scanners) Geographic Positioning System(GPS)	Pryor(2001) Ardagh(2007) Colwel(2008) Hore and West (2005), Sørensen *et al* (2008)

Source: Summarized extract from literature review

The main objective of this study is to establish this level of adoption as it seeks to document the information and communication technology application in construction projects and the views of different stake holders on this application, and also determining the challenges facing increased adoption of this technology then develop a working model that can be applied by the Kenyan local contractors

Subsequently, a number of surveys similar to or modified versions of the IT- Barometer have been carried out in different countries. Examples includes samuelson (1998), samuelson (2000) and samuelson (2002) in Canada; Sarshar and Isikdag (2003) in Turkey; Goh (2005) in Singapore; Oladapo (2005) in Nigeria Samuelson (2008) in Sweden and Finland. Other surveys which concentrated more on a specific part of the construction industry have also been performed. For instance, Arif and Karam (2001) measured Architectural Practices and Their Use of IT in the Western Cape Province, South Africa

The IT barometer survey shows that the infrastructure of IT is well developed with access to computers, the Internet, e-mail and mobile phones for a large number of employees in construction firms .In the focus areas there has been a clear increase of the use of IT in the last few years. The possibility of making use of IT to support new ways of working and to make the process more efficient is also increasing.

The ICT barometer results indicated that most players in the construction industry apply ICT mainly in the following areas

1. General administration.
2. Design.
3. Project management.
4. Site management.
5. Purchase/ Selling.

The result of applying ICT being recorded as

1. Work done more quickly.
2. Better quality of work.
3. Faster access to information.
4. Better financial control.
5. Simpler/faster access to common information.

6. Better communications.
7. Possibility of sharing information.
8. Easier to handle large amounts of data
9. Satisfying customers.

In addition the ICT barometer results also indicated that during the actual construction project implementation application of ICT helps in the following areas

1. Improve efficiency of work
2. Reduce the risk of errors and rework by ensuring that everyone in the project team is working with the most current drawings and other documents
3. Save time in the query (request for information, RFI) and approval process, by allowing the design team to mark up and comment on drawings online
4. Eliminate the risk of losing important files, by maintaining all current and past versions in one central location
5. Improve team communication by enabling team members to raise and respond to queries in a structured way
6. Maintain a complete log of all communications for tracking purposes (audit trail Facility)
7. Provide clients and other participants with a view of the project as it is built; as Some software have incorporated virtual reality models to denote the status of a Project at any point in time (a snap shot view of a project)
8. Provide a collaborative environment whereby the diverse participants can Perform online collaboration via the web
9. The real exchange of information takes place via other, informal channels, where Other forms of information and communication technology such as e-mail, SMS

Messaging and mobile telephones, which enable direct contacts between projects members in network-like cooperation (Çaglar, 2005; Peansupap, 2004).

From literature review and the IT barometer results, ten broad categories of IT hardware clearly identified for use by building contractors and their specific application during construction project implementation were identified in table 2.3

Table 2.3: Possible ICT Hardware and their Applications during Construction Project Performance

	ICT platform	Application	Information source
1	Personal Digital Assistant(PDA)	data collection application for maintenance inspection	Repass *et al.* (2000)
2	Pocket PCs	automates the collection, recording, processing, and distribution of field inspection data relative to quality compliance	Cox *et al*. (2002)
3	Desk top PCs	provide an essential way to manage and enhance communication EDMS allow precise delivery of document and information to the right person in time and can reduce waiting time within any decision making process Teleconferencing to enhance communication between parties involved in construction projects.	(Bjork, 2002) (Peansupap, 2004).
4	PDA-based mobile computing system	record inspection reports, access drawings and specifications, check the position of structural members, and monitor progress	Kimoto *et al*. (2005)
	Laptops	provide an essential way to manage and enhance communication, also allow precise delivery of document and information to the right person in time and can reduce waiting time within any decision making process	Bjork (2002)

	ICT platform	Application	Information source
		Teleconferencing to enhance communication between parties involved in construction projects.	
5	RFID-based (Radio Frequency Identification)	providing dynamic operation control and management	Wang *et al.* (2007)
6	Smartphone application	Enables recording and storing data at the work site	Dainty *et al.* (2006)
7	Telematics digital workbench	captures digital images of a defect with a note regarding the defect, defines the location of the defect, and sends the information to an off-site database	Dong *et al.* (2009)
8	iPhone-based "Construction Equipment Finder"	application finds the equipment rental location closest to the jobsite	Irizarry and Gill's (2009)
9	Mobile collaboration tool	functions as a phone, fax, e-mail, and canvas for drawings, and demonstrated that the application was efficient in dealing with dynamic changes to site drawings and approvals at remote construction sites	McCullouch, B. (1997)
10	Mobile phone-based graphical user interface	inspecting field activities, monitoring progress, eliminating defects, improving quality, setting up the site layout, and locating construction	Haas *et al.* (2002)

Source: Summarized extract from literature review

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter describes the procedures and processes that were used to conduct the study. It includes the type of research design employed, types of data, sources of data, target population, sampling methods, methods of collecting data, instruments of recording data, and methods of analyzing data in order to achieve the desired results.

3.2 Research design

This research is organized in four phases; the first one is the proposal for identifying and defining the problems and establishment of the objectives of the study and development of research plan. The second phase of the research includes literature review where literatures of ICT adoption were reviewed. The third phase of the research include the design of data gathering tools and administration which involved the following steps

1. Questionnaire design
2. Sampling technique/Sample Selection
3. Determination of sample size
4. Pilot Questionnaire
5. Main Questionnaire administration
6. Secondary Questionnaire administration

Questionnaires were distributed to different professionals, supervisors and workers engaged by firm owners and who are directly involved with these projects and who in my opinion have relevant information to this study. The fourth phase was to analyze this data to establish the level of ICT adoption by local contractors in Kenya. After analysis, levels of ICT adoption and factors hindering higher levels of adoption were established.

A secondary questionnaire was developed whose analysed results were used to develop a model that can be used to increase levels of ICT adoption by contractors during project implementation.

The aspects that were considered during the research include:

3.3 Nature and sources of data

The type of data used was qualitative and quantitative.

The sources of data used were:

- Primary data sources
- Secondary data sources

3.3.1 Primary data sources

Primary data is data that was collected from the field .Persons with experience in the construction industry and engaged by contractors were interviewed by the use of questionnaires so as to provide information on the study.

3.3.2 Secondary data sources

Secondary data refers to data collected from, text books, journals, newspapers, magazines and internet.

Secondary data for this research was used to find out what has already been done on the study subject and also find out the current position of the study subject.

3.3.3 Extracts from literature review

To satisfy the first objective the research embarked on a detailed literature review and classification of information obtained from it to establish potential platforms of information and communication technology during construction performance especially in developed countries in order to develop a framework for its potential application in Kenya. This was done by employing a customized version of the IT – Barometer survey developed at KTH, Stockholm Sweden in autumn 1997. This initiative was aimed at creating a method to perform a survey for measuring the use of IT in the construction industry (Samuelson, 1998).

These ICT platforms and their applications obtained from the literature review and the IT barometer were used in the questionnaire design

Classical levels have also been extracted from the samuelson IT barometer, Samuelson (1998) and further modified to be used to determine extent of ICT adoption by Kenyan building contractors during construction project implementation and the level ranking done as indicated below

Very high level of adoption **4.50 ≤ mean score ≤ 5.00**

High level of adoption **3.50 ≤ mean score ≤ 4.50**

Moderate level of adoption **2.50 ≤ mean score ≤ 3.50**

Low level of adoption **1.50 ≤ mean score ≤ 2.50**

No adoption **1.00 ≤ mean score ≤ 1.50**

Instances to establish percentage of users of specific ICT applications within organizations is not in the scope of this research.

3.4 The Questionnaire

Based upon a review of current literature and research objectives, structured questionnaire was prepared and self-administered to the various respondents. Almost all the questionnaires have closed-ended questions to ensure consistency of respondent feedback. Because it is not entirely possible to design all questions as closed-ended, some questions were left open-ended.

For the purpose of the study, the questions were grouped under four main sections.

1) General Information;
2) ICT Infrastructure;
3) Extent of ICT usage and;
4) Factors hindering ICT usage.

The first section, "General Information" dealt with the demographics with respect to firm's financial class, years of experience in construction and the professional background of respondents. This aspect was deemed necessary in order to ascertain the reliability and credibility of the data provided.

The second section "construction stage" asked more specific questions in relation to objective one of this study. This aspect covered firms ICT hardware platforms, software in use, operating systems, communication and network platforms and ICT workforce and Extent of ICT usage and in detail inquires about the level of ICT usage by the firms. This is in relation to proportion of tasks and activities carried out digitally or by the computer and usage ICT tools and applications within the construction firms.

Five point type Likert ordinal scale was employed to measure level of usage by responding firms from "Never" to "Always" that is, 1= Never, 2= Not always, 3=Average, 4= Quite always, 5= Always. The third and the final section "Factors hindering ICT usage" asked responding firms to score identified reasons hindering the use of ICT by contractors in the construction industry. Based on the criteria identified,

the Likert rating scale was again adopted to extract the appropriate ratings as per their influence as a reason hindering use of ICT by contractors in Kenya. Once more, the five point likert ordinal scale (1-5) was used where

1= Very weak, 2= Weak, 3= Average, 4= Strong, 5= Very strong.

3.5 Target Population and Sampling Methods

This study targets all local contractors, registered with the National Construction Authority in all categories but those in financial classes NCA 1 and NCA 2 were selected as the most suitable for the study by virtue of their financial class and nature of works for they have the capacity and requisite personnel to invest and use ICT for their operations. For purposes of clarity, national construction authority classifies contractors from NCA1 to NCA8 with NCA1 being the highest and NCA8 being the lowest

A list of all registered local contractors in class NCA1 and NCA2 and based in Nairobi as at February 2015 was obtained from the National Construction Authority register and found to contain 559 in Class NCA1, and 361 in NCA2

Nairobi County is the largest city in Kenya and hosts a large number of reputed building contractors ranging from small to large who are involved in construction projects that range from simple to complex and therefore sampling Nairobi County gives a representative result that most likely represent same scenarios in many parts of Kenya.

It was observed that some contractors have registered themselves in more than one class and although registered in different classes they are under the same management with the same management styles and therefore are by nature expected to have almost the same level of ICT adoption. Any firm registered in more than one class was counted as one to get a wider spectrum of the firms. Those registered for classes that are not directly related to construction were also left out because the ICT platforms identified for this study are construction related and the register was hence adjusted.

3.6 The Sample Size

The most ideal approach in determining sample size of any study is to use the entire population as the sample but the cost considerations and practicability make this impossible especially for large populations.

Israel (1992) cited several approaches used in determining the sample size for a study.

These, include using a census for small populations, imitating a sample size of similar studies, using published tables, and lastly applying formulas to calculate a sample size.

Most of the above methods of determining sample size presume that the attributes being measured are distributed normally or nearly so. However, use of formulas in determining sample size are the most preferred by most researchers (Singh & Masuku, 2012).

Most of these commonly used formulas include Kish's formula, Cohen's formula, Cochran's formula, Yamane's formula and Rao's formula with Kish's formula being the most preferred (Singh & Masuku, 2012).

The population of contractors registered within Nairobi and their specific classes obtained from the National Construction Authority register in classes NCA1 and NCA2 totaled to 920. Kish formula was then used to determine the sample size as shown below

$$n = n^1/(1+n^1/N) \quad - \quad \text{(Kish, 1965)}$$

where n = Sample size

$n^1 = S^2/V^2$

N = Population size

V = Standard error of sampling distribution = 0.05

$S^2 = P(1-P) = (0.5)(0.5) = 0.25$

P = the proportion of standard deviation in the population element (total error = 0.1 at 95% confidence level.

From the kish (1965) formula above, sample size is 80.65 which was rounded to 80

From the adjusted register number in NCA1 is 227 while number in NCA2 is 192 which is a ratio of 1.2:1 which implies that 43 will be picked from NCA1 and 37 from NCA2 to make a total of 80 which is also tabulated I n table 3.1

Table 3.1: Sample Frame of the Contractors

CONTRACTOR CLASS	QUESTIONNAIRES ALLOTTED
NCA 1	43
NCA 2	37
TOTAL	**80**

Source: Field data

Simple random sampling was then used to pick the 80 to be used for study

The final list for the study was made by combining the 43 from NCA1 and the 37from NCA2 to make a total of 80

Telephone contacts were sought from the directory to locate their geographical locations in Nairobi for the administration of questionnaires

3.7 Pilot Questionnaire

Before the main survey was undertaken, a draft version of the questionnaire was piloted in three construction companies in Nairobi. This pilot study was intended to elicit responses that would help to test the wording of the questionnaire, identify ambiguous questions, and also provide an indication of the time to complete the questionnaire.

Some of the comments and suggested amendments from the pilot study respondents were used to amend the questionnaire prior to its final distribution.

3.8 Main Questionnaire Administration

The administration of the main questionnaire was carried out in Nairobi between 4th July to mid-august 2015. A total of 80 questionnaires were administered to the contractors in financial classes NCA1 and NCA2, of which 60 were returned constituting 75% response rate. Table 3.2 shows the breakdown of the number of response received from the selected organizations. From the survey results twenty nine (29) questionnaires out of 60 were received from NCA1 contractors and thirty one (31) out of 60 received from NCA2 contractors constituting 67.4% and 83.7% responses respectively as indicated on table 3.2. It is noticeable that, the gap between the responses from the two groups of contractors in the survey was not generally wide.

Table 3.2: Details of Response Rate

CONTRACROR CLASS	QUESTIONNAIRES ADMINISTERED	QUESTIONNAIRES RECEIVED	RESPONSE RATE (%)
NCA 1	43	29	67.4
NCA 2	37	31	83.7
TOTAL	**80**	**60**	**75**

Source: Field data

3.9 Data Analysis Tools

Data collected from the questionnaires were analyzed using three methods. These include Frequency Analysis, Mean/average Index Score and One Sample T-test In order to generate the result. SPSS and excel software were mainly used for data analysis

3.10 Frequency Analysis

Descriptive statistical methods such as tables, bar charts and pie charts were used to analyze the responses from the questionnaire.

3.11 Mean Score

A formula popular with researchers was used to generate ranking of the variables of interest based on the scores assigned by the respondents. The formula states that

Mean score (I) = Σ a1x1 (Egbu and Botterill, 2002.

Σ xi

Where I=Mean Score, a=Rank of event i and x=frequency of event

3.12 One Sample T-Test

One sample t-test is a statistical procedure used to examine the mean difference between the sample and the known value of the population mean. The test normally compares the mean score of a sample to a known value which is usually the population mean. That is, the observed mean (from a single sample) is compared to an expected (or reference) mean of the population (e.g., some theoretical mean), and the variation in the population is estimated based on the variation in the observed sample. The procedure involves drawing a random sample from the population and then compares its mean with the population mean and make a statistical decision as to whether or not the sample mean is different from the population. . The t-test is the most commonly used method to evaluate the differences in means between two groups. The test also uses the standard deviation of the sample to estimate (the population standard deviation). If the difference between the sample mean and the test mean is large relative to the variability of the sample mean, then is unlikely to be equal to the test mean(Singh AS, MB Masuku 2013)

The data obtained from the one sample T-test was then used to provide a basis for a statistical decision to be made as to whether or not the population mean and sample mean are equal

3.13 Ethical Issues

A short briefing was given to each individual participant before filling in the questionnaires informing them of the following

The purpose of the research, expected duration and procedures and how their data will be used

Participants' rights to decline to participate and to withdraw from the research once it has started, as well as the anticipated consequences of doing so.

Limits of confidentiality, such as data coding, disposal, sharing and archiving, and when confidentiality must be broken was also communicated to the participants.

Issues of honesty, objectivity, and respect for intellectual property, social responsibility and confidentiality were also personally communicated to the participants.

Participants were also informed that as an inducement to spend time in filling the questionnaire that once the research work was completed they would receive a copy of the findings for it may proof a useful tool towards better ICT adoption.

A separate list of email contacts for the participants was drawn for use in later communication. This was done to de-link the identity of the participants from the contacts for confidentiality.

3.14 Field Constraints

Several constraints were encountered during the actual administration of the questionnaires ranging from unwillingness to fill questionnaires to promises to fill them later which was never done. The identified participants are also scattered in different geographical locations in Nairobi and locating them proofed a daunting task.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter covers data analysis and presentation of results of the study based on the earlier objectives stated as:

i. To identify areas of potential application of information and communication technology (ICT) in construction project performance by building contractors
ii. To assess the extent of adoption of ICT by Kenyan local contractors in the construction project performance
iii. To determine the significant factors hindering Kenyan building contractors from achieving higher levels of adoption of ICT during construction project performance
iv. To develop a model for adoption of ICT by Kenyan building contractors

According to Yin *et al*. (2007), data analysis involves examination, categorization, tabulation, or otherwise recombining the evidence to address the initial propositions of a study. It begins with descriptive analysis of the demographics variables of the selected firms and respondents followed by analysis of the firms ICT infrastructure platforms and current levels of ICT usage. Result from one sample T-test on identified factors hindering the use of ICT by Kenyan contractors are then analyzed. The main statistical tools used were Mean Score and the One Sample T-test. Data collected from the questionnaires were tabulated and analyzed according to their ranking on relative index. Charts were created, where appropriate, in support of the descriptive analysis for further clarification.

4.2 Field Data Analysis

4.2.1 Demographic Variables and Profiles of Respondents

The working experience of the companies surveyed indicated that 6.7% had worked as contractors in the construction industry for over 20 years, 13.3% between 11-20 years, 48.3% between 6-10 years and 31.7% between 0-5 years as indicated by fig 4.1. The high cumulative percentage of 68.3% of firms with experience of over 6 years is significant to provide some understanding on ICT uses and challenges.it also assumes the contractor had time to accumulate adequate resources to invest in ICT adoption

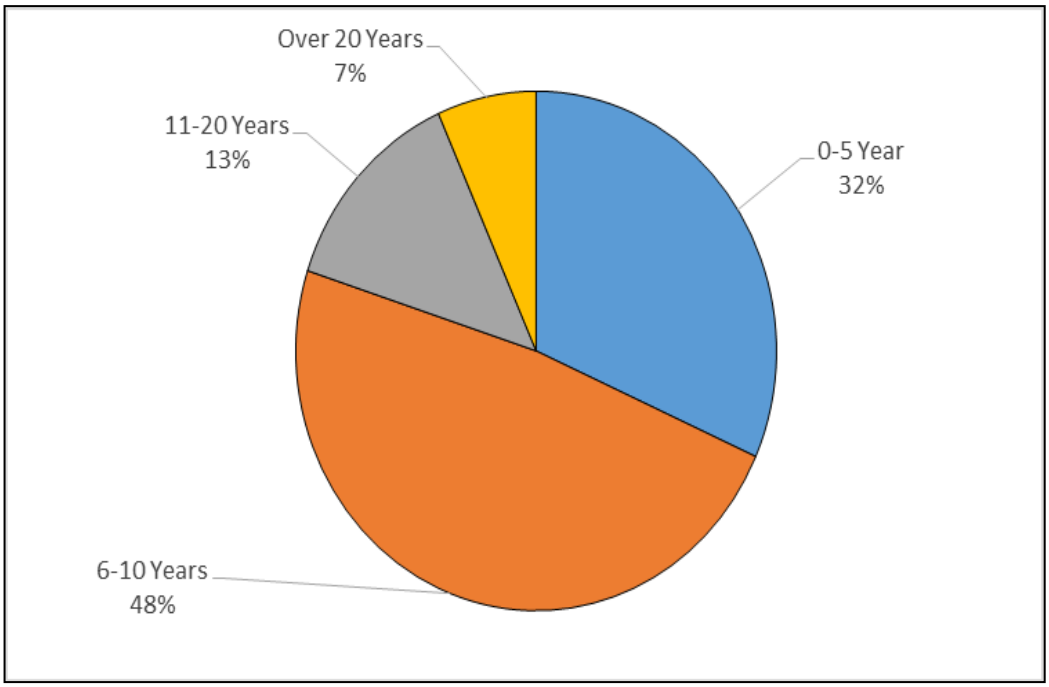


Figure 4.1: Firms' Experience Profile

Source: Field data

4.2.3 Respondents Professional background

The data analysis also revealed that varied professional backgrounds in the contractor's organizations were represented in the survey. According to Fig 4.2, the backgrounds of respondents comprised 16 contractors/builders (26.7%), 12 construction project managers (20.0%), 5 sub-contractors (8.3%), 5 site/resident engineers (8.3%), 3 quantity surveyors (5.0%) 7 clerk of works/site agent (11.7%),skilled laborers(6.7%), site supervisors(5.0%), 5 building construction consultants(8.3%), The high representation of contractors and project managers(46.7%) was crucial as these are the very key targets of this study as directly involved in project implementation. Presence of other professionals in varied percentages represents a normal distribution.

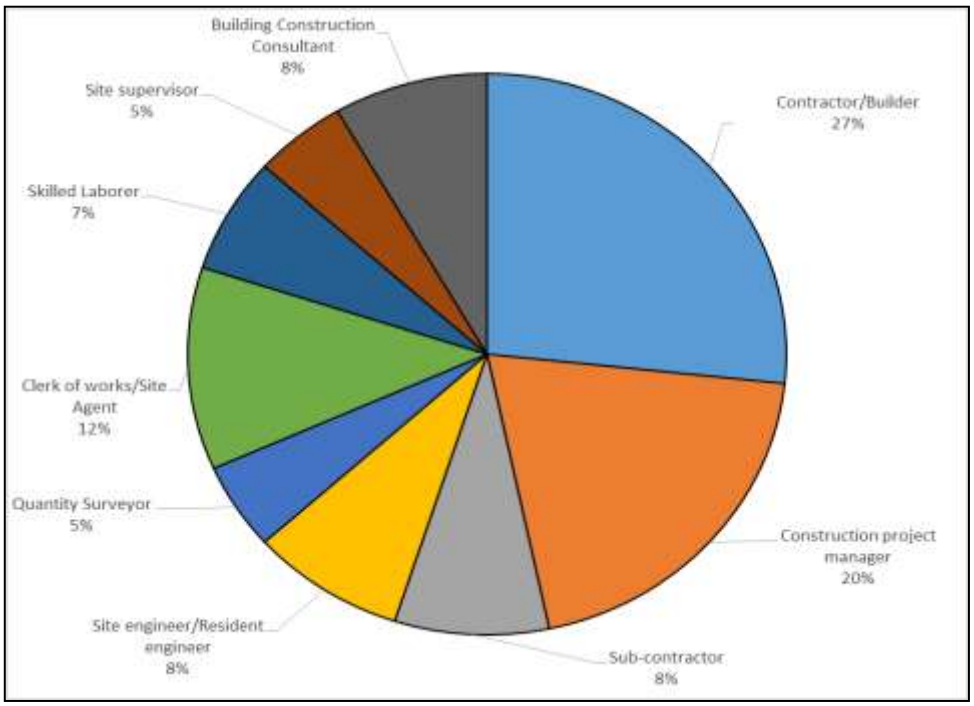


Figure 4.2: Respondents' Professional background

Source: Field data

4.2.4 Respondents personal experience

Concerning respondent's personal experience in the construction industry, the survey revealed as shown on figure 4.3 that a majority with experience of between 6 to 10 years constitute (46.7%) and have been in the industry for between 6-10 years, while only 6.7% have over 20 years of experience and 28.3% had between 0-5 years of experience.

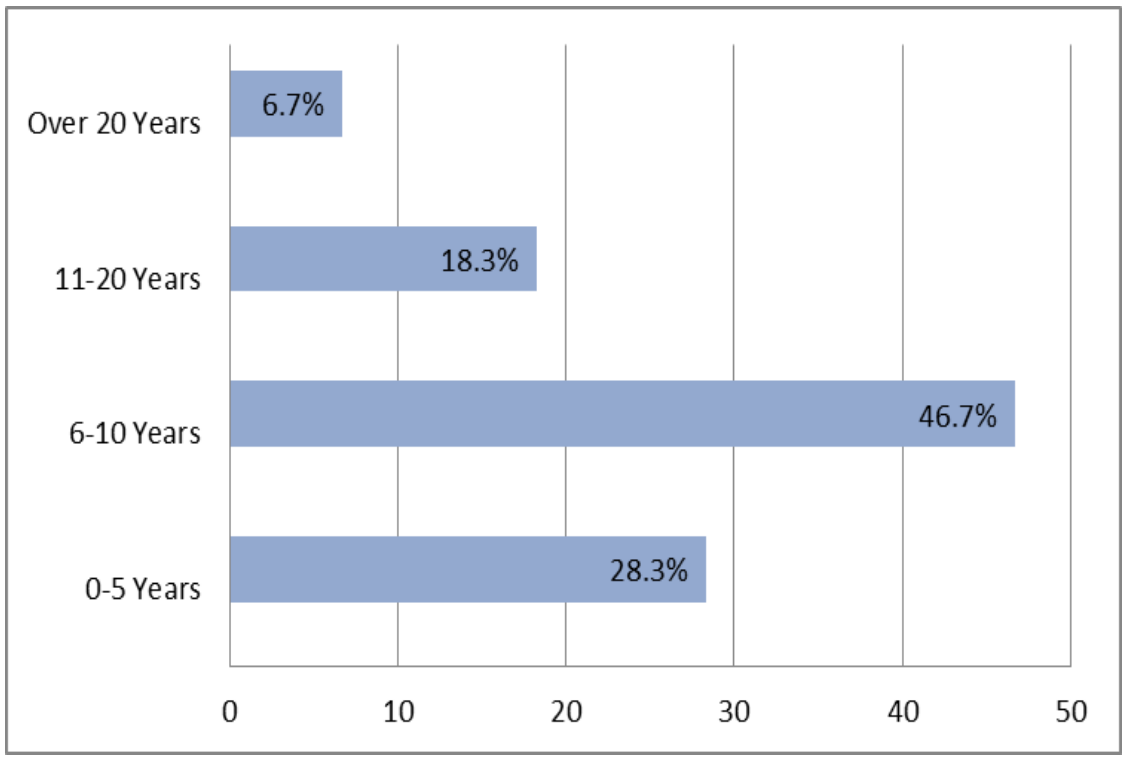


Figure 4.3: Respondents' Personal Experience in the Building Industry

Source: Field data

4.2.5 Respondents Age Brackets

The study revealed that majority of the respondent age is between is 31-40 forming 48.3% and that the majority 36.7% have been involved in between 6-10 projects this is a generally young generation but have gained enough experience. This is significant since the older generation is perceived to have less computer skills therefore their input on ICT issues may not be relied on.

These percentages are clearly indicated by table 4.1

Table 4.1: Assessment of Respondent's Age Bracket

Respondent's age bracket	Frequency	Percent
18-30 Years	18	30
31-40 Years	29	48.3
41-50 Years	10	16.7
Over 50 Years	3	5
Total	**60**	**100**

Source: Field data

4.3 Application of ICT during Project Implementation

There is a part of the questionnaire that sought information from respondent's on the firm's general ICT infrastructure and application. Majority 41.7% said they quite often use ICT in their work while those who said they rarely apply any ICT were the minimum 1.7%. Those that reported they use it most times were 21.7% while those who reported they use ICT always were 35% as indicated in Fig 4.4. Analysis of other parts of the questionnaire revealed that what the respondents referred to as using ICT always actually meant only the basic application as Ms word, Ms excel and Ms power point for typing letters book keeping and power point presentations respectively and not much of other applications

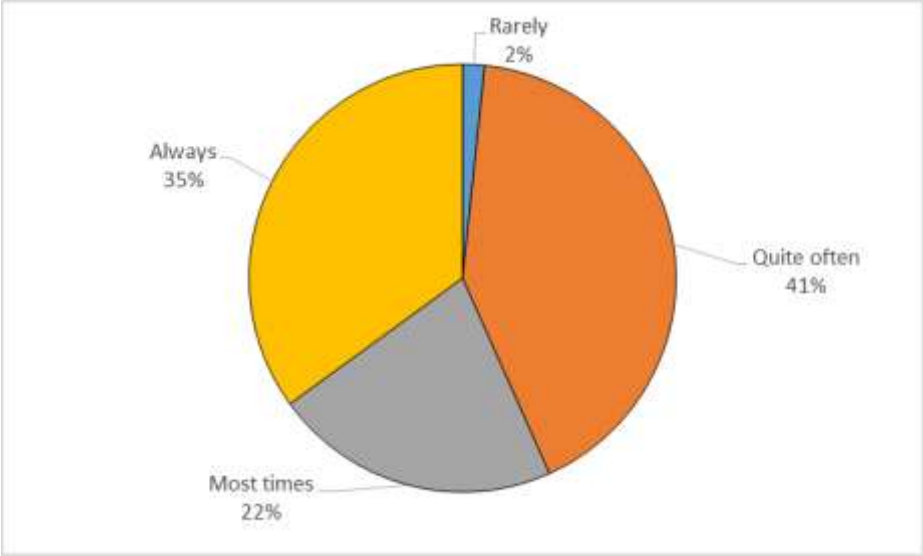


Figure 4.4: Respondents' view of the Firms ICT Application

Source: Field data

4.3.1 Firms' Communication and Networks

Networked computers, firms personalized websites; separate IT divisions and having someone in charge of the IT division within the firm are evidence of a higher level of ICT adoption. The study wanted to interrogate the contractors current network platforms as a basis of their ability to communicate electronically both within and externally. On this out of the 60 respondents 60.0% reported their computers are net worked while 40.0% reported that their computers are not net worked.

On the issue of websites and separate IT divisions 50% reported their firms have personalized websites while 50% reported they don't have any while 28.3% reported they have a separate division or someone responsible for IT. 71.7% of the respondents reported such arrangements don't exist. In general the survey revealed average state of connectivity as shown on Table 4.2

Table 4.2: Assessment of Firms' Computer Connectivity

	YES(PERCENTAGE)	NO(PERCENTAGE)	TOTAL
Firms has networked computers	60	40	100
Firms has personalized website	50	50	100
Firms has Separate IT division or someone responsible for IT	28.3	71.7	100

Source: Field data

4.3.2 Firms ICT Infrastructure Platforms

In this section, the respondents indicated the ICT infrastructure platforms available for use in their firms and whether just a few, several many or very many. The statistical analysis used in this section is the mean index score. in order to determine the level of adoption by the contractors, a classification based on a Five point type Likert ordinal scale was employed to measure level of usage by responding firms from "Never" to "Always" that is, 1= Never, 2= Not always, 3=Average, 4= Quite always, 5= Always .

4.3.3 ICT Platforms as used by Firms

ICT platforms that can be used by contractors were listed and the mean index score of the responses from the respondents calculated as shown on table 4.3

Table 4.3: Assessment of ICT Platforms available for use by Contractors

Activities	***Mean***	***Std deviation***	***Ranking***
Smart phone application	3.07	1.604	1
Desk top PCs	3.03	1.365	2
Laptops	2.82	1.334	3
PDA-based mobile computing system	1.72	1.277	4
Pocket PCs	1.61	1.017	5
Personal digital assistant(PDA)	1.43	0.871	6
Mobile phone-based graphical user interface	1.39	0.831	7
RFID-based(radio frequency identification)	1.38	1.059	8
Telematics digital work bench	1.35	0.881	9
Mobile collaboration tool	1.32	0.792	10
iphone-based “construction equipment finder”	1.25	0.728	11
Average mean	1.852		

Source: Field data

On the average a mean index of 1.852 indicates a low level of adoption of these identified ICT platforms. Out of the 11 platforms identified slightly more than half (6 number) had a standard deviation greater than 1.0. This is an indication that more than half of the respondents had variations in the rating of their level of adoption while slightly less than half (5 number) had a standard deviation of less than 1.0. This in essence implies that the level of agreement on the level of adoption among the respondents was in the ratio of about half to half

According to the survey the ICT platform with the highest level of adoption is the smart phone application (mean 3.07) followed by the desk top pcs (mean 3.03), Laptops (2.82) in that order.

Moderately level adopted platforms are PDA-based mobile computing system (1.72), Pocket PCs (1.61) and Personal digital assistant (PDA) (1.43) in that order while the platforms with the least levels of adoption are Mobile phone-based graphical user interface (1.39), RFID-based (radio frequency identification) (1.38), Telematics digital work bench (1.35), Mobile collaboration tool (1.32) and iphone-based "construction equipment finder" (1.25) in that order.

From the findings above, it can be conclude that most construction firms have embraced smart phones and computers as tools of work but are yet to embrace other available ICT platforms such as RFID-based (radio frequency identification), Telematics digital work bench, Mobile collaboration tool and iphone-based construction equipment finder.

4.3.4 ICT Software as used by Firms

The ICT platforms that contractors can use during construction project implementation were analyzed and the mean index score of the responses from the respondents calculated based on the the likert scale to obtain the mean and the standard deviation in order to be able to rank the extent of application by the contractors

4.3.5 ICT Software used by Firms for General Project Administration

ICT software available for use by contractors for general project administration were itemized as extracted from samuelson IT barometer and the mean index score of the responses from the respondents were also calculated as indicated on Table 4.4

Table 4.4: Assessment of general project Administration Software used by |Contractors

Activities	Mean	Std deviation	Ranking
Ms office word	**3.88**	1.379	1
Ms excel	**3.10**	1.504	2
Ms office power point	**2.62**	1.415	3
Ms office access	**2.37**	1.484	4
Spread sheets	**2.27**	1.448	5
Ms office publisher	**1.83**	1.210	6
Ms office outlook	**1.80**	1.338	7
Ms office one note	**1.63**	1.207	8
Ms office groove	**1.43**	1.064	9
Ms office info path designer	**1.37**	0.920	10
Average mean	**2.23**		

Source: Field data

On the average a mean index of 2.23 indicates a low level of adoption of these identified ICT softwares. Out of the 10 softwares identified majority (9 number) had a standard deviation greater than 1.0. This is an indication that almost all the respondents had variations in the rating of their level of adoption while only one had a standard deviation of less than 1.0. This in essence implies that the level of agreement on the level of adoption among the respondents was very varied

According to the survey the ICT software with the highest level of adoption is the Microsoft word (mean 3.88) followed by the Microsoft excel (mean 3.10), Ms office power point (2.62) in that order.

Moderately level adopted software are Ms office access (2.37), Spread sheets (2.27) and Ms office publisher (1.83) in that order while the softwares with the least levels of adoption are Ms office outlook (1.80), Ms office one note (1.63), Ms office groove (1.43) and Ms office info path designer (1.37) in that order.

It can be concluded From the findings above that most construction firms have use Microsoft word, Microsoft excel and Microsoft power point as tools of work but are yet to embrace other available ICT softwares such as Microsoft office groove and Microsoft office info path finder as work tools to enhance their performance in general project administration

4.3.6 ICT Software used by Firms for Design and Drawing

Analysis of ICT platforms available for contractors during construction project implementation were analyzed and the mean index score of the responses calculated as indicated on table 4.5

Table 4.5: Assessment of Drawing Software used by Contractors

Activities	Mean	Std deviation	Ranking
ArchiCAD	**3.57**	1.332	1
AutoCAD	**3.33**	1.398	2
Architectural desktop	**1.88**	1.472	3
Autodesk building system	**1.85**	1.412	4
Building Information Modeling(BIM)	**1.75**	1.129	5
MiniCAD	**1.50**	1.066	6
Revitt	**1.40**	0.785	7
FastCAD	**1.35**	0.880	8
IntelliCAD	**1.23**	0.673	9
Micro station	**1.17**	0.557	10
Snape Vector	**1.12**	0.415	11
Average mean	**1.832**		

Source: Field data

On softwares used by contractors for drawing purposes the average a mean index of 1.832 indicates a low level of adoption of these identified ICT softwares. Out of the 11 platforms identified slightly more than half (6 number) had a standard deviation greater than 1.0. This is an indication that more than half of the respondents had variations in the rating of their level of adoption while slightly less than half (5 number) had a standard deviation of less than 1.0. This in essence implies that the level of agreement on the level of adoption among the respondents was in the ratio of about half to half

According to the survey the ICT software with the highest level of adoption is ArchiCAD (mean 3.57) followed by AutoCAD (mean 3.33) in that order. Architectural desktop software follows in a distant third (mean 1.88)

Other design and drawing softwares such as Intelli CAD, Micro station and Snape Vector are least known by contractors and therefore rarely used in the course of their work.

4.3.7 ICT Software used by Firms for Planning and Scheduling

The software's that contractors can use for planning and scheduling were Analyzed and results tabulated as indicated on Table 4.6

Table 4.6: Assessment of Planning and Scheduling Software used by Contractors

Activities	Mean	Std deviation	Ranking
Microsoft project	**2.47**	1.467	1
Enterprise resource planning(ERP)	**1.48**	1.017	2
Primavera	**1.48**	1.017	3
Power project	**1.47**	1.016	4
pMsystems	**1.17**	0.557	5
Average mean	**1.614**		

Source: Field data

On softwares used by contractors for planning and scheduling purposes the average a mean index of 1.614 indicates a low level of adoption of these identified ICT softwares. Out of the 5 platforms identified for out of five had a standard deviation greater than 1.0. This is an indication that more than half of the respondents had variations in the rating of their level of adoption while only one had a standard deviation of less than 1.0. This in essence implies that the level of agreement on the level of adoption among the respondents was very low

According to the survey the ICT software with the highest level of adoption is Microsoft project (mean 2.47) followed by Enterprise resource planning(ERP) (mean 1.48), Primavera(mean 1.48), Power project(mean 1.47)and pM systems (mean 1.17) in that order.

4.3.8 ICT Software used by Firms for Cost Control

ICT software available for use by contractors for cost control were also itemized as extracted from samuelson IT barometer and the mean index score of the responses from the respondents were also calculated as indicated on Table 4.7

Table 4.7: Assessment of Cost Control Software used by Contractors

Activities	Mean	Std deviation	Ranking
Electronic tendering(E-tendering)	**2.30**	1.510	1
Masterbill	**1.78**	1.209	2
WinQS	**1.68**	1.081	3
Esti-mate	**1.60**	1.045	4
Manifest	**1.27**	0.861	5
Resource cost sheet	**1.25**	0.654	6
Buildsoft	**1.22**	0.666	7
CATOpro	**1.18**	0.596	8
WinSmesta	**1.17**	0.526	9
Average mean	**1.494**		

Source: Field data

On softwares used by contractors for cost control purposes the average a mean index of 1.494 also indicates a low level of adoption of these identified ICT softwares. Out of the 9 softwares identified five out of nine had a standard deviation less than 1.0. This is an indication that most of the respondents were in agreement on the level of adoption while only four had a standard deviation of more than 1.0. This in essence implies that the level of agreement on the level of adoption among the respondents was moderate. In general the study reveals that almost all the softwares used for cost control have very low mean which means they are rarely used by contractors during project implementation

4.3.9 ICT Software used by Firms for General Communication

The software's that contractors can use for general communication were Analyzed and results tabulated as indicated on table 4.8

Table 4.8: Assessment of General Communication Software used by Contractors

Activities	***Mean***	***Std deviation***	***Ranking***
Mobile phones(SMS, conversations)	**4.07**	1.448	1
E-mail service	**3.80**	1.560	2
Mobile internet(skype, whatsapp, tweeter, instagram etc)	**3.72**	1.209	3
Intranet	**2.20**	1.400	4
Geographic Information Service (GPS)	**2.05**	1.523	5
Dropbox, yousendIT	**1.95**	1.371	6
Teleconferencing	**1.52**	1.033	7
Video conferencing	**1.45**	0.964	8
Average mean	**2.595**		

Source: Field data

On softwares used by contractors for general communication the average a mean index of 2.595 indicates a low level of adoption of these identified ICT softwares. Out of the 8 softwares identified only one out of eight had a standard deviation less than 1.0. This is an indication that most of the respondents responses were not in agreement on the level of adoption. According to the survey the ICT software with the highest level of adoption is the Mobile phones(SMS, conversations) (mean 4.07) followed by the E-mail service (mean 3.80), Mobile internet(skype, whatsapp, tweeter, instagram etc) (3.72) in that order.

Moderately level adopted software are the Intranet (2.20) and Geographic Information Service (GPS) (2.05) in that order while the softwares with the least levels of adoption are Dropbox, yousendIT (1.95), Teleconferencing (1.52) and Video conferencing (1.45) in that order

4.3.10 ICT Software used by Firms for Site Security

Table 4.9 shows an analysis of responses from contractors on software's used for site security

Table 4.9: Assessment of Site Security Software used by Contractors

Activities	***Mean***	***Std deviation***	***Ranking***
Site Surveillance Technologies	**1.88**	1.075	1
Global positioning system(GPS)	**1.65**	1.191	2
Bar coding	**1.35**	0.840	3
Radio Frequency Identification(RFID)	**1.22**	0.613	4
Average mean	**1.525**		

Source: Field data

On softwares used by contractors for site security the average a mean index of 1.525 indicates a low level of adoption of these identified ICT soft-wares. Out of the 4 softwares identified two out had a standard deviation less than 1.0 which is half. This is an indication that level of agreement of respondents responses on the level of adoption was half. According to the survey the ICT software with the highest level of adoption is the Site Surveillance Technologies (mean 1.88) followed by the Global positioning system (GPS) (mean 1.65), Bar coding (1.35) in that order.

The softwares with the least levels of adoption was the Radio Frequency Identification (RFID) (1.22)

4.4 Challenges facing Kenyan Building Contractors during Adoption

The one sample t-test was employed to analyze the challenges facing building contractors in their effort towards ICT adoption. This statistical tool was employed basically to ascertain the significant and most important reasons hindering usage by contractors.

The one-sample t-test compares the mean score found in an observed sample (sample mean) to a hypothetically assumed value and establishes whether the sample mean is significantly different from a hypothesized mean. Typically the hypothetically assumed value is the population mean.

By the central limit theorem, a normal distribution can be assumed when the sample size is more than 30 (Hair *et al.,* 1998). Therefore, with a sample size of 80 it can be assumed that, the underlying suppositions of the central limit theorem were applied and that, the sample size is relatively adequate for use in this statistical inference.

Typically, a one sample t-test reports on the mean of the test group, degree of freedom for the test, the t-value (which is an indication of the strength of the test) and the p-value (which is the probability value that the test is significant) (Hair *et al*., 1998). With the

use of SPSS, a statistical analysis was performed to determine whether the population agreed on a particular factor as a strong reason or not. The t-test analysis from SPSS usually produces two reports, namely, the one sample statistics and the one sample test showing test significance. If the difference between the sample mean and the test mean is large relative to the variability of the sample mean, then is unlikely to be equal to the test mean.

With reference to the 5-point Linkert rating scale adopted, ratings of 4 and 5 representing severe and very very severe reasons respectively. By that, the populations mean μ o was set at an appropriate level of 2.0 and the significance level was also set at 95% in accordance with expected risk levels (Cohen, 1992).

Therefore, based on the five-point Linkert rating scale, a factor was considered critical if it had a mean of 2.0 or more. Where two or more criteria have the same mean, the one with the lowest standard deviation was assigned the highest importance ranking (Field, 2005). The standard error is the standard deviation of sample means and is a measure of how representative a sample is likely to be to the population. A large standard error suggests that there is a lot of variability between means of different samples. A small standard error suggests that most sample means are similar to the population mean and so the sample is likely to be an accurate reflection of the population. Clearly, the standard error for all the means is in the close of zero which indicate that the sample chosen is an accurate reflection of the population as indicated table 4.10

Table 4.10: Results of T-Test for one Sample Values

FACTORS HINDERING ICT ADOPTION	N	Mean	Std. Deviation	Std. Error Mean
Lack of information by contractors on areas of adoption	60	2.65	1.260	.163
Inadequate financial resources	60	3.10*	1.349	.174
Lack of qualified personnel to handle ICT adoption	60	2.75	1.445	.187
Little return on investment	60	2.95	1.213	.157
High cost of training ICT professionals	60	3.20*	1.325	.171
High cost of employing ICT professionals	60	3.35*	1.287	.166
Inadequate knowledge about return on ICT investment	60	3.13*	1.420	.183
Fear of job losses/making professionals redundant	60	2.98	1.408	.182
Satisfaction with the existing method of working	60	3.15*	1.260	.163
Rapid changes in ICT technologies	60	3.37*	1.327	.171
Software and hardware reliability problems	60	2.97	1.414	.183
Security concerns / privacy fears	60	2.95	1.407	.182
Lack of legal support for use of ICT	60	2.95	1.501	.194
*mean>3.0 (population mean)				

Source: Field data

From the results in table 4.10, it can be observed that almost all the variables had standard deviation values of more than 1.0. This provides the indication that, the respondents had different interpretations for the factors.

4.5 T-Test Significance

With the use of SPSS, a statistical analysis was performed by a two tail test on each factor to determine the significance values (p-value) of each factor hindering adoption of ICT by the contractors as indicated by Table 4.11

Table 4.11: Results of One Sample T-test showing test significance (2-tailed)

Test Value = 3						
					95% Confidence Interval of the Difference	
FACTORS HINDERING ICT ADOPTION	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**	**Upper**
Lack of information by contractors on areas of adoption	-2.152	59	.036	-.350	-.68	-.02
Inadequate financial resources	.574	59	.568	.100	-.25	.45
Lack of qualified personnel to handle ICT adoption	-1.340	59	.185	-.250	-.62	.12
Little return on investment	-.319	59	.751	-.050	-.36	.26
High cost of training ICT professionals	1.169	59	.247	.200	-.14	.54
High cost of employing ICT professionals	2.107	59	.039	.350	.02	.68
Inadequate knwoledge about return on ICT investment	.727	59	.470	.133	-.23	.50
Fear of job losses/making professionals redundant	-.092	59	.927	-.017	-.38	.35
Satisfaction with the existing method of working	.922	59	.360	.150	-.18	.48
Rapid changes in ICT technologies	2.140	59	.037	.367	.02	.71
Software and hardware reliability problems	-.183	59	.856	-.033	-.40	.33
Security concerns / privacy fears	-.275	59	.784	-.050	-.41	.31
Lack of legal support for use of ICT	-.258	59	.797	-.050	-.44	.34

Source: Field data

The two tailed significance value was divided by two to obtain a one tailed significance value which was then used to provide a basis for a statistical decision to be made as to whether or not the population mean and sample mean are equal and the results tabulated in Table 4.12

Table 4.12: Results of One Sample T-test showing test significance (1-tailed)

Test Value = 3						
					95% Confidence Interval of the Difference	
FACTORS HINDERING ICT ADOPTION	**t**	**df**	**Sig. (1-tailed)**	**Mean Difference**	**Lower**	**Upper**
Lack of information by contractors on areas of adoption	3.996	59	.18	.650	.32	.98
Inadequate financial resources	6.315	59	.284	1.100	.75	1.45
Lack of qualified personnel to handle ICT adoption	4.019	59	.0925	.750	.38	1.12
Little return on investment	6.065	59	.3755	.950	.64	1.26
High cost of training ICT professionals	7.015	59	.1235	1.200	.86	1.54
High cost of employing ICT professionals	8.128	59	.0195	1.350	1.02	1.68
Inadequate knowledge about return on ICT investment	6.183	59	.235	1.133	.77	1.50
Fear of job losses/making professionals redundant	5.409	59	.4635	.983	.62	1.35
Satisfaction with the existing method of working	7.070	59	.18	1.150	.82	1.48
Rapid changes in ICT technologies	7.976	59	.185	1.367	1.02	1.71
Software and hardware reliability problems	5.296	59	.428	.967	.60	1.33
Security concerns / privacy fears	5.229	59	.392	.950	.59	1.31
Lack of legal support for use of ICT	4.904	59	.3985	.950	.56	1.34

Source: Field data

4.6 Interpretation of Results

Referring to the summary of results in Table 4.10 and Table 4.11 , it can be deduced that the most important factors from the study are: Rapid changes in ICT technologies (Mean= 3.37), High cost of employing ICT professionals (Mean= 3.35), High cost of training ICT professionals (Mean= 3.20), Satisfaction with the existing method of working (Mean=3.15), Inadequate knowledge about return on ICT investment (Mean= 3.13), Inadequate financial resources (Mean= 3.10), Fear of job losses/making professionals redundant (Mean= 2.98), Software and hardware reliability problems (Mean= 2.97), Security concerns / privacy fears (Mean= 2.95), Lack of legal support for use of ICT (Mean= 2.95), Little return on investment(Mean= 2.95), Lack of qualified personnel to handle ICT adoption(Mean= 2.75) and Lack of information by contractors on areas of adoption(Mean= 2.65) in that order.

When these factors on Table 4.11 are considered together with the Results of One Sample Test showing test significance on Table 4.12 it is revealed that the significant ones where respondents seem to have greatest agreement on as reasons hindering the use of ICT by the contractors are:

1. Fear of job losses/making professionals redundant
2. Lack of qualified personnel to handle ICT adoption
3. High cost of training ICT professionals
4. Satisfaction with the existing method of working
5. Rapid changes in ICT technologies

From the Tables 4.10 and 4.12 it can clearly be seen that whereas rapid changes in ICT technologies (mean= 3.37, P=0.185) came out as the highest ranked factor, Lack of information by contractors on areas of adoption (mean=2.65, P= 0.18) was ranked the lowest in terms of the factors hindering ICT usage by the respondents. This suggests that although Lack of information by contractors on areas of adoption may appear very significant, it was largely perceived by the respondents as not an important barrier to ICT usage.

The perception of the respondents also suggests that, their focal concern was *rapid changes in* ICT technologies. This basically agrees with the growing challenge of how to cope with rapid changes in ICT technologies as sited in the literature review. Tables 4.10 and 4.11 further reveal that High cost of employing ICT professionals (mean=3.35, P= 0.0195), Satisfaction with the existing method of working (mean=3.15, P= 0.18), Inadequate knowledge about return on ICT investment (mean=3.13, P= 0.235) and Inadequate financial resources (mean=3.10, P= 0.284) were ranked 2nd, 3rd, 4th and 5th significant factors respectively.

The fact that the cost of employing ICT professionals was ranked second at a significance of (*P=0.0195)*. brings to the fore the need to recognize that, there are still less professionals trained and qualified to handle ICT in construction hence the simple rule of demand and supply dictating the cost of employing these professionals. As a result, focus on training for ICT use in construction by both private organizations and government is quiet critical. Universities and technical training institutes that offer training in building related fields should focus more on training ICT professionals in a more practical way than the way they seem to do it.

It also agrees with the findings of Songer *et al.* (2001) and Weippert *et al.* (2003). These studies found lack of training as a key barrier to adopting and using ICT applications. Traditionally, problems in learning and training in training institutions has been use of outdated curriculum and especially in ICT that seem to change more rapidly compared to other fields. It is therefore notable to justify training as an essential factor for success of ICT implementation and usage.

It is important to note that *satisfaction with existing method of working* was ranked third at a significant of *(P=0.18).* Basically this may reflects the respondents‟ strong view of their level of ICT literacy that still ties with the issues of training since people are by nature reluctant to expose their ignorance. This position of respondents seems to suggest the need for Kenya to seriously re - think ICT in its construction education to include a

robust construction software skills acquisition and culture. This may be necessary both in certificate, undergraduate / postgraduate courses to create more receptive and highly trained construction professionals .It is therefore important to restate that, education in these levels play a great role in developing and shaping the understanding of ICT as a form technological change and innovation in construction.

With the view that *Majority of respondents have little knowledge about return on ICT investment,* the respondents considered it at a significance level of *(P=0.235)* and ranked fourth on the scale. Clearly, this finding suggests the need for an increased awareness campaign especially by designers of these ICT technologies to contractor organizations on the available ICT resources at their disposal

Another point worth noting from Table 4.10 and 4.12 above is that, whereas factors such Lack of qualified personnel to handle ICT adoption *(mean= 2.75, P= 0.0925)* Lack of information by contractors on areas of adoption *(mean=2.65, P= 0.18),* are considered unimportant (mean < 3.0) by the respondents and ranked 10^{th} and 11^{th} respectively, they were surprisingly found to be statistically significant ($p \leq 0.2$).

This appears to suggest that, although, these factors might not necessarily qualify as major reasons hindering their ICT usage; they should be noted as quiet significant in the context of the Kenyan contractor's organization.

Reports from the one sample T-test indicate that factors hindering higher levels of ICT adoption are of varying significance as indicated in Table 4.12 ranging from the most significant with a mean of 3.37 to the least significant with a mean of 2.65. The complete ranking is as indicated on Table 4.13

Table 4.13: Ranking of significance of factors hindering higher levels of ICT adoption

	FACTORS HINDERING ICT ADOPTION	Significance (Mean)
1	Rapid changes in ICT technologies	3.37
2	High cost of employing ICT professionals	3.35
3	High cost of training ICT professionals	3.20
4	Satisfaction with the existing method of working	3.15
5	Inadequate knowledge about return on ICT investment	3.13
6	Inadequate financial resources	3.10
7	Fear of job losses/making professionals redundant	2.98
8	Software and hardware reliability problems	2.97
9	Security concerns / privacy fears	2.95
10	Lack of legal support for use of ICT	2.95
11	Little return on investment	2.95
12	Lack of qualified personnel to handle ICT adoption	2.75
13	Lack of information by contractors on areas of adoption	2.65

Source: Field data

4.7 Development of ICT Adoption Framework

This research work started with establishing ICT systems that can be used by Kenyan contractors in order to enhance construction project success. The levels of this adoption was determined because measurement is one of the first steps in any improvement process (Lee *et al.,* 2005)which was generally found to be low and factors that contribute to this low adoption levels were also established.

Lastly the research sought to develop a framework that if applied by Kenyan contractors can help overcome the challenges and hence improve the level of construction project success.Development of an adoption framework should be multidimensional and facilitate alignment of the performance indicators with an organization's strategic objectives and should link the indicators with key managerial processes of the organization (Costa *et al*., 2006).

Thus, key adoption requirements needs to be undertaken through a structured methodology and for this reason a short secondary questionnaire was developed and used to conduct an interview with eight managers/ owner of construction firms that had been identified during physical site visits in first questionnaire administration registered in financial class NCA1 and perceived to have high levels of ICT adoptions.

The structured questions majored on experiences during adoption, how to establish best strategies for adoption and how to overcome challenges in adoption as sited in the first questionnaire. It examined across a range of contexts that included technological, organizational, environmental, individualistic, and economic. It is equally important that the selected teams share what they have learned with the aim of creating an atmosphere in which knowledge transfer is actively encouraged (Hinton *et al.,* 2000) and cited in (Costa *et al*., 2006).

ICT can impact a company on three different levels that is individualistic or user level, organizational level and external or environmental level. In addition, technological and economical contexts are of great importance in facilitating organizational decision regarding which ICT to adopt, how to use it, and should be taken into account as well. Therefore, influencing factors for ICT adoption

Considering a company as a complex adaptive system requires mixed, multidimensional, multi-stakeholder, explicitly value-based assessments approaches. ICT depends on many factors and its effects are different for every organization, since technological systems are socially constructed, ICT needs to be taken into account together with its interactions with people, organization and processes. Hence one way to consider ICT effects on a company is to use systems theory method. Following that lead the systems theory was employed as outlined in figure 4.5

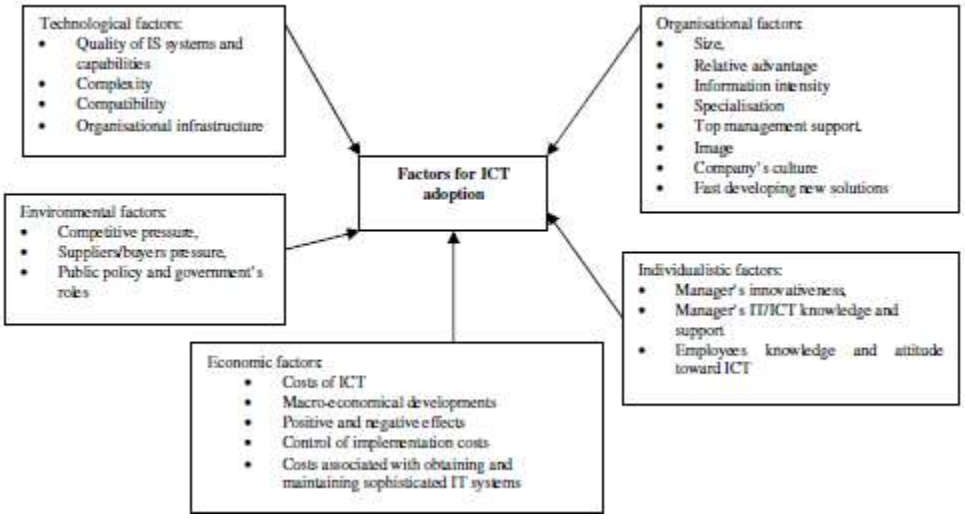


Figure 4.5: Factor consideration in ICT Adoption

Source: Haron (2013)

In order to achieve this, a two-stage multidisciplinary qualitative-comparative analysis and the systems theory methods were used. After the model was developed it was distributed to six of the participants. Four responded that it represented their views and is suitable for use by Kenyan construction firms in order to achieve higher levels of adoption, one indicated it did not represent his views while one did not reply.

Results of the interview were analyzed and the narratives used to prepare a model of ICT adoption as represented in figure 4.6

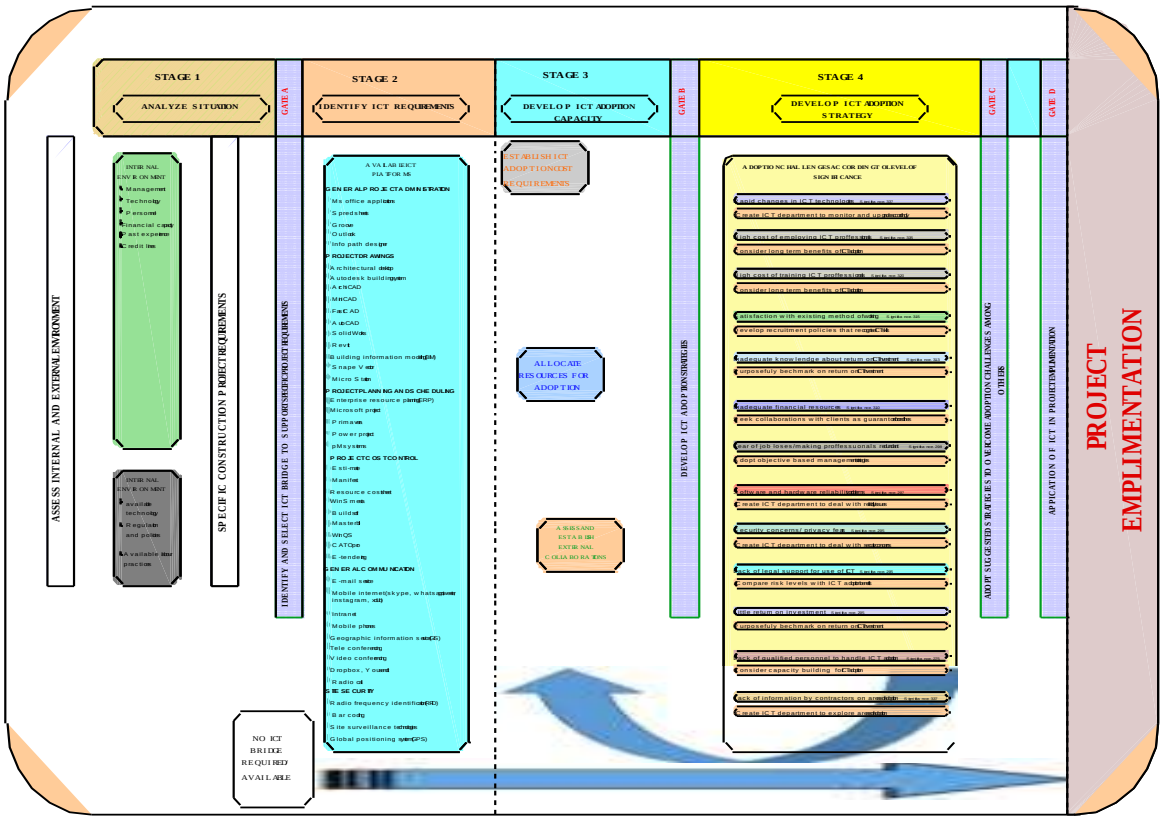


Figure 4.6: Model for ICT Adoption

Source: Field data

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECCOMMENDATIONS

This chapter summarizes the results from the research and draws conclusions from the analyzed data. It begins by summing up all the core issues discussed earlier in previous. Afterward, a review of how the key objectives were satisfied and a summary of the results are described. Finally, conclusions are drawn and recommendations for action are also included.

5.1 Summary of the research

The research methodology was sequentially adopted to answer the key objectives of the study as presented in the research analysis and findings

In addressing the aim and the objectives of the research, the main approach used was to review the current state of affairs in construction ICT infrastructure. This was then followed by investigating the use of these findings in the Kenyan construction industry through survey questionnaire. At the end of the empirical study, the level of ICT infrastructure in the firms, the extent of ICT usage and a set of reasons hindering the use of ICT reflecting the different perspectives of the contractors were appropriately established and a model developed which if appropriately used can increase levels of ICT adoption by Kenyan building contractors. The research came out with key findings some of which addressed the main aim and objectives.

5.2 Research findings

The study produced some significant findings that are summarized thus.

5.2.1 Objective 1: To assess the ICT platforms that exist for application by Kenyan building contractors

As indicated previously, this research objective was achieved by a research framework drawn from the IT Barometer surveys, 1999-2010 to cover firms ICT hardware, software in use, communication, networks status and ICT workforce.

The findings have shown that there are varieties of ICT platforms available for use by Kenyan building contractors during construction project implementation and the main ones include

Personal Digital Assistant (PDA), Pocket PCs, Desk top PCs, PDA- based mobile computing system, Laptops, RFID-based(Radio frequency identification), Smart phone application, Telematics digital work bench, iPhone –based "construction equipment finder", Mobile collaboration tool and Mobile phone- based graphical user interface.

The ICT platforms identified have various applications during the construction project implementation that have been classified into six broad categories with each category having specific software that can be used as indicated below

5.2.1.1General Project Administration

This involves book keeping, record keeping, presentations, preparation of pay rolls and reports and the software available for use by construction firms in this classification include Spread sheets, Ms office word, Ms office excel, Ms office access, Ms office power point, Ms office groove, Ms office one note, Ms office outlook, Ms office publisher and Ms office info path finder.

.2.1.2 Making of project drawings

This involves preparation of conceptual design, sketches, detailed designs, modeling and visualization. Softwares available for use by construction firms in this classification include Architectural Desktop, Autodesk Building System, ArchiCAD, MiniCAD, FastCAD, AutoCAD, IntelliCAD, Revitt, Building Information Modeling(BIM), Snape Vector and Micro station

5.2.1.3 Project planning and scheduling

This involves preparation of work schedules and resource management. Softwares available for use by construction firms in this classification include Enterprise resource planning (ERP), Microsoft project, Primavera, Power project and pMsystems.

5.2.1.4 Project cost control

This involves preparation of cash flow charts, budgeting, estimating, costing, accounting, financial management, cost calculations and procurement procedures. Softwares available for use by construction firms in this classification include Esti-mate, Manifest, Resource cost sheet, WinSmesta, Buildsoft, Masterbill, WinQS, Catopro and Electronic tendering (E-tendering)

5.2.1.5 General communication

This involves general internal communication within the firm and external communication with other collaborators outside the firm. Softwares available for use by construction firms in this classification include e-mail service, mobile internet like skype, whatsapp, tweeter, instagram, xclub etc. others are also intranet, mobile phones, geographic information service, teleconferencing, video conferencing, Dropbox and Yousendit.

5.2.1.6 Site security

This involves applications that can be used for site security functions and Softwares available for use by construction firms in this classification include radio frequency identification (RFID), bar coding, site surveillance technologies and global positioning systems (GPS). This research objective was achieved by analyzing responses from sixty respondents which were administered to various professionals within the construction firms by use of the mean score.

The survey revealed that Majority of the contractors use ICT and this was reflected in the responds on their ICT use levels with 35% reporting that they use it always, 22% reporting they use it most times, 41% use it quite often with only 2% reporting they use it rarely. Results from the investigation also identified a high usage of ICT hardware such as Desktop PC, Laptops and mobile phones among the contractors. However, most potable mobile ICT hardware such as Personal Digital assistance (PDAs) and Tablet PCs were found unpopular.

Concerning general project administration, the study has shown that usage of standard application tools such as Microsoft office word and Microsoft office excel had the most popular usage followed by the application Microsoft office power point, spread sheets and Microsoft office access in that order. Others like Microsoft office one note and Microsoft info path designer were least known. With regard to making project drawings, ArchiCAD was the highly used software followed by AutoCAD. Other design software such as MiniCAD, FastCAD, Snape vector and Micro station are least used by the contractors.

Among project planning and scheduling software, Microsoft Project was the most popular while others such as primavera, etc had low usage among the firms. On project cost control, the result revealed that most of the firms do not benefit from the usage of computer aided cost estimating and quantity surveying software with all of the available

use below the mean of 2. On the issue of firms' general communication status, this study has found that usage of mobile phones for both conversation and short messages was the most extensively used while the use of email service came second for both internal and external communication. Mobile Internet such as skype, whatsapp, tweeter, instagram etc came a distant third while teleconferencing and video conferencing are rarely used.

In summary average mean for general project administration was found to be 2.23 while that of making project drawings was 1.832. Others like planning and scheduling, cost control, general communication and site security were 1.614, 1.494, 2.595 and 1.525 respectively. the average mean for all these applications was found to be 1.882 which when assessed against the earlier determined adoption level assessment criteria falls in the range of $1.50 \leq$ mean score ≤ 2.50 which is classified as Low level of adoption.

From the average mean of each classification the findings also revealed that the classification with the highest level of adoption is general communication with a mean of 2.595 followed by general project administration with a mean of 2.23 while the classification with least level of adoption is cost control with a mean of 1.494 followed by site security with a mean of 1.525 and the third from last being planning and scheduling with a mean of 1.614

5.4.1 Objective 2: To identify the challenges that affect Contractors in Kenya towards higher ICT adoption

This objective was fulfilled by identifying thirteen relevant factors affecting the use of ICT drawn from the literature review. Responding firms were asked to score identified reasons hindering the use of ICT by contractors in the construction industry and based on the criteria identified, the Likert rating scale was again adopted to extract the appropriate ratings as per their influence as a reason hindering use of ICT by contractors in Kenya. Once more, the five point likert ordinal scale (1-5)

The results points to a number of key factors that inhibit the extensive use of ICT by the contractors. Data obtained from the survey indicates that, 6 out of 13 factors obtained from literature as hindrances on their use of ICT were identified as important (see chapter 4, Table 14). These include: rapid changes in ICT technologies (Mean= 3.37), high cost of employing ICT professionals (Mean= 3.35), satisfaction with the existing method of working (Mean= 3.15),

Inadequate knowledge about return on ICT investment (Mean=3.13), high cost of training ICT professionals (Mean= 3.20) and Inadequate financial resources (Mean= 3.10).

Finally, a test for significance (see chapter 4, Table 16) on the results has revealed that, the four most significant reasons hindering the use of ICT by building contractors in Kenya include:

1. High cost of employing ICT professionals;

2. Lack of qualified personnel to handle ICT adoption;

3. High cost of training professionals in ICT and

4. Satisfaction with the existing method of working

5.5.1 Objective 3: To develop a framework that can be used by Kenyan building in order to gain higher levels of ICT adoption

In order to achieve this, a short secondary questionnaire was developed and used to conduct an interview with eight managers/ owner of construction firms that had been identified during physical site visits in first questionnaire administration and perceived to have high levels of ICT adoptions.

In order to achieve this, a two-stage multidisciplinary qualitative-comparative analysis and the systems theory methods were used. After that a framework was developed and distributed to six of the participants. Four responded that it represented their views and is suitable for use by Kenyan construction firms in order to achieve higher levels of adoption, one indicated it did not represent his views while one did not reply.

Results of the interview were analyzed and the narratives used to prepare a model of ICT adoption by Kenyan building contractors.

5.3 Conclusions

The following conclusions can now be confidently drawn from the study:

Irrespective of the many challenges the Kenyan construction industry faces, Information and Communication Technology (ICT) is well recognized by building contractors in Kenya as a significant tool that can help increase the effectiveness of communication and data during the construction process. The study has revealed that, there is a significant level of awareness among the contractors about the potential benefits ICT could offer to their operations. While the use of some selected ICT hardware, notably Desktop PCs, Laptops, and mobile phones appears high, more advanced and potable mobile ICT hardware such as Personal Digital assistance (PDA) and Tablet PCs were found to be least known.

The current level of ICT usage in general appears to consist of basic hardware and software applications and more advanced technical applications of ICT remain unexploited. The overall usage of commercially available software applications for specific work tasks such as general office administration, planning and scheduling, architectural and engineering are on a mere average

Internet access and use of computer-supported communications such as E-mail and mobile internet applications are quite prevalent through the use of wireless network connections.

Short Message Services (SMS) and voice conversation through the use of mobile phones were significantly gaining adequate level of usage. As a whole, there appears to be a high level of optimism among the firms that more advanced ICT applications such as Electronic Purchasing, Modeling and visualization (eg.3D-Cad), Project Specific Websites, Electronic Tendering,

Videoconferencing and intranets applications could gain some patronage in the near future if the necessary awareness is created.

Lastly the survey also revealed that, the most significant factors affecting the use of ICT by building contractors are: rapid changes in ICT technologies, high cost of employing ICT professionals, satisfaction with the existing method of working, Inadequate knowledge about return on ICT investment, high cost of training ICT professionals and Inadequate financial resources .

These factors should explain the main reason behind current level of ICT usage by among building contractors in Kenya. It is therefore important to acknowledge that, while the interest towards ICT by building contractors in Kenya seems promising, these factors continue to be a major issue that stakeholders and individual organizations need to address in order to increase usage and derive the full benefit of ICT. The model developed in this study if used can be the missing bridge to enable Kenyan contractors attain a higher level of ICT adoption and be able to perform optimally in the ever increasing competitive market of construction projects.

5.4 Recommendations

On the basis of findings and conclusions drawn from the study, the following recommendations are proposed.

5.4.1 Financial investment by building firms on ICT

Construction firms should be motivated by the direct benefits of ICT and draw deliberate policies that provide some proportion of their internal budget for ICT investments. This will aim to improve both productivity and profitability to their benefit. Again, based on the understanding on the returns on ICT investment, financial institutions can assist building contractors in Kenya to finance their ICT investment by offering flexible credit facilities to firms seeking to invest in ICT. This will support their operations to improve efficiency and payback the facility. Furthermore, construction client may support contractors upon request, to procure ICT facilities for their contracts as a means to support efficiency and collaboration on their projects. This will be deducted on installments from their progress payments.

5.4.2 Personnel and training of ICT professionals

By recognizing the importance of ICT education in construction as indicated by the first three challenges hindering higher ICT adoption by contractors it is recommended that a robust content of ICT education which will generate adequate construction ICT skill acquisition should be incorporated in construction courses as a supplement to technical knowledge and expertise in various fields of construction study. Again, there should be a closer cooperation between ICT technology developers and contractors to train professional and also develop ICT systems that will address the specific operational needs of Kenyan contractors.

5.4.3 Client interest in Contractors ICT capacity

Construction customers/clients should also take into account the contractors ICT technological capabilities as a criterion for selection. Furthermore, clients could often mandate the use of specific ICT technologies on their project, for instance, tendering on-line, specifying project control technologies such as scheduling tools, cost control systems, and communication systems such as email and project webs.

This could boost the potential for competitive advantage through the use of ICT technology in the building firms and to an extent compel construction firms to work towards higher ICT adoption to remain competitive and relevant

5.4.4 Increase ICT content in construction awareness at all level

By recognizing the importance of ICT awareness in construction, it is recommended that a robust content of ICT education which will generate adequate construction ICT skill acquisition should be incorporated in contractor training as a supplement to technical knowledge and expertise in various fields of construction study. A keen attention in this respect will help to deliver the required ICT skills for the Kenyan construction industry.

This will also be significant to develop and support the understanding of how ICT could be used to support construction process at all levels to facilitate the necessary change and innovation.

Based on the interviewees' opinions, the government should invest more on ICT infrastructure and improve the internet speed and internet access nationwide. Personnel training should be more targeted and tailored for specific needs of them. ICT skills should be considered as requirement for job applicant in construction industry to encourage them for learning. Data security and backup systems should be improved to mitigate construction practitioners concerns and beside this, they should be aware of ICT benefits more. Highly experienced designers should supervise the design programs'

outputs to make these results more reliable for construction. Some regulations should be revised to facilitate ICT development in construction and should be adapted with ICT world.

Paper based systems should be eliminated to the possible extent. ICT developers should make their products user friendly and improve their support systems to encourage construction firms use ICT. Extra financial support from client or government can encourage them to improve their ICT capabilities. A common standard and policy should be developed among

5.5 Suggested areas for further study

This study has assessed the level of ICT adoption by Kenyan contractors and only concentrated on contractors in financial class NCA1 and NCA2 and results drawn and reflect only the views of these two classes. It is therefore recommended that further research should be undertaken to ascertain the situation in Small scale contractor (NCA3-NCA8) for scenarios in these lower classes could shed more light on the general level of ICT adoption and the challenges that hinder a cross cut of construction firms towards higher adoption. The study should also be expanded to cover construction consultants, clients and academia to give an objective view of the whole construction industry in Kenya.

REFFERENCES

Ahuja, V., Yang, J., & Shankar, R. (2009). Study of ICT adoption for building project management in the Indian construction industry. *Automation in construction, 18*(4), 415-423.

Ardagh, (2007). A strategic view of RFID in construction, RFID Centre Ltd in association with Construction Industry Computing Association. October, 2007.

Arif, A. A. & Karam, A. A. (2001). Architectural Practices and their use of IT in the Western Cape province, South Africa. *Itcon, 6*, 17-33.

Back, W.E. & Moreau, K.A. (2000). Cost and Schedule Impacts of Information Management on EPC Process. *J. Mgmt. in Eng., 16*(2), 59-70.

Barrie, D. S. & Paulson, B. C. (1992). *Professional construction management: including CM, design-construct, and general contracting.*, (3rd ed.). London: McGraw-Hil

Becerik, B. (2004). A review on past, present and future of web based project management & collaboration tools and their adoption by the US AEC industry. *International Journal of IT in Architecture Engineering and Construction*, *2*, 233-248.

Björk, B.C. (2002).The Impact of Electronic Document Management on Construction Information Management. CIB-W78 Conference 2002, Aarhus School of Architecture, June 12-14.

Bowden, S. (2004). *Application of mobile IT in construction*. Unpublished MSc Dissertation, Loughborough: University of Loughborough.

Bowden, S., Dorr, A., Thorpe, A., Anumba, C. J., & Gooding, P. (2005). Making the Case for Mobile IT in Construction, in International Conference on Computing in Civil Engineering. L. Soibelman and F. Pena-Mora, eds., ASCE

Brewer, G., Gajendran, T., McCann, J. & Chen, S. E. (2003). Creating a Benchmarking Service to Measure lCT Uptake for the Australian Construction Industry.CRC Cl Report, Australia.

Caglar (2005). Legal aspects of ICT implementation in Turkish construction industry; applicability of elegal framework.

Chen,Y., & Kamara, J. (2008). The mechanisms of information communication on construction sites.

Cohen, J. (1992). A power primer. *Psychological bulletin, 112*(1), 155

Colwell, D. (2008). Improving Risk Management and Productivity in Megaprojects through ICT Investment. Executive Director Construction Technology Center Atlantic

Constantinides, P., & Barrett, M. (2006). Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete. *Information and Organization*, *16*(1), 27-55.

Costa, D.B., Formoso C.T., Kagioglou, M., Alarcon, L.F. & Caldas, C.H. (2006). Benchmarking Initiatives in the Construction Industry: Lessons learned and improvement opportunities. *J. Mgmt. in Eng.*, *22*(4), 158-167.

Cox, S., Perdomo, J. & Thabet, W. (2002). "Construction field data inspection using pocket PC technology. International Council for Research and Innovation in Building and Construction, Proceedings of CIB

Dainty , M. & Murray, M. (2006). *Communication in construction: Theory and practice*. London: Routledge.

Dong, A., Maher, M.L., Kim, M.J., Gu, N., & Wang, X. (2009). Construction defect management using a telematic digital workbench. *Automation in Construction, 18*(6), 814-824.

Egbu, C.O. & Botterill, K. (2002). Information technologies for knowledge management: their use and effectiveness. *Electronic Journal of Information Technology in Construction(ITcon), 7*,

El-Ghandour, W., & Al-Hussein, M. (2004). Survey of information technology applications in construction. *Construction innovation, 4*(2), 83-98.

Engsbo, M., & Sandhu, M. (2007). Emerging e-communication technologies and their usage in project-based organizations. *Management, 2*(4), 285-301.

Enshassi, A., Liska, R., Sawalhi, N., & Radwan, I. (2003). Contributors to construction delays in Palestine. *AMERICAN PROFESSIONAL CONSTRUCTOR, 27*(2), 45-52.

Field, J. (2005). *Social capital and lifelong learning.* Bristol: policy press

Board, F. S. (2011). Progress in the Implementation of the G20 Recommendations for Strengthening Financial Stability, report of the Financial Stability Board to G20 Finance Ministers and Central Bank Governors. *Basel: Financial Stability Board*.

Goh, B. (2005). IT barometer 2003: Survey of the Singapore construction industry and a comparison of results. *Journal of Information Technology in Construction (ITcon), 10*(1), 1-13.

Grieson, D.E. (1992). Computer-automated optimal design of structural steel frameworks. in optimization and artificial intelligence in civil and structural engineering(pp.327-353)

Guevara, J. M. & Boyer, L. T. (1981). Communication Problems within Construction Engineering: pp. 552-557.

Haas, C.T., Richard, L.T., Kamel, S.S.,& Nicole, A.B. (2002). The value of handheld computers in construction. Proceedings to International Symposium on Automation and Robotics in Construction, 557-562. Diss. The University of Texas at Austin, US.

Hair, J.F., Anderson, R.E., Tatham, R.L.& William, C. (1998). Black(1998), Multivariate data analysis

Harris, F. & MacCaffer, R. (2001). *Modern Construction Management*. (5th ed.) London: Blackwell Science .

Haron, A.T. (2013). Organizational readiness to implement building information modelling :A framework for design consultants in Malaysia.

Hinton, M., Francis, G.& Holloway, 1. (2000). Best Practice Benchmarking in the UK. *Benchmark, 7*(1), 52-61.

Hore, A.V (2006). Use of IT in managing information and data on construction projects – a perspective for the Irish construction industry. Information Technology in Construction Project Management Engineers Ireland Project Management Society Talk: 21st March 2006

Hore, A.V & West, R.P. (2005). Attitudes towards Electronic Purchasing in the Irish Construction Industry", 2005 CIB W92/T23/W107 International Symposium on Procurement Systems, Las Vegas, USA. 120

Howard, R., Kiviniemi, A. & Samuelson, O. (1998). Surveys of IT in the construction industry and experience of the IT barometer in Scandinavia. *Itcon, 3*, 45-56.

Irizarry, J., & Gill, T. (2009). Mobile applications for information access on construction jobsites.

Israel, G.D. (1992). Determining sample size. University of Florida cooperative extension service, institute of food and agriculture sciences, EDIS,1992

Kazi, A. S., Hannus, M. & Laitinen, J. (2001). ICT support for distributed engineering in construction.

KNBS, (2014). *Kenya economic survey 2014,* Nairobi: KNBS.

Kenya National Bureau of Statistics (KNBS) report August 2010

Kimoto, K., Endo, K., Iwashita, S. &Fujiwara, M. (2005). The application of PDA as mobile computing system on construction management. *Automation in Construction, 14*(4), 500-511.

Kish, L. (1965). *Survey sampling.* Citeu-like: Deepdyve.

Klinc, R., Turk, Z., and Dolenc, M. (2010). ITC enable communication in construction 2. *Pollack Periodica, 5*(1), 109-120.

Kling, R. (1980). Social Analyses of Computing: Theoretical Perspectives in Recent Empirical Research. *ACM Computing Surveys, 12*(1), 61-110.

Lee, S.H., Thomas, S.R. & Tucker, R.L. (2005). Web-Based Benchmarking System for the Construction Industry. *J. Const. Eng. and Mgmt., 131*(7), 790-798.

Leuven, A.R. & Voordijk, H. (2001). Enterprise Resource Planning in Construction:An Evaluation of Recent implementations. Proc. of ARCOM 1 t' Annual Conf, Univ. of Salford, UK, I, 159-168.

Lucas, H. C. (1975). *Why information systems fail*. New York: Columbia University Press.

Markus, M. L., & Robey, D. (1988). Information technology and organizational change: causal structure in theory and research. *Management science*, *34*(5), 583-598.

Martin, B. (1992). *Network planning for building construction*. London: Heinemann.

McCullouch, B. (1997). Automating field data collection in construction organizations. Proceedings of Construction Congress V: Managing Engineered Construction in Expanding Global Markets, (1997), Minneapolis, MN.

McCullouch, B. G., & Gunn, P. (1993). Construction field data acquisition with pen-based computers. *Journal of Construction Engineering and Management*, *119*(2), 374-384.

McDonagh, N.H. (1995). Changing patterns of technology, in Brandon, p. and Betts, Med, integrated construction innovation.

Miah, T., Carter, C., Thoupe, A., Baldwin, A.& Ashby, S. (1998).Wearable computers-an application of BT's mobile video system for the construction industry. *BT Technology journal*, *16*(1), 191-199.

Molnár, M., Andersson, R., & Ekholm, A. (2007). Benefits of ICT in the construction industry-characterization of the present situation in house-building processes. In *24th W78 Conference Maribor 2007* (pp. 423-428).

Moniem, A. H. A. (2000). *The Role of Project Control Systems in the Integration of the Construction Site Processes. A Case Study Approach*, Unpublished MSc, Loughborough: Loughborough University.

Murray, M., Nkado, R., & Lai, A. (2001). The integrated use of information technology in the construction industry. In *Proc. of CIB 78 Conference: IT in Construction in Africa, Pretoria, South Africa* (pp. 39-1).

Muriithi, P. (2005). *A framework for integrating ICT in the teaching and learning process in secondary schools in Kenya.* Unpublished MSc dissertation, Nairobi: University of Nairobi.

Nathawani, S., Shroff, A., Romack, G. & Ricezz, M. (1995). PDA-based field data collection for Pontis. International Bridge Conference, Pittsburgh, PA, 342-346.

Newman & Robey. (1992). A social process of user – analyst relationships. *MIS Quarterly, 16*(2), 249-265.

Oladapo, A.A. (2005). The impact of ICT on professional practice in the Nigerian construction industry, *The Electronic Journal of Information Systems in Developing Countries, 24*(2), 1-19.

Orlikowski, W.J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science*, *3*(3), 398 - 427.

Orlikowski, W.J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*(4), 404 - 428.

Ozumba, A. O. U. & Shakantu, W. M. W. (2008a). Improving the Site Management Process through ICT, CIDB 2008 Post Graduate Research Conference, Bloemfontein, South Africa, 7 – 8 March 2008.

Peansupap, V. (2004). *An Exploratory Approach to the Diffusion of ICT in a Project Environment.* Unpublished PhD thsesis, Melbourne: RMIT University.

Perreira, C.S. & Saores, A.L. (2007). Improving the quality of collaboration requirements for information management through social networks analysis. *International Journal of Information Management, 27,* 86-103.

Pettigrew, A.M. (1985). *The awakening giant: Continuity and change in impercial chemical industries.* Oxford: Blackwell press.

Purba, S., Sawh, D. & shah, B. (1995). *How to manage a successful software project, methodologies, techniques and tools*, Canada: John wiley and sons

Repass, K.A., de la Garza, J.M., & Thaber, W.Y. (2000). Mobile schedule tracking technology at the jobsite. Construction Congress VI, Proceedings of Construction Congress VI: Building Together For a Better Tomorrow in Increasingly Complex World, Orlando, FL.

Retik, A. & Langford, D. (2001). *Computer integrated planning and design for construction*, London: Thomas Telfield.

Robey, D., & Boudreau, M. C. (1999). Accounting for the contradictory organizational consequences of information technology: Theoretical directions and methodological implications. *Information systems research*, *10*(2), 167-185.

Rogers, E.M. (1962). *Diffusion of innovations*, New York: The free press.

Samuelson, O. (1998). IT-Barometer 1998 – The Use of IT in the Nordic Construction Industry, *Electronic Journal of Information Technology in Construction, 7.* Retrieved from:http://itcon.org/1998/1/

Samuelson, O. (2000). IT-Barometer 2000 - the use of IT in the Nordic construction industry, *Journal of Information Technology in Construction*. Retrieved from: http://www.itcon.org/2002

Samuelson, O. (2002). IT-Barometer - the use of IT in the Nordic construction industry, *Journal of Information Technology in Construction, 7,* 1-26. Retrieved from: http://www.itcon.org/2002

Sarshar, M. & Isikdag, U. (2003). A survey of ICT use in the Turkish construction industry. *Engineering, Construction and Architectural Management, 11*(4), 238–47. 123

Singh, A.S. & Masuku, M.B. (2013). Fundamentals of applied research and sampling techniques, *International Jr. of Medical and Applied Sciences, 2*(4), 124-132.

Songer, A.D., Young, R. & Davis, K. (2001). Social Architecture for Sustainable IT Implementation in AEC, Paper w78-2001-26: Digital Library of Construction Informatics and Information Technology in Civil Engineering and Construction.

Sorensen, K.B., Christiansson, P., Svidt, K., Jacobsen, K. & Simoni, T. (2008). Radio Frequency Identification in Construction Operation and Maintenance – Contextual Analysis of User Needs, Proceedings of the 12th International Conference on Computing in Civil and Buildg engineering (2008), International Conference of IT in Construction (ICCCBE XII & INCITE 2008).

Sun, M. & Howard, R. (2004). Understanding I.T. in Construction. London: Spon Press.

KPDA, (2014).*The Kenya Private Developers Association report 2014*, Nairobi: KPDA.

Tsai, M.K. (2009). Improving communication barriers for on-site information flow: an exploratory study. *Advanced Engineering Informatics*, *23*(3), 323-331.

US Bureau of Labor Statistics report 2013

Wang, L.C., Yin, Y.C., & Lin, P.H. (2007). Dynamic mobile RFID-based supply chain control and management system in construction, *Advanced Engineering Informatics*, *21*(4), 377-390.

Weippert, A., Kajewski, S. L., & Tilley, P. A. (2003). The implementation of online information and communication technology (ICT) on remote construction projects. *Logistics Information Management*, *16*(5), 327-340.

Wikforss, Ö., & Löfgren, A. (2007, May). Rethinking communication in construction. In *4th Nordic Conference on Construction Economics and Organisation* (p. 15).

Walsham, G. (1993). Interpreting information systems. New York: John Wiley & Sons, Inc..

Yin, H., song, D., Egele, M., Kruegel, C. & Kirda, E.(2007). Panorama: Capturing system-wide information flow for malware detection and analysis. Proceedings of the 14th ACM conference on computer and communication security (pp.116-127)

APPENDICES

Appendix i: QUESTIONNAIRE

Dear Madam/Sir,

My name is Elias Nyaga Nelson, currently undertaking master's degree program at the School of Architecture and Building Sciences, Department of Construction Management, Jomo Kenyatta University of Agriculture and Technology, Kenya under the supervision of Dr. Ahmad Omar Alkizim and Dr. Kiplimo Mutai

You are kindly invited to validate my findings on the research entitled "An assessment of the level of adoption of information communication technology by local building contractors during project implementation"

The research aims at assessing the level of adoption of information communication technology by local building contractors during project implementation. I am requesting for your kind cooperation in giving your time, experience and thoughts by answering the questionnaire form provided. Your cooperation is most essential as the deliverables of the research could be beneficial to both industry and academia. Once this survey is completed I personally undertake to send you a copy of my major findings and recommendations for they might provide you with useful information which could enhance your contract performance through ICT adoption possibilities.

For the purpose of this research, information and communication technology is defined as a collective reference to the integration of computing technology and information processing and comprises a wide range of technical approaches to a variety of problems in construction industry (El-Ghandour W. and Al-Hussein;2004) .

ICT can also be defined as the application of decision support tools, which uses electronic machines and programs for processing, storage, analysis, control, transfer and

presentation of construction information data during the whole life cycle of a construction project (El-Ghandour & Al-Hussein;2004).

Yours faithfully

Elias Nyaga Nelson

Please tick the appropriate box next to the nearest correctly suggested statement for each of the following questions:

Section A – General

About your firm

Please indicate the registration class of your firm by NCA

NCA1 ☐

NCA2 ☐

How long has your firm operated in the Kenyan construction industry?

☐ 0-5 years

☐ 6-10 years

☐ 11-20 years

☐ Over 20 years

About the respondent

1. Please state your designation in the building industry

- ☐ Contractor/builder
- ☐ Construction project manager
- ☐ Sub-contractor
- ☐ Site engineer/resident engineer
- ☐ Quantity surveyor
- ☐ Clerk of works/site agent
- ☐ Skilled laborer
- ☐ Site supervisor
- ☐ Site manager
- ☐ Others (specify)……

2. How long have you been in the building industry?

- ☐ 0-5 years
- ☐ 6-10 years
- ☐ 11-20 years
- ☐ Over 20 years

3. What is your age bracket?

- ☐ 18-30 years
- ☐ 31-40 years
- ☐ 41-50 years
- ☐ Over 50 years

4. How many building projects have you been involved in?

- ☐ 0-5
- ☐ 6-10
- ☐ 11-20
- ☐ Over 20

Section B- construction stage

5. To what extent do you use information and communication technology in your work during construction project implementation?

- ☐ Never
- ☐ Rarely
- ☐ Quite often
- ☐ Most times
- ☐ Always

6. Are the computers networked?

☐ Yes

☐ No

7. Does your firm have a website?

☐ Yes

☐ No

8. Does your firm have a separate IT division or someone responsible for IT within the firm?

☐ Yes

☐ No

9. please indicate the ICT platforms available for use in your firm during construction project implementation **(note 1=none; 2=a few ;3=several;4=many;5=very many)**

	ICT platform	**1**	**2**	**3**	**4**	**5**
a	Personal Digital Assistant(PDA)					
b	Pocket PCs					
c	Desk top PCs					
d	PDA-based mobile computing system					
e	Laptops					
f	RFID-based (Radio Frequency Identification)					
g	Smartphone application					
h	Telematics digital workbench					

	ICT platform	1	2	3	4	5
j	iPhone-based "Construction Equipment Finder"					
k	Mobile collaboration tool					
l	Mobile phone-based graphical user interface					
	Other ICT platforms (specify)					
m						
n						
p						

10. Please indicate the frequency of use of these ICT platforms for the indicated functions in your firm during construction project implementation **(note 1=never; 2=rarely; 3=quite often;4=most times;5=always)**

	ICT application	Available software	1	2	3	4	5
a	**General project administration** Book keeping, record keeping, , presentations, preparation of payrolls and reports	Spread sheets					
		Ms office word					
		Ms office excel					
		Ms office access					
		Ms office power point					
		Ms office groove					
		Ms office one note					
		Ms office outlook					
		Ms office publisher					
		Ms office info path					
		Others (specify)					

	ICT application	Available software	1	2	3	4	5
b	**Making project drawings** Conceptual design, sketches, detailed designs, modeling and visualization	Architectural Desktop					
		Autodesk Building					
		ArchiCAD					
		MiniCAD					
		FastCAD					
		AutoCAD					
		IntelliCAD					
		Revitt					
		Building Information					
		Snape Vector					
		Micro station					
		Others (specify)					
c	**Project planning, and scheduling** Work schedules and resource management	Enterprise resource					
		Microsoft project					
		primavera					
		Power project					
		pMsystems					
		Others (specify)					
d	**Project cost control** cash flow charts, budgeting, estimating, costing, accounting, Financial management, cost calculations and procurement procedures	Esti-mate					
		Manifest					
		Resource cost sheet					
		WinSmesta					
		Buildsoft					
		Masterbill					
		WinQS					
		CATOpro					
		Electronic tendering (E-					
		Others (specify)					

	ICT application	Available software	1	2	3	4	5
e	**General communication**	E-mail service					
		Mobile Internet(skype,					
		Intranet					
		Mobile phones(Short					
		Geographic information					
		Teleconferencing					
		videoconferencing					
		Dropbox, yousendit					
		Others (specify)					
f	**Site security**	Radio Frequency					
		Bar coding					
		Site surveillance					
		Global positioning					
		Others (specify)					
	Other ICT platforms used						
g							
h							
j							
k							
l							

11. Please indicate the challenges you think affect contractors generally towards higher ICT adoption in order of severity (select only the ones that are applicable) **(note 1=not at all; 2=mildly ;3=severe;4=very severe;5=very very severe)**

	ICT platform	**1**	**2**	**3**	**4**	**5**
1	Lack of information by contractors on areas of adoption					
2	Inadequate financial resources					
3	Lack of qualified personnel to handle ICT adoption					
4	Little return on investment					
5	High cost of training ICT professionals					
6	High cost of employing ICT professionals					
7	Inadequate knowledge about return on ICT investment					
8	Fear of job losses /making professionals redundant					
9	Satisfaction with existing method of working					
10	Rapid changes in ICT technologies					
11	Software and hardware reliability problems					
12	Security concerns/privacy fears					
13	Lack of legal support for use of ICT					
	Any other					
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						

Appendix ii: SECONDARY QUESTIONNAIRE

A guided interview with managers/owners of selected construction firms on ICT adoption strategies

1. From your experience on ICT adoption what broad stages can it be divided into?

   Stage one…….

   Stage two…….

   Stage three…….

   Stage four…….

2. What internal environment affect ICT adoption by a construction firm?

   ……
   ……
   …….

3. What external environment affect ICT adoption by a construction firm?

   ……
   ……
   ……

4. How does specific construction project requirements affect choice of ICT platforms for doption?

   .....
   .....
   .....

5. How would a contractor build ICT adoption capacity?

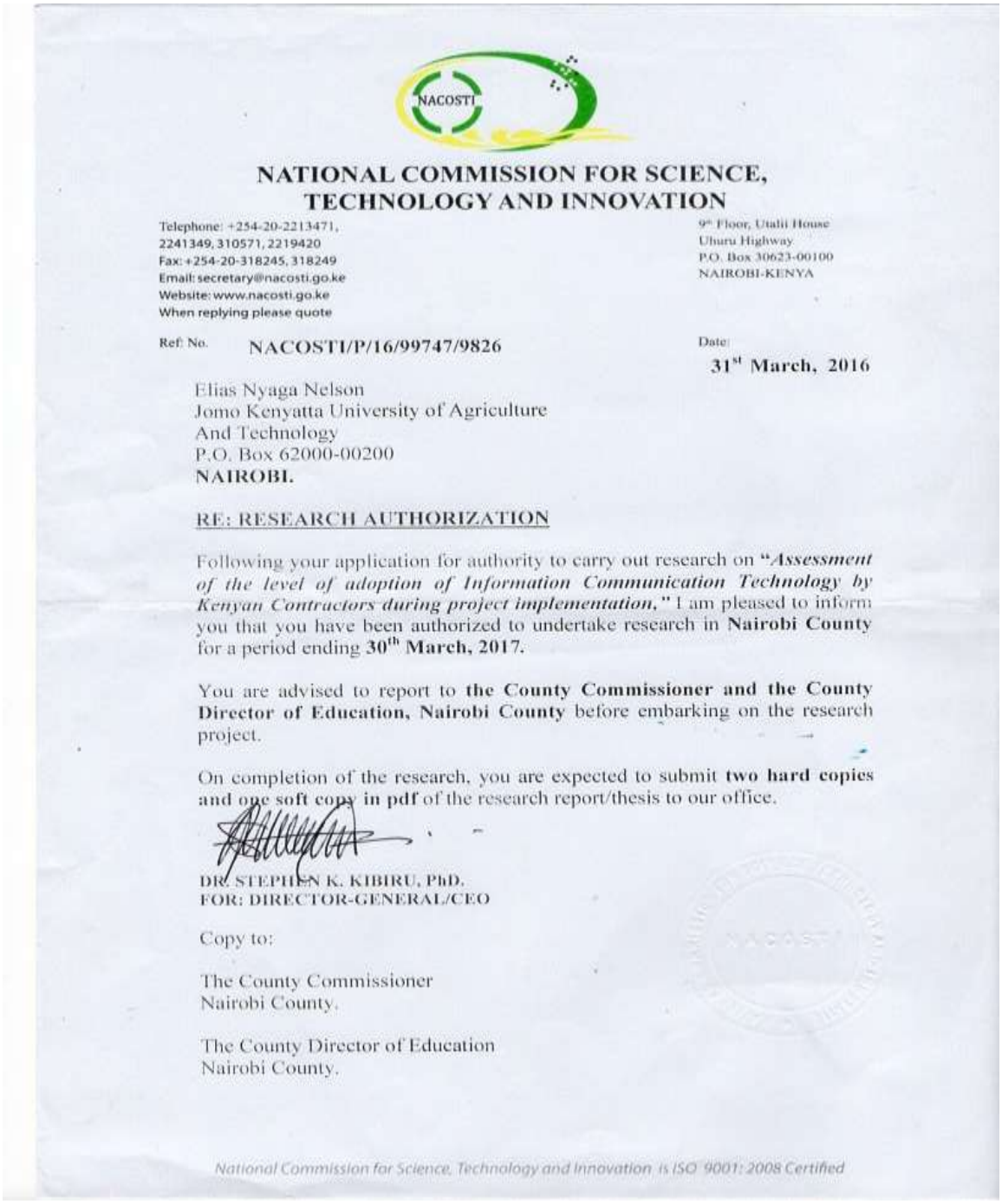
   ……

   ……..

6. In your opinion what is the best strategy in dealing with each listed challenge towards ICT adoption?

	CHALLENGE	OVERCOMING STRATEGY
1	Lack of information by contractors on areas of adoption	
2	Inadequate financial resources	
3	Lack of qualified personnel to handle ICT adoption	
4	Little return on investment	
5	High cost of training ICT professionals	
6	High cost of employing ICT professionals	
7	Inadequate knowledge about return on ICT investment	
8	Fear of job losses /making professionals redundant	
9	Satisfaction with existing method of working	
10	Rapid changes in ICT technologies	
11	Software and hardware reliability problems	
12	Security concerns/privacy fears	
13	Lack of legal support for use of ICT	

Appendix iii: Permit to conduct research



NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

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

Ref: No. **NACOSTI/P/16/99747/9826**

Date: **31st March, 2016**

Elias Nyaga Nelson
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 ***"Assessment of the level of adoption of Information Communication Technology by Kenyan Contractors during project implementation,"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for a period ending **30th March, 2017.**

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

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified