INCORPORATING IMPACT OF COVID-19 INTO ROUTINE ROAD MAINTENANCE BY LOCAL GOVERNMENT: CASE STUDY OF THE GREATER NEBBI

BY

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A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE IN CONSTRUCTION TECHNOLOGY AND MANAGEMENT OF KYAMBOGO UNIVERSITY

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DECLARATION

I, **KUBI JAMES** declare that this dissertation report titled "***INCORPORATING IMPACT OF COVID-19 INTO ROUTINE ROAD MAINTENANCE BY LOCAL GOVERNMENT: CASE STUDY OF THE GREATER NEBBI"*** is my original work and has never been submitted or presented to any university or institution of higher learning.

Signature……………………………… Date……………………………

Kubi James

APPROVAL

We the undersigned certify that this dissertation entitled "***INCORPORATING IMPACT OF COVID-19 INTO ROUTINE ROAD MAINTENANCE BY LOCAL GOVERNMENT: CASE STUDY OF THE GREATER NEBBI"*** has been compiled under our guidance and supervision. It is now ready for submission to the Directorate of Research and Graduate Training with our approval.

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God bless you all abundantly.

DEDICATION

I dedicate this dissertation to my dear wife Christine Kubi Mungu-cia, who stood by me throughout my academic struggle.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BIM	Building Information Modelling
CFA	Confirmatory Factor Analysis
CAO	Chief Administrative Officer
DRC	Democratic Republic of Congo
DUCA	District, Urban and Community access
LG	Local Government
MCO	Movement Control Orders
MoFPE	Ministry of Finance, Planning and Economic Development
MoW&T	Ministry of Works and Transport
MVD	Marburg Virus Disease
NDP1	First National Development Plan
NDPII	Second National Development Plan
NDPIII	Third National Development Plan
SDA	Safari Day Allowance
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
SOPs	Standard Operating Procedures
UNRA	Uganda National Road Authority
URF	Uganda Road Fund
WEF	Work Economic Forum

ABSTRACT

In projects, a contingency cost is included to account for potential variation that may arise during the construction phase. These variations may result from factors such as unforeseen conditions, design errors, or changes in scope. Contingency costs are normally allocated 10% to 15% of the project cost. Despite the provision of contingency costs, there are eventualities termed as "force majeure" that can occur during construction that exceed the contingency cost. Such eventualities include earthquake, wars and epidemics. The emergence of the COVID-19 pandemic is an example of such unforeseen circumstances. Its impact on the construction industry, particularly with regard to the increase in material costs, had not been encountered before. The main objective of this study was to incorporate impact of COVID-19 into routine road maintenance framework for District Local Governments in Greater Nebbi. To achieve this main objective, the study focused on identifying road characteristics which affect maintenance cost per kilometre in the Greater Nebbi, established the impact in change of unit rate of road maintenance on cost per kilometre before, during and after COVID-19 pandemic, statistically tested the mean difference in the unit rate before and after the COVID-19 pandemic and developed framework for road maintenance that incorporates the impact of COVID-19. The study adopted a case study approach. A total of five (5) roads were selected from the greater Nebbi of which one was sampled from Jonam-Pakwach District, two from Padyere-Nebbi District, and two from Okoro-Zombo District. The field data collected were analysed using Microsoft Excel, because it had data analysis package for analysing research data. The analysed relied on both descriptive and inferential statistics. Field data were tested using t-Test: Paired Two Sample for Means to test statistical significant difference between mean. The research identified several factors that influence the maintenance cost per kilometre of roads in the Greater Nebbi, including terrain, climatic conditions during maintenance, road class and road condition, level of service, soil type, drainage condition and road surface type. The study concluded that road maintenance projects in the area underwent substantial changes in the unit rate of maintenance costs per kilometre before, during and after the COVID-19 pandemic. The research recommends that future investigations should develop a predictive model that account for the effects of global disruptions (such as pandemics) on supply chains and inflation could help road maintenance authorities anticipate cost changes. These models could use historical data from COVID-19 and previous economic shocks to forecast material and labour price trends and guide proactive budgeting strategies.

CHAPTER ONE: INTRODUCTION

1.1. Introduction

This study incorporated impact of COVID-19 into routine road maintenance framework for District Local Governments in Greater Nebbi. Road characteristics (physical and functional) in this study was conceived as the independent variable while maintenance cost per kilo-meter the dependent variable. This chapter gives the background of the study, statement of the problem, purpose of the study, research objectives, research questions, hypothesis of the study, conceptual frame work scope of the study, significance of the study, justification of the study and operational definitions.

1.2. Background to the Study

Road maintenance has emerged as a global issue that demands proactive action from all road authorities, to fulfil United Nations Sustainable Development Goal (SDG) 9, target 9.1. Worldwide, road maintenance has been as a result of several parameters in relation to road characteristics. Roads allow people to easily reach distant places where they can access resources and opportunities. The aim of quality roads is to ensure affordable and equitable access for all (United Nations, the 2030 Agenda and the Sustainable Development Goals: An opportunity for Latin America and the Caribbean (LC/G.2681-P/Rev.3), Santiago, 2018). However, extremely busy roads (operation of heavy vehicles and pedestrians) depreciate very fast attracting a higher maintenance cost and impact negatively on health (in-terms of local air and noise pollution) of individuals living around compared to less busy roads. (Friedrich and Bickel, 2001; Delucchi and McCubbin, 2010; Van Essen *et al.,* 2020). Across nations, functionality of roads greatly influence maintenance cost of roads compared to physical characteristics of these roads. With countries aware of the specific road characteristics influencing road maintenance in their region, it is possible to have a unit rate forecast that could help in reducing the cost of maintenance with the use of functional framework in place (Gundlach *et al.*, 2018; Anciaes *et al.*, 2018; Anciaes and Jones, 2020).

In Africa, the significance of road development and maintenance is recognized by key political decision-makers, as evidenced by Agenda 2063, "the Africa we want" (2015). The political leaders ensure finances are allocated for road construction and maintenance. In a survey conducted by Work Economic Forum (WEF) in 2019 focusing on “Quality of roads” in Africa indicate that 61% of African roads do not meet international quality standard as 38 African countries were sampled. The survey revealed that African roads on an average score of 3.43 points, with highest scores (5.3 points) coming from Namibia. (Islam, M., Mohamed, S. F., & Mahmud, S. H. (2022). Therefore, previous surveys and research in Africa have pointed out quality standards of roads, road maintenance costs. However, knowledge on road characteristics which is beneficial in road maintenance frame-work and planning is still lacking and this research will contribute to bringing the knowledge gap by pointing out the road characteristics.

The Government of Uganda, in both its fourth 1st and 2nd National Development Plan (NDP1) plans for infrastructural development for the country. In NDP1 (2010/11 - 2014/15, April 2010) plans of upgrading, rehabilitation, and maintenance of district, urban, and community access roads were made a priority and in NDP2 under the infrastructure Development objective, development of adequate, reliable, and efficient multimodal transportation network by rehabilitating and maintaining roads across the country. However, road rehabilitation and maintenance are complex systems and if road characteristics are not put into consideration, the cost of operation and maintenance become a real problem and a major issue. Without the knowledge of these road characteristics coupled with a functional maintenance road frame-work (for sustainability), infrastructural development in Uganda will take more years and resources to meet the international road quality standard as per WEF. According to a reporter at Daily Monitor Newspaper of Uganda, on Special Report of 2021, the unit cost per kilometre for road maintenance/rehabilitation in Uganda on average was between US$750,000 to 1M (Ushs 2.5 billion to 3.5 billion) which is more expensive compared to other East African counties like Kenya, Rwanda and others that average between (Ushs 2.0 billion to 2.8 billion).

In financial year 2019/2020 budget for road development and maintenance for district and community Access roads was 17.07%. (Guidelines for the Works and Transport sector for the financial year 2019/2020). District roads network alone which account for 12.5% of the national road length and was allocated 13.81% of the budget for road maintenance to cover 214 District. At the District level in greater Nebbi, allocation of the fund for maintenance of selected District roads is the mandate of the District Council who are not guided by a functional framework for resource allocation. In addition, the technical officers are left with no option apart from utilizing the allocated resources regardless of the road sectional characteristics. Thus efficient utilization of the allocated resources is essential. Considering factors such as the condition of sectional roads, including the extent and quality of deterioration, the rate at which deterioration is occurring, and the significance of various sections, enables the accomplishment of this task. Hence, it is difficult to plan for the different road activities with the allocated resources especially when the allocation did not put into consideration the sectional characteristics of the roads.

The impact of the COVID-19 pandemic on road maintenance efforts poses additional challenges alongside existing issues. The global disruption caused by the pandemic has strained government budgets designated for infrastructure development and maintenance. Resources diverted to pandemic response have further constrained funds for road maintenance. Changes in transportation patterns, including reduced traffic volumes and altered travel behaviour, have both positive and negative effects. While decreased traffic has lessened immediate maintenance needs, reduced revenue from transportation-related sources has impacted available funds. The pandemic has also disrupted supply chains, affecting the availability and cost of construction materials, leading to delays in material procurement and construction activities, complicating the timely execution of maintenance tasks.

Addressing road maintenance issues requires all-inclusive approach by majorly considering road characteristics and functional frameworks enhanced by financial considerations. A pandemic such as COVID-19 worsens issues by straining budgets and disrupting transportation patterns. Integrating functional frameworks that account for road characteristics is crucial for sustainability.

1.3. Statement of the Problem

Despite the unprecedented impact of the COVID-19 pandemic on road transportation systems worldwide, road maintenance was being impacted on by variables related to road characteristics. The impact of this pandemic and identification of road characteristics are to be incorporated into an existing framework if any for sustainable road maintenance. In the case of Greater Nebbi, Uganda, information on unit cost range for various district road interventions and key road works activities, road classification and level of service are available and in use. However, there has been a gap in understanding road characteristics that influence road maintenance and the condition has been further worsened by the impact of the COVID-19 pandemic. The persistent knowledge gap and failure to account for pandemic effects in a functional framework, may lead to poor road maintenance and in the long run becomes costly.

This study aims to investigate the key road characteristics coupled with the impact of COVID-19 to develop a functional road maintenance framework by identifying and analysing the dependable and intervening variables.

1.4. Objectives of the Study

1.4.1. Main Objective

The main objective of this study was to incorporate impact of COVID-19 into a routine road maintenance framework in Greater Nebbi.

1.4.2. Specific Objectives

The specific objectives were:

i) To identify road characteristics which affect maintenance cost per kilometre in the Greater Nebbi;
ii) To establish the impact in change of unit rate of road maintenance on cost per kilometre before, during and after COVID-19 pandemic;
iii) To statistically test the mean difference in the unit rate before and after the COVID-19 pandemic; and
iv) To develop framework for road maintenance that incorporates impact of COVID-19.

1.5. Research Questions

The research was aimed to address the following inquiries:

i) What were the characteristics of roads in the greater Nebbi?
ii) What are the unit rates of routine road maintenance before, during and after COVID-19 in Greater Nebbi?
iii) Is there any statistically difference in the unit rate before and after the COVID-19?
iv) How can impact of COVID-19 be incorporated in road maintenance framework?

1.6. Research Hypotheses

The null hypotheses Ho was;

Ho: There is no mean significant difference in the unit rate for routine road maintenance in the Greater Nebbi before and after the COVID-19 pandemic.

While the alternative hypotheses Ha was;

Ha: There is a mean significant difference in the unit rate for routine road maintenance in the Greater Nebbi before and after the COVID-19 pandemic.

1.7. Significance of the study

The findings of this study will serve as a valuable resource for district local government councils by providing practical guidance in road maintenance planning and financing. Additionally, the outcomes will assist Local Government Engineers in determining appropriate allocation of funds for each road designated for maintenance, thereby enhancing the efficiency and effectiveness of resource utilization. Furthermore, the results of the study will support the procurement process by informing the selection and contracting of road maintenance contractors, ultimately contributing to better-managed and more sustainable rural road infrastructure.

1.8. Scope of the Study

1.8.1. Depth of Investigation

The research was limited to routine road maintenance planned for in one financial year.

1.8.2. Content

The research involved collecting and analysing data in relation to the routine road maintenance activities.

1.8.3. Sample Size

The study sample size composed of five (5) roads of which one (1) was sampled from Jonam-Pakwach District, two (2) from Padyere-Nebbi District, and two (2) from Okoro-Zombo District.

1.8.4. Geographical location

The research project was carried out in the greater Nebbi Districts of Pakwach, Nebbi and Zombo. This is a representative of the West Nile region and climate.

1.8.5. Time Frame

The research spanned duration of nine months, encompassing data pertaining to one fiscal year period. This timeframe was ample time to gather the necessary data from the three Districts.

1.8.6. Financial Limit

The estimated total cost for the research was UShs 9,595,000/= to cover expenses such as monthly data bundles, stationary, printing and binding services, transport and welfare for the research team.

1.9. Conceptual Framework

According to this concept in Figure 1.1, it is anticipated that the characteristics of roads and changes in unit rates of maintenance costs per kilometre will remain consistent before, during and after the COVID-19 pandemic. During implementations, the unit rates should consider factors such as government policies and regulations. Neglecting government policies and regulations during implementation and maintaining roads with challenging characteristics using unit rate elements based on pre-COVID-19 normal prices led to increased maintenance costs per kilometre.

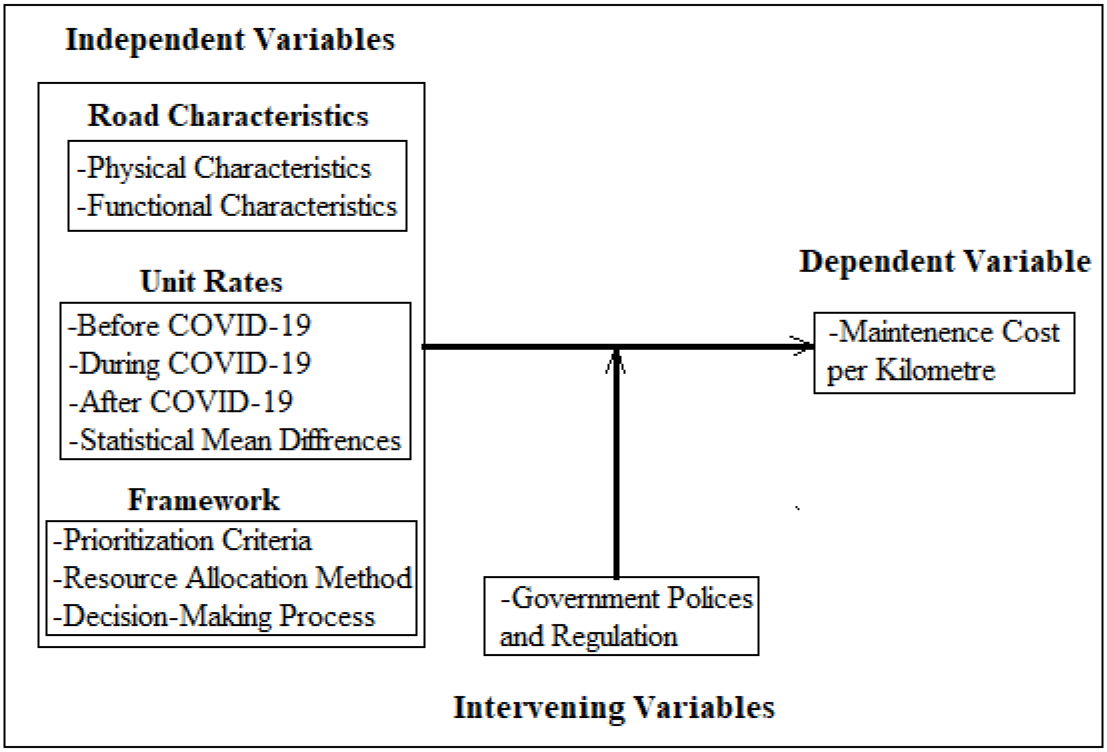

Figure 1. 1: Conceptual Framework

Physical road characteristic sub-element includes terrain, climatic condition, soil type and drainage condition and road surface type. Difficult physical road conditions contribute to higher unit rate elements. The sub-elements of functional road characteristics include road class, level of service, and road condition. Functional road characteristics are influenced by government policies and regulations.

The unit rate sub-elements include the cost of hiring plants, materials, labour and indirect/overhead costs before, during and after the COVID-19 pandemic. Plant unit rate component includes plant hire rate and daily operating cost (operators' allowances, fuel, lubricant, repair and maintenance). Plant operating hours is expected to control plant rate. Material unit rate component considered include costs right from purchase, extraction, loading, transport, placing and finishing in final position. Labour unit component includes cost for skilled, semi-skilled and causal labourers. Indirect/overhead unit cost component considered include allowance to supervisors and the drivers, fuel for supervision, transportation of plants, welfare, service van/motorcycle and plant repair labour cost.

1.10. Chapter Summary

The chapter has covered what the research did to find solutions to issues of maintenance costs per kilometre by addressing problems identified through the specific objectives stated. By addressing the specific objectives, the research questions raised were then answered. The extent to which the research was handled was covered under the scope. Important issues were raised under the justification and significance of the research which raised the need to have the research undertaken. Finally, the conceptual framework proposed indicated the influence of factors for maintenance costs per kilometre in order to realize the desired research outcomes of incorporating impact of COVID-19 pandemic into routine road maintenance. The concept will further be understood by highlighting some key words, in the research topic as listed in the next chapter on literature review.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter involves theoretical review of literature concerning road maintenance and conceptual review literatures on impact of COVID-19 pandemic and characterisation of road infrastructures. By the end of the chapter, gaps in existing literature were identified for solution seeking.

A number of scholars have done research/ surveys on road maintenance and others have provided knowledge on characteristics of quality roads and global road quality standards. However, there is no evidence that considerations of road characteristics and pandemic impacts like Covid-19 have been looked into as playing significant role in achieving sustainable quality roads, through a popularized road maintenance framework. Every financial year in Greater Nebbi region, resources are allocated for road maintenance/ rehabilitation but the roads barely last, besides during and after COVID-19 pandemic most district roads got abandoned due to financial constraints. This indicated that if there was provision in planning for such pandemics, road maintenance as an activity could still be conducted in a particular financial year.

2.2. Theoretical Review

2.2.1. Road Maintenance

Over the years to attain easy and comfortable movements within and across continents, research and studies focused on improving different transport systems, with some researchers/scholars specializing in studies that aimed at improving the road transport sector. (Berg, Deichmann, Liu and Selod, 2015; Asher and Novosad, 2020) state that Road connectivity is key for inclusive development. Substantial work has been done on estimating gaps in road infrastructure (looking at access and road sustainability) (Fay and Yepes, 2003; Roberts, Shyam and Rastogi, 2006; World Bank, 2016; Iimi, Ahmed, Anderson, Diehl, Maiyo, PeraltaQuirós, 2019) and Sally Burningham and Natalya Stankevich (2005) explained that to have quality roads, road maintenance has to be conducted in the following categories: routine, periodic and urgent. They observed that routine maintenance involves small-scale, regular works that aim to ensure the daily usability and safety of existing roads in the short term, as well as prevent premature deterioration of the roads (PIARC, 1994). Periodic maintenance, on the other hand, entails activities performed on a specific road section at regular and relatively long intervals, with the goal of preserving the road's structural integrity (WB Maintenance website). Urgent maintenance is carried out for unforeseen repairs that require immediate attention, such as collapsed culverts or landslides that obstruct a road. In addition, MoW&T (2017) revised guideline explain that, scheme for maintaining District, Urban and Community access (DUCA) roads using own equipment and road gangs recommend three (3) road maintenance schemes: Routine Maintenance, Rehabilitation, and Periodic Maintenance. (Zhang and Alhelyani, 2022) also elaborated that adequate maintenance practices are crucial for sustaining efficient road infrastructure, facilitating economic activities, and enhancing connectivity for communities and also facilitate internal and external market integration (Jaworski, Kitchens, and Nigai, 2020; OECD, 2020).

Both Sally Burningham and Natalya Stankevich (2005) and MoW&T (2017) above, concentrated on state of roads and when road maintenance activity can be undertaken, (routine, periodic and urgency), while leaving out the aspect of quality road sustainability. It is fine to understand the nature of roads and when they can be maintained but more important to ensure that the consistence maintenance activities result to quality sustainable roads, which can only be achieved when one is knowledgeable of the road characteristics coupled with appropriate pre-planning that takes into consideration of natural disasters such as pandemics. Zhang and Alhelyani, 2022 explained that quality road networks serve as vital lifelines for nations, enabling the movement of goods, services, and people hence economic development

In the case of Greater Nebbi, a region characterized by predominantly rural areas, rural road maintenance assumes particular significance. The remote and geographically diverse terrain poses significant challenges in terms of accessibility, maintenance logistics and resource allocation. The maintenance of rural roads in Greater Nebbi is crucial for facilitating agricultural activities, connecting remote communities to essential services, and supporting economic development. Moreover, rural road maintenance in Greater Nebbi faces additional difficulties, such as limited funding and technical expertise (Ntambi, 2017). The region's resource constraints necessitate innovative approaches and partnerships between local communities, government agencies, and development organizations to address the maintenance needs effectively.

After worldwide common understanding of "Road maintenance components", Surveys/ Researches then conducted to explain what and if a particular road is of quality. The quality of road network is regularly surveyed by the World Economic Forum (WEF), who interview Business leaders of 144 countries to rate the quality of roads on a scale from1 (underdeveloped) to 7 (extensive and efficient by international standards). Thereafter a report is disseminated. But according to Moszoro and Soto (2022), road quality is based on the travel mean speed between large cities from Google map. This research as well gives a loophole, issues of road characteristics and how much a road is maintained should be considered.

2.3. Conceptual Review

The objective of conceptual literature is to enhance comprehension and insight into the literature regarding the impact of the COVID-19 pandemic on routine road maintenance. This is accomplished by conducting a critical analysis of established theories and introducing fresh concepts or frameworks. The subsequent literature showcases these concepts.

2.3.1. COVID-19 and Road Maintenance

From the year 2000, Uganda has experienced several pandemics its first was Ebola virus disease which had series of outbreaks with the first outbreak in the year 2000, then in 2014, 2017 and 2018. The one in the year 2000 was the biggest and massive killing of 224 people (Okware, 2022). Uganda has also experienced outbreaks of Marburg Virus Disease (MVD), resulting in fatalities and socioeconomic effects from loss of tourism (Knust et al, 2015).

The first recorded outbreak in Uganda occurred in the Kamwenge district in 2007, A second, larger outbreak occurred in the western Uganda districts of Kabale, Ibanda, and Kamwenge in 2012 and its last was experienced in 2014, In between, the country was also hit by outbreaks such as Crimean Congo Hemorrhagic fever, Yellow Fever, Rift Valley Fever, Avian Influenza and measles among others. Until 2019 where the country faced a global pandemic COVID-19, which was controlled by locking down the country, restricting movements within and outside the country. This pandemic was across the globe causing economic depression in various countries including Uganda, affecting various economic activities inclusive of road maintenance. Jallow, Renukappa and Suresh (2021) explored the impact of the Covid-19 outbreak on the infrastructure sector that revealed that the lockdown measures presented challenges in managing projects, as staff members were required to work remotely from home. This resulted in delays in project activities, as many employees were unable to physically be present on-site and carry out their work.

On a global scale, the COVID-19 pandemic prompted governments and transportation authorities to reconsider their road maintenance strategies and prioritize essential maintenance activities. King, Rahman, Fauzi and Haron (2021) revealed that the COVID-19 pandemic had severe repercussions on both the overall economy and the construction sector. With limited financial resources and competing priorities, authorities may need to allocate funds strategically to address critical maintenance needs and ensure the continued functionality of key transportation corridors. The pandemic also highlighted the importance of adopting innovative maintenance approaches, such as remote monitoring technologies and data-driven maintenance planning, to optimize resource allocation and minimize disruptions. Further moreover, the COVID-19 pandemic has worsened the challenges of rural road maintenance. The pandemic has led to disruptions in supply chains, restricted movement, and financial strains on governments and local communities (Cruz and Sarmento, 2021). These impacts have implications for road maintenance efforts, as limited resources and logistical constraints may hinder regular maintenance activities, potentially resulting in increased road deterioration and reduced accessibility to essential services in rural areas.

In the context of Greater Nebbi, the COVID-19 pandemic added further strain to an already challenging rural road maintenance landscape. Reduced funding availability and limited mobility due to lockdown measures hampered maintenance efforts. The impact was particularly felt in remote areas where access to essential resources and technical expertise may be limited. As a result, there was an increased risk of road deterioration, which hindered agricultural activities, impeded access to healthcare and other essential services, and exacerbated existing socio-economic disparities in the region.

Road maintenance was a global concern that hold immense importance for the economic and social well-being of communities. While road maintenance in general plays a crucial role in sustaining transportation networks, rural road maintenance presents specific challenges and considerations. In the case of Greater Nebbi, rural road maintenance assumes critical significance due to the unique characteristics and maintenance requirements of rural roads in the region. The COVID-19 pandemic has further complicated road maintenance efforts, with implications for resource allocation, accessibility and socio-economic development. It is crucial for policymakers, local authorities and development organizations to address these challenges proactively, adopt innovative maintenance approaches, and ensure the continued functionality and resilience of rural road infrastructure in the face of the on-going pandemic and future crises.

2.3.2. Characterisation of Road Infrastructure

Gianpiero Torrisi (2009) aims to offer a useful tool for critically analyzing the existing literature. Gianpiero focuses on defining infrastructure and proceeds to examine various categories of infrastructure discussed in the literature. These categories include personal, institutional, material, immaterial, economic, social, core and not-core, basic and complementary, network, nucleus and territory infrastructures. Finally, Gianpiero Torrisi (2009) addresses problems associated with measuring infrastructures and discusses financial-based and physical-based measures. It emphasizes that both types of measures have drawbacks due to economic and computational challenges, which need to be taken into account when interpreting results related to infrastructures.

Ross and Townshend (2018) introduced an economic-driven road classification system designed specifically for the South Africa road network. The authors categorized roads into four classes: Basic Access Roads, Strategic Roads, Tactical Roads and Surplus Roads. They discussed the distinct characteristics and prioritization of maintenance for each road class. Additionally, they presented an identification methodology that authorities can utilize to incorporate this information into their asset management systems. The aim of this integration was to enhance expenditure and investment outcomes related to road infrastructure

Sutheeraakul and Kronprasert (2019) conducted a study on the Functional and Contextual Classification Concept for the road network in Thailand. The study introduced a road classification system that considers both road functions and contextual settings. The preliminary findings revealed discrepancies in road classes when considering both function and context. They emphasized that road classification is a crucial step in planning and designing road networks to ensure efficient movement of people and goods. It enables the classification of roads based on hierarchy and facilitates proper design in terms of physical characteristics and environmental context. Furthermore, it clarifies the responsibilities of relevant agencies. The authors highlighted that traditional road classification systems often focus solely on road functions and neglect environmental and neighboring factors. This limitation in Thailand's system leads to either over-designed or under-designed facilities or inappropriate road usage by users.

2.3.3. Road Maintenance Cost and COVID-19 Pandemic

Li *et al.* (2021) conducted a quantitative study to investigate the impact of the COVID-19 pandemic on China's transportation and logistics sector. The findings indicate that the pandemic has had a significantly negative effect on the financial and industrial sectors of China as a whole. The study employed a research design using primary data collection and employed Structural Equation Modelling (SEM) analysis, including Confirmatory Factor Analysis (CFA) and path assessment. A structured survey questionnaire was administered, and the survey responses were measured on a scale from strongly, agree to strongly disagree. The results showed that the COVID-19 virus had a statistically significant negative impact on air freight and land freight. However, the impact on ocean freight was statistically insignificant during the pandemic. These findings suggest that policymakers should provide increased support to improve the performance of the transportation and logistics sector in China, taking into account the study's results.

In a study conducted by King, Rahman, Fauzi and A.T. Haron (2021) on ways to mitigate the negative impact of COVID-19 on the infrastructure construction industry, they gathered and examined interview data from industry professionals. The study revealed that the COVID-19 pandemic had severe repercussions on both the overall economy and the construction sector, particularly due to the implementation of Movement Control Orders (MCO) which resulted in the suspension of infrastructure projects. They observed that contractors faced significant losses and encountered numerous challenges stemming from the pandemic, despite receiving on-going financial assistance from the government. They emphasized that by identifying effective approaches to enhance existing government policies and strategies, contractors could better handle these issues. The analysis yielded significant findings, indicating that COVID-19 had financial and productivity implications for the infrastructure construction industry. To address these challenges, they proposed various mechanisms, including legal, financial, productivity and environmental support.

Cruz and Sarmento (2021) conducted a study on the impact of COVID-19 on highway traffic and management. The study aimed to address the challenges and responses to the pandemic from the perspective of a private highway operator and from a multidisciplinary standpoint. They highlighted that the COVID-19 pandemic caused significant disruptions in society, with transportation services, especially highways, being severely affected. Highway operators had to deal with two main challenges: managing potential disruptions caused by the pandemic and national lockdown, while ensuring the proper operation and maintenance of road services, and coping with the negative impact on traffic levels. The study revealed that highway operators responded by prioritizing the health and safety of their employees and clients to avoid service disruptions. They also faced the economic impact of the pandemic and implemented short-term measures in areas such as engineering, management and internal business management. The effects on traffic levels varied depending on the type of vehicles and the location of the highways.

2.4. Rural Road Maintenance

Road maintenance, as noted by Burningham and Stankevich (2005), is not intended to indefinitely extend the lifespan of a road. Instead, its primary goal is to ensure continuous and satisfactory conditions for uninterrupted, safe and efficient travel, as stated in the Force Account Guideline (2017). Like any road type, rural roads naturally experience deterioration over time due to aging and usage. Therefore, the objectives of maintenance include mitigating the adverse effects of aging and usage, while also improving the short-term performance of rural roads. From an engineering perspective, there exists a set of activities that are necessary throughout the lifespan of a road. While the terminology may vary, the literature generally acknowledges routine maintenance, periodic maintenance, emergency or special maintenance, rehabilitation, and reconstruction as key categories.

In their publication, they addressed the significance of road maintenance and provided insights into effective approaches. They highlighted that inadequately maintained roads restrict mobility, substantially elevate vehicle operating expenses, contribute to higher accident rates along with the associated human and property costs and exacerbate issues of isolation, poverty, poor health and illiteracy in rural communities. Thy emphasized the importance of prioritizing maintenance over the construction of new roads when faced with limited public resources. They underscored that maintenance should be carried out promptly and consistently, as delaying it would result in significantly higher costs in the future.

According to the International Labour Organization (2007), while most countries possess the capability to construct roads, it is crucial to have the technical capacity to maintain them in subsequent stages. The report further highlighted that the responsibility for providing and maintaining rural infrastructure, including rural roads, has been delegated to local government administrations. Additionally, the report outlined several essential activities for routine road maintenance, which include clearing any obstructions from the roadway, ensuring the unimpeded flow of water by clearing side drains, implementing erosion control measures for shoulders and slopes, maintaining culverts and other waterways, conducting minor repairs to culverts and retaining structures, addressing potholes, cracks, ruts and other minor damages on the road surface, performing grass cutting and vegetation control and ensuring the cleanliness and upkeep of road signs.

In July 2005, the World Bank emphasized that the objective of maintenance is to maintain the existing road rather than upgrade it. Unlike major road construction projects, maintenance activities need to be carried out on a regular basis. The World Bank also outlined a range of road maintenance activities, including the preservation of pavement, shoulders, slopes, drainage facilities, as well as other structures and properties within the road boundaries, aiming to keep them as close as possible to their original or renewed condition, as stated in the PIARC (1994) guidelines.

In the budget speech for the fiscal year 2021/22, the Minister of Finance, Planning and Economic Development placed emphasis on the rehabilitation of 200km of national roads and 400km of Community Access Roads as a priority within the Transport Infrastructure sector. Furthermore, the maintenance of both the national road network and the District Urban and Community Access (DUCAR) road network was highlighted as a key focus area.

2.5. District Road Classes

As per the functional road classification system and design classes established by the Ministry of Works and Transport (MoWT), the District Road Works Technical Manual A, Volume 1 (2004) defines three classes of district roads as District Class I, District Class II and District Class III.

2.5.1. District Class I

District Class I roads meet the criteria set by the Ministry of Works and Transport (MoWT) for the secondary and/or tertiary road systems within the Trunk Road network. These roads have the potential to be upgraded to the Trunk Road network in the future and would then fall under the responsibility of the MoWT or UNRA for maintenance and further expansion.

2.5.2. District Class II

District Class II roads serve the transportation requirements of the district by linking to the secondary or tertiary road systems established by the Ministry of Works and Transport (MoWT). These roads facilitate connections between the district headquarters, sub-county administrative centres, and various district facilities such as healthcare centres, educational institutions, markets and administrative offices. Typically, District Class II roads feature a gravel surface and have an average daily traffic volume of twenty (20) or more motorized vehicles, as stated in the Planning Manual Volume 1, Manual A "Functional Road Classification and Route Numbering" published by the Ministry of Works, Housing, and Communications in June 2002.

2.5.3. District Class III

District Class III roads function as connectors, linking District Class II roads and extending into the sparsely populated peripheral regions of the district. These roads are characterized by low motorized traffic volume and typically have an earth or gravel surface. On average, they carry fewer than twenty (20) motorized vehicles per day and generally do not offer direct access to major public activity centres.

2.6. Impact of COVID-19 on Rural Road Maintenance

Frank Richardson (2022) in his study on the economy of United State of America, highlighted that the construction industry is familiar with pricing volatility during times of economic growth, recession, or even war. However, the unparalleled impact of the COVID-19 pandemic on construction material costs has presented unique challenges that the industry has not experienced previously. He noted that the closure of "non-essential" manufacturing businesses during the pandemic led to supply shortages and substantial price increases. Despite the resurgence of the economy and persistent demand surpassing supply, the construction industry continues to grapple with elevated prices and delays. As a solution, he observed that Contractors can reduce the impact of COVID-19 on Construction Estimates by developing a contingency plan to handle material costs right from the start, and by addressing potential issues such as price fluctuations and delivery delays with timely and accurate cost estimates.

Daniel Angualia (2020) noted that, in a bid to contain and slow down the spread of COVID-19, the Government of Uganda put up restrictive measures under the Public Health Act. The regulations, among others, provided for closure of hardware shops, required construction sites to provide accommodation for the employees at the site and prohibited employees from leaving the site. It prohibited the use of public and private vehicles except those that were being used in the provision of essential services. He also noted that, Ministry of Works and Transport also issued Standard Operating Procedures (SOPs) for Building Construction Sites which required construction sites to have in place COVID-19 guidance signage on the site, clinic and First Aid room, among others. Construction sites were required to ensure constant provision of water for hand washing or sanitizers while observing social distancing. As a result of the above measures, he noted that, many construction sites and projects had to stall or had activities suspended. Affected projects included; 20km Kayunga-Busaana road, Hoima International Airport construction, Kampala Fly over project, among others. For contractors that managed to continue with construction, implementation of the SOPs had immediate cost implications on them. Furthermore, he noted that the construction industry is grappling with numerous questions related to the impact of COVID-19, such as whether contractors may be eligible for reimbursement of additional expenses incurred due to the implementation of standard operating procedures (SOP) at construction sites.

A study conducted by Jallow *et al.* (2021) explored the impact of the Covid-19 outbreak on the infrastructure sector in the United Kingdom. The findings revealed that the lockdown measures presented challenges in managing projects, as staff members were required to work remotely from home. This resulted in delays in project activities, as many employees were unable to physically be present on-site and carry out their work. However, the study highlighted that despite these difficulties, the use of technological tools such as video chats and online meetings proved highly effective in facilitating communication among project teams.

The study also noted the significance of Building Information Modelling (BIM)/Design, as the 3D design models assisted in visualizing the project during team meetings. This enabled compliance with Covid-19 regulations and social distancing guidelines while continuing work. However, the induction process for new starters became challenging during the pandemic and lockdown, particularly due to the requirement of a drug and alcohol test prior to commencing work on a project.

2.7. Unit Cost of District Road Maintenance

The unit cost of maintaining rural roads differs from one region to another. This variation in cost was highlighted in the Uganda Road Fund (URF) guideline of 2017.

2.7.1. Unit Costs for Schemes

As per the budgeting guideline provided by the Ministry of Finance, Planning and Economic Development (MoFPE) for the financial year (FY) 2020-21, Table 6a outlines the unit cost ranges for different interventions on district roads. This information, presented in Table 2.1, covers the period from FY 2016/17 to FY 2020/21 and serves as guidance for reference purposes.

Table 2. 1: Unit Cost range for various district road interventions

Maintenance Activity	FY 2017/18 UG /km	FY 2018/19 UG /km	FY 2019/20 UG /km	FY 2020/21 UG /km	Remark
Periodic	15,900,000	13,820,000	13,820,000	15,202,000	Flat terrain
Maintenance	15,900,000	26,890,000	26,890,000	29,579,000	Mountainous
Routine	1,300,000	1,400,000	1,400,000	1,540,000	Manual
Maintenance	4,000,000	4,550,000	4,550,000	5,005,000	mechanised

Source: MoFPE budgeting guideline for financial year (FY) 2020-21, Table 6a

2.8. Statistical Methods for Analysing Changes in Unit Rates

Longbrake (1973), in his work on statistical cost analysis, emphasized the importance of analyzing changes in unit rates to gain valuable information for decision-making. He highlighted that statistical cost analysis, based on cost accounting data, can provide insights for various cost-related decision problems. These include determining the average unit cost of a product, identifying incremental costs associated with variations in product characteristics or short-term output changes and forecasting costs resulting from long-term expansion or other changes.

Further, Longbrake (1973) developed a comprehensive cost function by accurately defining cost categories that are relevant to the analysis. For instance, he illustrated the costs associated with providing service to demand deposit customers, including fixed maintenance costs, variable maintenance costs and transport costs. Additionally, he identified measurable variables that explain the variations within each cost category, enabling a more thorough understanding of the underlying factors influencing costs.

Table 2. 2: Unit cost ranges of key road works activities

SN	Works Activity	Unit	DUCAR Regions UGX/unit (Using Force Account)				
			North	East	South	West	Central
1	Grading, shaping and compaction	Km	1,000,000 to 1,400,000	1,000,000 to 1,400,000	1,000,000 to 2,282,000	1,000,000 to 2,282,000	1,000,000 to 2,282,000
2	Re-gravelling	Km	7,000,000 to 10,000,000	7,000,000 to 10,000,000	8,000,000 to 12,000,000	8,000,000 to 12,000,000	8,000,000 to 11,000,000
3	Culvert installation –600mm	Lm	120,000 to 150,000	120,000 to 150,000	120,000 to 160,000	120,000 to 160,000	120,000 to 160,000
	–900mm	Lm	230,000 to 300,000	230,000 to 300,000	250,000 to 280,000	250,000 to 280,000	250,000 to 280,000
	–1200mm	Lm	350,000 to 380,000	350,000 to 380,000	350,000 to 400,000	350,000 to 400,000	350,000 to 400,000

Source: MoFPE budgeting guideline for financial year (FY) 2020-21

2.9. Equipment for Routine Road Maintenance

For mechanized routine maintenance, Government of Uganda through MoWT has provided DLGs with road maintenance equipment. They include Motor Grader, Wheel loader, Bulldozer, Vibrating Roller, Water Bowser, Tipper Trucks, Pickup, Motorcycles. Older Districts such as Nebbi has a Bulldozer.

Appropriate hand tools and implements are essential for manual labour. Good tools improve productivity. For manual routine maintenance, each road worker has the following key tools for road maintenance work a hoe, shovel, slasher and a panga or machete as a precondition for being recruited. The rest of the tools such as wheelbarrows, rakes, pick axes, handle axes, claw bars, tam-pers, claw hammers, sledge hammers, sharpening files, rolls of sisal ropes, movable cones, reflective triangles, movable hazard signs and flags are provided by the local government and provided to the workers on loan. The equipment is provided to the worker by the local government. The workers are responsible for the tools given to them. For cases where the road camps are established, the headman will have the following tools in his custody.

2.10. Climate Classification

The teachers of the Royals Cluster have created a blog to share learning materials in social studies specifically for primary five students. In one of their blog posts, they categorized Uganda's climate into four classifications: Tropical, Equatorial, Semi-Arid and Montane Climate.

They described Tropical climate as wet and dry having two main rain seasons with a marked period of drought. They noted that, in Uganda, rainfall seasons fall between March - May and August – October with some areas receive more rainfall than others while some regions experience higher temperatures than others. They noted that the hot tropical climate is experienced in places such as Arua, Nebbi, Moroto, Kotido, Oyam, Amuru, Kaabog, Napak and Kumi. Areas with more rainfall received are referred to as the humid tropical

Climate which are experianced in places such as Masaka, Kampala, Jinja, Mukono, Kabale, Kisoro, Kiruhura, Mbarara and Kasese among others.

They also described Equatorial climate as hot and wet throughout the year experienced mainly in some few parts of Uganda especially in areas mainly lying on the shores of Lake Victoria such as Entebbe and the Kalangala Islands which receives convectional rainfall as a result of the presence major water bodies such as Lake Victoria and the thick Mabira Forests. They observed that although Uganda is crossed by the Equator, it does not experience a true equatorial climate because the plateau in Uganda makes it to lie at a relatively high altitude which reduces the temperature that would be very high.

They described Semi - Arid climate as hot and dry with very high temperature and very low rainfall. They observed that this type of climate is experienced in the Northern and North Eastern Parts of Uganda in the districts such as Kaabong, Kotido, Moroto Napak, Nakapiripiriti, Amuru and Oyam.

According to this blog, Montane Climate is experienced in mountainous and highland areas which experience low temperatures because of the high altitude influence rain formation. They observed that this type of climate is experienced in areas like Mbale, Kisoro, Bundibugyo and Kabale.

2.11. Terrain Classification

Lebo and Schelling (2001) categorized terrain into three types: flat, rolling or mountainous. These classifications were based on both subjective descriptions and the average ground slope. They highlighted the significant variation in terrain conditions, both within countries and between different regions.

District Road Works, Technical Manual A, Volume 1, (2004) defined different types of terrain as Flat Terrain having ground contour ranging from 0 to 10 metre per kilometre (i.e.0 to 5% gradient), Rolling Terrain having ground contour ranging from 11 to 25 metre per kilometre (that is greater than 5% gradient but not more than 12.5% gradient) and Hilly

Terrain having ground contour greater than 25 metre per kilometre (that is greater than 12.5% gradient).

2.12. Chapter Summary

In conclusion, the chapter explained key literature on characterisation of road infrastructures, road maintenance cost and COVID-19 pandemic as well as statistical analysis methods to be applied in the next chapter.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter give how data for the study was collected, analysed and interpreted in order to answer the research questions or test the research hypotheses, thereby meeting the purpose of this study. This chapter therefore comprised research design, study population, determination of sample size, sampling techniques, data collection methods, data collection instruments, quality control, data collection procedures, data analysis, measurement of variables and ethical considerations.

3.2 Research design and Approach

3.2.1 Research Design

An analytical research design was employed to test objective theories by exploring the relationships between variables. These variables were collected and measured using appropriate instruments, such as observation checklist and recording sheets (gauge reading, fuel reading) enabling the analysis of numerical data through statistical procedures. In this study, numerical figures and descriptive information were obtained, giving it both a quantitative and qualitative research dimension.

3.2.2 Research Approach

The study adopted a case study design. The case study design was adopted because the study conducted intensive investigation on the variables under study in the Districts of the Greater Nebbi specifically as suggested by Oso and Onen (2008). As stated by Zainal (2007), a case study enables the incorporation of both quantitative and qualitative data analysis, while also allowing for a comprehensive understanding of complexities within real-life situations that may not be sufficiently captured through experimental or survey research methodologies.

3.3 Population and Sample

3.3.1 Population

The study was conducted in three districts Pakwach, Nebbi and Zombo in the greater Nebbi that has a total of 74 roads of which 28 roads were from Pakwach District, 23 roads from Nebbi District and 23 roads from Zombo District.

3.3.2 Sample and Sampling strategies

Purposive sampling technique was used to select 5 roads out of the 74 roads in the three districts of the greater Nebbi. All the 5 sampled roads were selected because they were roads planned for routine mechanised maintenance during the research period while other roads were planned for routine manual maintenance. From Nebbi and Zombo districts, 2 roads were sampled from each and one road was sampled from Pakwach district. Another reason for selecting these 5 roads was the different topography and soil type the roads possessed. The soil type ranges from sandy soil and clay soil in Jonam, Pakwach district, gravel soil and rocky soil in Padere, Nebbi district while gravel soil and clay soil in Okuro, Zombo District.

The 5 roads sampled, during the district road maintenance works in the Greater Nebbi included Ayila-Oweko-Erussi and Agwok-Kucwiny-Kikobe in Nebbi district, Fualwonga-Lobodegi in Pakwach district, and Omoya-Alangi and Omyo-Gamba-Congo Boarder in Zombo district.

The sample size was determined using the table 3.1 from a study by Morgan and Krejcie (1970, as cited in Amin, 2005). This therefore means that the sample will include 5 roads. The sample sizes are depicted in Table 3.1

Table 3. 1: Population Samples and Sampling Techniques

Category of population	**Population size**	**Sampling size**	**Sampling techniques**
Roads planned for routine mechanised maintenance in Nebbi district	2	2	Purposive sampling
Roads planned for routine mechanised maintenance in Pakwach district	1	1	Purposive sampling
Roads planned for routine mechanised maintenance in Zombo district	2	2	Purposive sampling
Total	**5**	**5**	

Source: Consolidated annual work-plan for Greater Nebbi region 2022-2023

3.4 Description of Study Area

The Greater Nebbi is located in North Western Region of Uganda. It is found between 200 30' and 200 45' North of the equator and 3000 45' and 3100 10' East of the Meridian bordered by the Districts of Madi Okolo in the North, Amuru and Bulisa in the East and South East respectively. The Democratic Republic of Congo (DRC) and Arua District borders it in the West and South West.

As a result of various tectonic activities, the relief is characterized by the flat lands of Jonam County gradually rising through Padyere plateau. The western arm of the rift valley is briefly seen in Panyimur and Jukia hill.

The geographic differences above have led to different soil structures thus affecting effective road maintenance arising from the loose nature of soil in Jonam County, with a combination of both loose and rocky soil formation in Padyere.

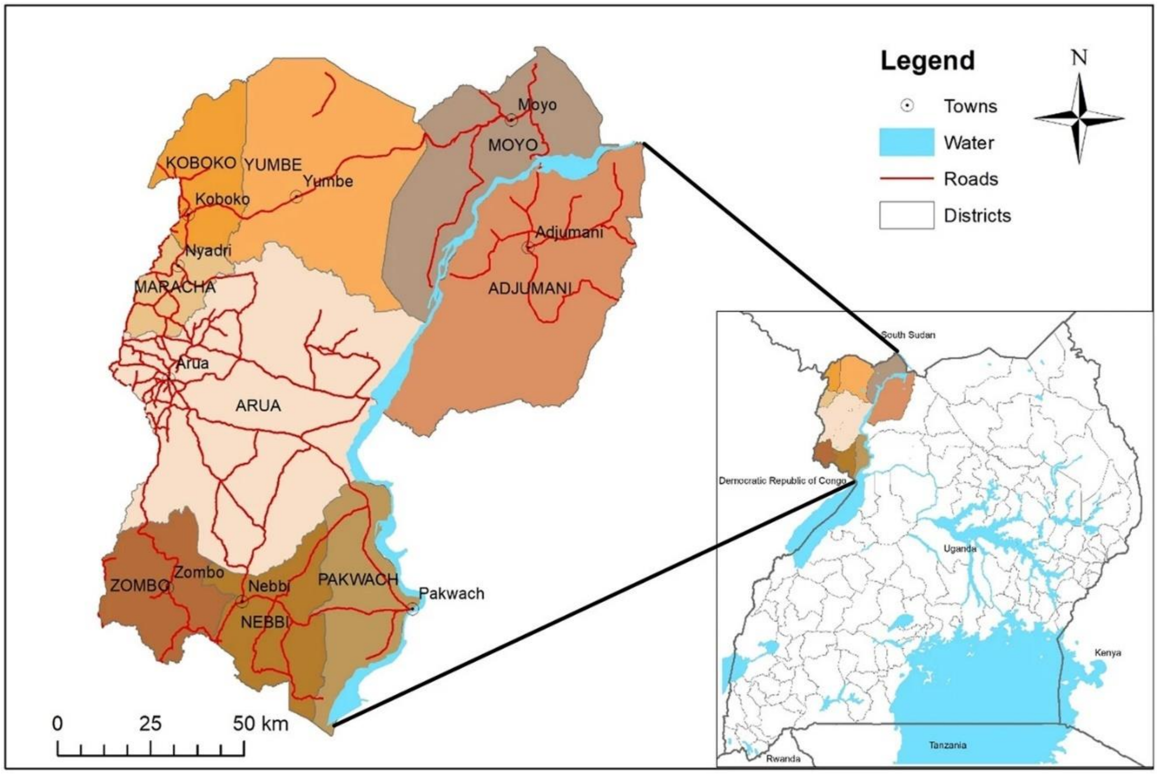

Figure 3. 1: Study Area Map (**Source:** Hermelink et al, 2023*)*

3.5 Data Collection

To ensure proper introduction, a letter from Kyambogo University was obtained and presented to the authorities at the Districts (copy of the received letter of introduction attached as Appendix A). The data collection process involved direct observations, linear measurement and the use of machine instruments to record readings of the daily field activities.

The data were collected from 5 essential activities related to road maintenance, namely bush clearing, grading and shaping, compactsion, provision of services and supervision work. Data related to bush clearing, grading and shaping were collected from motor grader, for compaction from vibro-roller, provision of service from tipper truck or pickup truck while for supervision was motor cycle or pickup truck. Copy of the data collecting tool attached as Appendix B.

3.6 Source of Data

Data were gathered from diverse sources using a combination of approaches, which will include both secondary and primary data collection methods:

3.6.1 Primary Data

Primary data for the after COVID-19 period were collected through field visits to various road maintenance sites. During these visits, data was collected through direct observation and photography. Specifically, the daily output of each road maintenance activity, the number and type of road machines used, their daily operating hours, fuel consumption, and the personnel involved in the maintenance activity were recorded. Additionally, quantities of inputs such as gravel and fill materials was collected.

The purpose of collecting these data was to determine the unit cost of plants, materials, labour, and indirect/overhead costs associated with road maintenance. This analysis was conducted for the periods before, during and after the COVID-19 pandemic.

3.6.2 Secondary Data

Secondary data for the periods before and during the COVID-19 pandemic were obtained from maintenance records of the roads under study. These records were sourced from the Road Sector within the Works Department and the Finance Department of the respective District Local Governments. The data captured key elements such as the daily output of each road maintenance activity, the number and type of road machines used, their daily operating hours, fuel consumption, and the personnel involved in the maintenance activity were recorded.

In addition, the review of secondary sources included information on fuel consumption per hour or per kilometre for various equipment, maintenance logs for the machinery, frequency of lubricant application (e.g., weekly, bi-weekly, or monthly greasing), equipment hire rates, allowances for operators and plant attendants, transport costs for mobilizing personnel to work sites, welfare provisions for the maintenance team, and costs associated with supervision and monitoring activities.

3.7 Developing Unit Rates

To develop the unit rate, for example bush clearance along the Ayila-Oweko-Erusi Road using a grader, a cost-based approach was applied by aggregating relevant cost components and standardizing them per unit length of road maintained. The formula 3.1 below was used:

$$BC_r = \frac{\sum(P_r + M_r + L_r + O_r)}{R_l} \quad \text{...(3.1)}$$

Where:

BC_r = Unit rate for bush clearance (UShs/km)

P_r = Plant unit rate (daily calculated)

M_r = Material unit rate (not applicable for bush clearance)

Lr = Labour unit rate (not applicable due to mechanized activity)

O_r = Overhead unit rate (daily calculated)

R_l = Total Road length maintained (km)

Since bush clearance was mechanized using a grader, both material and labour inputs were not considered. Therefore, the unit rate was primarily determined by plant and overhead costs.

a) *Plant Unit Rate* (P_r)

Common plant the district use for road maintenance include grader, wheel loader, vibro-roller, tipper trucks, pick-up truck and motorcycle. These plants were available in the three districts.

The unit rate for the plant was calculated by adding up the costs of fuel, lubricant, minor repairs, spare parts and operator allowance and then dividing the sum by the length of the road that was maintained by the plant under consideration.

Considering the above example of bush clearance along the Ayila-Oweko-Erusi Road, the formula 3.2 was used:

$$P_r = \frac{F_c + Lb_c + RM_c + Op_c}{L_m} \quad \text{..(3.2)}$$

Where:

F_c = Fuel cost (cost per day × quantity used)

Lb_c = Lubricant cost (daily cost of lubricants)

RM_c = Repair and maintenance cost

Op_c = Operator's and plant attendant's wage or allowance

L_m = Road length maintained per day (km)

Fuel cost for a plant was calculated from the quantity of fuel utilized multiplied by the fuel pump prices for that day. Obtaining accurate quantity of fuel utilized from the plant fuel meter reading gauge was a challenge as the instruments would read in quarters, halves, three quarters and full. Therefore, it was found necessary to use the plant hour meter reading and then subtracting the reading at the beginning of the day from the reading at the end of the day to determine the total number of hours the plant had been operating which was then multiplied by the fuel consumption rate of the plant.

Lubricant cost was calculated from the quantity utilised multiplied by the unit price of the lubricant. Costs of all the different lubricants utilized were then added up for a plant under consideration.

Cost of repair and spare parts was also calculated by adding labour cost of repair and the cost of the spare parts replaced. Common minor repair included tyre repair and replacement of consumable parts such as grader cutting blade and wheel loader bucket teeth.

Operators, drivers and plant attendants were paid SDA (Safari Day Allowances) of UShs 11,000/= was increased to Night Allowance of UShs 55,000/= after the COVID-19 pandemic as they are to be stationed at the sites. This amount also was being paid after the pandemic. Turn-man were paid SDA of UShs 11,000/=.

b) *Material and Labour Unit Rate*

Materials and labour were not considered as only cross cutting elements of unit cost that applied to all the districts were considered.

c) *Indirect/Overhead Cost* (O_r)

Indirect cost was mainly cost of supervision and provision of services during the road maintenance. Cost of supervision included SDAs paid to Road Inspector, Road Overseer and drivers not station at site and turn-man were paid SDAs of UShs 11,000/=.

Considering the above example of bush clearance along the Ayila-Oweko-Erusi Road, the formula 3.3 was used:

$$O_r = \frac{S_a+D_a+F_c+W_c}{L_m} \qquad (3.3)$$

Where:

S_a = Supervision allowance (inspectors and overseers)

D_a = Drivers' and turn-man's allowances for supply logistics

F_c = Fuel costs for supply transportation

W_c = Welfare costs for the road crew

L_m = Road length maintained per day (km)

3.8 Data Analysis

The collected field data were analysed using Microsoft Excel 2021, which offers a data analysis package specifically designed for research data analysis. The analysis involved utilizing both descriptive and inferential statistics. To test for statistically significant differences between means, the field data were subjected to a t-Test: Paired Two Samples for Means. The null hypothesis (H0) was evaluated at 5% significance level. The H0: There is no difference between the means of the data of "During" 2019/20 and "After" 2022/23 was accepted in each if and only if the p-value of the test statistic is greater than the significant level, otherwise reject the null hypotheses. The need for the test for difference is to access the impact of the eventualities on unit rates for plants, labour, materials and indirect cost on road maintenance.

3.9 Road characterisation

To address this research question, the researcher obtained field data by observing the physical and functional characteristics of roads. The roads were categorized based on both their physical characteristics, including terrain, climate, soil type and drainage condition, and their functional characteristics, such as road class, level of service and road condition.

3.9.1 Physical Characteristics

a) *Terrain:* Terrain type was categorised as flat, rolling or hilly terrain.
b) *Climate:* Climatic condition was categorised as wet or dry.
c) *Soil Type:* Soil type was categorised as sandy, gravel or clay soil.
d) *Drainage Condition:* Drainage condition was categorised as good, fair or poor.
e) *Road surface:* Road surface type was categorised as earth or gravel surfaces.

3.9.2 Functional Characteristics

a) *Road class:* The roads class was categorised as District Class II Road or District Class III roads.
b) *Level of service:* The level of service was classified as High, Medium, or Low. District Class II roads was categorized as having a Medium level of service, while District Class III roads was classified as having a Low level of service.
c) *Road Condition:* Road condition was categorized as good, fair, or poor. A road was considered to be in good condition when routine grading and spot repairs are sufficient. Fair condition was for the roads that has notable defects and requires reshaping or resurfacing (re-graveling) as well as spot repairs on drainage. On the other hand, poor condition was for roads having extensive defects, necessitating immediate reconstruction and major drainage works.

3.10 Developing a maintenance framework for routine road

To develop the framework for routine road maintenance for a decision-making, a logical, decision-tree-based approach was formulated to guide how unit rates would be revised. This involved mapping out potential decision points, such as monitoring SOPs, price changes, and road conditions. Statistical methodologies, like the Student t-Test for paired samples, were incorporated to assess whether price variations were significant enough to justify changes in unit rates.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the analysis of data collected from the field by direct observations, linear measurement and machine instrument readings for the daily field activities. The findings are analysed and presented in form of numerical results and percentages for comparison of the unit rates.

4.2 Empirical Findings

This part of the study presents in line with the study variables that are a basis of study objectives. The section presents analyses and interprets linear measurement and machine instrument readings for the daily field activities and analysis from direct observation collected using observation checklists.

4.2.1 Identified Road Characteristics

The physical characteristic identified were terrain, climatic conditions, soil type, drainage condition and road surface type. The functional characteristics identified were road class, level of service and road condition.

Table 4.1 shows characteristics of roads. In Pakwach the roads are of the nature that can be described to be predominantly rolling to flat. In Nebbi, the terrain varies from hilly to rolling and flat. On the other hand, the roads in Zombo are generally characterized as rolling. In terms of climatic conditions, road maintenance activities took place during both wet and dry seasons for the majority of the roads (80%). However, Agwok-Kucwiny-Kikobe road was specifically maintained during the dry season, making it an exception. In relation to road class, all the roads (100%) in question were classified as district class II roads and they were in a poor condition. The level of service for 80% of the roads was classified as medium, as they were existing district roads. However, one specific road, Fualwonga-Lobodegi, had a low level of service because it was originally a community road that was upgraded to a district road.

The soil types in Pakwach, Nebbi and Zombo were found to be sandy, gravel and clay, respectively. However, all the roads had poor drainage conditions, and the road surfaces were entirely composed of unpaved earth.

Table 4. 1: The Road Characteristics

		Physical Characteristics					Functional Characteristics		
District	**Road**	**Terrain Type**	**Climatic Condition**	**Soil Type**	**Drainage Condition**	**Road Surface**	**Road Class**	**Level of Service**	**Road Condition**
Pakwach	Fualwonga-Lobodegi	Rolling to Flat	Wet and dry	Sandy	Poor	Earth	Class II	low	Poor
Nebbi	Ayila-Oweko-Erussi	Hilly to Rolling	Wet and dry	Gravel	Poor	Earth	Class II	Medium	Poor
Nebbi	Agwok-Kucwiny-Kikobe	Flat	Dry	Gravel	Poor	Earth	Class II	Medium	Poor
Zombo	Omua-Alangi	Rolling	Wet and dry	Clay	Poor	Earth	Class II	Medium	Poor
Zombo	Omoyo-Gamba-Congo Border	Rolling	Wet and dry	Clay	Poor	Earth	Class II	Medium	Poor

Source: Primary Data, (2023)

Table 4.2 shows information on road maintenance cost and associated characteristics. A road with rolling terrain type was found to be more expensive to maintain than roads with Hilly and flat terrain types. The differences in the costs of maintaining a road in rolling and hilly, rolling and flat, and hilly and flat terrains were UShs 872,926, UShs 981,651, and UShs 108,725, respectively.

Roads maintained during wet season tended to be more expensive than roads being maintained in dry season. The differences in the costs/km of maintaining a road during dry condition was 53.9% of that for wet season. Therefore, this indicates that road maintenance works should mostly be scheduled in dry season to avoid over expenditure.

The study also found out that those roads with soil clay type tend to be more expensive to maintain than roads with sand and Gravel soil types. The costs of maintaining roads in sandy and gravel road as a percentage of that for clay soil were found to be 40% and 37%, respectively. Thus, when planning for road maintenance consideration of soil type is very important to ensure that appropriate cost is attached depending on the soil type.

Drainage conditions were found to be crucial characteristics for consideration when budgeting for road maintenance. Roads with poor drainage were as expected found to be very expensive to maintain compared to roads with good drainage condition. The cost of maintaining road with poor drainage was found to be 61.5% of that with good drainage.

In summary, physical characteristics such as soil type, drainage condition, and road surface were found to be critical and affecting road maintenance cost. Physical characteristics can be good predictors of road maintenance cost and should be considered in planning of road maintenance.

Maintaining a road in high level of service is more expensive than for the cases of low and medium service levels. The costs of maintaining roads in low and medium service level were respectively 42% and 71% of that for high level of service. In the study all the 5 roads were having poor road conditions.

Table 4. 2: Road characteristics and maintenance cost

Road characteristics	Description	Average Road maintenance cost/km (UGX)
Physical		
Terrain	Rolling	1,801,146
	Hilly	928,220
	Flat	819,495
Climatic condition	Wet	1,582,915
	Dry	729,325
Soil type	Sandy	909,665
	Gravel	828,773
	Clay	2,246,886
Drainage condition	Poor	1,412,197
	Good	869,219
Road surface	Earth	1,412,197
Functional		
Road class	Class I	
	Class II	1,412,197
Level of service	Low	909,665
	Medium	1,537,830
	High	2,165,995
Road condition	Poor	1,412,197
	Good	869,219

Source: ***Primary data 2022***

4.3 The impact in change of unit rate before, during and after COVID-19

Unit rate component for Bush Clearing (BC), Grading and Shaping (G&S), Compaction (Com), Service Van (SV), and Supervision (Sup) for the periods before, during and after the COVID-19 pandemic for the 5 road have been summarized in Table 4.3.

The data show a clear trend of increasing costs for all road activities during and after the COVID-19 pandemic. For every selected activity, the cost was greater during and after COVID-19 pandemic.

Comparatively, the cost of BC and G&S activities shows significant increases with average of 15.86% during and 47.48% after the pandemic for BC, and 15.54% during and 44.8% after the pandemic for G&S. These substantial increases can be attributed to factors such as labour shortages, increased material costs and logistical challenges during the pandemic caused by lockdown and restriction in movement.

Com also saw notable increases, especially for roads that initially had no costs, indicating the resumption of previously halted activities and the impact of delayed maintenance. The SV costs showed moderate increases, reflecting the operational challenges and increased transportation costs during and after the pandemic.

Sup costs remained relatively stable during the pandemic but increased after the pandemic, possibly due to the need for enhanced oversight and quality assurance as activities resumed at a higher pace.

In summary, the COVID-19 pandemic had a significant impact on the costs of road activities, with notable increases in all categories. These findings highlight the importance of contingency planning and flexible budgeting to accommodate unforeseen events that can disrupt infrastructure projects.

Table 4. 3: Unit rate components for 5 roads before, during and after COVID-19

Road activities	Roads	Before (UGX)	During (UGX)	Before-During Percentage Increase (%)	After (UGX)	Before-After Percentage increase (%)
Bush Clearing (BC)	1	216,406	254,181	17.5	360,541	66.6
	2	210,639	220,037	4.5	318,632	51.3
	3	465,617	520,625	11.8	793,283	70.4
	4	405,217	500,323	23.5	793,283	95.8
	5	152,481	186,053	22.0	260,116	70.6
Average		**290,072**	**336,244**		**505,171**	**74.2**
Grading & Shaping (G&S)	1	253,700	300,706	18.5	424,954	67.5
	2	285,214	350,551	22.9	472,095	65.5
	3	656,338	702,997	7.1	1,094,979	66.8
	4	665,833	720,979	8.3	1,094,979	64.5
	5	250,722	303,236	20.9	425,362	69.7
Average		**422,361**	**475,694**		**702,474**	**66.3**
Compaction (Com)	1	160,413	224,342	39.9	299,607	86.8
	2	188,940	234,568	24.1	317,058	67.8
	3	0	0		0	
	4	0	0		0	
	5	112,442	188,060	67.3	236,140	110.0
Average		**92,359**	**129,394**		**170,561**	**84.7**
Service van (SV)	1	1,755	2,906	65.6	3,492	99.0
	2	9,469	8,946	-5.5	12,886	36.1
	3	6,203	6,164	-0.6	9,186	48.1
	4	6,203	6,164	-0.6	9,186	48.1
	5	7,276	7,296	0.3	10,345	42.2
Average		**6,181**	**6,295**		**9,019**	**45.9**
Supervision (Sup)	1	1,165	1,137	-2.4	1,415	21.5
	2	1,805	1,762	-2.4	2,031	12.5
	3	3,999	3,999	0	4,889	22.3
	4	3,999	3,999	0	4,889	22.3
	5	987	978	-0.9	1,125	14.0
Average		**2,391**	**2,375**		**2,870**	**20.0**

Source: Primary data

***KEY*:** 1 = Ayila-Oweko-Erussi road, 2= Fualwonga-Lobodegi road 3= Omua-Alangi road 4= Omoyu-Gamba-Congo Boarder Road and 5= Agwok-Kucwiny-Kikobe road

4.3.1 Characteristics of unit rate of 5 roads before, during and after COVID-19

Figure 4.1 (a): Consideration of unit rate of activities before, during and after COVID-19 for Ayila-Oweko-Erussi road. Across this road, all activities except supervision were found to have notable cost increases during and after the COVID-19 pandemic. This highlights the substantial economic impact of the pandemic on construction and maintenance work. The SV activity recorded the most significant increase during COVID-19, with a 65.6% rise, highlighting the sharp logistical and transportation costs. Com and BC also showed considerable increases. After the pandemic, the upward trend in costs continued, particularly in BC and G&S, likely due to ongoing supply chain disruptions, labour shortages, and increased demand for construction materials.

For Fualwonga-Lobodegi Road, Figure 4.1 (b), indicates a broad increase in costs across most activities before, during and after COVID-19, reflecting the widespread economic effects of the pandemic. Significant cost rises were observed in BC and Com activities, especially after the pandemic. These increases could be attributed to higher labour costs, increased fuel prices, and persistent supply chain issues. Interestingly, the SV activity initially saw a cost decrease during the pandemic but then experienced a sharp rise afterward, possibly due to reduced demand during the pandemic and a subsequent surge during recovery.

While for Omua-Alangi Road, Figure 4.1 (c), there were substantial cost increases for BC, G&S, and SV activities after COVID-19, supporting trends of rising industry costs due to inflation, supply chain disruptions, and labour shortages. However, unlike other roads, the unit rates for SV and Sup activities remained relatively stable during the pandemic, with minimal changes observed. This stability suggests that these activities were less impacted initially, with the significant cost hikes emerging during the recovery phase due to increased demand for construction materials and labour.

Omoyo-Gamba-Congo Border Road, Figure 4.1 (d), also experienced significant cost increases in BC, G&S, and SV activities after COVID-19. These rises are consistent with industry trends, where costs surged during the post-pandemic economic recovery due to supply chain issues and inflation.

Similar to the Omua-Alangi road Figure 4.1 (c), the unit rates for SV and Sup activities remained stable during the pandemic, suggesting effective cost management or lower initial impact. The substantial cost increases post-pandemic indicate that the full economic effects were delayed, likely due to heightened demand and inflation during the recovery.

For Agwok-Kucwiny-Kikobe Road, Figure 4.2 (e), there were notable cost increases in BC, G&S, and SV activities after the pandemic, reflecting the broader economic impact of post-pandemic recovery. This trend reflects the rising costs seen across other roads due to ongoing supply chain disruptions, increased demand and inflation. The stability in SV and Sup activity costs during the pandemic suggests these activities were less immediately affected or were effectively managed. However, the sharp cost rise afterward, particularly in BC and G&S, indicates that the economic impact was more obvious during the recovery phase, driven by increased demand, supply shortages and inflation.

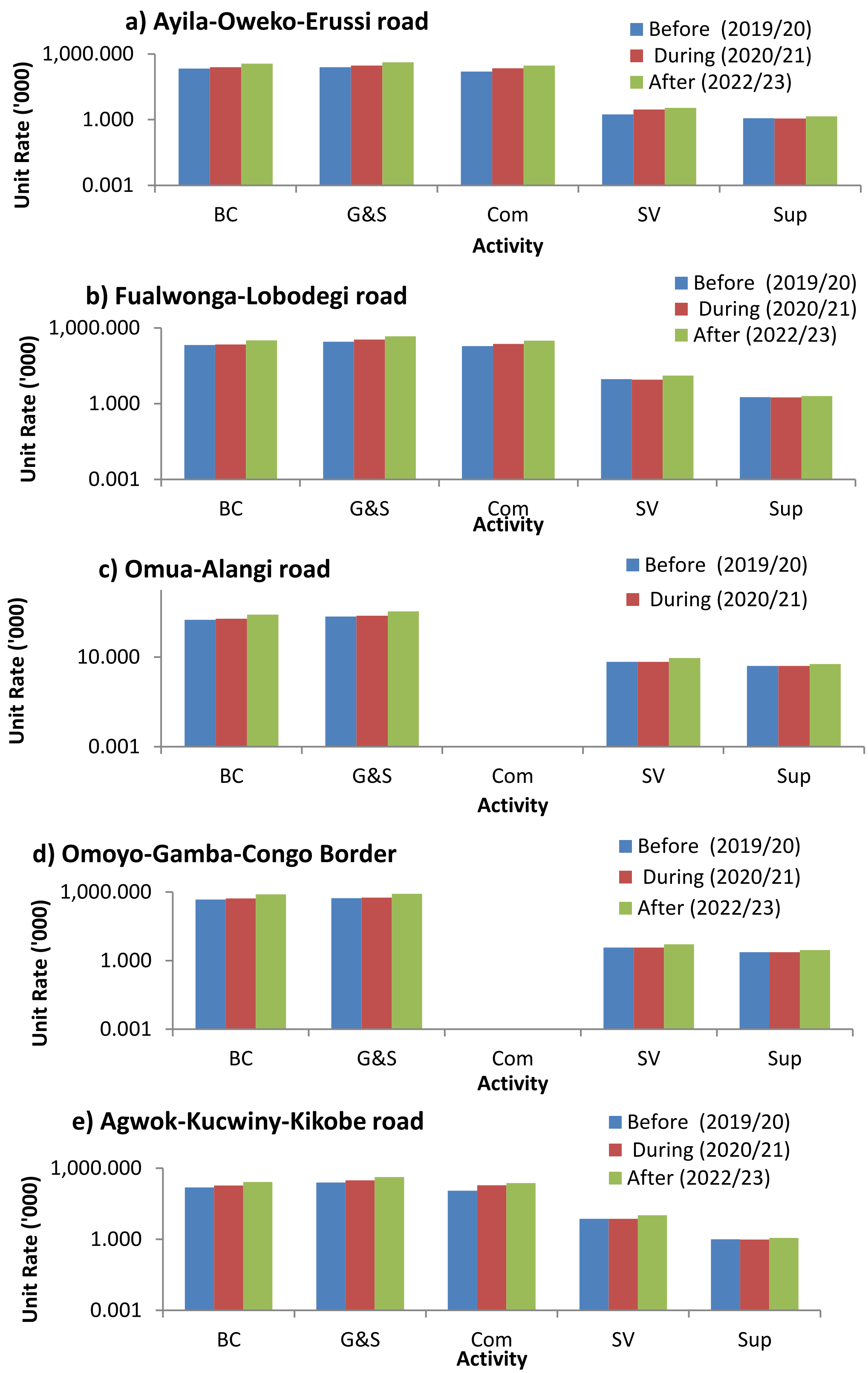

Figure 4. 1: Changes in unit rates for before, during and after COVID-19

Figures 4.2 Average unit rate of activities before, during and after COVID-19 for the 5 roads indicated that all the 5 sampled roads had a steady increase in the unit rate of activities: Bush Clearing, Grading & Shaping and Compaction when their unit rates are compared for before, during and after COVID-19. Therefore, this indicated that before COVID-19 unit rates of these activities were lower and cheaper.

Activities of service Van and supervision unit rates explained the contrary, when during, and after COVID-19 unit rates of these two activities were compared to that of before, the results indicated slight increase with minor fluctuations due to increased unit rates of Plant, labour, materials and Indirect Cost in the entire 5 roads during the during and after time periods. But the supervision cost was greatly affected due to restriction of people across the country. Hence a decrease in unit rate of supervision. In conclusion COVID-19 greatly impacted on road activity unit rates that led to increased road maintenance cost after the pandemic.

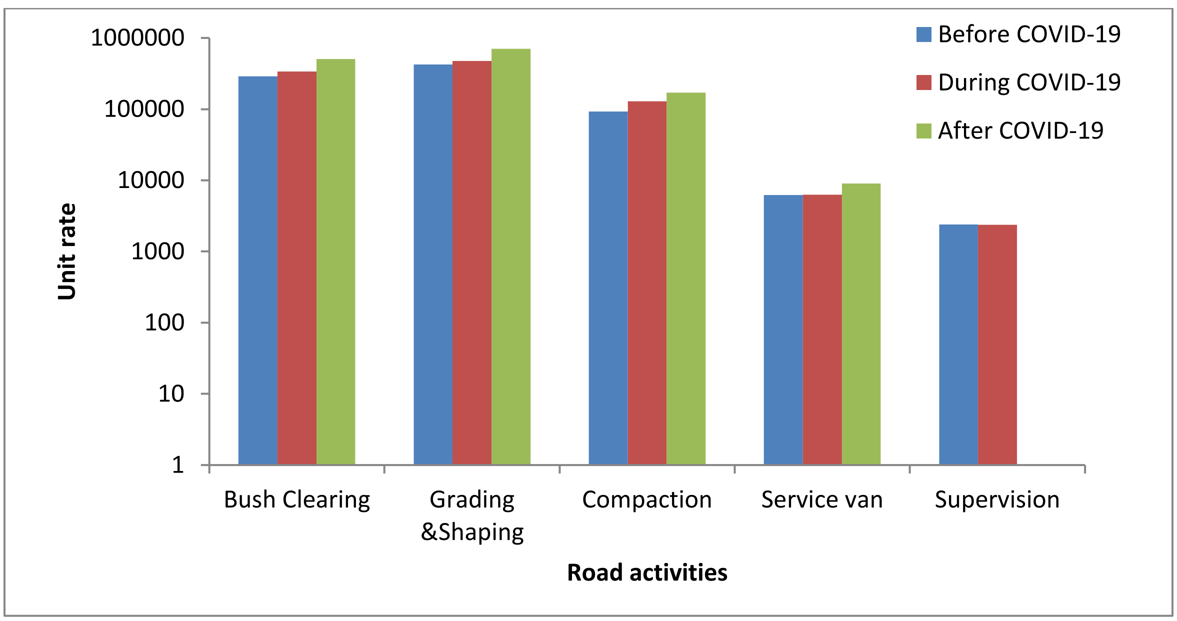

Figure 4. 2: Average unite rate of activities before, during and after COVID-19

4.4 Statistical mean differences in the unit rate of before and after the COVID-19

To address this research question, the student t-test was used to examine whether there was statistical mean difference between unit rate before and after COVID-19 Pandemic. Figure 4.3 is summary of Student t-Test: Paired Two Sample for Means. The analysis of p-values across the five road activities reveals that most activities experienced statistically significant differences before, and after COVID-19, as indicated by the cells in green colour. This suggests that the pandemic had a significant impact on the unit rates of various road maintenance activities. However, the p-values for the road 2), Fualwongo-Lobodegi in the "Grading & Shaping" and "Compaction" activities, and road 5), Agwok-Kucwiny-Kikobe in the "Service Van" activity, were not statistically significant (red cells), indicating that for these specific activities and roads, the differences were not as pronounced.

The results also highlight that activities such as "Bush Clearing" and "Grading & Shaping" consistently showed significant differences across all roads, reflecting widespread impacts of the pandemic on these particular activities. Equally, "Supervision" and "Service Van" had more mixed results, with some roads showing significant differences and others not, suggesting variability in how the pandemic affected these activities across different locations. Overall, the data indicate that while the pandemic universally impacted road maintenance costs, the degree of impact varied by activity and location.

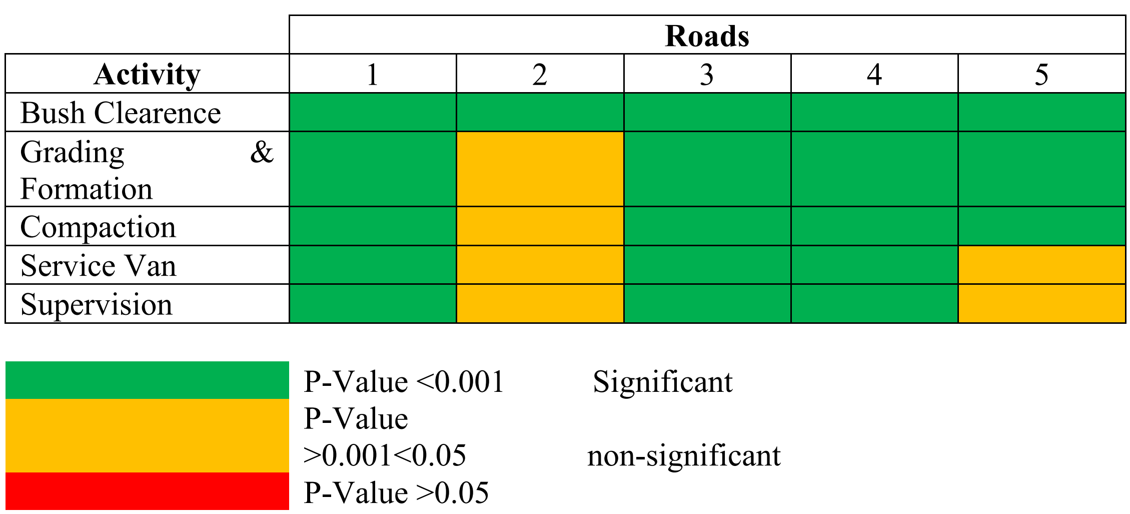

Figure 4. 3: The t-test results across the 5 roads activities and 5 roads

4.5 Incorporate impact of COVID-19 into road maintenance framework.

Figure 4.4 shows the framework outlining a structured process for revising the unit rates of road maintenance by considering various influencing factors including impact of COVID-19. The key steps involve are:

4.5.1 Invitation of Road and Works Committee

The framework begins by the Chief Administrative Officer (CAO) inviting the committee member on roads and work and technical service immediately after a pandemic has been declared by the Ministry of Health working in coordination with the World Health Organization (WHO). For an official declaration of a health crisis, it may be the President of Uganda to issue directives in response to recommendations from the Ministry of Health, which can include emergency measures and public health mandates.

The road committee comprised of the Members of Parliament who at national level would be in the know of the pandemic, the District Chairperson, The Mayor (Municipal Chairperson), Chief Administrative Officer, Town Clerk, District Engineer, Town Engineer and representative from UNRA.

While works Committee comprised the district councilor selected on the standing committee of works and technical services.

4.5.2 Formation of Ad Hoc Committee

An ad hoc committee is set up to monitor changes in the price of materials and labour, with subsequent decision point on whether price changes has occurred. The committee plays a critical role in ensuring accurate, timely and fair adjustments to unit rates.

a) Composition of the committee

A committee of around 8-9 members is ideal, as it ensures sufficient diversity of expertise without becoming too large for efficient decision-making. The committee should consist of a multidisciplinary team with the following members to ensure comprehensive coverage of all aspects affecting road maintenance costs:

i) Civil Engineers (2-3 members):

The District Engineer and the Town Engineer who are experts in road construction and maintenance must be in this committee. They understand the practical implications of material and labour price changes on road projects, particularly in terms of construction techniques and material selection.

ii) Quantity Surveyors (2 members):

These should be appointed in this committee as they have specialized in cost estimation and financial analysis, they ensure that changes in material and labor costs are accurately reflected in the budget. They also help calculate unit rates and ensure they align with industry standards.

iii) Procurement Specialists (1 member):

The District procurement officer must be appointed in this committee. He helps to tracks market trends and fluctuations in the prices of materials and labor. His insights into supply chain dynamics help the committee make informed decisions regarding price changes.

iv) Economists or Financial Analysts (1 member):

The District Planner should also be appointed to this committee. His role is to analyze macroeconomic factors like inflation, exchange rates, and price indices. He ensures that material and labor price changes are contextualized within broader economic conditions, particularly inflation.

v) Legal/Compliance Experts (1 member):

The District Court Prosecutor should also be appointed to this committee. His work is to ensure that all adjustments to unit rates comply with government regulations, contractual obligations, and any other regulatory framework in place.

vi) Representatives from Service providers (1 member):

A member from the public sector who is a service provider should also be appointed to this committee to ensure that decisions are aligned with national policies and public interests.

b) Output of the Committee

The primary output of the committee should be:

i) Reports on Price Changes

A comprehensive report outlining changes in material and labor costs, supported by data and analysis.

ii) Recommendations for Adjusting Unit Rates

Based on the price changes, the committee would propose adjustments to the unit rates for road maintenance, including detailed justifications.

iii) Economic Impact Assessments

A report detailing the broader economic implications of price changes, including potential inflationary pressures or supply chain constraints.

iv) Cost Forecasts

Forecasting how price changes may evolve in the near future to allow proactive adjustments to budgets.

c) Authority to Submit the Report

The committee should submit its report to the Road and Works committee. If a contractor was procured for the road maintenance work, the report should also be submitted to the contract committee who awarded the contract.

d) Duration of the Assessment

The committee should continuously monitor prices but produce formal reports on a quarterly basis or as often as major price shifts occur. The pandemic could cause rapid price fluctuations, requiring frequent assessment.

e) Duration of Committee's Operation

The committee should remain active until market conditions stabilize and prices return to predictable patterns. Even after the pandemic, it may be useful to maintain the committee (perhaps on a less frequent basis) to monitor other economic factors that could affect prices, like inflation.

f) Inflation Rates

The committee should take inflation into account when assessing price changes. The District Planner in the team should relate material and labor cost changes to broader economic indicators, ensuring that adjustments to unit rates are justified not just by market-specific factors but also by inflationary pressures. For instance, if prices are increasing at a higher rate than inflation, it could indicate supply chain disruptions or local shortages that the committee needs to address in their recommendations.

The committee may also propose cost escalation clauses or inflation-indexed adjustments in future contracts to manage price volatility.

4.5.3 Initial Review of SOPs and Policies

The Ad Hoc Committee formed would be responsible for reviewing the SOPs, policies, and regulations issued during the pandemic. The committee should carefully assess how these guidelines affect the costs and timelines of road maintenance projects considering the following factors:

a) Health and Safety Protocols

New health and safety measures, such as social distancing, mandatory personal protective equipment (PPE), and frequent sanitization requirements, increase labor and operational costs. These additional requirements need to be factored into unit rates.

b) Labour Availability and Workforce Restrictions

Pandemic-related restrictions (for example lockdowns, quarantines, or workforce reductions due to health issues) affect labour availability. This could lead to higher labor costs due to reduced productivity or the need to hire additional workers.

c) Supply Chain Disruptions

The global supply chain was heavily disrupted during COVID-19, affecting the availability of key materials like cement, asphalt and steel. This resulted in material shortages and price hikes, which must be factored into unit rate adjustments.

d) Logistics and Transport Costs

Movement restrictions increased the cost of transporting materials to work sites. Extended lead times and increased freight costs, including handling delays at borders, added extra expenses to material procurement.

e) Regulatory Compliance Costs

Governments may have issued new regulations specific to construction and infrastructure sectors during COVID-19, such as revised environmental guidelines or social distancing rules on construction sites. The cost of complying with these new rules can increase operational overheads.

4.5.4 Evaluation of Road Maintenance Progress

Concurrently, all roads planned for maintenance are assessed to see if road works are already in progress. If so, the physical and functional characteristics of the roads are evaluated.

4.5.5 Functional and Physical Characteristics Assessment

The functional characteristics (such as road class, level of service, and road condition) and the physical characteristics (such as terrain, climate, soil type, drainage and surface type) are examined.

4.5.6 Final Decision

Based on the evaluation, if there are statistically significant difference in unit rates, these are factored in to revise the unit rates for road maintenance. Such revisions could be implemented consider the different levels - District, Regional and National. Each level to have a specific requirements and implications for successful implementation.

At the District level, the road and work committee, after having received the ad hoc committee report recommending revision of unit rate for road maintenance, presents it to district executive or district council for discussion and approval. Once approved, its pass on to the District Engineer for implementation. This revision should be shared with URF and MoWT for their updates of information and alignment with national standards.

At regional level and national level, the MoWT should lead the initiative, closely collaborating with District Local Governments to ensure alignment with local needs and realities.

MoWT could begin by conduct pilot tests in selected districts to refine the framework, ensuring that the approach is practical and scalable. These could be further supported by developing national-level policies and guidelines for district implementation, ensuring that there is a standardized approach while allowing local flexibility where needed. Meanwhile, MoWT could under Training and Capacity Building for district-level personnel to effectively monitor and revise unit rates.

All this can be possible by budget allocation and financial Support to ensure adequate national funding support, especially for districts that lack resources for comprehensive data collection and analysis.

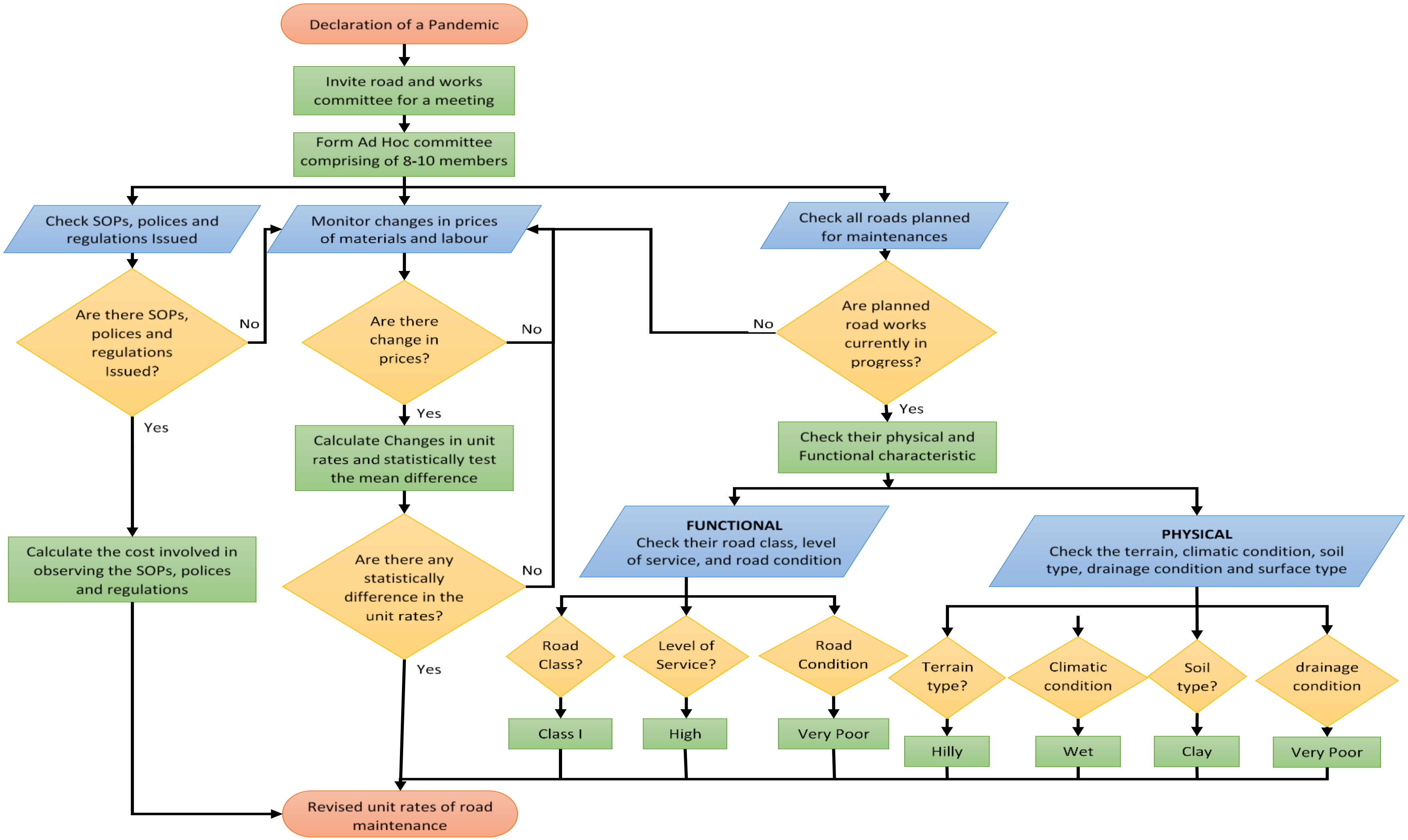

Figure 4. 4: Framework Outline

This framework provides a logical and systematic approach to revising road maintenance unit rates, ensuring that any changes in costs are addressed promptly and factually. The inclusion of SOPs and policies reflects the need to comply with regulatory requirements, while the committee's monitoring role ensures that any shifts in economic conditions (for example, inflation or supply chain disruptions) are tracked and accounted for.

One of the key strengths of this framework is the integration of both statistical and functional assessments. The statistical test for mean differences ensures that decisions are data-driven, reducing the likelihood of arbitrary or unjustified rate adjustments. Meanwhile, the physical and functional characteristics evaluation helps tailor the unit rates specifically to the conditions of each road, ensuring that the revisions are contextually appropriate.

The framework also emphasizes the need for thorough checks before implementing any revisions, preventing premature decisions based on incomplete information. This ensures a robust and comprehensive approach to maintaining road quality while controlling costs.

4.6 Chapter Summary

To summarize, the study yielded the following key findings:

a) The unit rate cost of road maintenance in the Greater Nebbi is influenced by the physical characteristics of the roads, while the functional characteristics remain consistent across all roads.
b) In the Greater Nebbi area, the maintenance cost per kilometre of roads is influenced by specific physical characteristics such as terrain, climatic conditions, and soil type. It was observed that these factors varied across different roads within the region. However, it was noted that the drainage conditions and soil type remained consistent across all the roads surveyed.
c) Before, during and after the COVID-19 pandemic, the unit rates for bush clearance, grading and supervision were found to be higher in Zombo compared to Nebbi and Pakwach.

d) During the assessment, it was noticed that roads in Zombo were maintained without undergoing compaction. Additionally, it was found that the unit rate for compaction was higher in Nebbi compared to Pakwach.
e) Service van is a requirement for any road maintenance activity
f) Statistically significant differences were found in the unit rate before and after the COVID-19 pandemic.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The objective of this study was to assess the influence of COVID-19 on routine road maintenance carried out by the Local Government in Greater Nebbi. The research was conducted in three districts: Pakwach, Nebbi, and Zombo DL. This chapter presents the researcher's findings and draws conclusions, followed by policy recommendations aligned with the specific objectives of the study. Additionally, areas for further research are identified. The first section outlines the conclusions, followed by recommendations that address the specific objectives of the study.

5.2 Conclusions of the Study

5.2.1 Maintenance Cost per Kilometre

The study concluded that;

a) Unit rates for bush clearance, grading and shaping, and supervision were consistently higher in Zombo compared to Nebbi and Pakwach, both before, during and after the COVID-19 pandemic;
b) Roads in Zombo were maintained without undergoing compaction, which could have contributed to the cost differences;
c) The unit rate for compaction was higher in Nebbi compared to Pakwach; and
d) A service van is an essential requirement for any road maintenance activity.

5.2.2 Road Characteristics Which Affect Maintenance Cost

The study concluded that;

a) The unit rate cost of road maintenance in the Greater Nebbi region is primarily influenced by the physical characteristics of the roads. Factors such as terrain, climatic conditions and soil type were found to have varying effects on the maintenance cost per kilometre of roads within the area;

b) The drainage conditions and soil type remained consistent across all the surveyed roads; and
c) When estimating and planning for road maintenance costs in the Greater Nebbi region, its importance to considering specific physical characteristics.

5.2.3 Impact in change of unit rate of road maintenance on cost per kilometre before, during and after COVID-19 pandemic

The study concluded that there was significant increase in the maintenance cost per kilometre in the greater Nebbi region following the COVID-19 pandemic. This finding highlights the impact of the pandemic on road maintenance expenses, suggesting that the pandemic has led to increased costs associated with maintaining the road infrastructure in the area.

5.2.4 Framework for road maintenance that incorporates impact of COVID-19

From the framework, the study concluded the followings especially regarding the structured process for revising unit rates in road maintenance in response to a pandemic:

a) Systematic Approach to Cost Management

The framework offers a structured approach to revising unit rates, which ensures all cost factors, such as SOPs, regulations, and price changes in materials and labour—are systematically reviewed before any adjustments are made. This helps prevent arbitrary or unaccounted cost increases, fostering transparency and accountability in budget management.

b) Comprehensive Assessment of Influencing Factors

By incorporating checks for SOPs, policies and regulations, as well as physical and functional road characteristics, the framework ensures a comprehensive evaluation of all factors that may impact maintenance costs. This includes health and safety requirements, environmental compliance and road conditions, leading to a nuanced adjustment of unit rates specific to each road's needs.

c) Importance of Interdisciplinary Collaboration

The formation of an Ad Hoc Committee is a critical step, bringing together experts from fields like civil engineering, quantity surveying, procurement, and economics. This interdisciplinary team enables a balanced perspective on both technical and economic aspects of maintenance costs, leading to well-informed, data-driven recommendations for unit rate adjustments.

d) Proactive Monitoring of Material and Labour Prices

The framework underscores the importance of ongoing price monitoring. By establishing a decision point to track changes in material and labour prices, the framework allows for timely adjustments, preventing cost escalations that could otherwise impact project viability. This proactive monitoring is especially relevant in volatile economic conditions where inflation, supply chain disruptions, or currency fluctuations might affect prices.

e) Incorporation of Statistical Analysis

The inclusion of statistical testing for mean differences in unit rates reflects a commitment to data-driven decision-making. This step ensures that any adjustments to unit rates are not only based on observed changes but are also statistically significant, adding accuracy and credibility to the decision-making process.

f) Alignment with Regulatory and Policy Changes

By making the review of SOPs, policies and regulations a foundational part of the framework, it ensures that unit rate adjustments remain compliant with current legal and safety standards. This step minimizes the risk of project delays or penalties related to non-compliance and underscores the importance of regulatory alignment in infrastructure maintenance.

g) Tailored Approach to Different Road Conditions

The framework consideration of both functional and physical characteristics of roads, such as road class, condition, terrain type, and climatic factors, allows for unit rate adjustments that are tailored to the specific needs of each road. This customization promotes efficiency, ensuring that resources are allocated based on actual conditions rather than a one-size-fits-all approach.

h) Enhanced Budget Accuracy and Financial Sustainability

By incorporating detailed assessments at each decision point, the framework facilitates accurate budgeting and financial planning. With adjustments based on real-time data and compliance with SOPs and policies, maintenance budgets can better reflect actual costs, enhancing financial sustainability and ensuring that projects are completed within allocated resources.

i) Support for Long-term Cost Management

The systematic approach outlined in the framework, including continuous monitoring and periodic reviews, supports sustainable long-term cost management. The framework allows for incremental adjustments that align with economic trends, mitigating the impact of inflation and other macroeconomic changes on maintenance costs over time.

5.3 Summary Conclusion

The framework provides a robust structure for revising road maintenance unit rates, focusing on comprehensive assessment, proactive monitoring, interdisciplinary collaboration, and regulatory alignment. This structured approach ensures that unit rates remain fair, accurate, and responsive to dynamic economic conditions, promoting both the financial viability and operational efficiency of road maintenance projects. By addressing specific needs of each road segment, this framework supports informed decision-making that benefits both project stakeholders and the communities relying on these vital infrastructure assets.

5.4 Future research

It is suggested that future investigations should develop a predictive model that account for the effects of global disruptions (such as pandemics) on supply chains and inflation could help road maintenance authorities anticipate cost changes. These models could use historical data from COVID-19 and previous economic shocks to forecast material and labour price trends and guide proactive budgeting strategies.

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APPENDICES

Appendix A; Letter of Introduction

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Website :www.kyu.ac.ug, Email: drgt@kyu.ac.ug
Directorate of Research and Graduate Training
Office of the Director

Date: 16/11/2022

CHIEF ADMINISTRATIVE OFFICER
NEBBI DISTRICT LOCAL GOVERNMENT
18 NOV 2022
REGISTRY
P. O. BOX 1, NEBBI

TO WHOM IT MAY CONCERN

RE: ......KURI JAMES 16/11/2022......

Dear Sir/Madam,

This is to introduce to you the above named student Reg: No 20/U/GMEZ/13137/PE pursuing MASTERS OF SCIENCE IN CONSTRUCTION TECHNOLOGY Department of CIVIL AND ENVIRONMENTAL ENG., Kyambogo University.

She/he intends to carry out research on INCORPORATING IMPACT OF EXTERNALITIES IN ROAD MAINTENANCE TOOL FOR LGs in partial fulfillment of the requirements for the award of MASTERS OF SCIENCE IN CONSTRUCTION TECHNOLOGY AND MANAGEMENT

The purpose of this letter therefore is to request you to grant him/her permission to carry out his/her study in your institution.

Any assistance rendered to him/her will be highly appreciated.

Yours sincerely,

Prof. Bosco Bua
AG. DIRECTOR

KYAMBOGO UNIVERSITY
16 NOV 2022
DIRECTOR
DIRECTORATE OF RESEARCH AND GRADUATE TRAINING

CHIEF ADMINISTRATIVE OFFICER
PAKWACH DISTRICT LOCAL GOVERNMENT
RECEIVED
18 NOV 2022
REGISTRY
P. O. BOX 64, PAKWACH

CENTRAL REGISTRY
Zombo District Local Government
22 NOV 2022
RECEIVED

KYAMBOGO UNIVERSITY

FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Date: November 16th, 2022

The Chief Administrative Officer,
Nebbi District Local Government,
P. O Box 1, Nebbi.

CHIEF ADMINISTRATIVE OFFICER
NEBBI DISTRICT LOCAL GOVERNMENT
RECEIVED
21 NOV 2022
REGISTRY
P. O. BOX 1, NEBBI

Dear Sir,

REF: REQUEST TO CARRY OUT RESEARCH DATA COLLECTION

As you are aware, I am for a master degree program in Construction Technology and Management at Kyambogo University in year 2, semester 2. It's a requirement to prepare and present research proposal, undertake research data collection and present the findings at the end of the academic year.

My research topic is "*Incorporating Impact of Eventualities in Routine Road Maintenance Tool for Local Governments-Case study of the Grater Nebbi*". The study will be carried out in the greater Nebbi districts of Pakwach, Nebbi and Zombo.

The purpose of this letter is to request permission to carry out data collection on any two (2) on-going routine road maintenance works in the district and also collect Historical Data on previous road maintenance preferably for the years just before and during COVID-19.

The University is expecting me to complete the data collection by the end of December 2022 and thereafter commence data analysis. Attached is letter of introduction from the Director of Research and Graduate training, Kyambogo University.

Yours faithfully,

Kubi James

STUDENT, KYAMBOGO UNIVERSITY

CC: Ag. District Engineer, Nebbi

Telephone:
District Chairperson - 0782071353
Chief Administrative Officer - 0782966450
D/Chief Administrative Officer - 0772303748
Chief Finance Officer - 0772479937
District Health Officer - 0772619078
E-mail info@nebbi.go.ug
Website: http://www.nebbi.go.ug

THE REPUBLIC OF UGANDA

OFFICE OF CHIEF ADMINISTRATIVE OFFICER
NEBBI DISTRICT LOCAL GOVERNMENT
P.O. BOX 1
NEBBI

CR/D/13002

22nd November, 2022

Kubi James
Student, Kyambogo University

PERMISSION TO CARRY OUT RESEARCH DATA COLLECTION

The above subject refers.

This is in response to yours dated 16th November, 2022, in which you requested to carry out research data collection in the greater Nebbi Districts of Pakwach, Nebbi and Zombo, for which I have no objection.

This is therefore to grant you permission to conduct data collection in Nebbi District that is my jurisdiction and to ask you to work in collaboration with works Department for further guidance.

Wamburu David Wasikye
CHIEF ADMINISTRATIVE OFFICER

CHIEF ADMINISTRATIVE OFFICER
NEBBI DISTRICT LOCAL GOVERNMENT
22 NOV 2022
P. O. BOX 1, NEBBI

Cc: District Engineer

KYAMBOGO UNIVERSITY

FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Date: November 16th, 2022

The Chief Administrative Officer,
Zombo District Local Government,
P. O Box 1, Zombo.

Dear Sir,

REF: REQUEST TO CARRY OUT RESEARCH DATA COLLECTION

I am a student of Kyambogo University undertaking a master degree program in Construction Technology and Management in year 2, semester 2. It's a requirement to prepare and present research proposal, undertake research data collection and present the findings at the end of the academic year.

My research topic is "*Incorporating Impact of Eventualities in Routine Road Maintenance Tool for Local Governments-Case study of the Grater Nebbi*". The study will be carried out in the greater Nebbi districts of Pakwach, Nebbi and Zombo.

The purpose of this letter is to request permission to carry out data collection on any two (2) on-going routine road maintenance works in the district and also collect Historical Data on previous road maintenance preferably for the years just before and during COVID-19.

The University is expecting me to complete the data collection by the end of December 2022 and thereafter commence data analysis. Attached is letter of introduction from the Director of Research and Graduate training, Kyambogo University.

Yours faithfully,

Kubi James

STUDENT, KYAMBOGO UNIVERSITY

CC: Ag. District Engineer, Zombo

CENTRAL REGISTRY
Zombo District Local Government
22 NOV 2022
RECEIVED

Appendix B; Field Data Collecting Tool

SUMMARY OF DAY'S ACTIVITY

Researcher/Assistant		**Date:**	
Road Name:		**Road legth:**	Km

Activity	**Unit**	**Width/ Thickness**	**Q'ty**	**Remarks**
Bush Clearing	Km			
Grading	Km			
Gravelling	Km			
Fills	m3			
Culverts	No.			
Stone pitching	m2			
Headwalls	m2			
Open drains	m			

Intervening Variables

Terrain Type:	Flat	Rolling	Hilly	Remark
Climatic Condition:	Dry	Wet		Remark
Road class:	Class 1	Class II	Class III	Remark
Road Condition:	Good	Fair	Poor	Remark
Level of Service:	High	Midum	Low	Remark
Soil Type:	Sandy	Gravel	Clay	Remark
Drainage Condition:	Good	Fair	Poor	Remark
Road Surface Type:	Gravel	Earth		Remark

DAILY EQUIPMENT COST

Researcher/Assistant		Date:	
Road Name:		Road length:	Km
Day's Activity:		Q'ty Achieved:	

Item	Equipment & Tool	Total Hrs.	Dry Rate/hr.			Total dry cost			Operational Cost (Fuel, Lubricants & repair)			Total cost		
		(a)	(b)			(c)= (a)*(b)			(d)			(e)=(c)+(d)		
		Year	2019	2020	2022	2019	2020	2022	2019	2020	2022	2019	2020	2022
1	Grader													
2	Wheel loader													
3	Bulldozer													
4	Vib. Roller													
5	Water Bowser													
6	Tipper Truck													
7	Low bed													
8	Pickup													
9	Pedestrian roller													
10	Motorcycle													
11	Water pump													
12	Hand tools													
Total Cost of Equipment:														

DAILY MATERIAL COST

Researcher/Assistant		Date:	
Road Name:		Road legth:	Km
Day's Activity:		Q'ty Achieved:	

Item	Materials	Unit	Q'ty	Rate (UGX)			Amount (UGX)			Remark
				2019	2020	2022	2019	2020	2022	
1	Gravel	m^3								
2	Cement	bag								
3	Aggregates	m^3								
4	Sand	m^3								
5	Bricks	No.								
6	Hardcore	m^3								
7	Steel	No.								
8	Timbers	No.								
Total Cost of Materials:										

DAILY LABOUR COST

Researcher/Assistant:		**Date:**	
Road Name:		**Road length:**	Km
Day's Activity:		**Q'ty Achieved:**	

Item	Personnel	No.	Days	Rate (UGX)			Amount (UGX)		
				2019	2020	2022	2019	2020	2022
1	Skilled labour								
2	Semi Skilled labour								
3	Casual Labour								
4	Watchman								
5	Store Keeper								
						Total Cost of labour:			

DAILY MACHINE OPERATING COST (Fuel, Lubricant and Repairs)

Researcher/Assistant: ____________ **Date:** ____________

Road Name: ____________ **Road length:** ____________ Km

Machine ____________ **Machine No.** ____________

Meter Reading: **Beginning of day:** ______ **End of day:** ______ **Total Km/Hr Travelled:** ______

Days Activity ____________

Item	Unit	Q'ty Used	Unit Cost			Total Cost		
			2019	2020	2022	2019	2020	2022
Petrol	ltr							
Diesel	ltr							
Engine Oil	ltr							
Hydraulic Oil	ltr							
Transmission Oil	ltr							
break fluid	ltr							
Grease	kg							
Filter	No.							
Tire	No.							
Cost of repair parts	Sum							
Cost of repair labour	Sum							
TOTAL								

Day's Work

Machine Hours	....	Preventive Maintenance Done
Operator's Other Work		

Km of Road Maintained ....