Influence of Cloud Computing Data Base Management Systems on performance of Building Construction Projects in Nairobi County, Kenya

Mwangi Laban Kamau

A Reserch Project Report Subitted in Partial Fulfillment of the Requirements for the Award of Degree of Master of Arts in Project Planning and Management, University of Nairobi

2021

DECLARATION

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

Mwangi Laban Kamau

L50/7401/2017

Signature _____ Date 26/11/2021

This research project report has been submitted for examination with my approval as University Supervisor

Signature _____ Date 26/11/2021

Dr. Angelina Sabina Mulwa

Senior Lecturer

Faculty of Education

University of Nairobi

DEDICATION

This research project is dedicated to my parents Mr. Peter Mwangi and Mrs. Cecilia Mwangi for always supporting my insatiable desire to learn.

AKNOWLEDGEMENT

I express my sincere gratitude and appreciation to my supervisor; Dr. Angelina Mulwa for her guidance and thoroughness throughout the process of writing this project.

My deepest gratitude goes to the lecturers at the University of Nairobi, Department of Management Science and Project Planning who took us through the masters' class, and especially Dr. Reuben Kikwatha who has also guided me in writing this proposal.

I am forever indebted to the class of 2017; Master of Arts in Project Planning and Management for the immense assistance you provided in my study.

Many thanks to my family, with a special mention of my wife Winnie Wachiuri for her strong encouragement and tangible support during the entire process of writing this proposal.

Finally, I thank Almighty God for His unconditional love.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AEC – Architecture, Engineering and Construction

API - Application Programming Interface

BIM – Building information modelling

BQ - Bill of Quantities

CACCIS - Context-Aware Cloud Computing Information System

CAIS - Context-Aware Information System

CC - Cloud Computing

DBMS – Database Management Systems

ETL – Extraction, Transformation and Loading

IaaS – Infrastructure as a Service

ISDN – Integrated Services Digital Network

ICPMK – Institute of Construction Project Managers Kenya

ISPs – Internet Service Providers

ICT – Information and Communication Technology

IT – Information Technology

NEMA – National Environment Management Authority

PSTN – Public Switched Telephone Network

QS – Quantity Surveyor

RAM – Random access memory

SaaS - Software as a Service

SPSS – Statistical Package for Social Sciences

UI – User interface

VPNs – Virtual Private Networks

WAN – Wide Area Network

ABSTRACT

There is an immense increase in big data and cloud computing-based solutions globally for the last decade. This is not different in Kenya, as many businesses are also adopting this phenomenon. Construction can clearly benefit from the tech, but its rate of adoption, more so in Kenya is soaring. This research therefore sought to examine the influence of the cloud computing database management systems (DBMS) on performance of building construction projects in Nairobi County, Kenya. The objective of this study was to establish how the following aspects of cloud computing DBMS influences performance of building construction projects: rapid elasticity nature of cloud computing DBMS, multi tenancy capabilities of cloud computing DBMS, on-demand self-service nature of cloud computing DBMS and broad network access capabilities of cloud DBMS. The study adopted two theories, namely; information system success model and Seddan's model of information success which examines the success, usefulness and relevance of information systems; cloud computing DBMS is a type of information system. The study adopted descriptive research design with a target population of 129; made up of construction project managers in three categories of fellow, corporate and graduate members classified based on the number of years practiced. Stratified random sampling technique was used to come select a sample size of 98 respondents who were served with questionnaires to obtain the primary data for the research. Data was coded and entered into Statistical Packages for Social Sciences (SPSS) which analysed it to give percentages, frequencies, means and standard deviation. Inferential data analysis was done to establish how independent variables related to dependent variable. Frequency tables were used to present quantitative data while quantitative data was presented in prose form stating explanations. The study found that the flexible provisioning of resources influence performance of building construction projects to a very large extent. Moreover, the study established that providing a set of behaviour stimulation resources adopted from a single common source influenced performance of building construction projects in Nairobi County to a moderate extent. Moreover, the study found that provision of resources such as network storage and automation of computing services influenced performance of building construction projects to a large extent. Further, the study established that enabling users to categorize and segment system influenced performance of building construction projects to a moderate extent. The study concluded that multi tenancy capabilities of cloud DBMS had the greatest influence on performance of building construction projects in Nairobi County, followed by on-demand self-service nature of cloud DBMS, then broad network access capabilities of cloud DBMS while rapid elasticity nature of cloud DBMS had the least influence on performance of building construction projects in Nairobi County. The study recommends that the leaders and the frontiers of the IT departments in the building construction projects in Nairobi County to acknowledge this trend in technology and embrace the strategic opportunities that can be accrued from it. Moreover, the study recommended that Multi-tenancy protections must be offered by cloud service providers for all layers of their offerings.The study also recommends that concerns on the use of cloud computing should be considered in the development of a road map.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Cloud computing is becoming very popular amongst other ICT in recent times, with many computer analyst and media giving it a lot of focus because of the opportunities it is offering. It is forecasted that cloud computing database services will increase by 17% in 2020 (Stanford, 2019). Cloud Computing database management systems is estimated to increase the cost efficiency of business application by up-to 300% and above 500% for consumer applications (Gupta & Saini, 2019).

Cloud database management systems refer to the use of virtual servers for data storage and access of the stored data through an Internet connection. This is also referred to as using cloud-based or web-based services. Moving to the cloud may refer to a number of things such as increasing the data bandwidth and retain the same size of ICT infrastructure, attaining a license for a web-based software and get billed on use basis or saving your files virtually in platforms such as drop box. This is not limited to desktops and laptops but also by use of other mobile devices such as tablets and smart phones. Cloud computing is therefore storage and sharing of data virtually by support of internet (Okonor, 2021).

Building and construction projects are often described as being fragmented with various stakeholders. A typical construction project has many players, comprising of consultants, contractors, developers and suppliers who process and share data amongst themselves through-out its lifecycle. In addition it is highly complex, collaborative and involving many different bodies and organizations for example clients, designers, consultant, contractors financiers and regulatory bodies such as NEMA and city council (Allen, 2019).

Files that are shared are but not limited to: 3D designs and models from Architects, structural and services Engineers, cost plans from the Quantity surveyor and work program forecasts from the Project Manager. Naturally these are bulky files which require large physical storage for the hardcopies and large capacity in the hard drive for the soft copies. Sharing data and coordinating all the stakeholders poses a challenge when depending on the use of third-party tools as a support system. It is thus believed that Cloud Computing platforms provide better, robust and efficient mechanism for the players in the AEC industry to share data and collaborate their activities as it offers a centralized system that is guided by the project manager (Inmor & Suwannahong, 2020).

It is approximately that 40 percent of Europe and the USA's total strength and resources are consumed in construction (Seymour, 2019) hence the multiple global megatrends which are shaping the future of construction. Statistics shows that 30% of global greenhouse gas emissions are attributable to buildings, and secondly, the population in the urban areas across the world increases by 200,000 people per day, meaning a perpetual increase for housing requirement and expansion of the transportation and utility infrastructure. These growths are a challenge but at the same time offer opportunities for the construction industry to offer an efficient way of speeding the construction process (Allen, 2019). Some of the innovations in the construction industry is use of modular system, development of automated bulldozers incorporating various digital systems, use of drones in large construction sites which take progress photos, 3D scanners and stereo cameras that gather terrain data, which is then transmitted to the bulldozers. Incorporation of intelligent machine-control systems to construction equipment enable them to work in autonomy thus increasing speed and efficiency by minimizing error margins (Philzona, 2018).

Many documents are produced by various parties in the construction industry which are bulky and many posing challenge in storage and sharing of these documents. It is indeed hard to find all the data of a single project by the time of closure as each party stores its data independently and rarely do they come together to compile them together (Buniya et al, 2020). The big question then is; how does the whole team in a project integrate all the data such that each player in the project can access and manipulate it for effective and smooth running of the project?

It is not uncommon to enter into an architect office and find a large chess box full of drawings. Or in a QS firm and find large shelves and drawers full of contract documents. These documents over time may be destroyed by insects, rot or even be destroyed by fire. Similarly those firms and companies that store their data and files in their computer hard drives, complain of low disk storage, some going extra miles of purchasing portable and large hard disks which are expensive without guarantee of not crushing. Similarly, what happens to the data and information stored in the computer internal hard disk in case of a computer breakdown or in the unfortunate event of fire? The truth is, all the data not backed up externally regardless of how crucial in running of projects is lost (Eelu, S., & Nakakawa, 2018).

In the recent past, in a bid to make construction industry functions coordinated, construction project managers are being employed to manage the construction projects; their major function

being to ensure all the project stakeholders work in collaboration in delivering the project on time, within set budget and to the desired quality. This has set them at the center of receiving and disseminating large files from and to other project parties. Many of these construction management firms are coming up with ingenious ways of managing the large arrays of databases by setting up centralized platform where all project players store and access data for the project. Examples of these platforms are BIM 360, basecamp among others (Kabata,, 2021). These solutions being sought by the construction project managers are all cloud based, and though are temporary in nature in that, different solutions are sought for different projects being executed within same office; they seem to make database management easier. For that, this study purpose to investigate how use of cloud computing database management systems influences construction project management firms in their day-to-day service delivery (Banta, 2019).

Project team is likely to benefit from the cloud's agility and ability to provide greater freedom and ease to access of project information such as progress photos, real time construction process anytime, remotely from every day place of work (Zhang et al., 2018). A good example is a construction project happening in Moyale, and the Project manager has his office in Nairobi, The architect is based in Kisumu and the engineer in Nakuru can easily coordinate their activities virtually in 'one house' and efficiently run the project in Moyale. This is possible provided there is internet connection and each one of the parties has password to access the virtual data stored in the cloud (Olufemi, 2019).

Using the cloud computing concept in the building construction projects therefore has strong appeal because of the bulky nature of files stored and shared among the parties in a particular project. Usually, there are a lot workers at the site with many processes happening concurrently at the site which necessitate greater access to company data while working in the field to aid in quick, well-supported decision making and reporting without having to call the head office. As Kenya has been Africa's leader in ICT innovation, hosting a number of regional centres such as IBM's research lab and headquarters for google in sub-Saharan Africa (ICT Authority, 2019), her location makes it ideal to utilize the benefits of cloud computing by construction project managers. Therefore, this study sought to establish influence of cloud computing data base management systems on the performance of building construction projects in Nairobi County, Kenya.

1.2 Statement of the Problem

There is an immense increase in big data and cloud computing-based solutions globally for the last decade. This phenomenon has continually gained momentum amongst most industrial players if not all, in attempt to gain competitive edge. This is not different in Kenya, as many businesses are also adopting this phenomenon. According to the strategic plan by ministry of Information, communication and technology (2013); cloud computing and big data analytics are among the key tools that will propel most Kenya based organizations to international platform. It will benefit the government and private sector by reducing monies spent in owning ICT infrastructure in addition to improved data security, reliability and availability of ICT services.

The construction industry is fragmented in nature, where design and production functions are separated contributing to the enormous lack of efficiency in service delivery (Masu & Wanyona, 2020).). Construction is notorious for being one of the least digitized industries in the world albeit considered to have complex workflows as it involves multiple players and most of the construction projects takes a long period of time from conception to when they are completed. The industry thus need to take advantage of all these emerging technologies such as use of cloud solution in a bid to improve on performance, collaboration of team members and seamless flow of data and information when transitioning from one stage to the next in the project lifecycle. Within the last couple of years, developers have been testing the potential of software-as-a service cloud solution for construction industry in devices that has 4G internet to see it effects on running of the construction process, communication amongst the project members and the overall effect to the construction projects (Mbugua & Winja, 2021).

Kenya is among the leading construction hub in Sub Saharan Africa as demonstrated by the various mega project that ongoing. BMI Research indicates 8.7% growth of Kenya's construction industry thanks to large construction projects and is projected to remain stable until 2026. Nairobi County is one of the counties with the highest construction development projects in the country with projects such as the Nairobi Mombasa Highway expansion project, expressway highway from JKIA to Westlands, 88eighty eight Nairobi condominium and Pinnacle towers. It is however revealed that on average, 35-60% of projects initiated in Kenya face cost overruns and 35-73% are not completed on time (Ronoh, 2020). Many construction projects also result in disputes arising from lack of proper paper trail of all the decisions that have been taken during project execution whose result is financial strain to both the developers and the contractors (Kihoro, 2020).

Lack of proper database management systems set out by the construction project managers has a large stake in most of these challenges aforementioned, with most project team members using traditional database management systems such as use of physical files, use of memory sticks which are easily misplaced or destroyed by viruses, hence loss of data and information (Mbusi, 2020). Martins, (2020) demonstrates how large and small businesses are gaining massive benefits by deploying cloud computing database management systems such as cost efficiency in maintaining their data, easy data backup, easy accessibility and retrieval of data, and remote access of business files by internal staff and their authorized suppliers resulting to an overall improved performances in terms of business profitability and efficiency. Could construction project management firms gain such benefits if they deployed cloud-based DBMS in running projects? It is in this light that this study sought to establish the influence of cloud computing data base management systems on the performance of building construction projects in Nairobi County, Kenya.

1.3 Purpose of the Study

The purpose of this study was to establish influence of cloud computing data base management systems on the performance of building construction projects in Nairobi County, Kenya

1.4 Research Objectives

i. To establish the influence of rapid elasticity nature of cloud DBMS on performance of building construction projects in Nairobi County
ii. To examine the influence of multi tenancy capabilities of cloud DBMS on performance of building construction projects in Nairobi County
iii. To evaluate the influence of on-demand self-service nature of cloud DBMS on performance of building construction projects in Nairobi County
iv. To assess the influence of broad network access capabilities of cloud DBMS on performance of building construction projects in Nairobi County

1.5 Research Questions

i. What is the influence of rapid elasticity nature of cloud DBMS on performance of building construction projects in Nairobi County?
ii. What is the influence of multi tenancy capabilities of cloud DBMS on performance of building construction projects in Nairobi County?
iii. What is the influence of on-demand self-service nature of cloud DBMS on performance of building construction projects in Nairobi County?

iv. What is the influence of broad network access capabilities of cloud DBMS on performance of building construction projects in Nairobi County?

1.6 Significance of the Study

It was hoped that the findings of this research would benefit the building construction projects, given that one of their major challenge is data management due to the fragmented nature and involvement of many divergent stakeholders in any building construction project. While many construction project managers have embraced computer technology in their practices by digitizing most of their services, their uptake of cloud service has been slow and cautious. The findings of this research would inform the construction project managers in Kenya the pros and cons of using cloud based database management systems when executing projects.

For the researcher, the study would enable him undercover the nature of data in any typical building construction project, the stakeholders involved and their unique contribution to the data flow; and how the construction project manager integrates all these stakeholders, ensuring that all information is well managed and accessed by the project team. In additional the researcher sought to find out the existing database management systems and the influence of using cloud based database management systems on time, cost and quality management of a construction project. More critically the findings would inform whether cloud-based management systems increases the efficiency of construction project management practice compared to the other forms of database management.

Moreover, this research would ignite the fire of innovation when carrying out construction project management process as cloud computing technology complements new concepts such Building information modeling (BIM) and therefore making the Kenyan construction industry at par with other developed nations such as UK as far as advancement in technology is concerned.

1.7 Delimitations of this Study

This study was limited to building construction projects that were within Nairobi County. This is where the capital city of Kenya is domiciled and it neighbors Kiambu County to the north, Kajiando County to the south and Machakos County to the east; these four counties form Nairobi metropolitan region. Many construction based firms are located within Nairobi due to its centrality making it a suitable county for this study.

This study was confined to establishing the influence of rapid elasticity, multi tenancy, on-demand self-service nature, broad network access capabilities of cloud computing DBMS on performance of building construction projects in Nairobi City County.

1.8 Limitations of this Study

The researcher encountered various difficulties while conducting the study. First the respondents were reluctant in giving information fearing that the information being sought might be used to intimidate them or print a negative image about them. This was handled by carrying an introduction letter from the University and a research permit to assure them that the information would be treated with confidentiality and would be used purely for academic purposes. Further, the study was also limited to the extent to which the respondents were willing to provide accurate, objective and reliable information. The researcher checked for consistency and test the reliability of the data collected.

1.9 Assumptions of the Study

The study assumed that all the respondents who were involved in this study had interacted with both cloud-based database management systems and the traditional database management systems. It was also assumed that most participants who were giving data understand the commonly used terms of cloud-based data base management systems. The study further assumed that most participants in giving data to the researcher were in tune with the current trends in the ICT sector.

1.10 Definition of Significant Terms in the Study

Definitions of the significant terms used in the study were as follows:

Broad network access: This is a feature whereby incorporated computing resources and networks are shared amongst various users that are not necessarily in a similar location. Cloud DBMS providers ensures that more network management functions are available virtually so that many users access their cloud resources with fewer customer devices.

Cloud database management system: This is a model that allows for convenience in storage, sharing, retrieving of data, resource and network as required by the user provided there is internet. Many users can access resources simultaneously with minimal indulgence of the service provider as the resources are rapidly and automatically distributed to the users based on their demands.

Multi tenancy: This is a collection of resources that are ready for use in assigning tasks to projects. In cloud computing DBMS, this feature assess requirements of a project or task and assigns resources based on that requirement. This makes it possible to have various tasks running remotely but requiring same resource to be happening at the same, each apportioned part of the resource commensurate to its requirement.

On-demand self-service: This is the aspect of allowing the user ability to choose what services to utilize based on their requirement. In cloud computing DBMS, this is made possible through automation of services and ability to scale up and down resources being used guided by the tasks that the user is performing. The user need not to go through the IT department to access certain data as it is available on request.

Rapid elasticity: This is the ability of cloud computing DBMS scaling resources automatically either by reducing or increasing it in response to the user requirements.

Performance: This refers to how well building construction projects achieve their intended goals in terms of timely completion, fitness for purpose, quality workmanship and within set budget.

1.11 Organization of the Study

This study was organized into five chapters. Chapter one comprises of the background of the study, statement of the problem, objectives, questions of the research, significance of the study, delimitation, limitation, assumption of the study, definition of the significant terms and organization of this research. Chapter two encompasses the literature review, theoretical framework, conceptual framework and potential areas of study related to the researcher's study topic. Chapter three consist of the research methodology which comprises of research designs, target population, sampling and sample techniques, research instruments and data collection procedures, data analysis and ethical considerations. Chapter four present analysis and findings of the study as set out in the research methodology. Chapter five which is the last chapter of the project presents the discussion, conclusion, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews existing literature written by other researchers on how cloud computing DBMS influences performance of building construction constructions. The emphasis of this review is based on study of the following aspects of cloud computing DBMS; rapid elasticity and scalability, multi-tenancy and resource pooling, on-demand self-service, and broad network access. Thereafter, theoretical review and an outline of the conceptual frameworks of the study have been presented. The chapter identifies knowledge gaps that this study is attempting to fill and finally a summary of the literature review.

2.2 Performance of Building Construction Projects

The benefits of applying cloud computing for construction sustainability was done in Nigeria by Oke, Kineber, Al-Bukhari, Famakin and Kingsley (2021). In their study, the cloud computing benefits-related data were retrieved from previous studies and complemented with a questionnaire survey to obtain data from stakeholders involved in the execution of construction projects in Lagos State, Nigeria, through a convenient sampling technique. In addition, the relative importance index (RII) technique was used to investigate the acquired data. At the same time, analysis was accomplished using exploratory factor analysis (EFA). Findings indicated that numerous benefits could be derived by adopting cloud computing in the Nigerian construction industry. The findings from RII analysis showed the significant benefits of data storage ubiquity, high situational awareness, team collaboration, compatibility with advanced production facilities and improved project planning. Therefore, this study shows that proper management of data is important especially when transitioning from one phase of a project to another but does not clearly show the aspect of performance.

Bello et al. (2020) highlighted the current contributions and use cases of cloud computing in construction practices. As such, a systematic review was carried out using ninety-two (92) peer-reviewed publications, published between 2009 and 2019. A key highlight of the findings is that cloud computing is an innovation delivery enabler for other emerging technologies (building information modelling, internet of things, virtual reality, augmented reality, big data analytics) in the construction industry. This study therefore shows that with proper data management systems in place the project manager is able to identify risks early enough so as

to put in place mitigation measures. The study however does not look into the performance aspect much.

Oke, Kineber, Albukhari, Othman and Kingsley (2021) evaluated the cloud computing implementation and its Critical Success Factors (CSFs) towards ensuring sustainable construction projects in Nigeria. Data were collected from previous literature, supplemented by a quantitative approach via a questionnaire survey. Data were collected from 104 construction professionals while cloud computing CSFs were examined using Relative Importance Ranking (RII) and Exploratory Factor Analysis (EFA). The results show that cloud computing's awareness level is 96.2%, which means that the respondents are aware of cloud computing concept. Furthermore, the result shows that most of the respondents are adopting the concept. The analysis of the CSFs indicated that reliable data storage, performance as well as cost of accessibility and availability were the four most significant CSFs to cloud computing applications. Analysis of the CSFs through EFA generated four main components which include human satisfaction, organization, client's acceptance, and industry-based. The study shows that performance is measured using timely completion of a construction project, minimal or zero variations from the original design, within budget and satisfying all the stakeholder's needs.

2.3 Rapid Elasticity Nature of Cloud DBMS on Performance of Building Construction Projects

A key aspect of cloud computing DBMS is the ability to allocate resources to the user promptly when needed and take them back when not needed, based on the demand of the task being carried out. Cloud computing DBMS also scale the resources up or down real-time depending on the complexity and resource requirement of tasks being executed. This therefore means that the capacity, usage and the associated charges also scale up and down without any additional contracts or penalties as it is an intrinsic feature for all cloud computing DBMS (Novkovic, 2017).

Cloud computing DBMS providers ensure that there are enough resources which is scalable on need basis for all their customers, which then provides flexibility and confidence amongst the users that their database management needs will always be met. The benefit of this is that there is less provisions in capital expenditure to the cloud customers as they easily access most of their computing services virtually, utilizing just the right type and capacity of services ranging from data creation, storage, retrieval and sharing to other users (Philzona, 2018).

The scalability and rapid elasticity nature of cloud computing DBMS allows businesses and industries to reshape their infrastructure to accommodate the ever-changing demands of their customers without relying on computer hardware and software that was relevant in the past. This they do without necessarily buying new hardware, or software; by redesigning their networks to allow for deployment of multi-cloud which address their existing problems and concerns, giving them flexibility to increase or decrease their operations (Banta, 2019).

According to (Talamantez, 2017) construction project managers have to manage hardware and software. New versions of software are released every year, requiring everyone in the office and amongst the project design team to upgrade as a way of ensuring compatibility in files. As a matter of fact, it is expensive to upgrade computers for everyone in the firm and even more challenging ensuring that computers from other project design team members have also been upgraded. As such use of software as service model of cloud computing DBMS makes it possible for the entire firm and the project team by extension to use the latest version of the software without upgrading the hardware. Its scalable nature automatically increases the capacity for the users to accommodate the requirements of the updated software.

Cloud computing services are all web-based hence accessible from various devices that have internet connection. Moreover cloud computing DBMS service providers are well equipped with hardware, technical skills and enjoys economies of large scale since the offer their services to multiple users. As such, they able to carry out analysis of business growth for their customers, thus offer suitable plans for their customers. In that regard, construction project management firms are able to plan for their existing hardware and software, minimizing on over purchase due to high levels of uncertainty (Zhang et al., 2018).

2.4 Multi-tenancy and Resource Pooling Capabilities of Cloud DBMS Sharing Tools on Performance of Building Construction Projects

Cloud computing DBMS are designed with features that allow them to support a model with many customers sharing the same applications and infrastructure, but at the same time each customer retaining security and privacy of their information. (Novkovic, 2017) equates this aspect of cloud computing to people living in a multi-story apartment block but still able to enjoy personal privacy within their own apartment.

In Cloud computing DBMS, the computing infrastructure provides resources through the internet therefore enabling the providers of cloud computing services to pool and manage the IT resources from a centralized storage space, which are then allocated as per the requirements

of the users. The users are charged according to their resource request and utilizations, and they need not to be concerned about how the infrastructure has been implemented. Cloud computing DBMS is characterized by resource sharing, with dynamic adjustments that are based on user increase and decrease in resource requirements. If the construction project management firm has an increase of application, then the resource is automatically increased to match the demand and consequently, if there is a reduction in application demands, the resources are reduced in equal proportion. This makes utilization of IT resources in the firm to be efficient and economical (Singh & Chana, 2016).

Another aspect of multi tenancy and resource pooling of cloud computing DBMS is virtualization of data which integrate data from many varying sources across the enterprise. In virtualization, data is extracted, transformed and loaded for the on-demand consumption by a large array of applications without necessarily owning the computer infrastructure. Dodd-Frank Act which is a mandate with a 360° view of the firms could easily be implemented with virtualized applications. It views risk and performance across all project portfolios within a construction project management firm, enforcing more compliance and regulatory reporting for the firms, giving them ability to calculate variation margins (Russom, 2017).

Virtualization also comes in handy when performing critical success factor on a construction project as it fetches large volumes of data from multiple sources and portfolios, studies historical trends of these portfolios and predict the outcome of an ongoing project. It also aids the construction project management firms in identifying resources consumption patterns and hence forecast for the future accordingly. It reduces on the challenges of combining many disparate data from public and private domains as it pools it to a centralized virtual source therefore, accessing that data from a single point (Davenport, 2019).

2.5 On-demand Self-Service Nature of Cloud DBMS on Performance of Building Construction Projects

On-demand self-service refers to provision of cloud services whenever they are required by the user. Cloud computing DBMS vendors deploy the services in various ways and forms necessitated by the end user needs, allowing them to access the specific cloud services in an online control panel. Users are able to scale up the required infrastructure without affecting the operations of the host, as it automatically allocates resources based on the magnitude of the tasks each user is undertaking. This means that a consumer is able to offer computing

capabilities unilaterally without any human interaction with the service providers (Dillon, Wu & Chang, 2015).

All services and resources are automated, and as such the users are not required to go through the IT department or own their IT infrastructure to carry out tasks as they perform all actions that leads to acquisition of the desired services. To make this possible, a cloud provider has invested in an infrastructure that execute consumer requests automatically by virtualizing needs for the various consumers in a pooled hardware. To flawlessly offer on-demand self-service computing, the vendor should plan intensively so that all the varying needs of the users are well met without a downtime; as such vendor offering construction-based cloud computing solutions need to monitor trends in resource usage in construction project management firms and plan for future situations well in advance (Kundra, 2016).

Sriram & Khajeh-Hosseini, (2019) intimates that the cloud provider cannot assume that the customer has significant specific knowledge pertaining their data requirement, hence the cloud providers put a lot of attention into offering an intuitive user interface and excellent technical specifics that process requests from various users as they have a lot of experience pertaining various user requirements for example, how much RAM will be required for a specific use case. There is also high amount of automation required to run a cloud as humans have no way of thoroughly inspecting the intricacies of a scenario and making informed choice for requests based on context; thus planning ahead of time is required, followed by putting in place a number of policies that can be implemented automatically by the cloud infrastructure. Different classifications have been established to capture the service layers of Cloud computing DBMS development, cloud business models and cloud architectural layer (Yang & Hsu, 2016)

Despite its popularity, many construction project management business strategists are unfamiliar with this concept of cloud computing DBMS which involves the provision of computing capabilities to many customers without the challenge of equipment or maintenance costs. This concept is a relatively affordable and feasible platform which supports dedicated computers. It offers networks and storage infrastructure as a service (IaaS) and software as a service (SaaS) provided there is availability of internet (Mell & Grance, 2011). In this information age, use of cloud-computing services is quite common, hence, construction project management firm strategist would find it easy to promote use of cloud-based applications and software.

Building construction projects can therefore realize a lot of benefits by exploring cloud computing offer of software as a service which enables the user to run and use a software virtually without owning or managing the infrastructure (Mell & Grance, 2011). Both the infrastructure and the operating system in which the software is installed is owned by the vendor who licenses the application to the customer as a service on demand through a "pay-as-you-go" subscription. This arrangement is cheaper and easier for the construction project team to access some of this tools that aid in tracking time and update on progress real-time in a shared platform such as share point. This not only increases efficiency but also enhances collaboration amongst the project team members (Ding, 2014).

2.6 Broad Network Access Capabilities of Cloud DBMS on Performance of Building Construction Projects

Cloud networking describes access of networking resources from a third-party provider using Wide Area Networking. Networks are shared amongst various users not necessarily in a similar location. Cloud DBMS providers ensure that more network management functions are available virtually so that many users access their cloud resources with fewer customer devices (Sosinsky, 2018).

In cloud computing DBMS resources are shared form various servers which have stored data in many different locations sharing similar networks creating a range of resources. Users are connected to this range of resources by running the applications in these servers. The missions of mining and allocating user the correct resources from a resource pool create the network's mission in cloud computing. Network performance in cloud applications determines how the Cloud computing DBMS performs in relation to speed of storage, retrieval and processing of the stored data into information (Jansen & Grance, 2019).

There exist two types of cloud, public and private clouds. In a private cloud, data could be shared through an intranet, with users accessing the server/ storage via a local area network. For large corporate entitles, cloud providers support their private cloud by virtual private networks (VPNs). Public cloud on the other hand requires internet to access the network, and sometimes may create a tension between security and performance. Cloud computing DBMS providers are encouraged to support encrypted tunnels as a way of improving data and information security. Encryption of data however increase delay and may impact on performance. Transit hops are created to address the issues of security and delays, as they improve on security without affecting the speed of the cloud DBMS. Construction project

management firms using public cloud are required to deploy such transit hops so that they are able to enjoy full benefit of a public cloud without compromising on security of their data. There are large construction project management firms in Nairobi which are a subsidiary of international firms, these for instance stand a big chance of benefitting from virtual private networks when accessing their private cloud (Grigorik, 2013).

Sultan, (2015) writes on the importance of determining the ability of the network to measure cloud computing DBMS performance and guaranteeing its consistency. The key thing to look for in exploring the impact of networks on Cloud computing DBMS performance is the differences that exist between the construction project management firm current application/network relationships and those that will exist under the cloud. Those differences are what will impact the database DBMS users (Lanier, 2014).

There is a lot of discussion and excitement in the architectural, engineering and construction (AEC) industry on how cloud computing DBMS is progressing in providing building construction projects with access to limitless data, services and applications, to an extent the industry players forget choice of network has a role to play in having an effective cloud architecture. A number of construction project management firms may have utilized a cloud architecture with zero consideration on its application limitations that comes with legacy networks to its performance. Focus to the applications themselves should be the approach to be considered when optimizing networks when construction project manager is deploying any cloud computing DBMS (Reese, 2019).

2.7 Theoretical Framework

This research evaluated two theories namely; Information system success model by DeLone and McLean and Seddan's model of information success.

2.7.1 Information System Success Theory by DeLone and McLean

This theory was developed in 1992 by William H. DeLone and Ephraim R. McLean. They improved this theory in 2003 to factor in input, criticisms and feedbacks from other scholars carrying out similar research. This theory conducted an extensive outlook of information success by evaluating six inter-related dimensions on information system success as graphically demonstrated below.

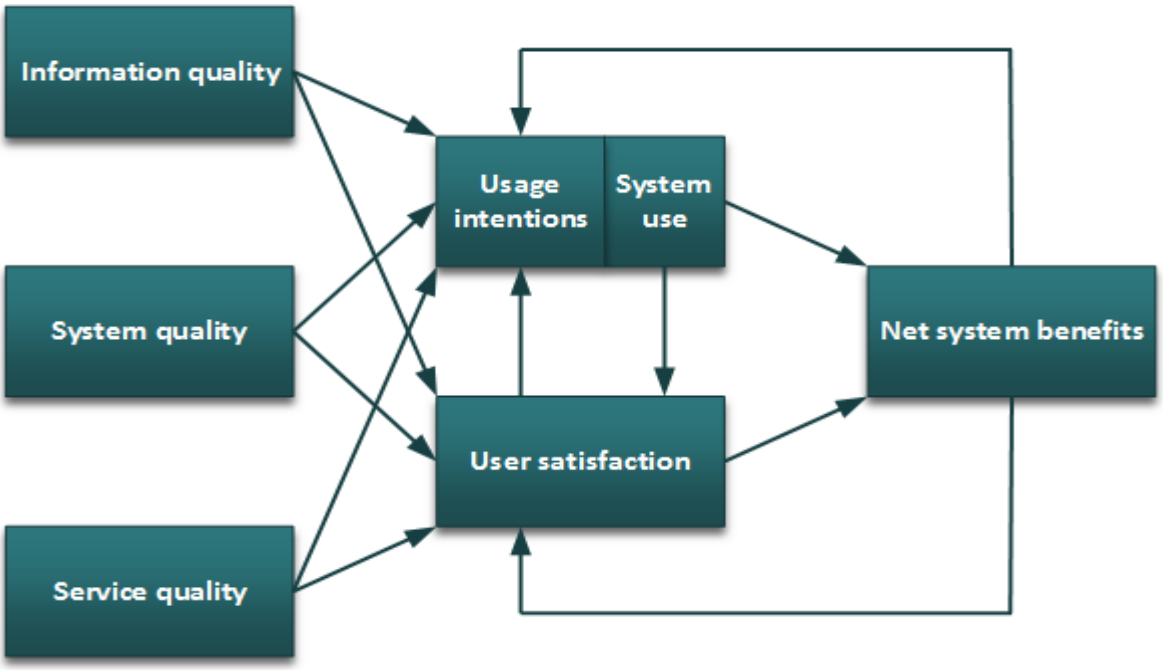


Figure 1: Graphical view of Delone and McLean Information System Success Theory

Information quality, which refers to the standard of information that the system store, deliver and produce in manner that is useful and fit to the intended consumer. It evaluates information completeness, relevance, easy to understand and the secureness of that information. Information quality affects both the user's satisfaction with the system and user's intentions to use the system, thus measuring the overall beneficial effects yielded by the user and the organization (Loukis et al, 2020).

System quality is very key aspect as it evaluates the characteristic of usability, availability and adoptability not to mention the timeliness of information delivery. That and service quality which measure information system success; evaluates how well services are delivered to the customers enabling them to meet their expectations (Chen, Chen & Lee, 2018).

Another dimension of Delone and McLean Information System Success Model is the net system benefits which measures the balance between the pros and cons of a particular information system. This dimension evaluates market growth as a result of using the system, efficiency of carrying out tasks and the alternative outcome of using competing/ similar information systems (Amron, Ibrahim & Chuprat, 2019). The theory suggested that organization uses various information systems as a way of evaluating their performance making it relevant for this study as it helps in understanding how cloud computing database management systems influence the performance of building construction projects, in Nairobi County, Kenya.

2.7.2 Seddon's Theory

Seddon used Delone (2003) theory to develop his theory which evaluates two aspects of information system namely; information system use and information system success. The IS use looks at the net benefit as result of using future IS use. On the other hand the success model information system examines the following:

Information and system quality which according to is determined by two aspects namely timeliness and accuracy of the output. This aspect further examines the ease of use of an information system, the appearance of the user interface and the ease of system maintenace.

General perceptual measures of net benefits of information system use. All the benefits such as increased performance and enhanced satisfaction by the user are examined. This aspect has an emphasis on the outcome of the whole process with a deep evaluation of all the pros and cons of adopting an information system (Alharbi, Atkins & Stanier, 2019).

Other measures of net benefits of information system use such as societal benefits and any other benefit that an organization is likely to derive.

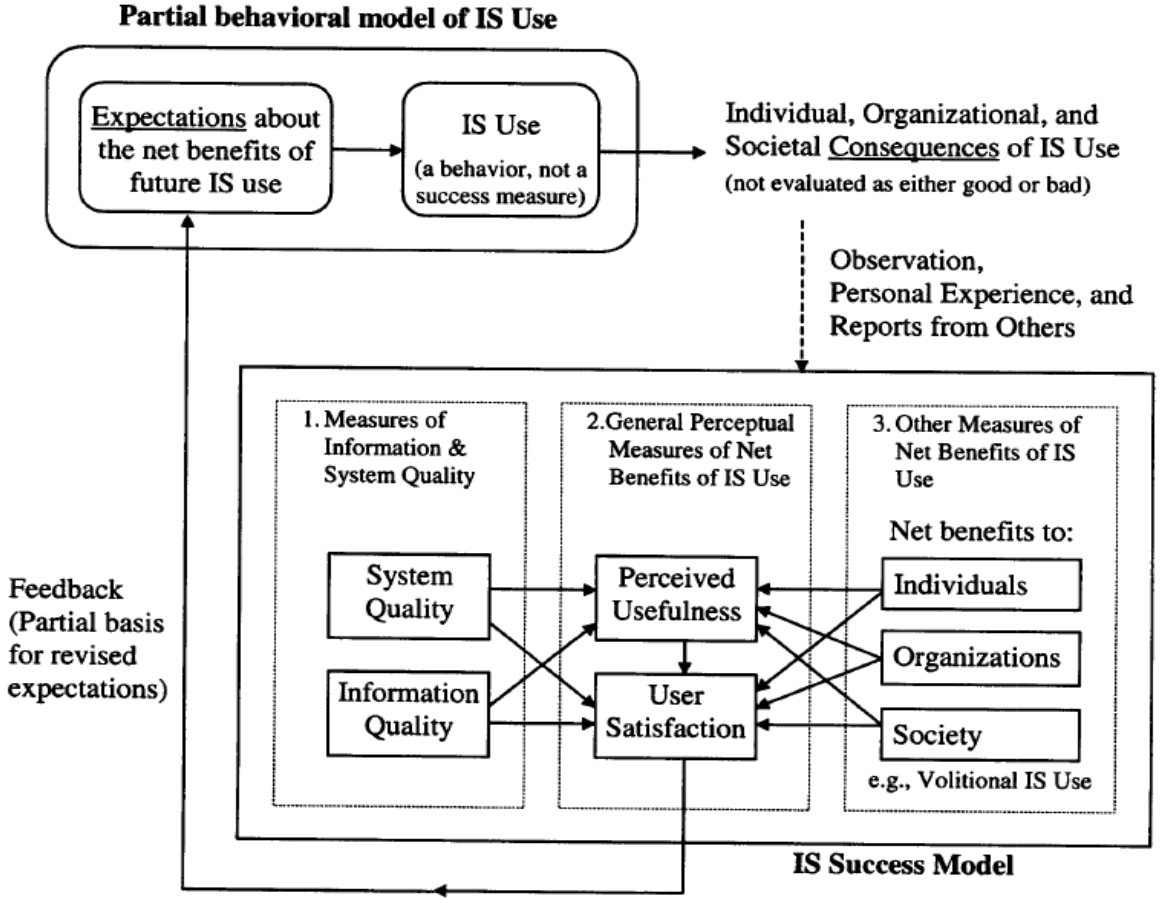


Figure 2: Seddons theory of information system success

In relation to this study, the two theories examine the success, usefulness and relevance of an information system. Cloud computing data base management system is type of information system which the research is seeking to study its influence on the performance of building construction projects in Nairobi County, Kenya.

2.8 Conceptual Framework

The purpose of this study was to determine to what levels the dependent variable relies on the independent variables. The conceptual framework is usually to illustrate how the system of concepts, expectations, beliefs, assumptions, and theories informs and support the research and forms a key part of the research design

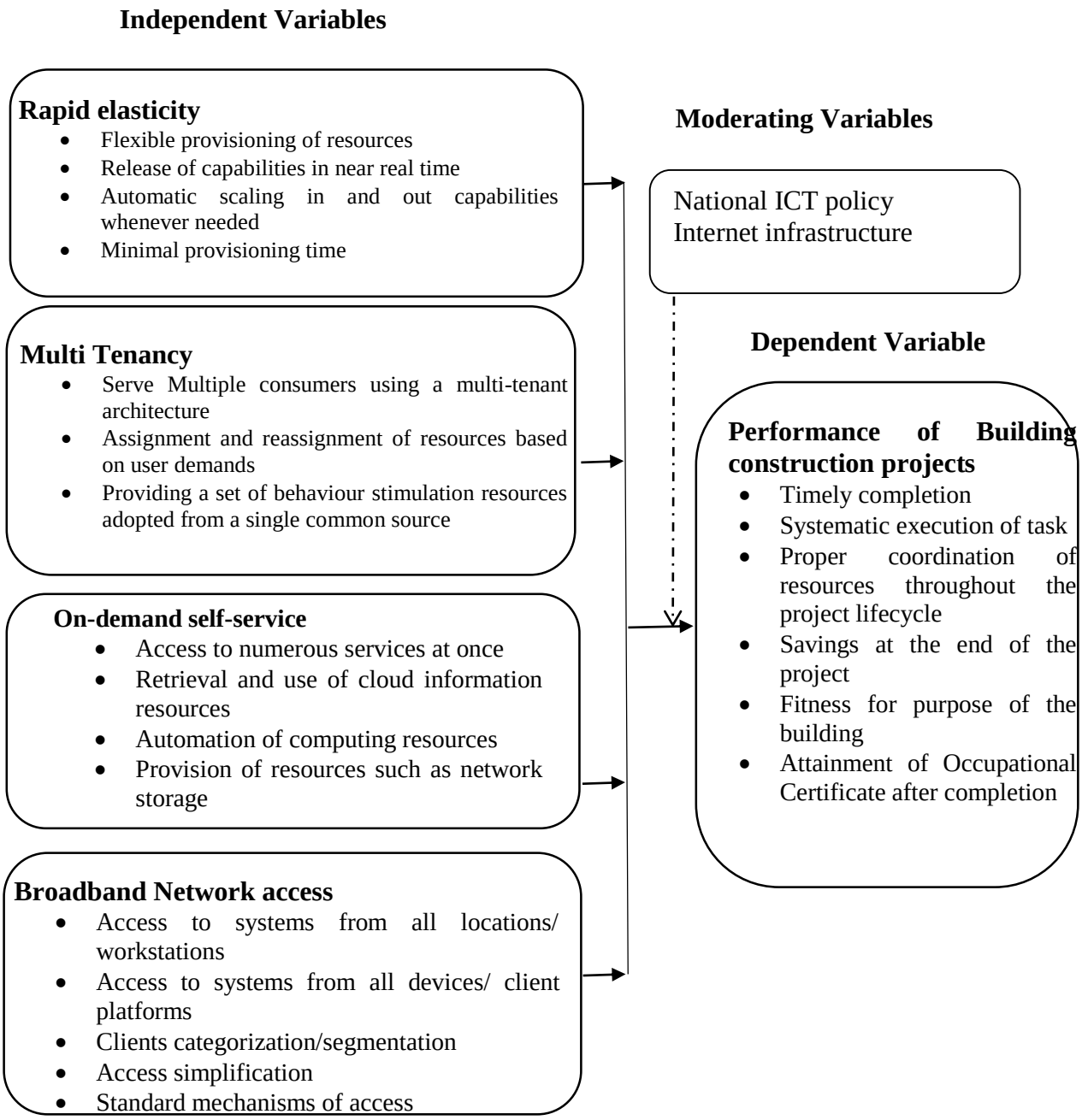


Figure 3: Conceptual Framework

The conceptual framework illustrated in figure 3 above demonstrates the linkage between the independent and dependent variables and how they interact. The independent variables comprise of the four aspects of cloud computing database management system; namely rapid elasticity, Multi tenancy, on-demand self-service and broadband network access. The dependent variable is the performance of construction project management firms. On rapid elasticity, the study used flexible provisioning of resources, release of capabilities in near real time, automatic scaling of capabilities whenever needed, and minimal provisioning time to assess it. The study used multi-tenant architecture, assignment and reassignment of resources

based on user demands, providing a set of behavior stimulation resources adopted from a single common source, and amalgamating sensing capabilities to measure the variable Multi tenancy capabilities of cloud computing. To measure on-demand self-service, the study adopted access to numerous services at once, retrieval and use of cloud information resources, automation of computing resources and provision of resources such as network storage. The study used access to systems from all locations/ workstations, access to systems from all devices, clients categorization/ segmentation, access simplification, and standard mechanisms of access as indicators for the broad network access. To measure the dependent variable, the study used timely completion, systematic execution of task, proper coordination of resources throughout the project lifecycle, savings at the end of the project, fitness for purpose of the building, and attainment of occupational certificate after completion.

2.9 Knowledge gaps

Table 2.1: Research gaps

Variable	Author (s)	Topic	Method	Findings	Research Gap	Focus of the Study
Rapid Elasticity Nature of Cloud DBMS	Bhatti (2020)	Influences on adoption of cloud based ERP systems in SMEs: The technological-organizational environmental framework.	The study used a descriptive study	The results identified relative advantage, top management support, technology readiness, competitive pressure and trading partner pressure as key determinants that influence the adoption of cloud-based ERP systems by SMEs.	The study looks at mostly the rate of the adoption of cloud computing and further looks at SMEs and not construction firms as in this current study	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya
	Simba (2018)	Adoption of cloud computing among small and medium enterprises in Kenya	The study used descriptive survey research design	The respondents were of the perception that cloud computing is cost effective, easier to use, solves problems and easier to learn. The study also found out that the major concerns for cloud computing adoption were security, privacy and reliability and that cloud computing adoption had positive impact on organizational performance.	The study focuses on small and medium enterprises which might not have the same impact as on the focus of this study which is	This study established the influence of cloud computing data base management systems on the performance of construction project management

					construction firms	firms in Nairobi County, Kenya
Multi-tenancy and Resource Pooling Capabilities of Cloud DBMS Sharing Tools	Ibrahim, Salleh and Misra (2019)	Empirical studies of cloud computing in education: a systematic literature review.	The study performed a systematic literature review (SLR) of empirical studies	It has been found that several universities are interested in using cloud computing in their education systems, and they have utilized different types of cloud computing service models (IaaS, PaaS, SaaS).	The study however utilized performed a systematic literature review (SLR) of empirical studies.	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya
	Njenga, Garg, Bhardwaj, Prakash and Bawa (2019)	Factors that information technology (IT) leaders consider to be impeding the adoption of cloud-computing in institutions of higher learning in Kenya.	A quantitative investigation using an online questionnaire was used	The key factors identified as hindering the adoption of cloud computing include concerns about the reliability of Cloud Service providers and lack of skills in cloud computing.	The study does not link the multi-tenancy and resource pooling capabilities of cloud DBMS Sharing Tools and Performance.	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya

On-demand Self-Service Nature of Cloud DBMS	Akhusama (2019)	Cloud computing adoption in insurance companies in Kenya	The study employed descriptive research design	The study found there was a relationship found between application development/deployment platform), productivity applications, Business Applications (CRM, SaaS), infrastructure on-demand (storage, network, server), finance applications, Core Business Application, databases and the adoption of cloud computing in the insurance companies p value was less than 0.05.	This study focuses on insurance companies	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya
	Kiriinya (2018)	Factors influencing cloud computing adoption in organisations adopting CIC INSURANCE Kenya as a case study	The researcher adopted the descriptive research design.	The study found that there was adoption of cloud computing in the organisations, CIC insurance Limited. CIC insurance is a firm that provides financial services to its clients and its customers.	The study did not use the same variables as in the current study	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya

Broad Network Access Capabilities of Cloud DBMS	Alshamaila, Papagiannidis and Li (2019)	Cloud computing adoption by SMEs in the north east of England: A multi-perspective framework.	The study adopted a qualitative exploratory study	The main factors that were identified as playing a significant role in SME adoption of cloud services were: relative advantage, uncertainty, geo-restriction, compatibility, trialability, size, top management support, prior experience, innovativeness, industry, market scope, supplier efforts and external computing support.	The study was done in another country	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya
	Wamuyu (2019)	Use of cloud computing services in micro and small enterprises: a fit perspective.	The research was quantitative in nature, in which, a theory-based model grounded on the task technology fit, organization information processing and technology-organization-environment theories, was developed and validated.	Study findings suggest strong correlations between MSEs' tasks and CCS and between MSEs' information processing needs and CCS information processing capabilities.	The study focuses on micro and small enterprises	This study established the influence of cloud computing data base management systems on the performance of construction project management firms in Nairobi County, Kenya

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter looked at the approach that was used in conducting this study to achieve the objectives as set out in chapter one. This was tackled by stating and evaluating the suitability of the research design, target population, sample size and sampling procedures, research instruments, data analysis and technique to be adopted in the study. The chapter also covered the ethical consideratons and operationaliation of variables.

3.2 Research Design

This is the strategy that was used in conducting the research, outlining how data was collected, measured, and analyzed (Cox, 2019). In this study, descriptive survey research approach was used. Descriptive designs are appropriate where the overall objective is to establish whether significant associations among variables existed at some point in time. This design involved the collection of quantitative data for carrying out inferential analysis and qualitative data for describing and explaining themes of behavior discerned about the influence of cloud computing DBMS on performance of building constructions projects in Nairobi County, Kenya. The outcome was explained through numbers and percentages (Frankfort-Nachmias & Leon-Guerrero, 2019).

3.3 Target Population

Target population is defined as the entire group of persons, units or elements to which the researchers is interested in generalizing the conclusions (Etikan, Musa & Alkassim, 2020). In this study, the target population comprised of fellow, corporate and graduate construction project managers as listed and registered by Institute of Construction Project managers Kenya (ICPMK), totaling to 129 as tabulated below. In these three categories, the fellow members are the highly experienced construction project managers with over 10 years, the corporate members have over 5 years of practice and the graduate members have less than 5 years work experience from when they graduate. These three categories of construction project managers have been involved in running of building construction project either as team leaders or in an assistance capacity. They have therefore managed data in those projects and experienced challenges of ensuring that data is stored, retrieved and accessed by all the relevant project team members on time and in the required format, thus a suitable target population for this study.

Table 3.1: Target Population

Category	Target Population
Fellow Construction Project Managers	37
Corporate Construction Project managers	56
Graduate Construction Project Managers	36
Total	**129**

3.4 Sample Size and Sampling Procedures

Sampling in statistical analysis is the process of picking from a larger population a predetermined number of observations which provide data that is used in drawing the study conclusions. This section looked at sampling size and sapling procedures.

3.4.1 Sampling Size

This is the number of observations from which the researcher comes up with an estimate of the study population (Smith, 2009). In this research, the Cochran Formula (1977) was used to come up with the sample size. According to Catherine, Douglas and Were (2019), Cochran formula is suitable when the population is known.

Cochran Formula:

$$n = \frac{N}{1+N(d)^2}$$

Where; n is the preferred sample size in a known population that is below 10,000

N is the target population and

D is the allowable margin of error which is estimated at 0.05 (95% Confidence level)

d^2 therefore is $(0.05)^2 = 0.0025$

$$\text{Thus, sample size } n = \frac{129}{1+129(0.0025)}$$

n = 98 respondents with the following distribution:

Table 3.2: Sampling Frame

Category	Target Population	Ratio	Sample Size

Fellow Construction Manager	37	0.756	28
Corporate Construction Managers	56	0.756	43
Graduate Construction Managers	36	0.756	27
Total	**129**		**98**

3.4.2 Sampling Procedures

Sampling in statistical analysis is the process by which a predetermined number of observations are picked from a larger population. Stratified random sampling technique was utilized in coming up with the study respondents with a goal of getting the desired representation from each category of the target population. Farrokhi and Mahmoudi-Hamidabad (2018) defines stratified random sampling as a selection mirroring the target population. The goal of stratified random sampling was to achieve the desired representation from various sub-groups in the population. In stratified random sampling subjects are selected in such a way that the existing sub-groups in the population are more or less represented in the sample. The formation of strata was based on the category in which the staff was working including fellow, corporate and graduate construction project managers as listed by the Institute of Construction Project Managers Kenya (ICPMK), making each stratum a group of units with special characteristics. Then simple random sampling was used to pick respondents from each stratum. The sample was distributed among the strata as shown in Table 3.2. The ration in Table 3.2 was computed as follows:

98/129= 0.756

3.5 Research Instruments

Primary data was obtained using questionnaires which were emailed to the respondents. The questionnaire was made up of both open ended and closed ended questions. The open ended questions were used to encourage the respondent to give an in-depth response without feeling held back in illuminating of any information and the closed ended questions allowed respondent to respond from limited options that had been stated. As per Ravitch and Carl (2020), the open-ended questions gave sincere answer of respondents. They are also easier to analyze as there are many close ended questions. The study used questionnaires so as to conserve time and money and also facilitate an easier analysis as they are in immediate usable form.

The research tool used a Likert scale from 1 to 5 where 5=very large extent, 4=large extent, 3=moderate extent, 2=low extent, and 1=very low extent. The questionnaire was divided into three sections. The first entailed the background information of the respondents. The second section comprised of questions on the independent variables including rapid elasticity, multi tenancy, on-demand self-service nature, and broad network access capabilities of cloud computing DBMS. The last section was mainly on the dependent variable which was performance of building construction projects in Nairobi City County.

3.5.1 Pilot Testing

The pilot study is the measurement between subjects of a dependent variable. Its focus was to guarantee that items in the instrument are clearly stated and that all respondents understand the same meaning. Pilot survey was done by sending the questionnaire to 8 respondents representing 10% of the sample size. One day later, the same participants were invited, but without prior notification, to respond to the same questionnaire, so that any change from the first test is captured aiding in identifying of unclear or vague questions and instructions. The feedback from the selected respondents also informed the researcher the areas of improvements hence make the instrument more efficient (Warner, 2019).

3.5.2 Validity of Research Instruments

Validity is the accuracy and meaningfulness of inferences, based on the research results. One of the main reasons for conducting the pilot study is to ascertain the validity of the questionnaire (Cox, 2019). Expert opinion was requested to comment on the representativeness and suitability of questions and give suggestions of corrections to be made to the structure of the research tools. This helped to improve the content validity of the data that was collected. Content validity was obtained by asking for the opinion of the supervisor, senior lecturers and other professionals on whether the questionnaire was adequate.

3.5.3 Reliability of Research Instruments

Reliability of a measurement means how unbiased the research instruments are, thus guaranteeing consistency in measurements in that similar results on different occasions under similar conditions can be obtained (Fail et al, 2019). Reliability is concerned with the question of whether the results of a study are repeatable. A construct composite reliability co-efficient (Cronbach's alpha (α)) of 0.7 or above was generally acceptable. Reliability coefficient of the research instrument was assessed using Cronbach's alpha (α) which is computed as follows:

$A=k/k-1\times [1-\sum (S^2)/\sum S^2 sum]$

Where: α= Cronbach's alpha

k=Number of responses

∑(S2) = Variance of individual items summed up

∑S2sum = Variance of summed up scores

3.5.4 Data Collection Procedures

Upon the approval of the research proposal, the researcher obtained a permit from the National Commission of Science Technology and innovation (NACOSTI). The researcher also asked for an introduction letter from the university which was presented to each leader so as to be allowed to collect the necessary data from the respondents. Research assistants who were used in administering questionnaires were trained on relational skills such as developing rapport, convincing respondents to provide relevant data and seeking clarifications whenever necessary. They were also used in administering the questionnaires were required to book appointment with respondent two days prior to visiting them for questionnaire administration. Upon getting the permission the researcher administered the research instruments to the respondents and gave them ample time to make thoughtful responses. The drop and pick method was used in administering questionnaire as it gave respondents adequate time to give responses which are well thought. The researcher gave the selected respondents a maximum of 3 days to complete the questionnaire after which it was collected for analysis. Due to the coronavirus disease pandemic, the researcher conformed to the ministry of health requirements on social distancing, sanitizing and wearing of masks during data collection. The data was then coded and stored in a computer file that was password protected.

3.6 Data Analysis and techniques

Data analysis is the process that evaluates data by deploying statistical and analytical tools in a bid to find useful information that help in decision making. It involves data coding, data entry and use of analysis methods such as data mining and data visualization (Warner, 2019). This study used both primary and secondary data in achieving the set objectives. Survey questionnaire was used in collecting primary data while findings from related studies written by scholars globally were used in obtaining secondary data.

The data collected in this study was analyzed qualitatively and quantitatively through use of Statistical Package for Social Sciences (SPSS Version 25.0). After data cleaning which entails checking for errors in entry, descriptive statistics such as frequencies, percentages, mean score and standard deviation was estimated for all the quantitative variables and information presented inform of tables. The qualitative data from the open-ended questions was analysed using thematic content analysis and presented in narrative form.

Inferential data analysis was done using multiple regression analysis. Multiple regression analysis was used to establish the relations between the independent and dependent variables**.** Since there are four independent variables in this study the multiple regression model generally assumed the following equation; $\boldsymbol{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon}$

Where: Y= Performance of construction project management firms

β_0=constant

$\beta_1, \beta_2, \beta_3$ & β_4 = regression coefficients

X_1= On-demand self-service

X_2= Rapid elasticity/ scalability

X_3= Broadband Network access

X_4= Multi tenancy and resource pooling capabilities

ε=Error Term

3.7 Ethical Considerations

Ethics should be considered when conducting any research especially when there is some form of qualitative study involving humans (Guillemin, 2004). There was no coaxing of participants and informed consent was sought from participants in addition to government institution such as the National Commission for Science, Technology and Innovation (NACOSTI). A summary of final report on the study was also available to the institutions and participants upon request. Throughout the research exercise, ethical principles were observed in the constitutional rights of every person and as such informed consent was sought from the respondents and was assured of confidentiality of the data and information to be collected. In addition, all participant identifiers were removed from the dataset for purposes of confidentiality.

3.8 Operationalization of Variables

Table 3. 3 - Operationalization of Variables

Objectives	Type of Variable	Indicator	Measuring of Indicators	Tools of analysis	Type of analysis
To establish the influence of rapid elasticity and scalability nature of cloud DBMS on performance of construction project management firms	Independent	Rapid elasticity and scalability	• Flexible provisioning of resources • Release of capabilities in near real time • Automatic scaling of capabilities whenever needed • Minimal provisioning time	Percentages Mean score Narration	Descriptive statistics Regression analysis Content analysis
To examine the influence of multi tenancy and resource pooling capabilities of cloud DBMS on performance of construction project management firms	Independent	Multi tenancy and resource pooling	• Serve Multiple consumers using a multi-tenant architecture • Assignment and reassignment of resources based on user demands • Providing a set of behavior stimulation resources adopted from a single common source • Amalgamating sensing capabilities	Percentages Mean score Narration	Descriptive statistics Regression analysis Content analysis
To evaluate the influence of on-demand self-service nature of cloud DBMS on performance of construction project management firms	Independent	On-demand self-service	• Access to numerous services at once • Retrieval and use of cloud information resources	Percentages Mean score Narration	Descriptive statistics Regression analysis Content analysis

			• Automation of computing resources • Provision of resources such as network storage		
To assess the influence of broad network access capabilities of cloud DBMS on performance of construction project management firms	Independent	Broad network access	• Access to systems from all locations/ workstations • Access to systems from all devices • Clients categorization/ segmentation • Access simplification • Standard mechanisms of access	Percentages Mean score Narration	Descriptive statistics Regression analysis Content analysis

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION OF FINDINGS

4.1 Introduction

The obtained findings from the used primary instrument in the study are presented in this chapter. It presents the respondents' reactions on the influence of cloud computing data base management systems on the performance of building construction projects in Nairobi County, Kenya. The researcher provided tables that summarized the collective reactions of the respondents to simplify the presentation and interpretation.

4.1.1 Response Rate

The researcher administered 98 questionnaires out of which only 72 were returned duly filled. This represented 73.6% which was within what Etikan, Musa and Alkassim (2020) prescribed that a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent. Based on the assertion, the response rate was deemed to be excellent. Table 4.1 shows the findings.

Table 4. 1: Response Rate

Total Questionnaires administered	Filled questionnaires	Response Rate.
98	72	73.6%

4.1.2 Reliability Analysis

Reliability of the questionnaire was evaluated through administration of the said instrument to the pilot group. The acceptable reliability coefficient is 0.7 and above (Cox, 2019). A construct composite reliability co-efficient (Cronbach alpha) of 0.7 or above, for all the constructs, is considered to be adequate for this study. The results were as shown in Table 4.2.

Table 4.2: Reliability Analysis

	Cronbach's alpha
Rapid elasticity nature of cloud DBMS	.711
Multi tenancy capabilities of cloud DBMS	.778
On-demand self-service nature of cloud DBMS	.701
Broad network access capabilities of cloud DBMS	.833
Performance of building construction projects	.742

From the results, broad network access capabilities of cloud DBMS was more reliable with an alpha value of 0.833, followed by multi tenancy capabilities of cloud DBMS with an alpha

value of 0.778, then performance of building construction projects with an alpha value of 0.742, then rapid elasticity nature of cloud DBMS with an alpha value of 0.711 while on-demand self-service nature of cloud DBMS with an alpha value of 0.701 had the least reliability. This, therefore, depicts that the research instrument was reliable and no amendments were required.

4.2 Background Information

In this study, the researcher collected data from different groups of respondents based on their gender, age bracket, highest level of education and number of years they have been practicing as a construction project manager. The findings for the demographic information were presented in tables.

4.2.1 Respondents' Gender

The respondents were requested to indicate their gender. Their responses were as shown in Table 4.3.

Table 4.3: Respondents' Gender

	Frequency	**Percent**
Male	43	59.6
Female	29	40.4
Total	**72**	**100.0**

From the findings, majority of the respondents as represented by 59.6% were male while 40.4% were female. This implied that the researcher was not gender biased in data collection since all the respondents were considered irrespective of their gender.

4.2.2 Respondents' Highest Level of Education

The researcher enquired on the respondents' highest level of education. The level of education was for ascertaining the competence of the respondents in responding the question related to the study. Table 4.4 shows a summary of their replies.

Table 4. 4: Respondents' Highest Level of Education

	Frequency	Percent
Certificate	7	9.2
Diploma	13	18.1
Degree	20	27.7
Masters	25	34.5
PHD	8	10.5
Total	**72**	**100.0**

The study findings show that 34.5% of the respondents had attained Masters, 27.7% had reached the Degree level, 18.1% had reached the Diploma level, 10.5% had reached the PhD level, while 9.2% had reached the Certificate level. This shows that all the respondents who participated on the study were learnt enough to understand and give reliable information related to the study.

4.2.3 Age Bracket of the Respondent

The respondents were further asked to indicate the age bracket to which they belong. Their responses were as shown in Table 4.5.

Table 4. 5: Respondents' Age Bracket

	Frequency	Percent
Below 25 years	6	8.5
25-30 years	7	9.2
30-35 years	17	23.1
35-40 years	18	25.1
40 – 45 years	17	23.4
Above 45 years	8	10.7
Total	**72**	**100.0**

The study results show that 25.1% of the respondents were aged between 35-40 years, 23.4% were aged between 40 – 45 years, 23.1% were aged between 30-35 years , 10.7% were aged above 45 years, 9.2% were aged between 25-30 years, and 8.5% were aged below 25 years. This shows that majority of the respondents were mature enough which meant that they would have diverse information on the subject under study and would also be cooperative in giving it.

4.2.4 Number of Years Practising As a Construction Project Manager

The researcher further explored how long the respondents had been practicing as a construction project manager. The results are as shown in Table 4.6.

Table 4. 6: Number of Years the Respondents had been Practicing as a Construction Project Manager

	Frequency	Percent
Less than 5 years	9	13.1
5-10 years	23	31.6
10–15 years	25	35.1
Above 15 years	15	20.2
Total	**72**	**100.0**

From the findings, 35.1% of the respondents had been practicing for 10–15 years, 31.6% had been practicing for 5-10 years, 20.2% had been practicing for above 15 years, while 13.1% had been practicing for less than 5 years. This implies that the respondents were experienced since majority of them had been practicing for many years and could comprehend the subject under study.

4.3 Rapid Elasticity of Cloud Computing DBMS

The study sought to establish the influence of rapid elasticity nature of cloud DBMS on performance of building construction projects in Nairobi County. The researcher required the respondents to indicate the extent to which the features of rapid elasticity of cloud computing database management system influence performance of construction management firms. The results are as shown on Table 4.7.

Table 4. 7: Influence of Rapid Elasticity of Cloud Computing Database Management System on Performance of Building Construction Projects

	Mean	Std. Dev.
Flexible provisioning of resources	4.763	0.619
Release of capabilities in near real time	3.449	0.719
Automatic scaling of capabilities whenever needed	4.347	0.675
Minimal provisioning time	3.546	0.514

The findings show that the respondents indicated that flexible provisioning of resources as expressed by a mean score of 4.763 influence performance of building construction projects to a very large extent. Further, automatic scaling of capabilities whenever needed as expressed by a mean score of 4.347 and minimal provisioning time as expressed by a mean score of 3.546 influence performance of building construction projects to a large extent. Moreover, the respondents indicated that the release of capabilities in near real time as expressed by a mean score of 3.449 influence performance of building construction projects to a moderate extent.

The researcher required the respondents to give their opinions on how rapid elasticity of cloud computing database management system influenced performance of building construction projects in Nairobi County, Kenya. They indicated that building construction projects require fast execution of tasks and production of documents/information to aid in decision making. Further, they indicated that online purchase of software by consultants is now easier and cheaper as one only purchases part of the software package relevant to their practice which enhances speed of work and accuracy of information. Others indicated that the projects have both bulky and smaller files enabling it to save and retrieve data based on size.

4.4 Multi Tenancy Capabilities of Cloud DBMS

The research aimed to examine the influence of multi tenancy capabilities of cloud DBMS on performance of building construction projects in Nairobi County. The respondents were asked to indicate the extent to which the characteristics of multi tenancy of cloud computing database management system influenced performance of building construction projects in Nairobi County. Table 4.8 displays the results.

Table 4. 8: Influence of Multi Tenancy of Cloud Computing Database Management System on Performance of Building Construction Projects

	Mean	Std. Dev.
Serves multiple consumers using a multi-tenant architecture	3.776	0.682
Assignment and reassignment of resources based on user demand	4.194	0.970
Providing a set of behaviour stimulation resources adopted from a single common source	2.789	0.662

The results revealed that the respondents indicated that assignment and reassignment of resources based on user demand as illustrated by a mean of 4.194, and serving multiple

consumers using a multi-tenant architecture as illustrated by a mean of 3.776 influenced performance of building construction projects in Nairobi County to a large extent. Moreover, providing a set of behaviour stimulation resources adopted from a single common source as illustrated by a mean of 2.789 influenced performance of building construction projects in Nairobi County to a moderate extent.

The respondents were further required to give opinions on how multi tenancy aspect of cloud computing database management system influence performance of building construction projects firms in Nairobi County, Kenya. They indicated that access to resources such as a building project model saved in the cloud platform by all project teams real time is key to how project performs because the team members can work fast, collaborate from their different offices, and coordinate the project well enough.

4.5 On-Demand Self-Service of Cloud Computing DBMS

The study sought to evaluate the influence of on-demand self-service nature of cloud DBMS on performance of building construction projects in Nairobi County. The researcher wanted to know the extent to which features of on-demand self-service of cloud computing database management system influenced performance of building construction projects. The results are as presented on Table 4.9.

Table 4.9: Influence of On-Demand Self-Service of Cloud Computing Database Management System on Performance of Building Construction Projects

	Mean	Std. Dev.
Access to numerous services at once	4.603	0.980
Retrieval and use cloud information resources	4.774	0.786
Automation of computing services	3.667	0.823
Provision of resources such as network storage	4.400	0.547

As per the results, the respondents indicated that retrieval and use cloud information resources as shown by a mean of 4.774 and access to numerous services at once as shown by a mean of 4.603 influenced performance of building construction projects to a very large extent. Moreover, the respondents indicated that provision of resources such as network storage as shown by a mean of 4.400 and automation of computing services as shown by a mean of 3.667 influenced performance of building construction projects to a large extent.

The respondents were also asked to indicate their opinions on how on-demand self-service aspects of cloud computing database management system influenced performance of building construction projects in Nairobi County, Kenya. They indicated that the aspects made it easier for local consultants to watch and learn from on-going international construction projects therefore gaining new knowledge in the industry. Moreover, they indicated that it makes it easier for data produced by the team members to be stored and retrieved by any team member when required. It also made it easier to borrow new technologies utilized in construction world over, hence improving on the existing technology.

4.6 Broadband Network Access of Cloud Computing DBMS

The study sought to assess the influence of broad network access capabilities of cloud DBMS on performance of building construction projects in Nairobi County. The respondents were asked to indicate the extent to which characteristics of broadband network access of cloud computing database management system influenced performance of building construction projects. The results are as show on Table 410.

Table 4. 10: Influence of Broad Network Access Capabilities of Cloud DBMS on Performance of Building Construction Projects

	Mean	Std. Dev.
Access to systems from all locations /workstations	4.506	0.699
Access to systems from all devices	4.173	0.866
Enables users to categorize and segment system	2.776	0.682
Simplified access to available resources in a network	3.894	0.970

The findings show that the respondents indicated that access to systems from all locations /workstations as shown by an average of 4.506 influenced performance of building construction projects to a very large extent. The respondents also indicated that access to systems from all devices as shown by an average of 4.173, and simplified access to available resources in a network as shown by an average of 3.894 influenced performance of building construction projects to a large extent. Further, the respondents indicated that enabling users to categorize and segment system as shown by an average of 2.776 influenced performance of building construction projects to a moderate extent.

The respondents were also asked to give their opinions on how broadband network access aspects of cloud computing database management system influenced performance of building construction projects in Nairobi County, Kenya. They stated that the ability of consultants to

inspect works and progress remotely has made it easier to make timely decision, leading to quality workmanship and timey competition. Further, they mentioned that it makes working amongst team members possible hence smooth workflow.

4.7 Performance of the Building Construction Project

The research sought to establish the trend in the past 5 years of how building construction project has been fairing when evaluated on various performance indicators. The outcomes are displayed on Table 4.11.

Table 4. 11: Performance of the Building Construction Project

	Mean	Std. Dev.
Timely completion	3.194	0.652
Systematic execution of tasks	3.347	0.788
Proper co-ordination of resources throughout the project lifecycle	2.765	0.835
Savings at the end of a construction project	2.122	0.853
Fitness for purpose of the building	3.667	0.621
Attainment of occupational certificate	3.525	0.884

The findings reveal that fitness for purpose of the building as depicted by a mean of 3.667 and attainment of occupational certificate as depicted by a mean of 3.525 had improved. Further, systematic execution of tasks as depicted by a mean of 3.347, timely completion as depicted by a mean of 3.194, and proper co-ordination of resources throughout the project lifecycle as depicted by a mean of 2.765 had been constant over the five years. The savings at the end of a construction project as depicted by a mean of 2.122 were indicated to have decreased over the five years.

The respondents were asked to indicate their opinions on how the use of cloud computing database management systems has affected performance of building construction projects in Nairobi County, Kenya. They indicated that through BIM 360 there have been smooth running of the projects whose overall effects are timely completion, quality buildings that are fit for purpose, and general team collaboration thus enhanced synergy. Also, Aconex provides digital document repositories and processes that enable efficient management of the huge volume of documents generated across the entire construction project lifecycle. This simplifies and automates document distribution and workflows, while mitigating risk and confusion by ensuring the entire project team is working off a “single version of the truth” for every document, as well as streamlining the management of change requests for all upstream and

downstream documents. Textura has been used to increase efficiency and control in construction payment management through a collaborative subcontractor invoicing and payment software system.

4.8 Multiple Regression Analysis

This section of the study presents the results and discussions of the regression output. In order to examine the influence of broad network access capabilities of cloud DBMS, on-demand self-service nature of cloud DBMS, multi tenancy capabilities of cloud DBMS, rapid elasticity nature of cloud DBMS and performance of building construction projects in Nairobi County, regression model was estimated. The regression analysis enables the researcher to empirically test how the independent variables affected the dependent variable. Table 4.12, 4.13, and 4.14 display the findings.

Table 4. 12: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.885	0.783	0.770	0.983

Table 4.12 is a model fit which establishes how fit the model equation fits the data. The adjusted R^2 was used to establish the predictive power of the study model and it was found to be 0.77 implying that 77% of the variations in performance of building construction projects in Nairobi County are explained by changes in availability of rapid elasticity nature of cloud DBMS, multi tenancy capabilities of cloud DBMS, on-demand self-service nature of cloud DBMS and broad network access capabilities of cloud DBMS.

Table 4. 13: ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	243.566	4	60.892	60.363	1.66E-21
	Residual	67.587	67	1.009		
	Total	**311.153**	**71**			

The probability value of 1.66E-21indicates that the regression relationship was highly significant in predicting how rapid elasticity nature of cloud DBMS, multi tenancy capabilities of cloud DBMS, on-demand self-service nature of cloud DBMS and broad network access capabilities of cloud DBMS influenced performance of building construction projects in

Nairobi County. The F calculated at 5 per cent level of significance was 60.363. Since F calculated is greater than the F-critical (value = 2.5087), this shows that the overall model was significant.

Table 4. 14: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.537	0.905		3.908	0.000
	Rapid elasticity nature of cloud DBMS	0.632	0.245	0.544	2.580	0.011
	Multi tenancy capabilities of cloud DBMS	0.843	0.333	0.785	2.532	0.013
	On-demand self-service nature of cloud DBMS	0.774	0.248	0.728	3.121	0.002
	Broad network access capabilities of cloud DBMS	0.702	0.331	0.631	2.121	0.036

The regression equation obtained from this outcome was: -

$Y = 3.537+0.632X_1 + 0.843X_2 +0.774X_3 + 0.702X_4$

From the findings, it was established that if all independent variables were held constant at zero, then the performance of building construction projects in Nairobi County will be 3.537. Further, the coefficient for rapid elasticity nature of cloud DBMS is 0.632 and was significant since p=0.011 is less than 0.05, meaning that a unit change in rapid elasticity nature of cloud DBMS leads to a 0.632 increase in performance of building construction projects in Nairobi County.

The study also found that a unit change in multi tenancy capabilities of cloud DBMS would lead to a 0.843 change in performance of building construction projects in Nairobi County. The findings presented also show that taking all other independent variables at zero, a unit increase in the multi tenancy capabilities of cloud DBMS would lead to a 0.843 increase in performance

of building construction projects in Nairobi County. The variable was significant since p-value=0.013<0.05.

The study further found that a unit change in on-demand self-service nature of cloud DBMS would lead to a 0.774 change in performance of building construction projects in Nairobi County. The findings presented also show that taking all other independent variables at zero, a unit increase in the on-demand self-service nature of cloud DBMS would lead to a 0.774 increase in performance of building construction projects in Nairobi County. The variable was significant since p-value=0.002<0.05.

The study also found that a unit change in broad network access capabilities of cloud DBMS would lead to a 0.702 change in performance of building construction projects in Nairobi County. The findings presented also show that taking all other independent variables at zero, a unit increase in the broad network access capabilities of cloud DBMS would lead to a 0.702 increase in performance of building construction projects in Nairobi County. The variable was insignificant since p-value=0.036<0.05.

Overall, multi tenancy capabilities of cloud DBMS (r=0.843) had the greatest influence on performance of building construction projects in Nairobi County, followed by on-demand self-service nature of cloud DBMS (r=0.774), then broad network access capabilities of cloud DBMS (r=0.702) while rapid elasticity nature of cloud DBMS (r=0.632) had the least influence on performance of building construction projects in Nairobi County. Since all the independent variables had p-values that were less than 0.05, they were all significant.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSIONS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter covers a summary, a discussion of each variable, conclusion and recommendations of the findings on influence of cloud computing data base management systems on the performance of building construction projects in Nairobi County, Kenya. This chapter summarizes the findings of the study from the research carried out and gives proposals for change of the study and suggestions for future research.

5.2 Summary of Findings

The study sought to establish the influence of rapid elasticity nature of cloud DBMS on performance of building construction projects in Nairobi County. The study found that the flexible provisioning of resources influences performance of building construction projects to a very large extent. Further, it was found that automatic scaling of capabilities whenever needed and minimal provisioning time influence performance of construction management firms to a large extent. Moreover, the research established that the release of capabilities in near real time influence performance of building construction projects to a moderate extent.

The research aimed to examine the influence of multi tenancy capabilities of cloud DBMS on performance of building construction projects in Nairobi County. The study found that assignment and reassignment of resources based on user demand, and serving multiple consumers using a multi-tenant architecture influenced performance of building construction projects in Nairobi County to a large extent. Moreover, the study established that providing a set of behaviour stimulation resources adopted from a single common source influenced performance of building construction projects in Nairobi County to a moderate extent.

The study sought to evaluate the influence of on-demand self-service nature of cloud DBMS on performance of building construction projects in Nairobi County. The research found that retrieval and use cloud information resources and access to numerous services at once influenced performance of building construction projects to a very large extent. Moreover, the study found that provision of resources such as network storage and automation of computing services influenced performance of building construction projects to a large extent.

The study sought to assess the influence of broad network access capabilities of cloud DBMS on performance of building construction projects in Nairobi County. The study found that the access to systems from all locations /workstations influenced performance of building construction projects to a very large extent. The research also found that access to systems from all devices, and simplified access to available resources in a network influenced performance of building construction projects to a large extent. Further, the study established that enabling users to categorize and segment system influenced performance of building construction projects to a moderate extent.

The research sought to establish the trend in the past 5 years of how building construction project has been fairing when evaluated on various performance indicators. The study found that fitness for purpose of the building and attainment of occupational certificate had improved. Further, systematic execution of tasks, timely completion, and proper co-ordination of resources throughout the project lifecycle had been constant over the five years. The savings at the end of a construction project were found to have decreased over the five years.

5.3 Discussion of the Findings

This section links the findings of this study and the findings of the studies done by other researchers before. It discusses the findings of broad network access capabilities of cloud DBMS, on-demand self-service nature of cloud DBMS, multi tenancy capabilities of cloud DBMS, rapid elasticity nature of cloud DBMS in relation to the performance of building construction projects.

5.3.1 Rapid Elasticity of Cloud Computing DBMS and Performance of Building Construction Projects

The study found that the flexible provisioning of resources influence performance of building construction projects to a very large extent. The findings are in line with Sagini, Dianga and Mbiti (2019) who stated that cloud computing DBMS also scale the resources up or down real-time depending on the complexity and resource requirement of tasks being executed. This therefore means that the capacity, usage and the associated charges also scale up and down without any additional contracts or penalties as it is an intrinsic feature for all cloud computing DBMS. This is also supported by Philzona (2018) who argues that cloud computing DBMS providers ensure that there are enough resources which is scalable on need basis for all their customers, which then provides flexibility and confidence amongst the users that their database management needs will always be met. The benefit of this is that there is less provisions in

capital expenditure to the cloud customers as they easily access most of their computing services virtually, utilizing just the right type and capacity of services ranging from data creation, storage, retrieval and sharing to other users.

Further, it was found that automatic scaling of capabilities whenever needed and minimal provisioning time influence performance of building construction projects to a large extent. The results are correlated with Banta (2019) who stated that the scalability and rapid elasticity nature of cloud computing DBMS allows businesses and industries to reshape their infrastructure to accommodate the ever-changing demands of their customers without relying on computer hardware and software that was relevant in the past. This they do without necessarily buying new hardware, or software; by redesigning their networks to allow for deployment of multi-cloud which address their existing problems and concerns, giving them flexibility to increase or decrease their operations.

Moreover, the research established that the release of capabilities in near real time influence performance of building construction projects to a moderate extent. This is in accordance with Zhang et al. (2018) who stated that construction project managers are able to plan and guide other construction consultants for their existing hardware and software, minimizing on over purchase due to high levels of uncertainty moving from one building construction project to the next.

5.3.2 Multi Tenancy Capabilities of Cloud DBMS and Performance of Building Construction Projects

The study found that assignment and reassignment of resources based on user demand, and serving multiple consumers using a multi-tenant architecture influenced performance of building construction projects in Nairobi County to a large extent. Chandra and Kumar (2018) assert that cloud computing DBMS is characterized by resource sharing, with dynamic adjustments that are based on user increase and decrease in resource requirements. If the construction project manager has an increase of application, then the resource is automatically increased to match the demand and consequently, if there is a reduction in application demands, the resources are reduced in equal proportion. This makes utilization of IT resources to be efficient and economical.

Moreover, the study established that providing a set of behaviour stimulation resources adopted from a single common source influenced performance of building construction projects in Nairobi County to a moderate extent. The findings are in line with Davenport (2019) who

asserts that virtualization comes in handy when performing critical success factor on a construction project as it fetches large volumes of data from multiple sources and portfolios, studies historical trends of these portfolios and predicts the outcome of an ongoing project. It also aids the construction project managers in identifying resources consumption patterns and hence forecast for the future accordingly. It reduces on the challenges of combining many disparate data from public and private domains as it pool it to a centralized virtual source therefore, accessing that data from a single point.

5.3.3 On Demand Self-Service of Cloud Computing DBMS and Performance of Building Construction Projects

The research found that retrieval and use cloud information resources and access to numerous services at once influenced performance of building construction projects to a very large extent. This agrees with Attaran and Woods (2018) who mentioned that users are able to scale up the required infrastructure without affecting the operations of the host, as it automatically allocates resources based on the magnitude of the tasks each user is undertaking. This means that a consumer is able to offer computing capabilities unilaterally without any human interaction with the service providers. In line with the findings, K Sriram and Khajeh-Hosseini (2019) stated that to flawlessly offer on-demand self-service computing, the vendor should plan intensively so that all the varying needs of the users are well met without a downtime; as such vendor offering construction-based cloud computing solutions need to monitor trends in resource usage in construction project management firms and plan for future situations well in advance.

Moreover, the respondents indicated that provision of resources such as network storage and automation of computing services influenced performance of building construction projects to a large extent. The findings relate to Snow (2020) who stated that despite its popularity, many construction project management business strategists are unfamiliar with this concept of cloud computing DBMS which involves the provision of computing capabilities to many customers without the challenge of equipment or maintenance costs. This concept is a relatively affordable and feasible platform which supports dedicated computers. It offers networks and storage infrastructure as a service (IaaS) and software as a service (SaaS) provided there is availability of internet.

5.3.4 Broadband Network Access of Cloud Computing DBMS and Performance of Building Construction Projects

The study found that the access to systems from all locations/workstations influenced performance of building construction projects to a very large extent. The results are in line with Sosinsky (2018) who stated that construction project management businesses using public cloud are required to deploy such transit hops so that they are able to enjoy full benefit of a public cloud without compromising on security of their data. There are large construction project management firms in Nairobi which are a subsidiary of international firms; these for instance stand a big chance of benefitting from virtual private networks when accessing their private cloud.

The research also found that access to systems from all devices, and simplified access to available resources in a network influenced performance of building construction projects to a large extent. The findings are in accordance with Reese (2019) who argues that a number of construction project managers may have utilized cloud architecture with zero consideration on its application limitations that comes with legacy networks to its performance. Focus to the applications themselves should be the approach to be considered when optimizing networks when construction project manager is deploying any cloud computing DBMS.

Further, the study established that enabling users to categorize and segment system influenced performance of building construction projects to a moderate extent. This is accordance to Ramgovind, Eloff and Smith (2020) who states that the key thing to look for in exploring the impact of networks on Cloud computing DBMS performance is the differences that exist between the construction project manager's current application/network relationships and those that will exist under the cloud. Those differences are what will impact the database DBMS users (Jansen & Grance, 2019).

5.4 Conclusions

The study concluded that rapid elasticity nature of cloud DBMS has a positive and significant influence on performance of building construction projects in Nairobi County. The study deduced that the capabilities available to users can be provisioned elastically and released when no longer needed, in some cases automatically. This allows rapid scaling, up or down, according to current demand. To the customer, these capabilities available for provisioning can appear to be unlimited and can be granted in any quantity at any time.

The study deduced that multi tenancy capabilities of cloud DBMS has a positive and significant influence on performance of building construction projects in Nairobi County. The research concluded that in cloud-based architectures, multi-tenancy means that customers, organizations, and consumers are sharing infrastructure and databases in order to take advantage of price and performance advantages that come with economies of scale.

The study further concluded that on-demand self-service nature of cloud DBMS has a positive and significant influence on performance of building construction projects in Nairobi County. The study also concluded that on-demand self-service nature of cloud DBMS enables end users to provision computing power, storage, networks and software in a simple and flexible way. Most users begin by using limited resources and increase them over time. On-demand self-service methodology authorizes users to request resources on run time. This transition mostly takes place immediately, although it can depend on the architecture and resource availability of the cloud provider. Implementing user self-service allows customers to quickly procure and access the services they want.

Moreover, it was concluded that broad network access capabilities of cloud DBMS has a positive and significant influence on performance of building construction projects in Nairobi County. The research also concluded that success of cloud computing depends wholly on the infrastructural availability such as broadband internet connectivity and availability. Broadband internet availability and affordability are key factors to the successfully deployment and operation of cloud computing platforms and services.

5.5 Recommendations

The study recommends that the leaders and the frontiers of the IT departments in the building construction projects in Nairobi County to acknowledge this trend in technology and embrace the strategic opportunities that can be accrued from it. Cloud computing is one of the most versatile and diverse technological innovation and many enterprises are interested to know more about it.

The study recommends that the building construction projects should adopt cloud computing as a future strategic technological and economic tool for competitive advantage as well as for use in IT operations. The construction project managers can focus on Hybrid cloud model since they can enjoy benefits accrued to both the private and public cloud models.

Moreover, the study recommended that Multi-tenancy protections must be offered by cloud service providers for all layers of their offerings (i.e., IaaS and SaaS). Cloud service providers owe it to their customers to have the latest and best approaches as available options. Tenants must ask and be clear about the ways in which they share responsibility for their security and the security of their tenants. Lack of security expertise needn't be a barrier to cloud service adoption, but security automation is key to making experts of would-be novices when it comes to securing a piece of the cloud.

The study also recommends that concerns on the use of cloud computing should be considered in the development of a road map. The concerns include but not limited to; security, privacy, vendor lock, legal issues, immature technology, compliance, insecure availability, security insufficient, compliance. Tackling these concerns will lead increased uptake of cloud computing data base management systems in execution of building construction projects. With cloud computing, building construction projects can offload the risk, time, and costs associated with management of the systems that are critical to the project. In exchange, the IT team will be freed to focus on the best management of the data generated by the project.

Also, cloud computing offers a single, reliable way to ensure the database is available from the office and the field. That means that the software will work more effectively, efficiently, and consistently in the cloud, compared with an existing on premises solution.

5.6 Recommendations for Further Studies

The study suggests that further research to be conducted on all the players in the Construction industry in Kenya to establish the level of Cloud computing use as a competitive advantage in the industry in Kenya. Further research should also be done to identify the role of learning institutions in facilitating the diffusion of cloud computing as an innovative database management system.

REFERENCES

Adane, M., (2018). Cloud computing adoption: Strategies for sub-Saharan Africa SMEs for enhancing competitiveness, *African Journal of Science, Technology, Innovation and Development* 10(2), 197-207.

Akhusama, P. M. (2019). *Cloud computing adoption in insurance companies in Kenya* (Doctoral dissertation, University of Nairobi).

Alharbi, F., Atkins, A., & Stanier, C. (2019). Understanding the determinants of cloud computing adoption in Saudi healthcare organisations. Complex & Intelligent Systems, 2(3), 155–171.

Allen, J. (2019). *Construction Document Management.* Retrieved from Connect & Construct:

Alshamaila, Y., Papagiannidis, S., & Li, F. (2019). Cloud computing adoption by SMEs in the north east of England: A multi-perspective framework. *Journal of enterprise information management*.

Alsmadi, D., & Prybutok, V. (2018). Sharing and storage behavior via cloud computing: Security and privacy in research and practice. Computers in Human Behavior, 85, 218–226.

Amron, M. T., Ibrahim, R., & Chuprat, S. (2019). A review on cloud computing acceptance factors. Procedia Computer Science, 124, 639–646.

APMG International. (2020). *Main Stages Of The Construction Phase*. APMG International: A Berkeley View of Cloud. Berkeley.edu.

Attaran, M., & Woods, J. (2018). Cloud computing technology: A viable option for small and medium-sized businesses. Journal of Strategic Innovation & Sustainability, 13(2), 94–106.

Bello, S. A., Oyedele, L. O., Akinade, O. O., Bilal, M., Delgado, J. M. D., Akanbi, L. A., ... & Owolabi, H. A. (2020). Cloud computing in construction industry: Use cases, benefits and challenges. *Automation in Construction*, 103441.

Bhatti, T. (2020). Influences on adoption of cloud based ERP systems in SMEs: The technological-organizational environmental framework. *Corporate Ownership & Control, 15(1-2),* 370-380.

Buniya, M.K.; Othman, I.; Sunindijo, R.Y.; Kineber, A.F.; Mussi, E.; Ahmad, H. (2020). Barriers to safety program implementation in the construction industry. Ain Shams Eng. J.,

Chandra, S., & Kumar, K. N. (2018). Exploring factors influencing organizational adoption of augmented reality in e-commerce: Empirical analysis using technology-organization- environment model. Journal of Electronic Commerce Research, 19(3), 237–265.

Chen, S. L., Chen, J. H., & Lee, Y. H. (2018). A comparison of competing models for understanding industrial organization's acceptance of cloud services. Sustainability (2071-1050), 10(3), 673.

Cleopatra, T.. (2020). *Cost Management explained*. Retrieved from Cleopatra:

Construction Management Association of America. (2020, June). Retrieved from

Cox, K. A. (2019). Survey research is a descriptive, nonexperimental method used to collect information through interviews and/or questionnaires. For this reason, survey research is a popular method in the. *Research Design and Methods: An Applied Guide for the Scholar-Practitioner*, 161.

Danielsson, J and R Macrae (2019). Systemic consequences of outsourcing to the cloud VoxEU, 2 December

Davenport, T.H. (2019). Process innovation: reengineering work through information technology, Brighton: Harvard Business Press.

Eelu, S., & Nakakawa, A. (2018). Framework towards enhancing adoption of electronic payment in a developing economy: A case of Uganda. African Journal of Information Systems, 10(3), 222–245.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2020). Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1–4.

Etro, F. (2019). The Economic Impact of Cloud Computing on Business Creation, Employment and Output in Europe: An application of the Endogenous Market Structures Approach to a GPT innovation. *Review of Business and Economics*, 54(2), 179–208.

Fail, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2019). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41(4), 1149–1160.

Farrokhi, F., & Mahmoudi-Hamidabad, A. (2018). Rethinking convenience sampling: Defining quality criteria. Theory and Practice in Language Studies, 2(4), 784–792.

Frankfort-Nachmias, C., & Leon-Guerrero, A. (2019). Social statistics for a diverse society (8th ed.). Thousand Oaks, CA: Sage Publications.

Gangwar, H., Date, H., & Ramaswamy, R. (2018). Understanding determinants of cloud computing adoption using an integrated TAM-TOE model. *Journal of enterprise information management*.

Gupta, P., Seetharaman, A., & Raj, J. R. (2018). The usage and adoption of cloud computing by small and medium businesses. *International journal of information management*, *33*(5), 861-874.

Gupta, S., & Saini, A. K. (2019). Cloud adoption: Linking business needs with system measures. Global Journal of Enterprise Information System, 9(2), 42–49.

Ibrahim, M. S., Salleh, N., & Misra, S. (2019). Empirical studies of cloud computing in education: a systematic literature review. In *International Conference on Computational Science and Its Applications* (pp. 725-737). Springer, Cham.

Inmor, S., & Suwannahong, R. (2020). The acceptance of cloud computing for IT workers in Thailand. Procedia Computer Science, 121, 1039–1046.

Kabata, V., (2021). Outsourcing records storage to the cloud: Challenges and prospects for African records managers and archivists, *Mousaion* 30(2), 137-157.

Kiarie, R. M. (2018). *Technology acceptance of cloud computing in ICT departments of the Kenya government ministries* (Doctoral dissertation, University of Nairobi).

Kihoro, S. (2020). Influence of safety compliance on performance of small and medium construction firms in Nairobi County (Doctoral dissertation, Strathmore University).

Kiriinya, D. (2018). *Factors Influencing Cloud Computing Adoption in Organisations: A Case of Cooperative Insurance Company of Kenya* (Doctoral dissertation, United States International University-Africa).

Lian, J. W., Yen, D. C., & Wang, Y. T. (2018). An exploratory study to understand the critical factors affecting the decision to adopt cloud computing in Taiwan hospital. *International Journal of Information Management*, *34*(1), 28-36.

Loukis, E., Kyriakou, N., Pazalos, K., & Popa, S. (2020). Inter-organizational innovation and cloud computing. Electronic Commerce Research, 17(3), 379–401. doi:10.1007/s10660-016-9239-2.

Masu, S. M., & Wanyona, G. (2020). An Evaluation of Impacts on Resource Levelling Practices and Performance by Construction Firms' in Kenya.

Mbugua, M., & Winja, M. (2021). Identification and Ranking of Key Performance Indicators in Building Construction Projects in Kenya. Engineering, Technology & Applied Science Research, 11(1), 6668-6673.

Mbusi, E. T. (2020). The Growth of the Construction Industry in Kenya (1977–2019). Africa Habitat Review, 14(3), 2065-2070.

Mohammed, F., Ibrahim, O., Nilashi, M., & Alzurqa, E. (2019). Cloud computing adoption model for e-government implementation. Information Development, 33(3), 303–323.

Mutiso, T. (2020). Subcontractor Oversight on Construction Cost Overruns in Real Estate Projects in Nairobi and Kisumu Counties, Kenya October 2021Journal of Sustainable Development 14(6):15

Njenga, K., Garg, L., Bhardwaj, A. K., Prakash, V., & Bawa, S. (2019). The cloud computing adoption in higher learning institutions in Kenya: Hindering factors and recommendations for the way forward. *Telematics and Informatics*, *38*, 225-246.

Ogechukwu O., M. A. (2019). Power Optimisation Model for Leveraging Cloud System, IEEE Conference.

Oke, A. E., Kineber, A. F., Al-Bukhari, I., Famakin, I., & Kingsley, C. (2021). Exploring the benefits of cloud computing for sustainable construction in Nigeria. *Journal of Engineering, Design and Technology*.

Oke, A. E., Kineber, A. F., Albukhari, I., Othman, I., & Kingsley, C. (2021). Assessment of Cloud Computing Success Factors for Sustainable Construction Industry: The Case of Nigeria. *Buildings*, *11*(2), 36.

Oke, A. E., Kineber, A. F., Albukhari, I., Othman, I., & Kingsley, C. (2021). Assessment of Cloud Computing Success Factors for Sustainable Construction Industry: The Case of Nigeria. *Buildings*, *11*(2), 36.

Okonor, M. O, (2021). Intelligent Approach to Minimising Power Consumption in Cloud-Based System Collecting Sensor data and Monitoring the Status of Powered Wheelchair, Intelligent system conference 1,

Olufemi, A. (2019). Considerations for the adoption of cloud-based big data analytics in small business enterprises. Electronic Journal of Information Systems Evaluation, 21(2), 63–79.

Phylisters M., D. K. (2018). *Academic Reserach Proposal Writing; Principles, Concepts and Structures.* Nairobi: Applied Research & Training Service.

Project Management Insitute. (2019). *Project management use of cloud collaboration*. Retrieved from Project Management Institute:

Punj R. & Kumar, R. (2019). Technological aspects of WBANs for health monitoring: a comprehensive review, *Wireless Networks*, vol. 25, no. 3, pp. 1125–1157.

Ramgovind, S., Eloff, M. M., & Smith, E. (2020). The management of security in cloud computing. Information Security for South Africa (ISSA), 1–7.

Ravitch, S. M., & Carl, N. M. (2020). Qualitative research: Bridging the conceptual, theoretical, and methodological. Thousand Oaks, CA: Sage Publications.

Reese, G. (2019). Cloud application architectures: building applications and infrastructure in the cloud. Sebastopol: O'Reilly Media, Inc.

Ronoh, D. K. (2020). Project management practices and performance of residential construction projects in Nairobi City County, Kenya.

Sagini, N. A. Dianga, S., Mbiti, T. K. (2019). Investigating Factors that Influence the Rate of Adoption of Innovative Construction Technologies in Kenya, *International Journal Of Engineering Research & Technology (IJERT)* Volume 05, Issue 01,

Simba, J. K. (2018). *Adoption of cloud computing among small and medium enterprises in Kenya* (Doctoral dissertation, University of Nairobi).

Snow, T. (2020). How the 'new normal' is changing cloud usage and strategy 16 June

Sosinsky, B. (2018). *Cloud computing bible*. Hoboken: John Wiley & Sons.

Spark, D. (2019). Which Methodology is Right for You? Qualitative? Quantitative? Or Both? DRG Spark

Sriram, I. & Khajeh-Hosseini, A. (2019). *Research Agenda in Cloud Technologies.*

Stanford. (2019). Gartner Forecasts Worldwide Public Cloud Revenue to Grow 17% in 2020.

Stieninger, M., Nedbal, D., Wetzlinger, W., Wagner, G., & Erskine, M. A. (2018). Factors influencing the organizational adoption of cloud computing: a survey among cloud workers. International Journal of Information Systems & Project Management, 6(1), 5–23.

The Chartered Institute of Building. (2020). *Quality Control for Construction Works*.

Universit, C. M. (2019). *Organization and use Project Information.* Retrieved from Organization and use Project Information:

Wamuyu, P. K. (2019). Use of cloud computing services in micro and small enterprises: a fit perspective.

Warner, R. M. (2019). Applied statistics: From bivariate through multivariate techniques (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Watad, M., Washah, S., & Perez, C. (2018). IT security threats and challenges for small firms: Managers' perceptions. International Journal of the Academic Business World, 12(1), 23–30.

Watt, A. (2020). *Project Management.* Retrieved from BC Campus:

Wibowo, M. A. (n.d.). The Contribution of the Construction Industry to the economy of Indonesia : A Systematic Approach. Indonesia.: Diponegoro University,.

Wikipedia. (2019). Retrieved from https://en.wikipedia.org/wiki/Project_management

Yaseen, Z.M.; Ali, Z.H.; Salih, S.Q.; Al-Ansari, N. (2020). Prediction of risk delay in construction projects using a hybrid artificial intelligence model. Sustainability, 12, 1514

Zhang, Q., Cheng, L. & Boutaba, R. (2018). Cloud computing: state-of-the-art and research challenges. *Journal of Internet Services and Applications*, 1(1), 7–18.

APPENDICES

Appendix I: Authorization Letter

Mwangi Laban Kamau,

University of Nairobi,

Faculty of Business and Management Science

P.O Box 30197,

Nairobi

November 26, 2021

Dear Respondent

RE: POST-GRADUATE RESEARCH

I am a masters student at the University of Nairobi, School of Open, Distance and E-Learning carrying out a study Influence of Cloud Computing Data Base Management Systems on performance of Construction Project Management firms in Nairobi County, Kenya as part fulfillment for the award of Masters of Arts Project Planning and Management.

I would like to request you to participate in a research by answering the questions in the attached questionnaire. Your responses will be treated anonymous and confidential with information provided by yourself being used for academic purpose only. In view of the above, accuracy of your information will go along way in making this research a success.

Your assistance will be highly appreciated

Yours faithfully,

Mwangi Laban Kamau.

Appendix II: Research Questionnaire for Fellow Construction Project Managers, corporate construction Project Managers and Graduate Project Managers

This questionnaire is to collect data for purely academic purposes. All information will be treated with strict confidence. Do not put any name or identification on this questionnaire

INSTRUCTIONS: Please tick in the appropriate boxes:

Alternatively, you can provide your response in the spaces provided

Section A – General questions

1. Please indicate your gender?

□ Male

□ Female

2. What is your highest level of education?

□ Certificate

□ Diploma

□ Degree

□ Masters

□ PHD

3. What is your age bracket?

□ Below 25years

□ 25 – 30 years

□ 30 – 35 Years

□ 35 – 40 years

□ 40 – 45 years

□ Above 45 years

4. How many years have you been practising as a construction project manager?

□ Less than 5 year

□ 5 – 10 years

□ 10 – 15 years

□ Above 15 years

Section B – Cloud Computing Data Base Management Systems on performance of Building Construction Projects in Nairobi County

Rapid elasticity of cloud computing DBMS

5. To what extent do the following features of rapid elasticity of cloud computing database management system influence performance of construction management firms?
   Very Large extent [5] Large Extent [4] Moderate Extent [3] Low Extent [2]
   Very low extent [1]

Rapid elasticity	**Extent of influence**				
	1	**2**	**3**	**4**	**5**
Flexible provisioning of resources					
Release of capabilities in near real time					
Automatic scaling of capabilities whenever needed					
Minimal provisioning time					

6. In your own opinion, how does rapid elasticity of cloud computing database management system influence performance of building construction projects in Nairobi County, Kenya?
   ……
   ……
   ……

Multi Tenancy

7. To what extent does the following characteristics of multi tenancy of cloud computing database management system influence performance of building construction projects in Nairobi County?
   Very Large extent [5] Large Extent [4] Moderate Extent [3] Low Extent [2]
   Very low extent [1]

Multi Tenancy/Resource Pooling aspects	**Extent of influent**				
	1	**2**	**3**	**4**	**5**
Serves multiple consumers using a multi-tenant architecture					
Assignment and reassignment of resources based on user demand					

Providing a set of behaviour stimulation resources adopted from a single common source					

8. In your own opinion, how does Multi Tenancy aspect of cloud computing database management system influence performance of building construction projects firms in Nairobi County, Kenya?

   ……

   ……

   ……

On-demand self-service of cloud computing DBMS

9. To what extent does the following features of on-demand self-service of cloud computing database management system influence performance of building construction projects?

   Very Large extent [5] Large Extent [4] Moderate Extent [3] Low Extent [2]

   Very low extent [1]

On-demand self-service aspects	**Extent of influence**				
	1	**2**	**3**	**4**	**5**
Access to numerous services at once					
Retrieval and use cloud information resources					
Automation of computing services					
Provision of resources such as network storage					

10. In your own opinion, how do on-demand self-service aspects of cloud computing database management system influence performance of building construction projects in Nairobi County, Kenya?

    ……

    ……

    ……

Broadband network access of cloud computing DBMS

11. To what extent does the following characteristics of broadband network access of cloud computing database management system influence performance of building construction projects?

    Very Large extent [5] Large Extent [4] Moderate Extent [3] Low Extent [2]

    Very low extent [1]

Broadband network access aspects	**Extent of influence**				
	1	**2**	**3**	**4**	**5**
Access to systems from all locations /workstations					
Access to systems from all devices					
Enables users to categorize and segment system					
Simplified access to available resources in a network					

12. In your own opinion, how does broadband network access aspects of cloud computing database management system influence performance of building construction projects in Nairobi County, Kenya?

    ……

    ……

    ……

Section C: Performance of the Building Construction project in Nairobi County

13. Looking at the trend in the past 5 years, how has building construction project faired when evaluated on the following performance indicators?

    Greatly increased [5] Large Extent [4] Moderate Extent [3] Low Extent [2]

    Very low extent [1]

	1	2	3	4	5
Timely completion					
Systematic execution of tasks					
Proper co-ordination of resources throughout the project lifecycle					
Savings at the end of a construction project					

Fitness for purpose of the building					
Attainment of occupational certificate					

In your own opinion, how has use of cloud computing database management systems affected performance of building construction projects in Nairobi County, Kenya?
……
……

Thank you for your time

Appendix III: Letter of Transmittal

UNIVERSITY OF NAIROBI
COLLEGE OF HUMANITIES & SOCIAL SCIENCES
FACULTY OF BUSINESS AND MANAGEMENT SCIENCES

Telephone: 4184160-5 Ext 215
Telegrams: "Varsity" Nairobi
Telex: 22095 Varsity

P.O. Box 30197
Nairobi, KENYA

26 October 2021

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER FOR RESEARCH
MWANGI LABAN KAMAU – REGISTRATION NO. L50/7401/2017

This is to confirm that the above named is a bona fide student in the Master of Arts in Project Planning and Management degree program in this University. He is conducting research on ***"Influence of Cloud Computing Data Base Management Systems on Performance of Building Construction Projects in Nairobi County, Kenya".***

The purpose of this letter is to kindly request you to assist and facilitate the student with necessary data which forms an integral part of the research project. The information and data required is needed for academic purposes only and will be treated in **Strict-Confidence**.

Your co-operation will be highly appreciated.

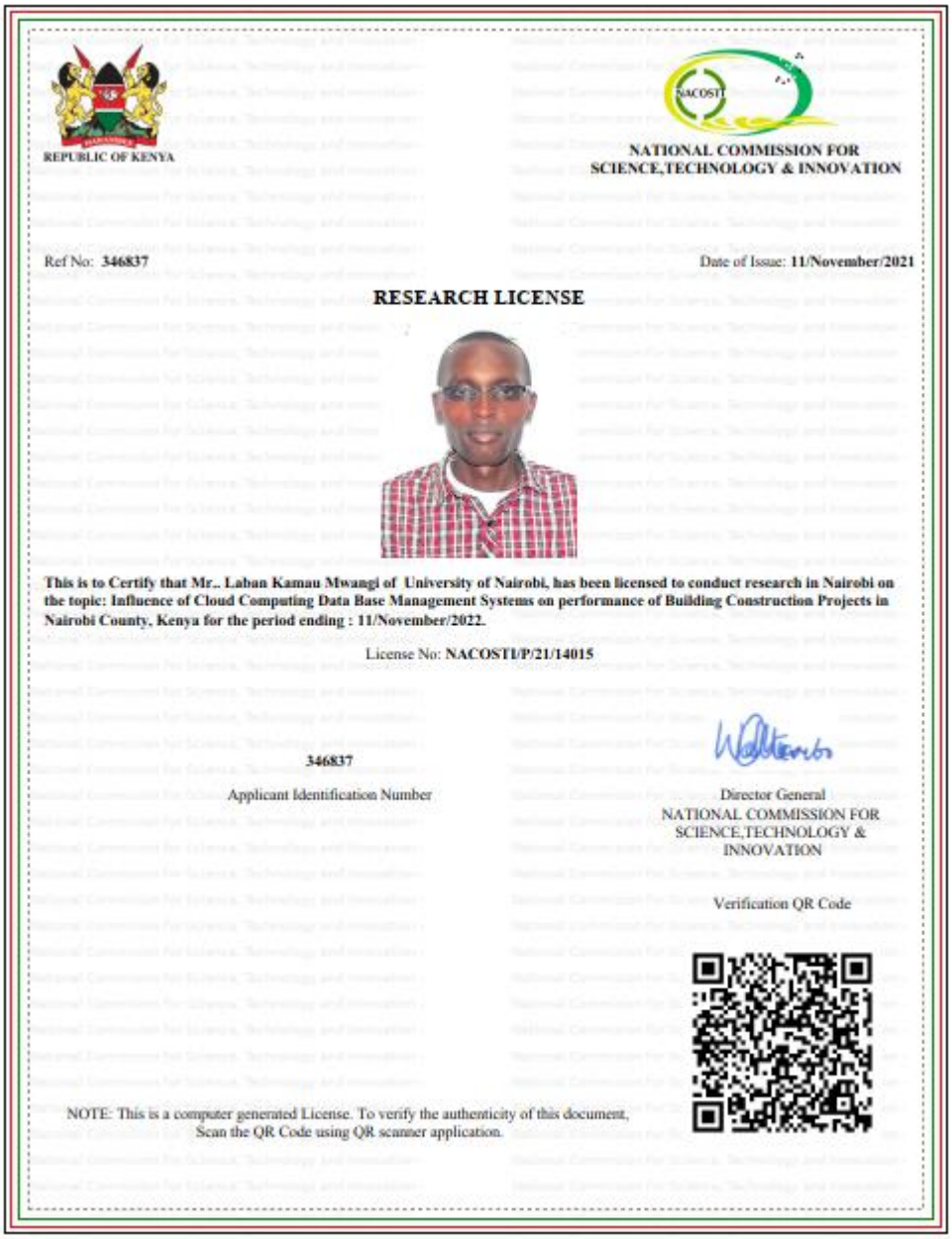
UNIVERSITY OF NAIROBI
26 OCT 2021

Thank you.

PROF. JACKSON MAALU
DEAN, FACULTY OF BUSINESS AND MANAGEMENT SCIENCES

JM/jo

Appendix IV: Research Permit



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **346837**

Date of Issue: **11/November/2021**

RESEARCH LICENSE

This is to Certify that Mr.. Laban Kamau Mwangi of University of Nairobi, has been licensed to conduct research in Nairobi on the topic: Influence of Cloud Computing Data Base Management Systems on performance of Building Construction Projects in Nairobi County, Kenya for the period ending : 11/November/2022.

License No: **NACOSTI/P/21/14015**

346837

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.