UTILIZATION OF GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY ON IMPLEMENTATION OF KENYA RURAL ROADS AUTHORITY'S ROAD CONSTRUCTION PROJECTS IN KENYA

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A Research Project Report Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Arts in Project Planning and Management of the University of Nairobi

2023

DECLARATION

The present paper represents an original contribution and has not been previously submitted to the University of Nairobi or any other academic institution for the purpose of obtaining a degree.

Signature. Date: **18/11/2023**

FREDRICK OTIENO OKONG'O

L50/84484/2016

The present Research Report has been duly filed with my endorsement as the academic supervisor at the institution.

Signature…… ………... Date: **18/11/2023**

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DEDICATION

Dedicated to my wonderful wife, Emma Bosibori, and our beloved children, Valerie and Trevor, this research stands as a tribute to their unwavering support, patience, and prayers throughout the academic journey. Emma, your love is my anchor, and Valerie and Trevor, your presence fills this process with joy. This work is as much theirs as it is mine, reflecting the love and encouragement that surrounds me daily. To my family, thank you for being my pillars of strength, cheering through highs and standing by through lows. Emma, Valerie, and Trevor, you are my inspiration, and this research is dedicated to the profound bond we share and the countless moments of grace you've brought to my life.

ACKNOWLEDGEMENT

I thank the heavenly entity for the privilege of pursuing this scientific pursuit. Prof. Christopher Gakuu, my advisor, and Dr. Reuben Kikwatha, the course coordinator, have provided me with excellent guidance and feedback during this important academic project, and I am really grateful to them. I want to thank my lecturers for everything they did to help me finish the course successfully with their instruction and advice.

The management and staff of KeRRA deserve my sincere appreciation for allowing me to conduct this research at the Authority with their kind cooperation and time. Additionally, I appreciate their role as respondents, as they provided the necessary data that facilitated the development of this report.

Special appreciation to my parents Mr. Pius Okong'o Onyina and Mrs. Maryrose Auma Okong'o for their encouragement during my studies.

I would like to express my gratitude to my wife, Emma Bosibori, as well as my children, Valerie and Trevor, for their support and encouragement while I was pursuing my education. During the times when I have been very busy, I have a deep appreciation for your patience, moral support, and understanding.

In addition, I would like to extend my deepest thanks to my fellow students in the Master of Arts in Project Planning & Management program, especially Kennedy Ojwang, as well as the Research Assistants, under the direction of Mr. Samuel Ndanu, for their support and encouragement during the process of putting together this report.

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ABBREVIATIONS AND ACRONYMS

CAD - Computer Aided Design

COTS - Commercial Off-The-Shelf

CPM - Critical Path Method

CS - Corporate Services

ESRI - Environmental Systems Research Institute

FHWA - Federal Highway Administration

GIS - Geographic Information System

GIT - Geospatial Information Technology

GPS - Global Positioning System

ICT - Information and Communications Technology

KeRRA - Kenya Rural Roads Authority

P,D & E - Planning, Design and Environmental Interests

PERT - Program Evaluation and Review Technique

R, S & C - Research, Strategy and Compliance

RAM - Road Asset Management

ROI - Return on Investment

RSI - Relative Strength Index

SDG - Sustainable Development Goals

SPSS - Statistical Package for Social Scientists

UTAUT - Unified Theory of Acceptance and Use of Technology

ABSTRACT

The success of any road construction project relies heavily on effective and efficient planning, implementation and monitoring of the construction progress. Studies have indicated the integration of GIS technology with the traditional management tools as a promising approach to overcome the limitations of the traditional tools in road project management especially implementation. Though adopted by various sectors including the roads authorities all over the world, GIS technologies have not been utilized to its full potential more so in Kenya and other low and middle-income economies. This research, titled "Utilization of Geographic Information System Technology on Implementation of Kenya Rural Roads Authority's Road Construction Projects in Kenya," set out to determine the causes of the relatively low uptake of GIS technology by KeRRA during the construction of roads, despite the authority's recognition of the technology's potential for mitigating problems with conventional methods of road management. As a theoretical framework, this research relied on the Technology Acceptance Model, the Technology Organization Environment Framework, and the Unified Theory Acceptance and Use of Technology theorems.

After conducting a stratified random sample of the workers at the KeRRA Directorates, Departments, and Projects according to their job cadres, a cross-sectional survey was conducted to collect answers from at least 142 respondents. The replies were then ranked on a 5-point Likert scale, with 1 indicating strongly disagreeing and 5 indicating strongly agreeing, based on the questionnaire's framework. The collected data was analyzed descriptively at univariate, bivariate levels using SPSS Version 29.0 to compute the measures of central tendencies and dispersion to aid the accurate description of the responses.

Cronbach's alpha analysis, used to measure reliability, provided a value of 0.877, and open-ended interviews with senior KeRRA management were used to determine content validity.

Based on an examination of parameters including access to GIS technology, availability of GIS data, GIS staff capacity, and GIS startup cost, the research found that the use of GIS technology significantly affects the realization of KeRRA road construction projects with a linear prediction model of $Y = 0.368X_1 + 0.092X_2 + 0.174X_3 + 0.642X_4 - 0.317$ whereby Y represents implementation of the projects while X_1 to X_4 represents the parameters respectively.

Therefore, the research suggests that efforts be made to boost GIS technology utilization in the execution of road construction projects by allocating more financial and human resources and establishing an enabling application environment. This will go a long way in improving road construction management process not only at the national government level but also at the county government level.

CHAPTER ONE

INTRODUCTION

1.1 Background of The Study

Roads play a crucial role in transportation, with over 80% of goods traffic and nearly 90% of passenger travel relying on them. Consequently, they are vital for the growth of any nation and particularly important in rural regions where commercial agricultural operations take place. In order to accomplish Sustainable Development Goal 9, which focuses on industry, innovation, and infrastructure, there is an urgent need to use cutting-edge technology like Geographic Information Systems (GIS) in road construction projects, particularly in rural regions that are characterized by a lack of roadways that are accessible to the general public. Enhancing access to rural roads within a 2km distance is a key indicator of SDG Goal 9, and it is especially relevant in developing countries like Kenya, where small holder farming is prevalent, but inadequate road access hinders market connectivity.

This study was informed by three theoretical frameworks: The Technology Acceptance Model (TAM), the Technology-Organization-Environment (TOE) Framework, and the Unified Theory of Acceptance and Use of Technology (UTAUT). The TAM hypothesis describes how people's impressions of a technology's utility and its usability are linked. On the other hand, the TOE framework analyzes the influence of technical, organizational, and environmental aspects on the acceptance and usage of a technology. On the other side, the UTAUT theory clarifies how demographics like gender, age, experience, and voluntariness have a role in a technology's uptake and application. These factors from the three theories were therefore considered in development of the research data instrument so as to comprehensively study the effect of utilization of GIS technology in implementation of road construction projects.

While CAD systems are commonly used in engineering and architectural design in middle-income economies, they have limitations in handling databases involving both locational and thematic attributes. On the other hand, GIS provides a more comprehensive and integrated approach, enabling precise bill-of-materials lists based on design drawings while incorporating geographical and topical considerations. The underutilization of GIS in Kenya's 47 counties, as highlighted in a GIS needs assessment report, is primarily attributed to challenges like lack of hardware and software components, capacity gaps, staffing issues, and undefined data and sharing policies. However, GIS has the potential to overcome these challenges and improve decision-making ultimately contributing to the optimization of road projects and infrastructure.

By embracing GIS and innovative technologies, the implementation of road projects can be optimized, aligning with the SDG Goal 9 and contributing to the vision of 2030 of Kenya. The current reliance on traditional project methods like bar charts, CPM, and PERT in the road construction industry lacks the spatial aspects necessary for real-time data analysis and decision-making. This deficiency emphasizes the importance of GIS, which excels in managing both spatial and attribute data and can aid project managers in making informed choices and optimizing resource allocation. Hence, it is vital to do a comprehensive investigation on the utilization of GIS in road initiatives within the African setting. This research endeavor is crucial in order to effectively tackle infrastructure obstacles and promote enduring progress in the area.

1.1.1 Geographic Information System

According to ESRI, GIS is a comprehensive system comprising interconnected computer hardware and software applications, geographic data, and trained professionals. Its purpose is to collect, manage, analyze, and present data with spatial components (Karan & Delavar, 2018). The key components of a GIS include computer hardware, GIS application software, human resources specialists, and data, which collectively function as an information system (Bansal, 2017). GIS offers various processes such as data management, display, exploration, analysis, and modeling, all accessible through a unified interface. It combines spatial data and non-spatial data, allowing users to access and analyze diverse information effectively. The GIS system records the geometry of features as spatial data, while attribute data is organized in tabular form, describing the distinctive properties of different features in the GIS (Bansal, 2017). GIS applications have increasingly been employed in road construction, providing real-time project progress information and aiding decision-making through high-quality spatial maps that efficiently convey large volumes of data (Sedki & Esmaeel, 2022). Additionally, GIS has proven valuable in various aspects, including construction progress monitoring, networking solutions, site location, 3D data analysis, construction scheduling, mapping client distance, and 3D visualization (Sebt et al., 2018).

By integrating project tools with GIS, access to both geographical and temporal aspects of road construction projects become more efficient. Project managers and teams from diverse backgrounds can obtain accurate real-time information about the project's progress and activities (Bansal, 2017). GIS facilitates the storage, maintenance, and analysis of GIS-referenced data, combining standard database operations with unique mapping visualization and data interpretation methods (Balawejder & Wójciak, 2017). The integration of GIS in spatial decision support systems (SDSS) for road infrastructure has proven successful, enhancing decision-making efficiency in resolving spatial choice problems (Felke, 2019). To optimize road construction projects in the face of dynamic demands, accurate planning, scheduling, execution, and administration are essential (Khwaja & Bussell, 2017). Traditional methods, like using scheduling and drawing software separately, can be laborious and time-consuming. However, by integrating GIS topology with CAD drawings and schedule sheets, a four-dimensional view of road construction projects can be generated, leading to improved optimization and real-time monitoring (Naik et al., 2021).

1.1.2 Implementation of Road Construction Projects

GIS technology applications provide promising solutions to the road construction encounters of planning, scheduling, procurement and logistics among others by enhancing optimization of land use, efficiency of the proposed road construction design as well as its marketability. Additionally, GIS as a digital tool is vital in the of spatial information (Jayavarapu, 2017).

Besides, GIS applications adds intelligence to spatially collected data by their ability to measure distances and areas, carry out vicinity identification and network analysis through combination and overlay of various data sets (Bolstad,2018). Through GIS, raw data can be entered, measurements, and field sketches can be embedded directly into the GIS, enabling efficient of data in a geo-database containing other spatial information. In this way, GIS technology assists in the collection, importation, conversion, analysis and storage of spatial measurements and computational fabrics thereby providing additional opportunity of integrating computations including traverse least squares, pre-existing networks and importation spatial data features (Jayavarapu, 2017).

In addition, GIS applications may be expanded to include the implementation of environmental analyses, which can throw light on the varied effects of alternate modes of transportation. Highway maintenance, traffic modeling, study of road accidents, route planning, and environmental evaluation of road systems and buildings are just some of the applications of geographic information systems that have been put to use (Al-Ramadan, 2018). When it comes to civil engineering, GIS has many potential applications due to its ability to combine different kinds of geographical data and the properties that describe them. This is particularly true for the effective execution of road projects (Bolstad,2018).

1.1.3 KeRRA Road Projects in Kenya

Established in 2007 as parastatal, KeRRA was mandated to manage, develop rehabilitate and maintain the rural road networks within the Republic of Kenya as spelt out in the Kenya Roads Act, 2007(KeRRA Annual Report, 2017). The enactment of the Constitution of Kenya (CoK), 2010, which classified roads as either national trunk or county roads, resulted in the reorganization of the Authority in accordance with the fourth schedule of the CoK, 2010. Following this reclassification, KeRRA managed roads currently fall under class C roads with a total of 19,504 Km length out of the total 39,975Km of the national roads' coverage (KeRRA Annual Report, 2017).

KeRRA implements its mandate through planning, designing and implementation supervision road projects. As by the end of the year 2021, KeRRA had a road project portfolio length of about 11,226Km with 5,596 Km of this completed from the year 2007,4605Km ongoing and 1025Km planned for translating to a road project portfolio of about Ksh. 806 Billion distributed across the country. To effectively and efficiently undertake this huge mandate therefore requires excellent project management tools to coordinate decision making at all the stages of the project management cycle.

The current reliance on traditional project methods like bar charts, CPM, and PERT in the road construction industry lacks the spatial aspects necessary for real-time data analysis and decision-making. This deficiency emphasizes the importance of GIS, which excels in managing both spatial and attribute data and can aid project managers in making informed choices and optimizing resource allocation considering the magnitude of public investment and diversity in locations of road projects implemented by KeRRA.

1.2 Statement of the Problem

The utilization of integrated GIS technology has numerous benefits for project implementation in various sectors, including road construction. However, in middle and low-income economies, particularly in the road construction sector, there remains a predominant reliance on traditional methods for project planning, scheduling, and progress monitoring (Sit & Mu, 2018). Despite the abundance of merits offered by GIS technology, there is a noticeable reluctance to fully harness its potential in planning construction activities for road projects in these economies, even within state road construction departments like KeRRA. In order to shed light on the problems preventing the complete integration of GIS in the efficient execution of road projects, this study seeks to investigate and comprehend the elements that affect KeRRA's acceptance and usage of GIS technology.

Despite the fact that GIS technology in the road building business has a number of outstanding benefits, the widespread resistance in countries with middle-income and low-income levels to completely adopting it is a major cause for worry. KeRRA's adoption of GIS technology without its full utilization exemplifies this issue. GIS technology has the capacity to revolutionize project planning and execution by providing real-time data, spatial analyses, and efficient utilization of resources, leading to improved decision-making and overall project outcomes. The failure to fully embrace and integrate GIS technology may hinder progress and efficiency in road construction projects, impeding economic development and infrastructure growth. Understanding the reasons behind this reluctance and identifying the variables influencing GIS adoption in KeRRA is crucial to bridge the existing research gap and facilitate more effective road project implementations.

Despite the evident potential and merits of GIS technology in the road construction sector, there is a research gap in understanding the factors influencing its full adoption and utilization in middle and low-income economies, particularly within organizations like

KeRRA. While some adoption may have occurred, the reluctance to embrace GIS to its maximum capabilities hinders the sector's progress. Previous studies may have explored the benefits of GIS technology, but there is a lack of comprehensive research on the specific variables that affect its implementation and integration in organizations like KeRRA, particularly in the context of road projects in middle and low-income economies. Therefore, this study seeks to answer the question: what is the influence of the utilization of GIS in implementation of road projects in Kenya by KeRRA?

1.3 Purpose of the Study

This study aims to investigate the various factors influencing the utilization of GIS technology in the implementation of road projects in Kenya, focusing on KeRRA as the case study. The research seeks to provide a detailed analysis of these influencing factors, aiming to offer a nuanced understanding of the complexities shaping the integration of GIS technology in road infrastructure development. By exploring these dynamics, the study intends to contribute valuable insights that can inform strategies and policies to optimize GIS technology usage in the context of road projects, enhancing overall efficiency and effectiveness in Kenya's infrastructure development landscape.

1.4 Objectives of the Study

i. To determine the extent to which access to GIS technology influence implementation of KeRRA road projects in Kenya.

ii. To assess the extent to which availability of GIS data influence implementation of KeRRA road projects in Kenya.

iii. To examine the extent to which the initial start-up cost of GIS infrastructure influence implementation of KeRRA road projects in Kenya.

iv. To assess the extent to which staff capacity influence implementation of KeRRA road projects in Kenya.

1.5 Value of the Study

For project management in road construction, the study's significance lies in the potential to enhance project planning, execution, and monitoring. Understanding the variables affecting GIS adoption can help project managers and teams proactively address challenges and optimize GIS utilization for more efficient project delivery. By leveraging GIS technology, project managers can access real-time data, perform spatial analyses, and make data-driven decisions, leading to improved resource and better over project timelines and budgets. The study's insights can be translated into practical project management strategies that empower construction teams to harness the capabilities of GIS technology to ensure successful road construction projects.

The conclusions of this research will have substantial ramifications for policy development within the road construction industry, namely in the realm of road project management. The elements that affect KeRRA's use of GIS technology will shed light on the obstacles preventing its widespread use in transportation projects. This information will help in formulating policies and strategies to promote the effective integration of GIS technology into road construction planning, scheduling, and progress monitoring processes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section offers a summary of the research done on the topic of how GIS technology has been used to the fields of construction planning and the road building sector. The study also includes a presentation of the theoretical framework, conceptual framework, and research gaps that have been accepted. The literature assessment delves into key conceptual factors related to the utilization of GIS technology in road construction projects. It examines variables such as access to GIS technology and its use in road projects, the availability of GIS data and its utilization in road projects, initial GIS startup costs and their impact on road projects, as well as staff capacity and its influence on GIS utilization within the case under investigation. The review further analyzes the theoretical, conceptual foundations of the study and research gaps from previous similar studies providing a synthesis of relevant literature on the subject.

2.2 Theoretical Framework

The present research was informed by three theoretical frameworks, namely the Technology Acceptance Model, the Technology-Organization-Environment (TOE) Framework, and the Unified Theory of Acceptance and Use of Technology (UTAUT).

2.2.1 Technology Acceptance Model (TAM)

Fred D. Davis is credited with the development of this idea in 1986. People are more likely to embrace new technologies if they are seen as beneficial and simple to use, as proposed by the TAM. How much a person thinks utilizing the technology will improve their performance is what we call its perceived usefulness, and how simple and intuitive it will seem to use is what we call its perceived ease of use.

In the present research, the TAM was used to gain insights into the determinants that impact the adoption of Geographic Information System (GIS) technology by the KeRRA in the execution of road building initiatives. The study investigated how road construction professionals within KeRRA perceive the usefulness of GIS technology in improving project planning, scheduling, and monitoring. Additionally, the study explored how road construction staff perceived the ease of use of GIS technology and whether it affected their intention to adopt and fully utilize GIS in their projects.

2.2.2 Technology-Organization-Environment (TOE) Framework

The model under consideration was established by Tornatzky and Fleischer in the year 1996. The model presented is a complete framework that elucidates the process of technology acceptance and deployment within organizational contexts. The analysis takes into account three primary aspects, namely technical factors, organizational factors, and environmental variables. Technological considerations include the inherent attributes of the technology, including its intricacy and its compatibility with pre-existing systems. Organizational variables include the structural elements, available resources, and inherent capacities of an organization to effectively embrace and integrate technological advancements. Environmental considerations include the external elements that possess the potential to impact the adoption of technology, including market needs and regulatory rules.

The TOE Framework was used in this investigation in order to investigate the elements that have an impact on KeRRA's decision to make use of GIS technology in the course of the delivery of road construction projects. In the research, technical aspects of GIS were studied. These aspects included its ease of integration with preexisting road building procedures and its compatibility with other technologies that KeRRA employs. Additionally, the study explored the organizational readiness of KeRRA, including its resources, expertise, and willingness to embrace GIS technology. Furthermore, the study considered the external environment in which KeRRA operates, such as government policies, funding availability, and market demands, to understand how these factors may have impacted on the adoption and implementation of GIS technology in road construction projects.

2.2.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

In addition, the UTAUT served as the overarching theoretical foundation for this study. Professionals and academics' desire to learn more about the elements that influence people's adoption of new technologies prompted the development of this model (Mutlu & Der, 2017). In order to construct this model, this knowledge is essential. The information management systems (IS) industry, along with other sectors that rely heavily on technology, has found an application for the UTAUT. It places a focus on the major individual level elements that impact technology acceptance and also helps in enumerating the aspects that may affect technology use or adoption. Several individual-level variables affect whether or not someone will embrace new technology (Thong and Xu, 2016). After looking at the eight most popular models for user acceptance of technology, the UTAUT model emerged as the frontrunner (Venkatesh et al., 2016).

The study utilized the UTAUT model to investigate the utilization of GIS technology in road construction projects. It focused on the key component of Performance Expectancy (PE), which assessed the potential benefits of effectively utilizing GIS technology in road construction for enhancing job performance (Venkatesh et al., 2018). Effort Expectancy (EE) refers to the perceived ease of adapting modern technology to meet individual needs, such as the GIS software utilized in road construction projects (Lai, 2017). Social Influence (SI) pertains to the extent to which individuals perceive that their peers, including engineers, architects, friends, and managers, consider it important for them to adopt the new system, specifically the GIS technology in this case. The concept of Facilitating Conditions (FC) refers to the belief in one's ability to effectively utilize a particular invention, such as GIS technology, due to the high quality of their existing organizational and/or technological infrastructure. Hedonic Motivation (HM) pertains to the satisfaction or pleasure derived from utilizing state-of-the-art electronics. Lastly, Habit (HB) is determined by the extent to which individuals perceive their actions to be controllable by a machine, as discussed by Lai (2017).

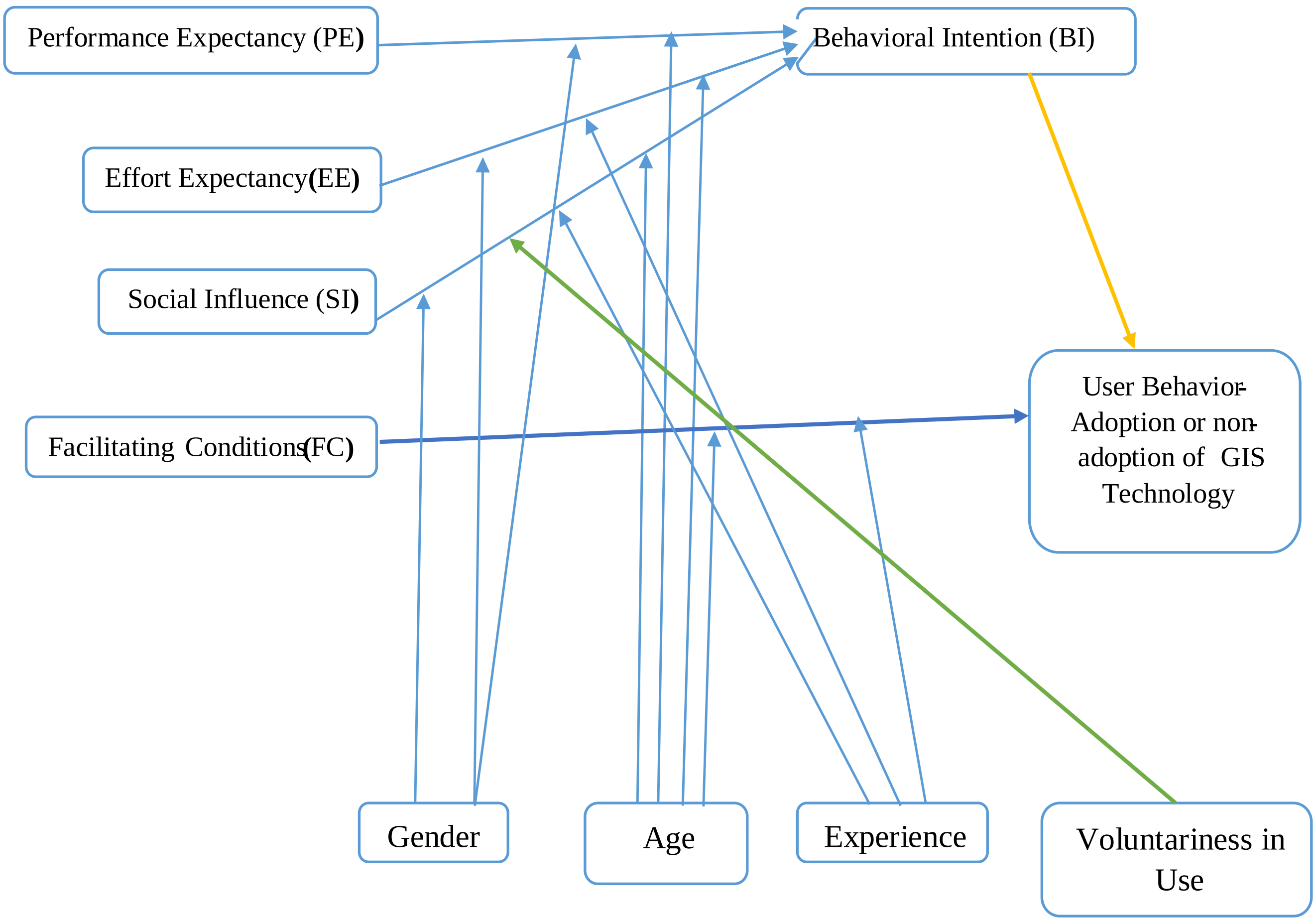

Figure 2.1: Theoretical Framework- UTAUT (Venkatesh, 2003)

2.3 Determinants of Project Implementation

This study reveals some crucial conceptual issues for the use of GIS technology in road building projects. The factors/variables under investigation in the study include access to GIS technology and its utilization in road projects, availability of GIS data and its utilization in road projects, initial GIS startup cost and its utilization in road projects and lastly staff capacity and how it influences GIS utilization in the case under investigation.

2.3.1 Access to GIS Technology and Implementation of Road Construction Projects

Technology-related responsibilities within a GIS project include an evaluation of all the available alternatives, which may include the creation of applications via the use of tool kits or the installation of products that are available "out of the box" (OOTB) (Jayavarapu, 2007.). This necessitates doing an in-depth and methodical study, as well as making decisions about the system architecture (servers, network, redundancy, storage), and making a thoughtful choice regarding the appropriate technology that is capable of connecting with other systems. Furthermore, all existing and future GIS technology-related requirements must be addressed, therefore a consistent and comprehensive approach is required for the project's success.

Real-time applications are supported by GIS technology at a number of different organizations. In situations like this, having access to GIS apps is really necessary (Jayavarapu,2017). The obligation for maintaining and developing the necessary database systems, application servers, terminal server technologies, synchronization system, storage systems, and restoration technology falls on the GIS or ICT teams.

The accessibility of the technology, which includes the expenses of hardware, software, and data, is an essential part of a successful implementation of GIT. This accessibility also plays a role in the importance of a suitable technology. In addition, the management of infrastructure now requires the use of systems that include several disciplines (Mennecke & Jr, 2001). For instance, the creation of road infrastructure and the effective maintenance of that infrastructure need data from utility organizations, such as water and electricity, and all of this data has to be integrated. More than that, there should be considerations made to improve the incentive of stakeholders to combine their efforts together, such as across sectors the necessary ministries and perhaps departments with an eye on the institutionalization of GIT (Amade et al., 2018).

Numerous GIS and TAM applications have in-built system designs that are generally distinct from one another. As a result, integration may provide certain challenges. According to Budzynski et al. (2018), several government organizations are striving to address this issue by updating their antiquated legacy systems with newer ones that are better connected. It is interesting to note that even integrated systems need frequent software and version updates, which may add a substantial amount of additional expense to a GIS development operation. Updating one piece of software often necessitates updating other pieces of software that are connected to it in order to preserve compatibility. Some government organizations have made their GIS designs easier to understand by building specialized software solutions that are able to integrate a wide variety of systems and data (Stepniak & Turek, 2020).

It takes a lot of time, effort, and input from the actual users for the sessions to develop the data models. Everyone on the team needs to understand not only the fundamentals of GIS (feature classes, subtypes, domains, relationships, annotations, subclasses, labels, symbology, data sets, and history), but also the long-term consequences of the decisions made today. Additionally, the teams need to make judgments on connectivity, topology, annotation rules, and other related topics. Building an enterprise GIS is made much easier by using the data models provided by ArcGIS. However, in order for these models to satisfy the GIS technology criterion, a comprehensive engineering activity is required.

2.3.2 Availability of GIS Data and Implementation of Road Construction Projects

The implementation of GIS technology requires a significant amount of data. Not only does the quality and accuracy of the underlying geographical and tabular data play a significant role in the appropriate performance of any GIS application, but so does the latency of that data. The predicted level of variety from the GIS system brings a rise in the modeling difficulties associated with the GIS (Jayavarapu, 2017).

Bush clearing and grubbing, excavating, dumping borrow earth, earth dozing, grading and rolling borrow earth, dumping, grading, laying and compacting bituminous macadam, applying tack coat, and laying and compacting thick bituminous macadam (DBM) are the primary processes in the building of any road (Somers R.M., 2019). Several tasks involve spatially and non-spatially connected information that is separately maintained by different participants of the project using various commercially accessible technologies. Errors in construction are common when such data are inconsistent (Naik et al., 2021). Such data may be kept and analyzed using software from a variety of fields all through the duration of a building project. While construction and operations teams employ blueprints, planners often use computer-aided design (CAD) software and other application tools like Primavera and Microsoft Project. Without well-established standards and procedures for sharing information across project teams, inefficiencies like data duplication, unnecessary steps, and subpar output are inevitable (Akomolafe et al., 2019).

By embracing a variety of standards from a variety of data providers, national governments and organizations may take significant steps toward eliminating geographical data incompatibility and incompleteness. Creating national-scale base maps for use with other data gathering initiatives is an important first step (Mennecke & Jr, 2021). Important physical features and political borders are included on the base maps. The maps are as straightforward as updated topography data or rectified RSI, but they have a dual purpose. One major benefit is that it's no longer necessary for each database manufacturers to fork out money to develop their own set of foundational maps. As a result, more information is generated at a lower cost (Mennecke & Jr, 2021). Attribute data used in GIS and related applications is governed by yet another set of guidelines. Sometimes, planning may be made more difficult by the growing sophistication of ICT applications (FHWA, 2022). There is major cause for alarm since many users' demands are not being met by the current crop of tools designed to mine databases for relevant data to use in GIS modeling and decision support (Al-Ramadan, 2018). These guidelines may be used to create a meta-data repository and a national level data dictionary that include all of the necessary data components, as well as construct attribute domains for commonly used characteristics (Mennecke & Jr, 2021). With this change, we should anticipate a decrease in data collection severance as a result of improved data exchange and integration.

Additionally, concerns about whose data are whose arise often when GIS and TAM interfaces share data. Whose job is it to gather information and examine it? As in, whose job is it to make sure it stays current? If someone has the means to buy and maintain the systems, please let me know. Agencies that want to combine GIS and TAM activities often fail to do so because they cannot agree on who will own and pay for the system (Sit & Mu, 2023).

Mwaniki and Mutua (2017) found that high levels of data sharing were shown at about 80% sharing within county departments and at around 86% with external agencies in their evaluation report on the readiness of county governments to use GIS technology. Almost every national institution surveyed said they shared data with other entities; these entities ranged from private businesses to county governments to federal agencies to non-profits. Data sharing GIS could be enhanced with the embracement of GIS technologies in data management within the key players and more so in planning for road construction projects to ensure efficiency by reducing duplication of activities (Mwaniki & Mutia, 2017).

Furthermore, there are various data standards challenges that have a significant influence on GIS and TAM initiatives. A difficulty is that information is gathered differently for various asset classes and geographical locations (Song et al., 2018.). To begin with, the frequency of data collection may be different, the level of granularity may also be different, and the referencing system may be different as well. The key agencies have discovered that there is a risk of widespread use of different data gathering technologies, which makes it impossible to combine the data into a single, statewide system. Some government organizations tackle this problem by developing comprehensive strategies for managing data. Thus, the total cost of data integration difficulties is reduced, and the number of inputs requiring uniformity inside the database is greatly reduced. Agencies have also found success in addressing this problem by standardizing on a single Linear Referencing System (LRS), which guarantees that materials are always placed in the same places along construction lines (Prof & Esmaeel, 2022).

The second problem with standards is the data used by GIS applications. When it comes to GIS, the majority of the market for GIS products is led by a single private corporation that adheres to its own data standards. Alternate data standards are made available by a number of other businesses and organizations; however, they are neither as widespread nor as well recognized (Kang & Seo, 2018.). Numerous government agencies either adhere to the dominant standard or transform their data into a format that is compatible with that standard in order to make it easier to exchange information with other government agencies. Companies will have an easier time entering the market as a result of the efforts being made by various interest groups to encourage the adoption of open data standards. It is anticipated that diversification will offer agencies with additional options about the software packages they employ, as well as the ability to acquire modules from other software vendors that will function appropriately with the same systems (Felke, 2018).

The translation of data between asset management systems and geographic in GIS presents a further challenge pertaining to data standards. To facilitate the import of TAM data into GIS systems, several providers of COTS TAM software are designing their systems (or providing modules) to output TAM data in a GIS-friendly manner (or are offering these export modules). Unfortunately, many older systems lacked this feature, therefore converting data once (or twice if converting at the point of input into data storage systems) is necessary before it can be used in a geographic information system. This is because GIS requires the data to be in a specific format. This may be time-consuming, particularly when dealing with data that has to be updated on a frequent basis (Ouattara et al., 2017.)

2.3.3 Start-up Cost and Implementation of Road Construction Projects

The Access to GIS Technology s for geographic information system (GIS) operations are often split across a number of different projects at most organizations. The consolidation of synergy and energy that is necessary to migrate towards new trends in GIS applications is hindered by this distribution approach's focus on decentralization. Within the framework of the budget cycle at certain other organizations, the money designated for GIS components are spread out across a number of years (Jayavarapu, 2017). In such circumstances, it is of the utmost importance to have a strategic plan that guides the business in the direction of achieving its GIS objectives.

The gathering of data is an essential component of both TAM and GIS projects; nevertheless, it represents a significant barrier to the efficient use of GIS to transportation management TAM (France-Mensah et al., 2017). Time and resources needed to compile an inventory of all the assets within the scope of the vast majority of government entities could be prohibitive. The majority of government entities struggle with determining how much data should be sent to interstate roadways.

The ROI on implementing GIS applications is influenced by a number of factors, one of which is the quality of the decisions made at the technical and administrative levels (Mennecke & Jr, 2021). For instance, using ArcGIS Desktop, modifying ArcGIS Desktop or coming up with any custom application using Arc Objects technology, provide solutions to the business requirements(Jayavarapu,2017). The process aspects of any GIS applications needs are often the least elements taken into account; yet, they ultimately play a substantial impact towards the cost and timeline for successfully establishing an enterprise GIS application (Jayavarapu,2017).

Although it may be costly to acquire geographical data, there are methods that can be used to lower data-related expenses and increase support for GIS deployment. In this regard, GPS and remotely sensed data offer particularly promising prospects, since they can collect vast amounts of useful information at very low prices (Mennecke & Jr, 2021). Users are able to employ affordable gadgets to record their location by using contemporary GPS technology, which allows for this capability. The coordinates of items of interest may be recorded as a normal part of workers' everyday activities or operations if they are provided with GPS devices, which can be obtained by supplying project personnel with these devices. Despite the added complexity, this kind of investment provides fairly cheap hardware and software to link GPS inputs to laptops, therefore gathering exact attribute data and a geographic location (Mennecke & Jr, 2021).

Another form of data that may be used in the development of maps is remotely sensed data. This includes data obtained from satellites and aerial photography. The price of the maps that are made through the use of ground-based methods is much higher than the price of the maps that are developed through the use of remotely sensed imagery. This is the primary benefit of remotely sensed imagery. In their study from 1997, Pratt and colleagues proved that conducting a mapping project utilizing RSI in conjunction with accurate field verification results in a considerable reduction in the expenses associated with the acquisition of data as opposed to doing field mapping on its own. The availability of high-quality data for most parts of the globe from a wide range of public and private organizations is another advantage of RSI (Mennecke & Jr, 2021).

2.3.4 Staff Capacity and Implementation of Road Construction Projects

The majority of organizations have a limited number of staff members who are committed to GIS and GIS-related asset management, and most of these personnel are also very engaged in the actual road construction operations. (Lane, 2019.). Given the ongoing contraction of the economic space, there is a limit on the amount of money available for staff training and travel expenses in the contemporary world. As a direct consequence of this, the staff members of the agency have restricted capabilities when it comes to expanding GIS programs and purposefully integrating them with other GIS-related initiatives. For instance, the Michigan Department of Transportation (MDOT), which has more than 50 personnel working in its Asset Department, has trouble locating people who can assist its regions with GIS. Some people have discovered that taking part in web-based collaborative organizations, such as the GIS for Strategic Asset (GSAM), is the best method for them to keep up with the latest developments in the sector (Mallela et al., 2018).

Integration of GIS and TAM programs is a complicated process that requires the assistance of leadership at construction and transportation agencies. Leaders are responsible for advocating for funds, approving initiatives, enforcing policy changes, and using the program's outcomes. Program champions still may have trouble convincing upper management to pay for GIS software and training for their teams even after all of these measures have been taken. This is the case even though all of those other things have been done. The majority of government organizations do not have a concrete method to measure advantages in order to justify the expenditure of creating integrated solutions (Somers R.M., 2019). Still further, the majority of CEOs are not yet acquainted with the technology and are hesitant to install applications that have not yet been tested. Their reluctance may be made worse by the forced personnel cutbacks and dwindling finances that are affecting a number of different states and municipalities. There are a lot of constraints on managers' ability to commit to integrated GIS and TAM projects, such as travel restrictions, budgetary constraints, and so on. Workers at the Ohio Department of Transportation said it's not always easy to win approval from upper management to spend money on technology. However, executives and decision-makers have welcomed the outcomes, which include having technical data displayed on easy-to-read maps (Stepniak & Turek, 2020).

In spite of the fact that attempts are being made to show the potential for GIS usage in social work as a tool for planning, and research, there is still more work that has to be done in order to bring about its full acceptance. Students and professionals need to learn GIS in a way that is more relevant to civil engineering works in addition to land management if they want to increase the likelihood that it will be employed in the field. The incorporation of information and training on GIS at both the undergraduate and graduate levels is the most effective method for achieving this goal. Given the diverse range of applications that may be made for GIS, informative material on the topic could be included in many foundational social work classes. The most obvious option is a course in research methodologies, but students may also take courses in practical areas including community organizing, policy, and social work administration, or a combination of these. The most effective way to include this material is to first design and then teach optional classes that are solely devoted to various uses of GIS.

Students and practitioners of social work would have the greatest chance to gain the necessary skills to make effective use of GIS technology in the field if they had access to a comprehensive course that focused entirely on this topic. A number of training hours equal to or equivalent to those obtained through the implementation of a commercial training program might be obtained via the implementation of such a course. It is possible that partnerships between departments and other academic institutions that already utilize or provide GIS-based curriculum might be a fruitful way to go forward (Muthama et al., 2018). A worker's ability to utilize GIS technology may be increased by highlighting the ways in which it is already being used, which is one approach to do this. It was recently said that the number of publications and talks dedicated to GIS uses has increased over the last several years. Because of this trend, it is essential that technology continue to rise in prominence as a practical option for preparatory, operational, and evaluation endeavors. In light of this new emphasis, maybe school and government officials will work harder to equip their students and workers with GIS expertise (Muthama et al., 2019). Those who do research using GIS tools have a duty to share their results with the wider community. This may be done via presentations and publications on a local, national, or international scale. This is important for academics who use spatial statistics in their work and for those who are creating novel approaches to utilize GIS in practice (Sit & Mu, 2021).

2.4 Research Gap

The study identified various research gaps as tabulated below:

Table 2.1: Research Gap

Author & Year	Topic Researched	Findings	Research Gap Identified	How the Current Study Addresses the Gap
Jayavarapu, 2017	GIS Project Evaluation and Implementation	Comprehensive approach required for GIS success	Lack of focus on systematic evaluation of GIS projects	The current study focuses on the determinants of GIS implementation, including project evaluation and systemic approach.
Sandip, 2019	GIS in Construction Planning	Streamline processes and reduce costs	Limited focus on challenges in low and middle-income economies	The current study investigates challenges specific to KeRRA in a low/middle-income context.
Mennecke, 2021	GIS Data Standards and Integration	Adoption of standards reduces inefficiencies	Limited discussion on challenges with data integration	The study discusses challenges and solutions related to data standards and integration in the context of road projects.
Taiwo & Downe, 2018	Technology Acceptance Model	PE, EE, SI, FC, HB as determinants	Need for deeper understanding of these determinants	The study applies TAM to road construction, exploring these determinants and their impact on GIS adoption.
Venkatesh, 2021	Unified Theory of Acceptance and Use of Technology	Theoretical framework for tech acceptance	Lack of application in road construction context	The current study adapts this framework to road construction, enhancing its practical applicability.
Lane, 2019	Staff Capacity in GIS Adoption	Limited staff capacity hinders GIS use	Limited focus on GIS capacity in road projects	The current study examines staff capacity as a determinant and its role in GIS utilization by KeRRA

2.5 Conceptual Framework

Access to GIS technology, Availability of GIS data, GIS Start-up Cost, and GIS Staff Capacity are some of the elements that influence usage of Geographic Information System. In this research, the GIS in execution of roads projects is the dependent variable, while the factors that influence utilization of Geographic Information System are the independent variables. The influence of the Government Policy on ICT Development in Kenya is a moderating factor in the connection between the independent and dependent variables. Diagrammatic representation of the relationships between the variables is shown in figure 2.1.

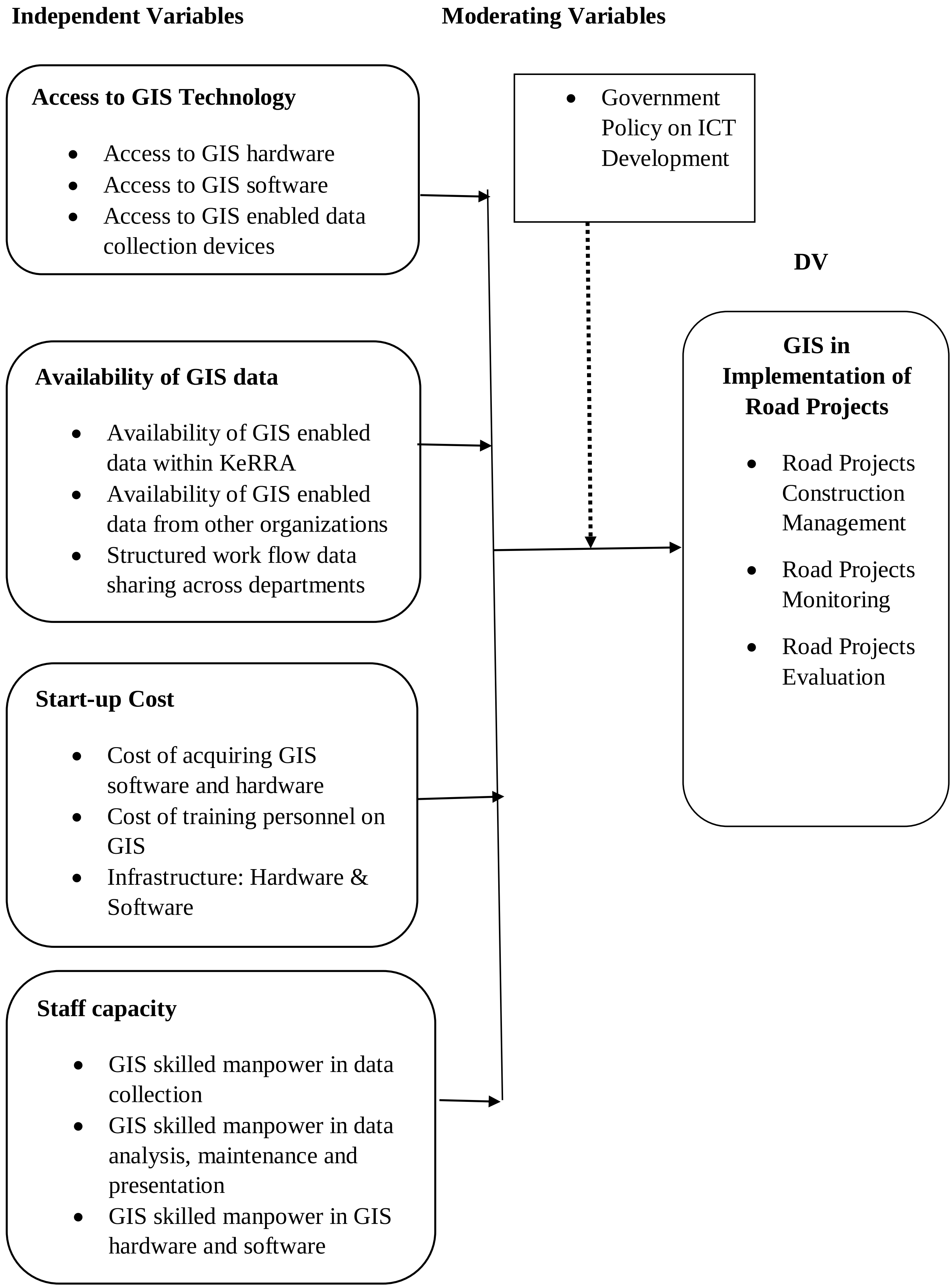

Figure 2:2 Conceptual Framework

2.6 Research Hypothesis

This current research study will test the following hypothesis:

H_{01}: There is no significant relationship between access to GIS technology and its utilization in Kenya Rural Roads Authority's implementation of road projects in Kenya

H_{02}: There is no significant relationship between availability of GIS data and its utilization in Kenya Rural Roads Authority's implementation of road projects in Kenya

H_{03}: There is no significant relationship between staff capacity and its utilization in Kenya Rural Roads Authority's implementation of road projects in Kenya

H_{04}: There is no significant relationship between initial start-up cost of GIS technology and its utilization in Kenya Rural Roads Authority's implementation of road projects in Kenya

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section describes research design, target population, sample size and sampling procedure, research tools, data analysis techniques, validity and reliability, ethical considerations and finally operationalization of the study.

3.2 Research Design

The present study used a descriptive research strategy in order to collect data from the participants. The chosen design was deemed preferable for this investigation due to its ability to accurately depict the phenomena as it exists within the field. This approach allowed the researcher to get deep understanding of the participants' experiences and perspectives.

3.3 Target Population

This study targeted employees and contractors staff working with KeRRA in the country with the unit of analysis being the road construction projects. A total of 304 participants were planned to participate in this analysis:

Table 3.1: Target Population

Category	**Frequency**
Deputy Directors	16
Regional Directors	20
Site Supervision Staff	125
Contractors’ Staff	143
Total	**304**

3.4 Sample Size and Sampling Procedure

According to Schindler (2015), a "frame of sampling" is a set of criteria that will be used to choose sample members.

3.4.1 Sample Size

A sample is a subset of the population being studied that is carefully selected to accurately reflect the characteristics and attributes of the whole population. The sample size table developed by Krejcie and Morgan was used to determine a sample population size of 171, with a confidence level of 95% and a margin of error of 5%. Table 3.2 presents the sample that was acquired.

Table 3.2: The Sampling Matrix

Category	Target population	Sampling Ratio	Sample size
Deputy Directors	16	0.559	9
Regional Directors	20	0.559	12
Site Supervision Staff	125	0.559	70
Contractors' Staff	143	0.559	80
Total	**304**		**171**

3.4.2 Sampling Procedure

The research used a stratified proportional random sampling methodology, which is a type of sampling that aims to reduce bias by dividing a diverse population into more homogeneous subgroups and then choosing participants within each subgroup to guarantee a representative sample. Using stratified random sampling helped us get a good cross-section of the population's many demographic subsets. Subsequently, respondents were picked from each subgroup via the use of random sampling, hence facilitating the selection of participants within each stratum.

3.5 Research Instruments

The major data for this study was gathered via the use of questionnaires filled out by the participants themselves. These questionnaires were designed to include a combination of open-ended and closed-ended questions. Snyder (2019) contends that open-ended or unstructured queries are often more straightforward to assess. Questionnaires were used with the aim of optimizing time and financial resources, while also enhancing the ease of analysis due to their readily applicable format. To facilitate comprehension of the study variables, interviews were undertaken with key informants.

3.6 Pilot Test

The pilot study was used to highlight questionnaire items so as to be clear to respondents and ascertain whether the questionnaires address all the sections. This pilot was carried out in Machakos county due to its proximity to Nairobi and the diversity of the road construction project staff. However, those who took part in the preliminary research were left out of the final analysis.

3.7 Reliability of the Research Instrument

According to Kothari (2004), the assessment of a research instrument's dependability is based on its capacity to provide consistent results over an extended period of time. Reliability may be defined as the extent to which a certain instrument produces consistent results over several trials. By using this approach, the researchers were able to maintain the legitimacy of the collected results while mitigating the potential for any distortions. A survey consisting of six sections and a total of 27 questions was sent to a sample of 142 participants. The acquired Cronbach's Alpha Coefficient of 0.877 provided evidence supporting the reliability of the research instrument used in the study.

3.8 Validity of the Research Instrument

The idea of validity, as defined by Borg and Gall (1989), refers to how well a test measures the construct it sets out to evaluate. Face validity refers to a situation in which a question is subject to misinterpretation or misunderstanding. According to Cooper and Schindler (2006), the potential for face validity may be reduced by conducting pre-tests on instruments to address any ambiguity or lack of clarity in the questions. The term "content validity" is used to describe how well a certain social notion is measured. The research ensured content validity by consulting experts in the relevant area, namely the supervisor. This was accomplished by conducting open-ended interviews using the interview guide provided in Appendix III.

3.9 Data Collection Procedures

The University of Nairobi sent an invitation letter to the researcher. The researchers had clearance from the NACOSTI before beginning data gathering. The researcher used Google Forms to conduct the online questionnaires herself. This choice was made based on the suitability of the instrument for the research, considering the geographical breadth of the respondents and the time constraints of the study. The individuals who had the capacity to reply were selected based on their respective Directorates/Departments, and an online questionnaire was delivered to them for the purpose of implementation. The surveys were then gathered at a predetermined later period via the researcher's email account. The researcher scheduled meetings with the main informants and conducted in-person interviews by personally visiting each of them. Detailed records were made documenting the provided replies.

3.10 Data Analysis

The data underwent cleaning, coding and analysis. With the assistance of SPSS software version 29.0, the raw data were tabulated and analyzed for the purpose of improving clarity. SPSS is a computer-generated program that is used for the purposes of statistical analysis. It can show data statistically and contains built-in equations to facilitate analysis. The qualitative information collected from the interviews was subjected to a content analysis. The relative importance of the main predictors was calculated using a multivariate regression model. The following model guided the regression analysis:

$$Y = \beta_\theta + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where:

Y= Implementation of KERRA road construction projects

β_θ = Constant term

β_1-β_4 are the coefficient function of the independent variables

X_1 = Access to GIS Technology

X_2 = Availability of GIS Data

X_3 = Staff Capacity

X_4= Start-up Cost & ε = Error term

3.11 Ethical Consideration

In preparation of the data collection, KeRRA was formally requested for an opportunity to collect data on its road construction projects. The study objectives were clearly stated to dispel any misconceptions. In order to start collecting the respondents' data, consent forms were drafted and sent to them along with instructions on how to read and sign them. Only participants who have reached the age of majority were considered for the research. The anonymity of the respondents was protected throughout the whole process by preventing the distribution of individual replies in their unprocessed form. Only the data in aggregate form was discussed.

3.12 Operational of Variables

The research variables must be operationalized, and their definitions are shown in table 3.3 below.

Table 3.3: Operational of Variables

Independent Variables	Indicators	Scale of Measurement	Statistical Analysis
Access to GIS Technology factors on implementation of road construction projects	No of respondents reporting existence of relevant ICT hardware. No of respondents reporting capacity of the GIS hardware to meet the project's requirements. No of respondents reporting existence of relevant ICT software. No of respondents reporting capacity of the GIS software to meet the project's requirements. No of respondents reporting availability of GIS compatible and enabled electronic gadgets and devices No of respondents reporting capacity of the gadgets to collect requisite data	Ordinal (5-Point Likert Scale)	Descriptive Statistics
Initial Start-up cost of GIS Technology factors on implementation of road construction projects	No of respondents reporting cost of purchase and installation of GIS technology as an impediment No of respondents reporting cost hiring and retaining skilled GIS personnel as an impediment No of respondents reporting cost of building capacity of ICT staff on GIS technology as an impediment No of respondent reporting cost of establishing reliable internet connectivity	Ordinal (5-Point Likert Scale)	Descriptive Statistics

	to support GIS technology as an impediment No of respondents reporting cost of repair and maintenance of GIS technology as an impediment		
Staff Capacity on implementation of road construction projects	No of respondents reporting familiarity with GIS data collection procedures for implementation of road construction projects. No of respondents reporting competency in data analysis, maintenance, and presentation. No of respondents citing familiarity with GIS technologies in real time verification of road construction quantities No of respondents citing familiarity with management and maintenance of GIS hardware and software. No of respondents reporting access to knowledgeable in troubleshooting for utilizing GIS technology for project needs	Ordinal (5-Point Likert Scale)	Descriptive Statistics
Availability of GIS Data on implementation of road construction of road projects	No of respondents reporting availability of well-established and readily accessible GIS enabled data for project purposes. No of respondents citing whether GIS data within KeRRA is regularly updated and maintained to ensure accuracy and relevance. No of respondents reporting accessibility of GIS enabled data from external organizations. No of respondents reporting availability of efficient workflow for sharing GIS data across different departments within KeRRA	Ordinal (5-Point Likert Scale)	Descriptive Statistics

Utilization of GIS technology on implementation of road construction projects	No of staff reporting real-time update on road construction progress on GIS platform. No of staff reporting possibility of timely decision-making during road construction implementation due to utilization of GIS technology No of staff reporting improved monitoring and evaluation of road construction process due to utilization of GIS technology. No of staff reporting effective and efficient management of road construction process due to utilization of GIS technology.	Ordinal (5-Point Likert Scale)	Descriptive Statistics Regression Analysis

CHAPTER FOUR

DATA PRESENTATION, DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the data analysis, as well as presentations and discussions of the results. This study's findings were designed to correspond with its aims, and each part of this report analyzes the study's outcomes in relation to each purpose. The main sections include; a discussion on questionnaire return rate, description of the respondents' demographic profiles, a discussion on checking for statistical assumptions in the data set and analysis of the data per objective of the study.

4.2 Questionnaire Return Rate

The questionnaire return rate shows the rate at which the subjects actually responded to the questionnaire over the targeted stated subjects for the study. It is important since the response rate gives you adequate data for a study that gives accurate results (Kikwatha,2018). According to Mugenda (2012), a response rate that is similar to fifty percent is considered sufficient for data analysis and reporting, while sixty percent is considered to be satisfactory. However, a response rate that is more than seventy percent is considered to be an exceptional return rate for analyzing findings and drawing conclusions. In the study the target respondents were 171, however, 142 respondents participated translating to a return rate for questionnaires of 83%. According to Jack (2008), the objective is to get a response rate over 60%. Hence, the response rate obtained in this research may be considered sufficient for drawing conclusions.

4.3 Demographic Information and Respondent's Profiles

Overall, demographic information was derived from considerations of gender, age, academic qualification, the duration of service at KeRRA, and the respondents' Directorates/Departments of work. Given the diverse groups and strata involved in this study, a comprehensive analysis of their demographic profiles was deemed essential. To achieve this, frequencies of each group within every category, along with their corresponding percentages relative to the sample size, were utilized for the analytical process.

4.3.1 Distribution of the Respondents by Gender

The gender variable was measured based on two levels that is male and female for all the groups sampled in this study. Overall distribution by gender was checked and the individual analysis of the gender distribution by gender was done as tabulated below.

Table 4.1: Distribution by Gender

Gender	Frequency	Percentage
Male	116	81.7
Female	26	18.3
Total	**142**	**100**

Based on the data shown in table 4.1, 116 (81.7%) of the total respondents were male, while only 26 (18.3%) of the respondents were female. This demonstrates that people of both sexes participated in the initiative, with male participation having the largest number.

4.3.2 Distribution of the Respondents by Level of education

The purpose of the research was to determine the average years of schooling held by those who participated in the survey. Table 4.3 provides a presentation of the answers received.

Table 4.2: Distribution by Level of Education

Level of education	Frequency	Percentage
Diploma	27	19.0
Higher Diploma	3	2.1
Bachelor's Degree	96	67.6
Post Graduate Degree	16	11.3
Total	**142**	**100**

According to table 4.2, the majority of the participants had completed their education to the level of a bachelor's degree, which accounts for 67.6% of the total; 19.0% of the participants had a diploma; 2.1% of the participants had a higher diploma; and 11.3% of the participants had postgraduate academic qualification. This demonstrates that the majority of participants have some level of education, and as a result, they are able to interpret the questions in the questionnaire and express their sincere opinion.

4.3.3 Distribution of the Respondents by Age

The purpose of this study was to identify the demographic distribution of participants depending on their age. Results are shown in Table 4.2 which follows.

Table 4.3: Distribution of the Respondents by Age

Age	Frequency	Percentage
20 – 25	8	5.6
26 – 30	26	18.3
31 – 35	39	27.5
36 – 40	25	17.6
41 and above	44	31.0
Total	**142**	**100**

From table 4.3, most of the respondents were aged above 41 years with 44(31.0%), between 20 – 25 years were 8 (5.6%), between 26 – 30 years were 26 (18.3%), between 31-35 years with 39 (27.5%) while 25 (17.6%) were between 36 and 40 years.

Collectively, the participants included in this research ranged in age from 20 to 57 years, suggesting that they had the necessary level of maturity to provide the requested information.

4.3.4 Distribution of the Respondents by Period Worked in KeRRA

This study set out to analyze the demographics of the Kenya Rural Roads Authority (KeRRA) staff in terms of their tenure with the organization. The findings were as shown in Table 4.4.

Table 4.4: Distribution by Period Worked in KeRRA

Period Worked	**Frequency**	**Percentage**
1 year and below	12	8.5
2-5 years	49	34.5
5 year and above	81	57.0
Total	**142**	**100**

According to the data shown in the table, a majority of the participants said that they had been employed at KeRRA for a period exceeding five years. Specifically, 81 respondents fell into this particular group. Those that had worked for less than 1 year were 12 (8.5%) while those that had worked for between 2 and 5 years were 49 (34.5%).

This was an indication that most respondents had worked in KeRRA for long enough to understand the dynamics of construction project implementation process in KeRRA thus were capable to provide reliable information for the study

4.3.5 Distribution of the Respondents by Directorates/Departments

The study's primary aim was to categorize respondents according to the divisions where they hold positions. Table 4.5 displays the results.

Table 4.5: Distribution by Directorates/Departments

Directorates/Departments	Frequency	Percentage
P,D & E	32	22.5
Development	34	23.9
RAM	16	11.3
R, S & C	0	0
CS	4	2.8
Audit Services	7	4.9
Supply Chain	4	2.8
Legal Services	0	0
Construction Projects	45	31.7
Total	**142**	**100**

According to Table 4.5, the majority of respondents (31.7%), 45 in total, were employed as contractor staff in construction projects. The rest was distributed among other directorates/departments with 32 (22.5%) under P,D&E, 34 (23.9%) under Development, 16 (11.3%) under RAM, 4 (2.8%) under CS, 7 (4.9%) under Audit Services and 4 (2.8%) under Supply Chain Management.

This finding suggests that a majority of the participants were affiliated with the Directorates responsible for overseeing the execution of road construction projects, including the P,D&E, Development, RAM, and the Contractors. This finding suggests that a majority of the participants in the research were actively engaged in the execution of road building projects within KeRRA, hence possessing the ability to provide reliable data for the study.

4.4 Utilization of GIS and Implementation of KeRRA Road Construction Projects

Access to GIS technology, availability of GIS data, initial start-up cost of GIS, and staff capability were all taken into consideration as sub-variables of the independent variable, which was the use of GIS.

4.4.1 Access to GIS Technology

The initial purpose was to learn how much of an impact easy access to GIS technology had on the successful completion of Kenya's road building projects funded by the KeRRA. Indicators of the independent variables were analyzed individually, and the findings are shown in table 4.6.

Table 4.6: Access to GIS Technology and Implementation of Road Projects

Items	SD F (%)	D F (%)	N F (%)	A F (%)	SA F (%)	Total	Mean	Std. Dev
6a. There is sufficient availability of GIS hardware for project implementation	7 (4.9)	44 (31.0)	28 (19.7)	55 (38.7)	8 (5.6)	142	3.09	1.058
6b. The provided GIS hardware meets the project's technological requirements	19 (13.4)	39 (27.5)	22 (15.5)	54 (38.0)	8 (5.6)	142	2.95	1.193
6c. There is adequate access to a variety of GIS software options for project planning and implementation	19 (13.4)	63 (44.4)	18 (12.7)	34 (23.9)	8 (5.6)	142	2.64	1.151
6d. The available GIS software meets the specific needs and objectives of the projects	11 (7.7)	27 (19.0)	23 (16.2)	69 (48.6)	12 (8.5)	142	3.31	1.112
6e. There is reliable access to GIS-enabled data collection devices for acquiring accurate project data	7 (4.9)	19 (13.4)	30 (21.1)	62 (43.7)	24 (16.9)	142	3.54	1.076
6f. The provided GIS-enabled data collection	11	11	22	74	24	142	3.63	1.096

devices are suitable for various project data collection tasks	(7.7)	(7.7)	(15.5)	(52.1)	(16.9)			
Composite Average = 3.19 **Composite S.D = 0.767** **Composite Standard error = 0.064** **Cronbach Alpha Coefficient = 0.777**								

On the item 6A which sought to establish whether there was sufficient availability of GIS hardware for project implementation. Results indicate that 63(44.3%) of the respondents agreed with this item, meaning that there is GIS hardware. The average score (M) for this item was 3.09 and the S.D was 1.058. This indicates that most respondents felt that having access to adequate GIS hardware had an impact on the timeliness with which road projects are completed. The purpose of 6B was to determine whether the available GIS equipment was enough for the needs of the project. Results indicate that 62(43.7%) of the respondents agreed with this item, meaning that most GIS hardware met the project's technological requirements. The average score (M) for this item was 2.95 and the S.D was 1.193.

The next item ,6C, looked at whether there was adequate access to a variety of GIS software options for project planning and monitoring. Results illustrate that 82(57.7%) of the respondents disagreed with this item. A minority 42(29.6%) agreed with the statement. The average score for this item was 2.64 and an S.D of 1.151. This result implies that majority of the respondents disagreed with the statement that adequate access to a variety of GIS software options for project planning and implementation in KeRRA. Item 6D sought to establish whether the available GIS software met the specific needs and objectives of the projects. The results indicate that majority 81(57.0%) of the respondents agreed with this item, meaning that the available GIS software met the specific needs and objectives of the projects. The average score (M) for this item was 3.31 with an S.D of 1.112.

The item 6E on the other hand sought to establish whether there was reliable access to GIS-enabled data collection devices for acquiring accurate project data. The results show that majority 86(60.6%) of the respondents agreed with this item, meaning that was reliable access to GIS-enabled data collection devices for acquiring accurate project data. The average score (M) for this item was 3.54 with an S.D of 1.076. The last Item,6F, sought to establish the extent to which provided GIS-enabled data collection devices are suitable for various project data collection tasks. Results indicate that majority 98(69.0%) of the respondents agreed with the item while 22(15.4%) disagreed to this item. This means that the provided GIS-enabled data collection devices are suitable for various project data collection tasks which can help the management to make an informed decision. The average score for this item was 3.63 with an S.D of 1.096.

In summary, the overall composite average for the extent to which the Access to GIS technology influence implementation of road construction project was 3.19 and the overall composite S.D (STD) was 0.767. The results imply that majority of the respondents were not certain whether Access to GIS technology influence implementation of road construction project. However, analysis of the individual indicators illustrates that there is adequate hardware and GIS enabled data collection device although corresponding software to run this hardware is not adequately provided for hence hampering utilization of GIS in implementation of road projects.

4.4.2 Availability of GIS Data

This subsection aimed to determine the impact of GIS data availability on the construction of KeRRA highways. The following is a presentation of the findings:

Table 4.7: Availability of GIS Data and Implementation of Road Projects

Items	SD F (%)	D F (%)	N F (%)	A F (%)	SA F (%)	Total	Mean	Std. Dev
7a. KeRRA has well established and readily accessible GIS enabled data for project purposes	8 (5.6)	55 (38.7)	34 (23.9)	34 (23.9)	11 (7.7)	142	3.11	1.077
7b. GIS data within KeRRA is regularly updated and maintained to ensure accuracy and relevance	8 (5.6)	42 (29.6)	24 (16.9)	56 (39.4)	12 (8.5)	142	2.85	1.113
7c. External organizations readily share GIS enabled data with KeRRA for collaborative projects	24 (16.9)	37 (26.1)	44 (31.0)	33 (23.2)	4 (2.8)	142	3.31	1.113
7d. The availability of GIS data from other organizations contributes significantly to KeRRA's project planning and execution	8 (5.6)	20 (14.1)	45 (31.7)	61 (43.0)	8 (5.6)	142	2.71	0.972
7e. The is an efficient workflow for sharing GIS data across different departments within KeRRA	54 (38.0)	30 (21.1)	39 (27.5)	19 (13.4)	0 (0.0)	142	2.16	1.083
7f. The sharing of GIS data among departments is streamlined, reducing data silos and promoting collaboration	50 (35.2)	34 (23.9)	39 (27.5)	19 (13.4)	0 (0.0)	142	2.19	1.065
Composite Average = 2.72 **Composite S.D = 0.570** **Composite Standard Error = 0.048** **Cronbach Alpha Coefficient = 0.497**								

Item 7A sought to establish if KeRRA has well-established and readily accessible GIS enabled data for project purposes. Results indicate that 63(44.4%) of the respondents disagreed while 45(31.7%) agreed with this, meaning that KeRRA has no well-established and readily accessible GIS enabled data for project purposes to a larger extent. The average score (M) for this item was

3.11 and the S.D was 1. 077.Item 7B sought to establish whether GIS data within KeRRA is regularly updated and maintained to ensure accuracy and relevancy. Results show that 68(47.9%) of the respondents agreed with this item while 50(35.2%) disagreed with the statement. This attest to the fact that there is GIS data within KeRRA which is regularly updated and maintained to ensure accuracy and relevancy. The average score for this item was 2.85 and an S.D of 1. 113.Item 7C sought to establish whether external organizations readily share GIS enabled data with KeRRA for collaborative projects. Results indicate that most at 61(43.0%) of the respondents agreed with this statement while 37(26.1%) disagreed with the statement. The average score for this item was 3.31 with an S.D was 1.113.

Item 7D sought to establish the extent to which the availability of GIS data from other organizations contributes significantly to KeRRA's project planning and execution. The result indicates that most 69(48.6%) of the respondents agreed with this item, meaning the availability of GIS data from other organizations contributes significantly to KeRRA's project planning and execution. The average (M) for this item was 2.71 with an S.D of 0.972**.** Item 7E sought to establish whether there is an efficient workflow for sharing GIS data across different departments within KeRRA. Results indicate that majority 84(59.2%) of the respondents agreed with the item while 23(13.4%) disagreed to this item. The average score for this item was 2.16 with an S.D of 1.083. This result implies that majority of the respondents confirmed that there is no efficient workflow for sharing GIS data across different departments within KeRRA. Item 7F sought to establish whether the sharing of GIS data among departments was streamlined, reducing data silos and promoting collaboration. Results indicate that majority 84(59.2%) of the respondents agreed with the item while 23(13.4%) disagreed to this item. The average score for this item was 2.19 with an S.D of 1.065. This result implies that majority of the respondents confirmed that GIS data among departments was not streamlined to reducing data silos.

In summary, the overall composite average for the extent to which the Availability of GIS Data influence implementation of road construction project was 2.72 and the overall composite S.D (STD) was 0. 570.The results imply that majority of the respondents were not certain whether Availability of GIS Data influence implementation of road construction project. However, analysis of the individual indicators illustrates that whereas there is available GIS data from not only within KeRRA but also other external organizations like other government bodies, efficient workflow for sharing this GIS data across different departments within KeRRA is lacking thus utilization of GIS in implementation of road projects is not achieved effectively since data forms a very integral part of GIS management.

4.4.3 Staff Capacity

Staff Capacity is very vital in any public entity. This study sought to establish the influence of Staff Capacity on the implementation KeRRA road construction project. The results are presented as shown

Table 4.8: Staff Capacity and Implementation of Road Projects

Items	SD F (%)	D F (%)	N F (%)	A F (%)	SA F (%)	Total	Mean	Std. Dev
8a. KeRRA has a proficient team of GIS skilled personnel for effective data collection	7 (4.9)	15 (10.6)	38 (26.8)	47 (33.1)	35 (24.6)	142	3.62	1.116
8b. The GIS manpower is well trained and capable of efficient collecting relevant project data using GIS	4 (2.8)	19 (13.4)	26 (18.3)	73 (51.4)	20 (14.1)	142	3.61	0.982
8c. KeRRA has competent GIS personnel proficient in data analysis, maintenance, and presentation	0 (0.0)	18 (12.7)	26 (18.3)	66 (46.5)	32 (22.5)	142	3.79	0.937
8d. The GIS skilled workforce can effectively analyze, manage, and present GIS data to support decision making	0 (0.0)	15 (10.6)	30 (21.1)	57 (40.1)	40 (28.2)	142	3.86	0.950
8e. There are skilled experts in KeRRA who managed and maintain GIS hardware and software	0 (0.0)	14 (9.9)	18 (12.7)	86 (60.6)	24 (16.9)	142	3.85	0.819
8f. The GIS personnel are knowledgeable in troubleshooting and utilizing GIS technology for project needs	0 (0.0)	19 (13.4)	33 (23.2)	70 (49.3)	20 (14.1)	142	3.64	0.886
Composite Average = 3.73 **Composite S.D = 0.764** **Composite Standard Error = 0.064** **Cronbach Alpha Coefficient = 0.892**								

Item 8A sought to establish the extent to which KeRRA has a proficient team of GIS skilled personnel for effective data collection. Results indicate that 82(57.7%) of the respondents agreed with this item, meaning that the respondents are satisfied that KeRRA has skilled GIS personnel. The average score (M) for this item was 3.62 and the S.D was 1.116. Item 8B sought to establish the extent to which GIS manpower is well-trained and capable of efficiently collecting relevant project data using GIS technology. Results show that 93 (65.4%) of the respondents agreed with this item meaning that the respondents are convinced that the GIS manpower in KeRRA are well trained and capable of efficient collecting relevant project data using GIS. The average score for this item was 3.61 and an S.D of 0.982. Item 8C sought to establish the extent to which KeRRA has competent GIS personnel proficient in data analysis, maintenance, and presentation. Results show that 98 (69.0%) of the respondents agreed with this item meaning that the respondents are of the opinion that that KeRRA has competent GIS personnel proficient in data analysis, maintenance, and presentation. The average score for this item was 3.79 and an S.D of 0.937.

Item 8D sought to establish the extent to which GIS skilled workforce can effectively analyze, manage, and present GIS data to support decision-making. Results indicate that majority 97(68.3%) of the respondents agreed that the GIS skilled workforce can effectively analyze, manage, and present GIS data to support decision-making. Only a minority 15 (10.6%) of the respondents disagreed that GIS skilled workforce can effectively analyze, manage, and present GIS data to support decision-making. The average score for this item was 3.86 with an S.D was 0.950. Item 8E sought to establish whether there are skilled experts in KeRRA who could manage and maintain GIS hardware and software. The result indicates that majority 110(77.5%) of the respondents agreed with this item meaning that there are there are skilled experts in KeRRA who can manage and maintain GIS hardware and software. The mean, (M) for this item was 3.85 with an S.D of 0.819. Item 8F sought to establish the extent to which the GIS personnel are knowledgeable in troubleshooting and utilizing GIS technology for project needs. The result indicates that majority 90(63.4%) of the respondents agreed with this item, meaning that the GIS personnel are knowledgeable in troubleshooting and utilizing GIS technology for project needs. The mean, (M) for this item was 3.64 with an S.D of 0.886.

In summary, the overall composite average for the extent to which the Staff Capacity influence implementation of road construction project was 3.73 and the overall composite S.D (STD) was 0. 764.The results imply that majority of the respondents agreed that staff capacity influence implementation of road construction project. This is supported by analysis of the individual indicators which confirm that KeRRA has a proficient team of GIS skilled personnel for effective data collection, analysis and presentation. Additionally, they are skilled experts in KeRRA to manage and maintain GIS hardware and software. Adequately resourced GIS personnel therefore improves utilization of GIS in implementation of road projects.

4.4.4 Start-up Cost

Every project needs to undertake Start-up Cost since it has great influence on implementation KeRRA road projects. The results are presented as shown:

Table 4.9: Start-up Cost and Implementation of Road Projects

Items	SD F (%)	D F (%)	N F (%)	A F (%)	SA F (%)	Total	Mean	Std. Dev
9a. High cost of purchasing and installing all the components of GIS system influences its utilization in road projects implementation at KeRRA	7 (4.9)	8 (5.6)	7 (4.9)	46 (32.4)	74 (52.1)	142	4.21	1.097
9b. The high expense of bringing on board trained GIS professionals slows its adoption in KeRRA's execution of road projects.	3 (2.1)	8 (5.6)	3 (2.1)	66 (46.5)	62 (43.7)	142	4.24	0.906
9c. KeRRA's use of Geographic Information System (GIS) technology in the construction of road projects is hampered by the high initial cost of regularly educating people in GIS technology.	3 (2.1)	20 (14.1)	3 (2.1)	70 (49.3)	46 (32.4)	142	3.96	1.051
9d. The high expense of establishing stable internet access for GIS has an impact on its use in the construction of road projects at KeRRA.	7 (4.9)	16 (11.3)	7 (4.9)	69 (48.6)	43 (30.3)	142	3.88	1.114
9e. High costs related to fixing of malfunctioning GIS technology components influence its utilization in road projects planning at KeRRA	3 (2.1)	12 (8.5)	19 (13.4)	54 (38.0)	54 (38.0)	142	4.01	1.024
Composite Average = 4.06 **Composite S.D = 0. 893** **Composite Standard Error = 0.075** **Cronbach Alpha Coefficient = 0.913**								

The results indicate that composite average was 4.06 with a standard error of 0. 893.Results from the table show that majority of the respondents 120(84.5%) indicated that the statements that high cost of purchasing and installing all the components of GIS system influences its utilization in road projects implementation at KeRRA were true with an S.D of 1.097. The same is reflected with a majority respondent,128(90.1%), average of 4.24 and an S.D of 0.906 for the statement that the high initial cost of hiring, training and retaining GIS skilled staff influences its utilization in road projects implementation at KeRRA. The findings of the study indicate that a significant proportion of the participants, namely 116 individuals (81.7%), agreed with the statement that the high initial cost associated with constantly educating workers in Geographic Information System (GIS) technology has an impact on its use in the construction of road projects at the Kenya Rural Roads Authority (KeRRA). Furthermore, the average score obtained for this statement was 3.96, with a standard deviation of 1.051. Out of the total number of respondents, 112 individuals, accounting for 78.9% of the sample, expressed that the high cost associated with establishing a dependable internet connection for GIS significantly impacts its use in road project execution at the KeRRA. The average score obtained from the respondents about this issue was 3.88, with and a S.D of 1.114. The findings also reveal that a significant majority of the respondents, namely 108 individuals (76.1%), expressed agreement with the assertion that the elevated expenses associated with repairing malfunctioning GIS technology components have a notable impact on its usage in road project planning at KeRRA. This consensus was reflected in an average score of 4.01, with a SD of 1.024.

In summary, the overall composite average for the extent to which the Start-up Cost influence implementation of road construction project was 4.06 and the overall composite S.D was 0. 893.The results suggest that majority of the respondents agreed that start-up cost influence implementation of road construction project. This is supported by analysis of the individual indicators which confirm that in order to have a fully operational GIS system, financial resources are required to purchase and install components of the system, have skilled personnel and to acquire support services like internet connectivity among others. Start-up cost therefore plays an important role in ensuring effective utilization of GIS in implementation of road projects

4.4.5 Utilization of GIS and Implementation of Road Projects

This section sought to establish the influence of Utilization of GIS on Implementation of KeRRA roads. The results were presented as follows:

Table 4.10: Utilization of GIS and Implementation of Road Projects

Items	SD F (%)	D F (%)	N F (%)	A F (%)	SA F (%)	Total	Mean	Std. Dev
10a. Utilization of GIS technology in road construction projects leads to real-time update on road construction progress	11 (7.7)	11 (7.7)	22 (15.5)	74 (52.1)	24 (16.9)	142	3.63	1.097
10b. Utilization of GIS technology in road construction projects leads to timely decision-making during road construction	7 (4.9)	8 (5.6)	7 (4.9)	46 (32.4)	74 (52.1)	142	4.21	1.096
10c. Utilization of GIS technology in road construction projects ensures efficient monitoring and evaluation of road construction process	3 (2.1)	20 (14.1)	3 (2.1)	70 (49.3)	46 (32.4)	142	3.86	0.950
10d. Utilization of GIS technology in road	3	8	3	66	62	142	4.24	0.906

construction projects ensures effective and efficient management of road construction process	(2.1)	(5.6)	(2.1)	(46.5)	(43.7)			
Composite Average = 3.98 **Composite S.D = 0.749** **Composite Standard Error = 0.063** **Cronbach Alpha Coefficient = 0.731**								

The results indicate that composite average was 3.96 with a composite deviation of 0. 749.Results from the table 4.10 show that majority of the respondents 98(69.0%) agree to the fact that utilization of GIS technology in road construction projects leads to real-time update on road construction progress with an average score of 3.63 and S.D of 1.097.Additionally, majority of the respondents at 120(84.5%) with an average score of 4.21 and an S.D of 1.096 for the statement that utilization of GIS technology in road construction projects leads to timely decision making during road construction. Majority of respondents,116(81.7%) with an average score of 3.86 and an S.D of 0.950 was realized for the statement that utilization of GIS technology in road construction projects ensures efficient monitoring and evaluation of road construction process at KeRRA. 128(90.1%) of the respondents said that utilization of GIS technology in road construction projects ensures effective and efficient management of road construction process at KeRRA with an average score of 4.24 and an S.D of 0.906.

4.5 Regression Analysis

Regression analysis was done to test the hypothesis in the study so as to establish relationship between Utilization of GIS technology and implementation of KeRRA road projects in Kenya. To test these hypotheses this, research conducted a linear regression $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon$. The results were as presented below:

Table 4.11: Regression Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2 Change	F Change	df1	df2	Sig. F Change
1	.913[a]	.834	.829	.310	.834	171.664	4	137	<.001

a. Predictors: (Constant), Start-up Cost, Availability of GIS Data, Access to GIS Technology, Staff Capacity

According to the data provided in the table, a positive and statistically significant correlation of 0.913 was obtained. The R-squared value was also calculated, and it came out to be 0.829. According to the numbers, a whopping 83% of the variation in the way road construction projects are carried out within KeRRA may be attributed to the degree to which GIS technology is used.

Table 4.12: Analysis of Variance (ANOVA)

Model	Sum of Squares	Df	Average Square	F	Sign.
Regression	65.882	4	16.471	171.664	<.001[b]
Residual	13.145	137	.096		
Total	**79.027**	**141**			

a. Dependent Variable: Implementation of Road Projects
b. Predictors: (Constant), Start-up Cost, Availability of GIS Data, Access to GIS Technology, Staff Capacity

From the table, the regression sum of squares was 65.882, the residual sum of squares was 13.145 and the total sum of squares was 79.027. The p value was less than 0.01 which is less than 0.05 level of significance. Therefore, we reject the null hypothesis and conclude that there is significant influence between all combined utilization of GIS technology and implementation of KeRRA road construction projects in Kenya at 95% level of significance.

Table 4.13: Regression Model Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig
	B	Std. Error	Beta		
Constant	-.317	.203		-1.560	.121
Access to GIS Technology	.359	.035	.368	10.298	<.001
Availability of GIS Data	.121	.046	.092	2.624	.010
Staff Capacity	.171	.043	.174	3.962	<.001
Start-up Cost	.539	.037	.642	14.660	<.001

a. Dependent Variable: Implementation of Road Projects

From the table 4.13 the model was significant and therefore,

$Y = 0.368X_1 + 0.092X_2 + 0.174X_3 + 0.642X_4 - 0.317$ is the prediction model.

This therefore, this means that if there is an increase in Access to GIS Technology, the implementation of road projects will increase by 36.8%, if Availability of GIS Data is well managed, road project implementation will increase by 9.2%, if the management puts more effort in Staff Capacity, the project implementation rate will increase by 17.4% and if the management focuses more on Start-up Cost, then implementation of road projects will increase by 64.2%. Overall, Start-up Cost had the highest score of 64.2% with Availability of GIS Data having the least score.

The results therefore illustrate that for KeRRA to improve on utilization of GIS in implementation of road projects then efforts should prioritize channeling adequate financial resources in purchasing and installing all the components of GIS system, hire & train skilled GIS staff and fix any malfunctioning GIS technology components so as to reap the full benefits of this technology on road construction projects. Also, effort should be made to increase access to GIS hardware and software not to mention ensuring availability of adequate data for effective utilization of GIS.

CHAPTER FIVE
SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a synopsis of the findings and the insights and recommendations that may be made from them. The outcomes of this research are summarized in a discussion of the findings for each of the four goals. Following a discussion of the findings, inferences are reached, and a deduction is made on the addition that this research adds to the current body of knowledge. The suggestions are then detailed in the next section. In addition to that, recommendations for more study are included.

5.2 Summary of Findings

The return rate of the questionnaire in this research was 83%, which was above the typical proportion; consequently, the results in this study give a strong basis for drawing inferences and making assumptions about the population based on these findings. The poll found that men made up the vast majority of respondents (81.7%), with women making up a far smaller percentage (18.3%). The majority of those who participated in the survey were educated to the level of a bachelor's degree or above. The parts that follow include a discussion of a summary of the results obtained from each of the objectives.

5.2.1 Access to GIS Technology and Implementation of KeRRA Road Construction Projects

The first thing that needed to be determined was how much of an impact the accessibility of GIS technology had on the actual process of putting KeRRA road development projects into action in Kenya. According to the findings of the research, there was a high level of internal consistency in the replies on the Likert scale for each of the questions. 3.19 and 0.767, respectively, were the values for the composite average and standard deviation. Due to the fact that the average estimate had a standard error of 0.064, which was a low figure, this demonstrated that the average estimate was an accurate representation of the average of the population. The average demonstrates that, on average, the vast majority of respondents said that the availability of GIS technology was considered in road implementation to a very little level.

The purpose of this study was to determine whether or not easy access to GIS technology influences the rate at which road building projects in Kenya are completed. The usage of GIS technology was shown to have a statistically significant positive link with the timely and efficient completion of road building projects. The results showed that implementing road improvement projects while using GIS increased their likelihood of success by a substantial margin. The hypothesis that the availability of GIS technology has no big influence on the implementation of KeRRA road construction projects was rejected since a significant prediction model was found using linear regression analysis.

5.2.2 Availability of GIS Data and Implementation of KeRRA Road Construction Projects

The second goal of this study is to assess the impact of GIS Data Availability on the execution of road development projects conducted by the Kenya Rural Roads Authority (KeRRA) in Kenya. In order to achieve this particular target, a total of six things were taken into consideration. The research revealed that there was an average score level of internal consistency seen in the Likert scale answers across all questions. The average and S.D of the composite variable were calculated to be 2.72 and 0.570, respectively. The standard error of the average estimate was calculated to be 0.048, indicating a modest magnitude. This suggests that the average estimate well represents the population mean. The data indicates that, on average, the majority of respondents said that the consideration of GIS Data Availability in the construction of KERRA road projects was low.

The research team behind this study set out to test the hypothesis that they wouldn't find any connection between the accessibility of GIS data and the efficiency with which the Kenya Rural Roads Authority (KeRRA) carried out their road construction projects. GIS data availability was shown to have a statistically significant positive effect on the efficiency with which the Kenya Rural Roads Authority (KeRRA) carried out road improvement projects. The findings demonstrated a statistically significant correlation between the accessibility of GIS data and the successful execution of road development projects by the Kenya Rural Roads Authority (KeRRA). The linear regression analysis yielded a significant prediction model, leading to the rejection of the null hypothesis that posited no meaningful association between the Availability of GIS Data and the execution of KeRRA road building projects in Kenya.

5.2.3 Staff Capacity and Implementation of Road Construction Project in Nairobi County

The study's ultimate goal is to evaluate how Staff Capacity affects the delivery of road construction projects in Kenya. The research revealed a high level of internal consistency in the Likert scale answers across all questions. The average and S.D of the composite variable were calculated to be 3.73 and 0.764, respectively. The standard error for the average estimate was determined to be 0.064, indicating a very modest value. This suggests that the average estimate well represents the population mean. The data indicates that, on average, the majority of respondents said that Staff Capacity was taken into account throughout the execution of KeRRA road building projects.

The purpose of this research was to analyze how Staff Capacity affected how quickly road construction projects in Kenya were finished for the KeRRA. Staffing levels were shown to have a statistically significant relationship ($r=0.274$) with the timely completion of KeRRA road constructing projects. The research concluded that the efficiency of KeRRA road construction projects was significantly correlated with the agency's ability to attract and retain talented workers. Due to our findings, we cannot accept the null hypothesis that there is no correlation between Staff Capacity and the successful completion of KeRRA road construction projects in Kenya

5.2.4 Start-up Cost and Implementation of KeRRA Road Construction Projects

The fourth goal of this research is to assess the influence that initial investment and program rollout have on the success of KeRRA road construction initiatives in Kenya. The study found that the respondents' responses on the Likert scale were highly consistent with one another. The average and S.D of the composite variable were calculated to be 4.06 and 0.893, respectively. The standard error of the average estimate was determined to be 0.075, indicating a modest magnitude. This suggests that the average estimate accurately represents the population mean. The data indicates that, on average, a majority of respondents said that the consideration of start-up costs was significant in the execution of KeRRA road building projects.

The purpose of this research was to test the hypothesis that initial project funding and successful completion of road construction projects in Kenya are not correlated. The research conducted revealed a noteworthy association between the initial investment required for commencing a project and the successful execution of road building projects by KeRRA. The correlation coefficient for this relationship was determined to be 0.642. The findings of the study demonstrated a statistically significant correlation between the initial investment required (start-up cost) and the successful execution of road building projects undertaken by the Kenya Rural Roads Authority (KeRRA). The linear regression-based prediction model demonstrated statistical significance. The cost of starting a business is a crucial factor that connects the idea with its execution. As a result, the null hypothesis was rejected.

5.3 Conclusions

The execution of KeRRA road building projects is significantly influenced by the use of GIS technology. Hence, it is essential for the government to guarantee the comprehensive integration of GIS technology in the execution of these projects. The study's overarching goal was to see how GIS has affected how the KeRRA carries out road construction projects. The results drawn in this research are based on the empirical data that was produced;

Access to GIS Technology has significant influence in implementation of KeRRA road construction projects in Kenya

Availability of GIS Data has a positive influence on the implementation of KeRRA road construction projects in Kenya.

Staff Capacity has significant influence on the implementation of KeRRA road construction projects in Kenya.

Start-up Cost of GIS has positive relation in implementation of KeRRA road construction projects in Kenya. This variable had the highest score indicating that it has a higher weight and influence on the implementation of these projects.

5.4 Recommendations

The findings of this study reveal a gap in the use of GIS technology to the implementation of road construction projects by the Kenya Rural Roads Authority (KeRRA). This inadequacy may potentially account for the frequent failure to meet the designated timelines for completion of road projects. The efficacy of workers' efforts is contingent upon the presence of robust policies to support them. Consequently, this research proposes the development of suitable policies that facilitate the provision of Geographic Information Systems (GIS), ensuring accessibility to GIS technology, enhancing personnel proficiency, and addressing initial financial requirements.

In addition to the aforementioned policies, it is imperative to establish requisite legislation that will effectively enforce the implementation of said policies in accordance with Sustainable Development Goal (SDG) number 9. This goal aims to promote sustainable development, particularly in developing nations, by facilitating enhanced financial, technological, and technical support. Geographical Information Systems (GIS) effectively fulfills this role. This is in line with the KeRRA's strategic plan 2017 – 2022, EAC's 2050 Regional Agenda on unified connectivity through roads and Africa Union's Agenda 2063 on aiding the delivery of world class infrastructure traverses Africa.

The present research used a descriptive survey methodology in order to provide evidence for a mixed method approach. The chosen approach was deemed suitable for this research due to its capacity to facilitate descriptive analysis, correlation and regression analysis, and the subsequent derivation of findings from these analyses. Consequently, in light of these findings, it is advisable that next investigations of a similar kind consider using the same research technique.

5.5 Suggestions For Further Studies

The scope of this research was restricted to the accessibility of GIS technology, the availability of GIS data, the staff capacity, and the start-up cost of KeRRA road building projects in Kenya. It is essential, for this reason, to analyze the same factors in other roads organizations such as KeNHA , KURA, and the 47 devolved County Governments. This will allow for a more straightforward comparison of the current study's findings to those of potential future studies.

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APPENDICES

APPENDIX I: LETTER OF TRANSMITTAL

Fredrick Otieno Okong'o
P.O Box 6538 - 40103,
Kisumu, Kenya.
Date……………….

Dear Respondent,

RE: UTILIZATION OF GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY ON IMPLEMENTATION OF KENYA RURAL ROADS AUTHORITY'S ROAD CONSTRUCTION PROJECTS IN KENYA

I am now enrolled at the University of Nairobi, where I am working towards earning a Master of Arts degree in Project Planning and. As a component of the aforesaid master's degree, I am in the process of completing the research paper entitled *"Utilization of Geographic Information System Technology on Implementation of Kenya Rural Roads Authority's Road Construction Projects in Kenya."* This paper is a part of the prerequisite that must be completed to get the master's degree.

This respectful letter is to notify you that you are one of the people who have been selected to provide information that will help the researchers achieve their goal. If you have a moment, I'd really value your feedback on the questions included in the included survey. Your information will be kept in the utmost confidentiality and will be put to use only for scholarly investigation if it is accepted.

Kindly refrain from providing any form of writing your name on the questionnaire. I would want to make a formal request that you answer the questions in a completely forthright way.

Yours Sincerely,
Fredrick Otieno Okong'o
Student, Faculty of Business and Management Sciences
University of Nairobi

APPENDIX II : QUESTIONNAIRE

This questionnaire is aimed at gathering research information on the topic entitled *"Utilization of Geographic Information System (GIS) Technology in Implementation of Road Projects: A case of Kenya Rural Roads Authority*" It is divided into various sections. Please reply by either checking the box (X) next to each question or writing in your answers where applicable. Your candid and prompt answer is truly valued, and it will be greatly appreciated.

SECTION A: Demographic Characteristics

1. Please specify your gender.
   a. Female [ ]
   b. Male [ ]
2. Please specify the highest level of schooling you have achieved.
   a. Diploma [ ]
   b. Higher Diploma [ ]
   c. Bachelor's Degree [ ]
   d. Post Graduate Degree [ ]
3. Kindly provide clarification on the age range to which you belong.
   a. 20-25 [ ]
   b. 26-30 [ ]
   c. 31-35 [ ]
   d. 36-40 [ ]
   e. 41 years and above [ ]
4. What is the duration of your tenure within your present department at KeRRA?
   a. 1 year and below [ ]
   b. 2-5 years [ ]
   c. 5 years and above [ ]
5. What Directorate/ Department do you belong at KeRRA?
   a. Directorate of Planning, Design & Environmental Interests [ ]
   b. Directorate of Development [ ]
   d. Directorate of Road Asset Management [ ]
   e. Directorate of Research, Strategy & Compliance [ ]
   f. Directorate of Corporate Services [ ]
   g. Directorate of Audit Services [ ]

h. Department of Supply Chain [ ]

i. Department of Corporation Secretary & Legal Services [ ]

SECTION B: Access to GIS Technology

This section is aimed at collecting your opinion on Access to GIS technology. Please tick in spaces provided to show the extent to which you agree or disagree with the statements given. The following scoring has been used: **1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree.**

Statement	1	**2**	**3**	**4**	**5**
Access to GIS hardware					
There is sufficient availability of GIS hardware for project implementation					
The provided GIS hardware meets the project's technological requirements					
Access to GIS software					
There is adequate access to a variety of GIS software options for project planning and implementation					
The available GIS software meets the specific needs and objectives of the projects					
Access to GIS-enabled data collection devices					
There is reliable access to GIS-enabled data collection devices for acquiring accurate project data					
The provided GIS-enabled data collection devices are suitable for various project data collection tasks					

SECTION C: Availability of GIS Data

This section is aimed at collecting your opinion on availability of GIS Data. Please tick in spaces provided to show the extent to which you agree or disagree with the statements given. The following scoring has been used: **1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree.**

Statement	1	2	3	4	5
Availability of GIS enabled data within KeRRA					
KeRRA has well-established and readily accessible GIS enabled data for project purposes					
GIS data within KeRRA is regularly updated and maintained to ensure accuracy and relevancy					
Availability of GIS enabled data from other organizations					
External organizations readily share GIS enabled data with KeRRA for collaborative projects					
The availability of GIS data from other organizations contributes significantly to KeRRA's project planning and execution					
Structured workflow data sharing across departments					
There is an efficient workflow for sharing GIS data across different departments within KeRRA					
The sharing of GIS data among departments is streamlined, reducing data silos and promoting collaboration					

SECTION D: Staff Capacity

This section is aimed at collecting your opinion on staff capacity. Please tick in spaces provided to show the extent to which you agree or disagree with the statements given. The following scoring has been used: **1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree.**

Statement	1	2	3	4	5
GIS skilled manpower in data collection					
KeRRA has a proficient team of GIS skilled personnel for effective data collection					
The GIS manpower is well-trained and capable of efficiently collecting relevant project data using GIS technology					
GIS skilled manpower in data analysis, maintenance, and presentation					
KeRRA has competent GIS personnel proficient in data analysis, maintenance, and presentation					
The GIS skilled workforce can effectively analyze, manage,					

and present GIS data to support decision-making					
GIS skilled manpower in GIS hardware and software					
There are skilled experts in KeRRA who can manage and maintain GIS hardware and software					
The GIS personnel are knowledgeable in troubleshooting and utilizing GIS technology for project needs.					

SECTION E: Start-up Cost

This section is aimed at collecting your opinion on start-up cost. Please tick in spaces provided to show the extent to which you agree or disagree with the statements given. The following scoring has been used: **1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree.**

Statement	**1**	**2**	**3**	**4**	**5**
High cost of purchasing and installing all the components of GIS system influences its utilization in road projects implementation at KeRRA					
KeRRA's use of GIS in the execution of road projects is hampered by the high expense of acquiring, training, and retaining GIS specialists.					
KeRRA's use of GIS technology in road project execution is hampered by the high expense of initial investment and ongoing personnel training.					
The high price of securing stable internet access for GIS-related purposes limits its use in the construction of road projects by KeRRA.					
KeRRA's road project planning is impacted by the high expense of repairing broken GIS technology components.					

SECTION F: Utilization of GIS and Implementation of Road Projects

This section is aimed at collecting your opinion on Utilization of GIS on Implementation of Road Construction Projects. Please tick in spaces provided to show the extent to which you agree or disagree with the statements given. The following scoring has been used: **1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree.**

Statement	**1**	**2**	**3**	**4**	**5**
Utilization of GIS technology in road construction projects leads to real-time update on road construction progress					
Utilization of GIS technology in road construction projects leads to timely decision-making during road construction					
Utilization of GIS technology in road construction projects ensures efficient monitoring and evaluation of road construction process					
Utilization of GIS technology in road construction projects ensures effective and efficient management of road construction process					

APPENDIX III: INTERVIEW GUIDE

This interview guide is aimed at collecting an in-depth data on utilization of GIS, please take your time and allow me to have a talk with you. The questions will be in a conversation form and are not so many. Thank you.

1. In your opinion, what are the main benefits of utilizing GIS technology in the implementation of road projects?
2. Are there any challenges or barriers related to accessing GIS technology that hinder its full utilization in KeRRA?
3. How does the accessibility of GIS technology affect the overall efficiency and effectiveness of road project execution in KeRRA?
4. In what ways does the availability of GIS data influence the accuracy and precision of project planning and Cost?
5. Are there any specific challenges or limitations related to accessing GIS data from other organizations or sources for road projects?
6. Can you provide examples of how the availability of comprehensive GIS data has contributed to successful road project outcomes?
7. In your opinion, what are the potential long-term benefits of investing in GIS infrastructure for road projects in KeRRA?
8. Can you share any success stories or experiences where the initial investment in GIS infrastructure led to significant improvements in project outcomes?
9. Are there any specific challenges or gaps in staff capacity that affect the full utilization of GIS technology?
10. How does the competence and training of GIS personnel impact the overall efficiency of project execution in KeRRA?
11. Can you provide examples of projects where the proficiency of GIS skilled staff led to successful outcomes?

APPENDIX III : RESEARCH PERMIT FROM NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **885419**

Date of Issue: **25/August/2023**

RESEARCH LICENSE

This is to Certify that Mr.. Fredrick Otieno Okong'o of University of Nairobi, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: UTILIZATION OF GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY ON THE IMPLEMENTATION OF ROAD CONSTRUCTION PROJECTS SUPPORTED BY KENYA RURAL ROADS AUTHORITY, KENYA for the period ending : 25/August/2024.

License No: **NACOSTI/P/23/29014**

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2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
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   ii. Adversely affect the lives of Kenyans
   iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
   iv. Result in exploitation of intellectual property rights of communities in Kenya
   v. Adversely affect the environment
   vi. Adversely affect the rights of communities
   vii. Endanger public safety and national cohesion
   viii. Plagiarize someone else's work
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14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

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