Application of Geographic Information System (GIS) and Multi-Criteria Decision Analysis (MCDA) to planning and prioritization of rural roads in Nigeria

by

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Thesis submitted for the degree of Doctor of Philosophy in Development Economics

August, 2022

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PUBLICATIONS FROM THESIS

This thesis has produced two original papers published in peer reviewed journals as listed below:

(i) Akpan, U. & Morimoto, R. (2022) An application of multi-attribute utility theory (MAUT) to the prioritization of rural roads to improve rural accessibility in Nigeria. *Socio-Economic Planning Sciences, 82*, 101256. DOI: https://doi.org/10.1016/j.seps.2022.101256 (Publisher: Elsevier)

(ii) Akpan, U. & Morimoto, R. (2022) Motorized Travel Mode Choices of Smallholder Farmers in Akwa Ibom State, Nigeria. *Transportation Research Interdisciplinary Perspective, 13*, 100569. DOI: https://doi.org/10.1016/j.trip.2022.100569 (Publisher: Elsevier)

The core theme of the thesis is rural transportation in Nigeria. The ideas, development and writing up of all the content of the thesis were the principal responsibility of myself, the student, working within the Department of Economics under the supervision of Dr. Risako Morimoto.

The inclusion of a co-author in each article reflects the fact that the work benefited from the active support of my supervisor (who is the co-author of both articles) and acknowledges her input into team-based research.

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ABSTRACT

Good quality rural road infrastructure seems to contribute substantially to improvements in several socio-economic indicators in rural areas: increases accessibility to markets, educational and health facilities, and stimulates economic activities. However, about 450 million people in sub-Saharan Africa or 70% of the rural population have been left without access to good transport infrastructure.

This study answers three broad questions related to rural road transportation in Nigeria: what are the travel choices of rural households in Nigeria in the face of poor rural road infrastructure? Which rural roads should be improved to yield the maximum socio-economic benefits in rural areas? What are the constraints to the improvements of the quality of rural road infrastructure? The study focuses on Akwa Ibom State, Nigeria.

To answer the first question, the study narrows its focus from rural households to rural smallholder farmers. The study uses an existing sampling frame of smallholder farmers obtained from the World Bank-supported Fadama III Project in Akwa Ibom State, and employs multistage sampling to generate data on travel mode choices. According to the data, motorcycles are the most owned means of transportation in the study area, and also the most used – even by persons who do not own any means of transportation. Further, we employ the multinomial logit model to examine the factors that influence their choices of means of transportation and we use motorcycle as the reference category. The result shows that the preference of respondents for the different means of transportation is influenced mainly by the attributes of the means of transportation. In addition, among the socio-economic variables included in the model, only the coefficient of income under saloon cars is significant. Given that motorcycles and tricycles are now dominating the rural transport landscape as an economical way to meet the transport needs of people, rural transport policy in Nigeria should be revised to reflect this reality. The operation of motorcycles and tricycles should be properly mainstreamed in rural transport policy to improve rural transport services.

For the second research question, the study uses Multi-Attribute Utility Theory (MAUT) to examine how rural roads in the study area may be prioritized for upgrade to maximize access to key socio-economic facilities. The MAUT uses different criteria: social, economic, demographic, financial, and political. Geographic information system (GIS) techniques are applied to process some of the data used in the performance matrix of the MAUT. The analytical hierarchical procedure (AHP) is used in determining the weights of the criteria. Scenario analyses are also carried out to examine the impact of changes in the weights of the different criteria on the value score of each alternative. The study identifies 10 roads that will yield the highest socio-economic benefits and promote rural accessibility. The study recommends that decision-makers adopt a similar approach in selecting rural roads for upgrade, instead of selecting roads based on mainly political considerations.

We also use sampling survey to answer the third question. Data are generated from stakeholders in rural transport infrastructure development in the study area. The data show that the top-5 major challenges to the development of rural road infrastructure in the study area as noted by our respondents are: non-release of funds to contractors; use

of rural road projects as political tools and abandoning the roads; poor planning for rural road development; misappropriation and embezzlement of public funds meant for road construction; and lack of funds for maintenance of roads. All of these falls within the economic, political, or institutional categories. The economic and institutional challenges may also be linked to political factors. This suggests that the solution to the challenge is beyond economic. The solutions seem to be more political than economic, given that most of the economic challenges are subsumed under political factors/actors.

ACKNOWLEDGMENT

This Thesis is a culmination of my doctoral research at the Department of Economics, School of Oriental and African Studies (SOAS), University of London and I want to use this opportunity to express my deepest gratitude to those who have made this journey a success.

First, I thank the Almighty God for His protection, preservation, and blessings within this period and I give all the glory to Him. This PhD is made possible by the Commonwealth Scholarship Commission (CSC), through an award of a full scholarship. I thank the management and staff of the Commission, and my Programme Officers Ms. Irene Costello, Ms Jasmin Osman, Bisola Oyedele, and Emmanuel Patterson for all their assistance. By extension, I thank the United Kingdom's Department for International Development (DfID) and the people of the United Kingdom, through whose taxes, the DfID funds the CSC.

To my first supervisor, Dr. Risako Morimoto, thank you! You have been a strong supporter since when you agreed to be my supervisor, through the scholarship application process, and throughout the period I was formally registered as a doctoral researcher in SOAS. Your contributions, perspectives and support are much appreciated. I also thank my second supervisor, Dr. Sara Stevano who has provided immense support in the course of this doctoral research. I thank other staff of the Department of Economics and the Doctoral School for their tremendous support.

I thank my wife, Uduak, for all the support, especially for taking care of the home and the children. I thank my children, Michael-Ekomobong and Raphael-Itorobong for their understanding in all the times I had to be away from home. I also thank my parents Mr. & Mrs. Sylvester E. Akpan; my siblings Anietie, Nameti, & Kufre; my in-laws Veronica Effiong, Judith Inwang, Edidiong Urua, and Mfonobong Urua who have been very supportive throughout this period. The journey of life has brought me very good friends who have been pillars to my personal development. I particularly thank Salisu Isihak for all his support and encouragement. I thank the staff of the Nigeria Erosion and Watershed Management Project (NEWMAP), Akwa Ibom State, Nigeria, led by Dr. Ubong

Harrison. I also thank the following persons in the following institutions who have assisted in different ways:

(i) Mr. Aniekan Etetim - The Rural Access and Agricultural Marketing Project (RAAMP), Akwa Ibom State, Nigeria.

(ii) Mr. Archibong Usen and Mr. Uwem Jeremiah – Fadama III project, Akwa Ibom State, Nigeria.

Finally, even though this work would not have been possible without the aforementioned persons and institutions, I take full responsibility for any error, misrepresentation, or omission in this work.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AfDB	African Development Bank
AHP	Analytic Hierarchy Process
AICD	Africa Infrastructure Country Diagnostic
AKS	Akwa Ibom State, Nigeria
AKROIMA	Akwa Ibom State Road and Other Infrastructures Maintenance Agency, Nigeria
CBA	Cost-Benefit Analysis
DFID	United Kingdom's Department for International Development
DFRRI	Directorate of Foods, Roads, and Rural Infrastructure, Nigeria
ELECTRE	ELimination Et Choix Traduisant la REalité (ELimination and Choice Expressing REality)
ERGP	Economic Recovery and Growth Plan
FERMA	Federal Roads Maintenance Agency, Nigeria
FRSC	Federal Road Safety Commission, Nigeria
FGN	Federal Government of Nigeria
FMT	Federal Ministry of Transportation
GDP	Gross Domestic Product
GIS	Geographic Information System
ICT	Information and Communication technology
IMT	Intermediate Means of Transport
IRAP	Integrated Rural Accessibility Planning
LGA	Local Government Area
MAUT	Multi-attribute Utility Theory
MCDA	Multicriteria Decision Analysis
MIS	Management Information System
MSMEs	Micro, Small and Medium Enterprises
NAPEP	National Poverty Eradication Programme
NDHS	National Demographic and Health Survey
PCI	Pavement Condition Index
PROMETREE	Preference Ranking Organization METHod for Enrichment of Evaluations
RAAMP	Rural Access and Agricultural Marketing Project
RAI	Rural Access(ibility) Index
ReCAP	Research for Community Access Partnership
REM	Road Economic Model
SSATP	sub-Sahara African Transport Project

SDGs	Sustainable Development Goals
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
UNDP	United Nations Development Programme
USA	United States of America
UTM	Universal Transverse Mercator
V&RIS	Village & rural road inventory system
WGS	World Geodetic System

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Quality economic infrastructure, especially in key sectors such as energy, ICT, and transportation, are crucial enablers and stimulators of economic activities in an economy, particularly in the agricultural, manufacturing, and service sectors (Adenikinju, 2005). There is an agreement in the literature that, given the right conditions, building the right infrastructure can help in promoting growth and development, and through this, help in reducing poverty (Calderón & Servén, 2010). Transport infrastructure, especially good road networks, plays a crucial role in the socio-economic transformation of developing countries. Good road network provides access to necessary social services and acts as an input in private sector production of goods and services; promotes easy mobility of goods and services; reduces travel time and the cost of repairs and maintenance of vehicles; reduces the overall cost of production due to reduced overhead cost (Akpan, 2014).

The quality[1] of road transport infrastructure in developing countries is generally poor when compared to that of developed countries and this seems to have been the case since the 1980s. World Bank (1988) highlighted the issue of the poor quality of primary roads in developing countries by reporting findings from an assessment of primary roads in eighty-five developing countries which were receiving financial assistance from the World Bank. The report noted that the road construction boom that followed the independence of several countries in the 1950s and 1960s was not accompanied by a corresponding level of funding and institutional capacity building for maintenance. Therefore, most of the roads constructed had deteriorated due to lack of maintenance and

[1] The quality of rural road infrastructure is used here in a descriptive manner because there is no standard measurement for rural road quality. In this study, we assume that the quality of rural roads ranges from "poor" to "good". A quality of a rural road may be described as "poor" if it is an earth road that becomes sodden and impassable during the rainy season. On the other hand, the quality of road may be described as "good" if it is an asphalt road with pavement condition index (PCI) above 70. Between these extremes, there may be undisturbed earth roads, gravel roads, or asphalt roads with PCI lower than 70.

overuse, and the costs of rehabilitating the roads were (in some cases) more than 10-times the cost that would have been expended on routine maintenance. This situation has not changed over the years. The Global Competitiveness Report (2017/2018 scorecard) of the World Economic Forum reported the perception of road quality in 137 countries and most counties in the bottom-third of the list were developing countries, specifically in sub-Saharan Africa (World Economic Forum, 2019). Furthermore, The Africa Infrastructure Country Diagnostic (AICD) study documented the state of road transport infrastructure in several countries in sub-Saharan Africa (Gwilliam, et al., 2008). The AICD noted that sub-Saharan Africa had a lower density of paved roads than other developing regions in the world when assessed in terms of landmass, population, and GDP as shown in Table 1.1.

Table 1.1: Comparison of density of paved roads in low-income countries in sub-Saharan Africa with that of other low-income countries

Description	Low-income countries in SSA	Other LICs
Density of paved roads by area (km of paved roads/ 1000km^2)	10.7	37.3
Density of paved roads by population (km of paved roads/ 1000 population)	269.1	700.7
Density of paved roads by GDP (km of paved roads/ US$)	663.1	1,210.0

Source: Gwilliam *et al.* (2008)

While the quality of road transport infrastructure is generally poor in most countries in sub-Saharan Africa, there are remarkable differences between the roads in urban and rural areas. Roads in urban areas have relatively better qualities. For example, in Ghana, urban areas like Accra, Kumasi, and other regional capitals have road networks that are "dense and fine-grained" when compared to those of other parts of the country (Dumedah & Garsonu, 2020). A similar situation may be observed in different urban areas in countries across sub-Saharan Africa such as Lagos and Abuja in Nigeria; Nairobi in Kenya; Arusha and Dar-er Salaam in Tanzania; etc. However, urban areas are plagued by a different set of road transport challenges such as congestions, noise pollution, air pollution, etc.

(Kumar & Barrett, 2008; Pucher *et al*., 2005). The road infrastructure situation in rural areas of developing countries seems to be worse. A report by the World Bank states that about 80% of the poor people in the world resides in rural areas where there is a substantial lack of infrastructure (World Bank, 2017a). Another report from the World Bank notes that about 450 million people in sub-Saharan Africa, or 70% of the rural population have been left without access to good transport infrastructure (World Bank, 2017b). The African Infrastructure Country Diagnostic Report stated that "African rural communities have by far the lowest accessibility to an all-season road in the developing world" (Foster & Briceño-Garmendia, 2010, p. 212).

In most developing countries, rural road infrastructure contributes substantially to improvements in several socio-economic indicators and poverty reduction in rural areas, and this is well documented in the literature. For example, improvement in rural road infrastructure led to an increase in productivity vis-à-vis of some staple crops, increased access to higher-order markets, reduced travel time to school and cost of transportation, among others in countries like Ghana, Nigeria, and Brazil (Asomani-Boateng *et al*., 2015; Inoni & Omotor, 2009; Iimi *et al*., 2015). Good quality rural road infrastructure contributed positively to employment in and income from non-farm enterprises in rural Indonesia (Gibson & Olivia, 2010), had several direct and indirect positive impacts on rural communities in the Philippines (Olsson, 2009), improved per capita income and working hours of households in Viet Nam (Cuong, 2011) and contributed substantially to poverty reduction (Hettige, 2006; Warr, 2010; Najman *et al*., 2010; Banjo *et al*., 2012). Hence, efforts to promote sustainable rural development have to be focused on the provision of access to key physical infrastructure such as roads.

Furthermore, the United Nations, in collaboration with the Heads of States and Governments launched the Sustainable Development Goals (SDGs) in 2015 as a new agenda for development. The SDGs sets out the development aspirations of the global community by 2030 and frames this into 17 Goals. Even though improvement in rural roads is not one of the SDGs, it is intrinsically connected to several SDGs as shown in

Table 1.2 and it is subsumed in one of the indicators of Goal 9 (i.e. Indicator 9.1.1 – the proportion of the rural population who live within 2km of an all-season road)

Table 1.2: Linkages between improvement in rural roads and Sustainable Development Goals

SDG	**Goal**	**Contribution of rural roads improvement**
SDG 1: No poverty	End poverty in all its forms everywhere	Poverty in some places is caused by isolation due to the inability of rural households to have easy access to social amenities. In addition, most rural households are agrarian and the lack of good roads increase the time and cost of evacuating produce to the markets and causes high post-harvest losses
SDG 2: Zero hunger	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	To end hunger and achieve food security, rural dwellers need improved accessibility which is facilitated by improved road networks
SDG 3: Good health and well-being for people	Ensure healthy lives and promote well-being for all at all ages	The cost and time taken to access basic health services is reduced with improved rural roads.
SDG 4: Quality education	Ensure inclusive and equita ble quality education and promote lifelong learning opportunities for all	The cost and time taken to access educational facilities are reduced with improved rural roads.

SDG 8: Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Improvement in rural roads infrastructure improves the accessibility to markets and opens up economic opportunities which may lead to economic growth
SDG 9: Industry, Innovation, and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	Improvement in rural roads infrastructure is one of the ways of building resilient infrastructure

Source: Author

In most developing countries, including Nigeria, road transport is the predominant mode of transportation as other modes of transportation such as rail and water are not efficient (Asomani-Boateng *et al*., 2015) while air transport is expensive. In Nigeria, roads are grouped into federal, state, and local government roads[2]. The federal roads are roads that connect two states; the state roads connect two LGAs; while the LGA roads connect two communities/villages. In 2017, it was estimated that the total length of roads in Nigeria was between 193000 and 195000 km. This is made up of 32,000 km of federal roads, 31,000km of state roads, and 130,000 to 132,000km of local government roads (World Bank, 2019). This implies that about 67% of roads in Nigeria are local government roads. Most of the local government roads are rural roads. The same study also reported that 40% of federal roads, 78% of state roads, and 87% of local government roads were in poor condition.

The poor condition of roads in Nigeria poses a barrier to the developmental aspirations of the country in general, and the development of rural areas in particular. The situation in rural areas is more challenging because of its implications on agricultural and rural

[2] Nigeria is a Federation made up of 36 states and a Federal Capital Territory. Each of the 36 states are further divided into local government areas (LGAs) and each of the LGAs are then divided into wards.

development. The agriculture sector contributes substantially to the gross domestic product (GDP) of Nigeria. Data from the World Bank show that agriculture contributed 24.143% to GDP in 2020 (World Bank database), reducing from about 40% between 2005 and 2009 (National Bureau of Statistics, 2009). Furthermore, the agricultural sector was responsible for 70% of employment in Nigeria in the early 2010s (Odetola & Etumnu, 2013). Over 80% of farmers in Nigeria are smallholder farmers[3] who reside in areas considered to be rural and are responsible for over 90% of agricultural output in Nigeria (Anderson *et al*., 2017; Sabo *et al*., 2017). The poor condition of rural roads in Nigeria affects the accessibility of the rural population to health facilities (Gbadamosi & Olorunfemi, 2016) and education facilities (Adedeji *et al*., 2014). Consequently, the development of rural road infrastructure is crucial to the economic transformation of rural areas in Nigeria, improvement of food security, and will be a significant enabler for Nigeria to meet the targets of the Sustainable Development Goals, especially targets related to SDGs 1, 2, 3, 4, 8 and 9.

1.2 Statement of Problem

Despite its huge economic potentials, Nigeria's economic indices have remained appalling over the years and the country performs poorly in most indices of human development. The 2019 Human Development Index (HDI) of the United Nations Development Programme (UNDP) shows that Nigeria ranks among countries with low human development indices (i.e. 158 out of 189 in the world) (UNDP, 2019). The causal factors of this situation are multifarious, they include weak institutions, corruption, non-conducive socio-political environment, risky socio-economic environment for private sector investment, and lack of quality infrastructure (Aluko, 2003; Omotola, 2008; Uzoh, 2013; Adindu *et al*., 2020).

[3] Farmers who own less than 5hectares of land

Nigeria has a substantial share of global poverty. Data from the World Poverty Clock[4] show that Nigeria has one the highest number of persons living in absolute poverty in the world based on poverty headcount. To put this in proper context, about 70.7 million Nigerians (about 33% of the population) live in absolute poverty compared to 83 million persons in India (or 6% of the population). This situation is exacerbated by the fact that the Nigerian economy is growing at a very slow pace, has only recently come out of recession, and it is at risk of falling back into recession. This has affected the financial standings of states and local government areas (LGAs) and has necessitated the country to redirect its focus from dependence on oil-related revenue to diversifying the economy. In line with this, the Federal Government of Nigeria (FGN) had developed an Economic Recovery and Growth Plan (ERGP) (2017-2020) which focused on three areas: (a) restoring growth (b) investing in our people, and (c) building a globally competitive economy (FGN, 2017). The document also outlined top execution priorities as follows: stabilizing the economic environment; achieving food sufficiency; ensuring energy sufficiency; supporting micro, small, and medium enterprises (MSMEs); and improving transportation infrastructure. The reduction in revenues implies that Nigeria's investments in improving transportation infrastructure in general, and roads in particular, have to be carefully planned and prioritized to unlock the socio-economic potentials of rural areas and achieve the highest possible economic benefit.

Planning for rural road infrastructure is important because it provides policy-makers with an understanding of the expected economic impact of developing roads that have strategic socio-economic importance, and helps in the allocation of scarce resources to obtain the highest possible socio-economic benefits. Several developing countries have recognized the importance of having well-defined rural road infrastructure development plans which are usually part of their rural development strategy. Rural road infrastructures are considered to be public goods and are provided by governments. In Nigeria, the upgrading of rural roads is usually done by the state governments even though local governments

[4] https://worldpoverty.io/ (accessed on 5th March, 2022). The methodology used in generating the data is published in Cuaresma *et al*. (2018)

also have the mandate to upgrade existing local roads and open up new ones. The decision on which road(s) should be upgraded among a set of poor quality roads is usually taken by political actors based on financial, economic, and sometimes political considerations. Studies have shown that political considerations play a vital role in the selection of roads for upgrade in developing countries (Mani & Mukand, 2007; Vergne, 2009; Blimpo *et al*., 2013). In discussing transport planning in sub-Saharan Africa, Porter (2007), p. 252 reports that "Decisions regarding which roads to improve or pave may often be more dependent upon political factors than agricultural or other economic potential along the proposed route". Presently, only few states in Nigeria have developed road infrastructure development plan that sets out a clearly defined plan for road infrastructure development based on socio-economic drivers that will drive economic transformation[5]. Given the shortages in financial resources, there is a need to ensure that investments in road infrastructure development are done in a manner that will yield the highest possible net socio-economic benefits. This is even more important given that Nigeria is a signatory to the Sustainable Development Goals of the United Nations and the development of rural road infrastructure is inextricably linked to some of the SDGs.

Given:

(i) the role of good quality rural road infrastructure in unlocking the socio-economic potentials of rural areas in Nigeria and in achieving the sustainable development goals;

(ii) the importance of planning and prioritizing rural roads to ensure efficient allocation of scarce resources to obtain the highest possible net socio-economic benefits; and

(iii) the fact that there are no definite rural road plans in many states in Nigeria;

[5] These road prioritization plans are mainly part of donor-funded projects. Rural road prioritization was done in Cross River State, Nigeria as part of the Rural Access and Mobility Project (RAMP) which was funded by the African Development Bank and the World Bank. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Nigeria_-_Rural_Access__Mobility_Project_-_Appraisal_Report.pdf (Accessed 9th March, 2020).

a comprehensive process of prioritizing rural roads for upgrade is needed to ensure efficient allocation of scarce resources in a manner that maximizes accessibility to key social amenities and economic opportunities. Several studies have carried out prioritization of rural roads for upgrade in different countries (Airey & Taylor, 1999; Yannis *et al*., 2020; Kumar & Kumar, 1999; van de Walle, 2002; Dalal *et al*., 2010; Bhandari *et al*., 2014; Mikou *et al*., 2019). However, this topic is under-researched in Nigeria and it might not be appropriate to extrapolate findings of road prioritization studies from other countries due to the differences in the socio-economic and socio-political situation across developing countries. Country-specific studies are needed to provide better insights on how prioritization of rural roads may be carried out in the country based on the local socio-economic and political situation. This study intends to fill this knowledge gap: the study examines how rural roads may be prioritized for upgrade in a manner that maximizes access to social and economic facilities in rural areas in Nigeria. We conceptualize our research problem as a multi-criteria decision problem. We use the Multi-Attribute Utility Theory (MAUT) instead of the commonly-used AHP because the number of roads to be prioritized (i.e. alternatives) is large.

Furthermore, the poor state of rural road infrastructure has led to the development of informal transport services in several urban and rural areas in Nigeria (Cervero & Golub, 2007). Informal transportation systems play an increasing role in meeting the mobility needs of people in rural areas across Nigeria, given the non-availability of good road networks, and the inability of policy-makers to develop and implement a robust transportation policy that meets the needs of the people. Indeed, it is difficult to find an urban or rural area in Nigeria with a functional, well-planned, efficient transportation system. Most government programs on road transport development focus on infrastructure improvement especially in urban areas and on inter-city transport. However, the government had included in its Draft National Transport Policy 2010 (Federal Government of Nigeria, 2010) a segment that highlights a rural transport policy to address rural accessibility thus: "(i) Open up the rural areas for local and regional

markets; (ii) Improve the institutional framework for rural road construction, maintenance and operation, for a more focused development; and (iii) Ensure sustainable funding for rural road construction and maintenance."

Planning for the improvement of the quality of rural roads is an activity targeted at improving rural accessibility. Rural accessibility includes the availability of good quality infrastructure as well as other aspects of rural transport services (Lebo & Schelling, 2001). While improvements in the quality of physical infrastructure is perhaps the most important part of improving rural accessibility, the cost of achieving this is often very high. Consequently, studies e.g. Porter (2007), have advocated that rural transportation policies need to also consider other aspects of rural accessibility such as building support systems that are useful and affordable to rural dwellers. One aspect of rural accessibility that has not received sufficient attention in research is rural travel demand. Studies have shown that understanding rural travel demand is very vital in developing policies and programs to promote rural accessibility (Bryceson & Howe, 1993). Understanding the transport choices made by rural households based on the available transport options and road quality can provide very useful information to guide policymakers in rural transport policy and planning. It will be difficult to make informed decisions on the improvement of rural accessibility without having a good understanding of the travel choices of users of these transport services.

Several studies have examined the travel mode choices of different segments of the population in Nigeria. For example, Olawole & Olapoju (2016) and Busari *et al*. (2015) examined the travel behavior and mode choices of undergraduates in Nigeria; Olawole & Aloba (2014) and Olawole (2015) examined the mobility characteristics of elderly people in South-Western Nigeria; Adetunji (2020) examined the travel behavior of women to markets in rural communities in South-Western Nigeria; etc. This present study intends to contribute to understanding the travel mode choices of rural dwellers by focusing on smallholder farmers. The study will provide useful data and insights on the travel mode

choices of rural smallholder farmers in the selected study area in Nigeria and the factors that influence these choices.

In addition, the fact that a large percentage of rural roads are in poor condition implies that there are some constraints to the improvement of the quality of rural roads. Having an understanding of these constraints is important to proffering possible solutions. Therefore, this study will also examine the constraints to the improvement of the quality of rural roads.

1.3 Objective of the study

As noted by Hine (2014), rural transport planning needs to be carried out holistically because an efficient rural transport system requires not just the infrastructure but several other aspects of rural transport services. In this direction, this study focuses on different aspects of rural accessibility and rural road infrastructure. The specific objectives of the study are as follows:

(i) To examine the travel mode choices of rural households in the study area in the face of poor quality of rural road infrastructure

(ii) To develop a comprehensive planning and prioritization framework for roads based on other socio-economic indicators for cost-effective and sustainable rural roads

(iii) To identify the constraints to the development of rural road transport infrastructure.

1.3.1 Research Questions

This study intends to answer three broad questions on rural transportation in Nigeria:

(i) What are the travel mode choices of rural households in the study area in the face of poor quality of rural road infrastructure?

(ii) Which rural roads should be improved to yield the maximum socio-economic benefits in rural areas in Nigeria?

(iii) What are the constraints to rural road infrastructure development in the study area?

1.4 Significance of Study

This study is significant in many respects. First, the study fits directly into the government's priority on infrastructure development as enunciated in the Economic Recovery and Growth Plan (ERGP). Moreover, given the economic challenges currently being faced by Nigeria at federal and state levels, a study that will present evidence with regards to how roads can be prioritized to maximize socio-economic potentials is very timely. The output of the study will be useful to decision-makers and planners in charge of public works. Political leaders at the state level may also gain useful insight as to alternative routes for unlocking economic opportunities at the sub-national level. The primary data that will be obtained in the course of this study will be useful to even a larger number of stakeholders who may use them for other research purposes. As this study falls directly within the bounds of a project funded by the World Bank in Nigeria, i.e. the Rural Access and Agricultural Marketing Project (RAAMP)[6], the result of the study will also be useful to the World Bank in Nigeria. The study also falls within the bounds of the DFID funded project called Research for Community Access Partnership (ReCAP)[7] which is implemented in some countries in South-East Asia and Africa (Nigeria not included). In terms of contribution to knowledge, this is - to the best of our knowledge - the first attempt in the application of geographic information system to support decision-making for the prioritization of rural roads upgrading in any part of Nigeria based on multi-criteria decision analysis.

Given the novelty and replicability of the methodology, it will provide an insight to support other studies that may be conducted in other states in Nigeria or other developing countries. Finally, this research is topical and relevant in the present-day development policy space, especially in the light of its relevance to the attainment of the SDGs.

[6] [6] The Rural Access and Agricultural Marketing Project (RAAMP) is a project of the Federal Government of Nigeria which has financial and technical support from the World Bank. The project as approved by the World Bank on February 18, 2020. The project development objectives (PDO) of RAAMP is "to improve rural access and agricultural marketing in selected participating states, whilst enhancing sustainability of the rural and state road network".

7 The overall objective of ReCAP is to "is to improve accessibility of the rural poor in Africa and Asia to economic opportunities and social facilities through improvements to infrastructure and transport"

Already, a consortium of multilateral and bilateral development partners have established the "Sustainable Mobility for All"[8], with the aim to, among other things, support rural transport access.

1.5 Limitations of Study

This study has several limitations. For the first objective, we collected data using sampling survey. However, we used a sampling frame instead of the entire population as defined. The use of sampling frame limits the generalizability of the findings.

For the second research question, we note that the study required an enormous amount of data. Some of the secondary data obtained using GIS techniques also required "ground truthing" to validate the data. The main limitation to this study is that the resources were not available to carry out primary data collection. Moreover, rural transport planning is a very vast area that requires inputs and variables from several stakeholders and user groups that play different roles in both the supply-side and the demand-side of rural transport services. For example, data on traffic count for each road would have been included in the performance matrix of the MAUT. These data are usually collected on different days of the week, on market days, on holidays, in different seasons, etc. to understand the variability of road usage on different days (Fouracre, 2001). Second, a key deliverable for studies of this nature is a robust GIS database and model. However, this will require advanced knowledge of GIS and programming. This study may only be able to develop a simple database. Notwithstanding these limitations, the study is designed to be scalable and replicable. Therefore, with the availability of time and resources, the study may be scaled up to obtain more detailed datasets.

[8] https://sum4all.org/priorities/universal-access (Accessed on October 30, 2019).

1.6 Overview of key terms

1.6.1 Infrastructure

There is no single definition for infrastructure. The Oxford Essential Dictionary of the U.S. Military (online version, 2002) defines infrastructure as "the basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a society or enterprise"; the Cambridge Dictionary (online version) defines it as "the basic systems and services, such as transport and power supplies, that a country or organization uses in order to work effectively"; while the Merriam-Websters Dictionary (online version) defines it as "the system of public works of a country, state, or region also: the resources (such as personnel, buildings, or equipment) required for an activity". From the foregoing, it may be seen that infrastructure includes "structures", "services", and/or "facilities" which are required for organizations or the society to function efficiently. Infrastructure plays a crucial role in the development of any society or country at large and has incited research interest in several engineering, science, and social science disciplines. In Economics, the roles of infrastructure in stimulating economic development, and the impact of lack of infrastructure on economic development have been examined extensively.

Several studies have differentiated among different types of infrastructures. Atolia *et al*. (2019) categorized infrastructures into "economic" and "social". Economic infrastructure refers to those infrastructures that may act as capital inputs to production which allow economies to function better. These include roads, railways, electricity, irrigation, etc.). Social infrastructure refers to those infrastructures that deliver social services such as health and education (Atolia, et al., 2019). Infrastructure may also be categorized as "hard" and "soft". "Hard" infrastructure refers to physical and tangible infrastructures such as roads, power lines, telecoms, ports, etc. while "soft" infrastructure refers to the institutions and systems required for the smooth functioning of the society. Furthermore, Buhr (2003) classifies infrastructure as "Institutional infrastructure" which refers to the legal and institutional framework for the smooth functioning of the society; "Personal

infrastructure" refers to human capital; and "Material infrastructure" refers to physical and tangible infrastructure.

1.6.2 Geographic Information System (GIS)

A Geographic information system (GIS) is a system of collecting, organizing, analyzing, editing, processing, visualizing, managing, and storing geographic information. According to Campbell & Shin (2019), GIS includes computer hardware and software used for processing and storing data, as well as methods and techniques for processing, analyzing, and visualizing the data. In some cases, the methods of collecting the data and the outputs are also considered as part of GIS. We present in Figure 1.1 a pictorial representation of information that may be extracted from real-world using GIS models

The Coordinate referencing system (CRS) is central to GIS. It is a method for locating features on the earth's surface. CRS may be divided into two broad categories: geographic CRS and projected CRS. The geographic CRS uses the degrees of latitude and longitude to represent points on the earth's surface. The height of the feature relative to the sea level is also represented in the geographic CRS. The World Geodetic System (WGS) 84 is the most popular geographic CRS. The projected CRS uses rectangular (Cartesian) graphs to represent points on the earth's surface. Since the earth is spherical and 3-dimensional (an irregularly shaped ellipsoid to be exact), the projected CRS attempts to represent this 3-dimensional shape on the 2-dimensional plane. The Universal Transverse Mercator (UTM) is often used in representing the projected CRS. UTM divides the earth's surface into 60 Zones and measures the distance in meters (Chang, 2006). Nigeria falls within UTM Zone 31N and 32N.

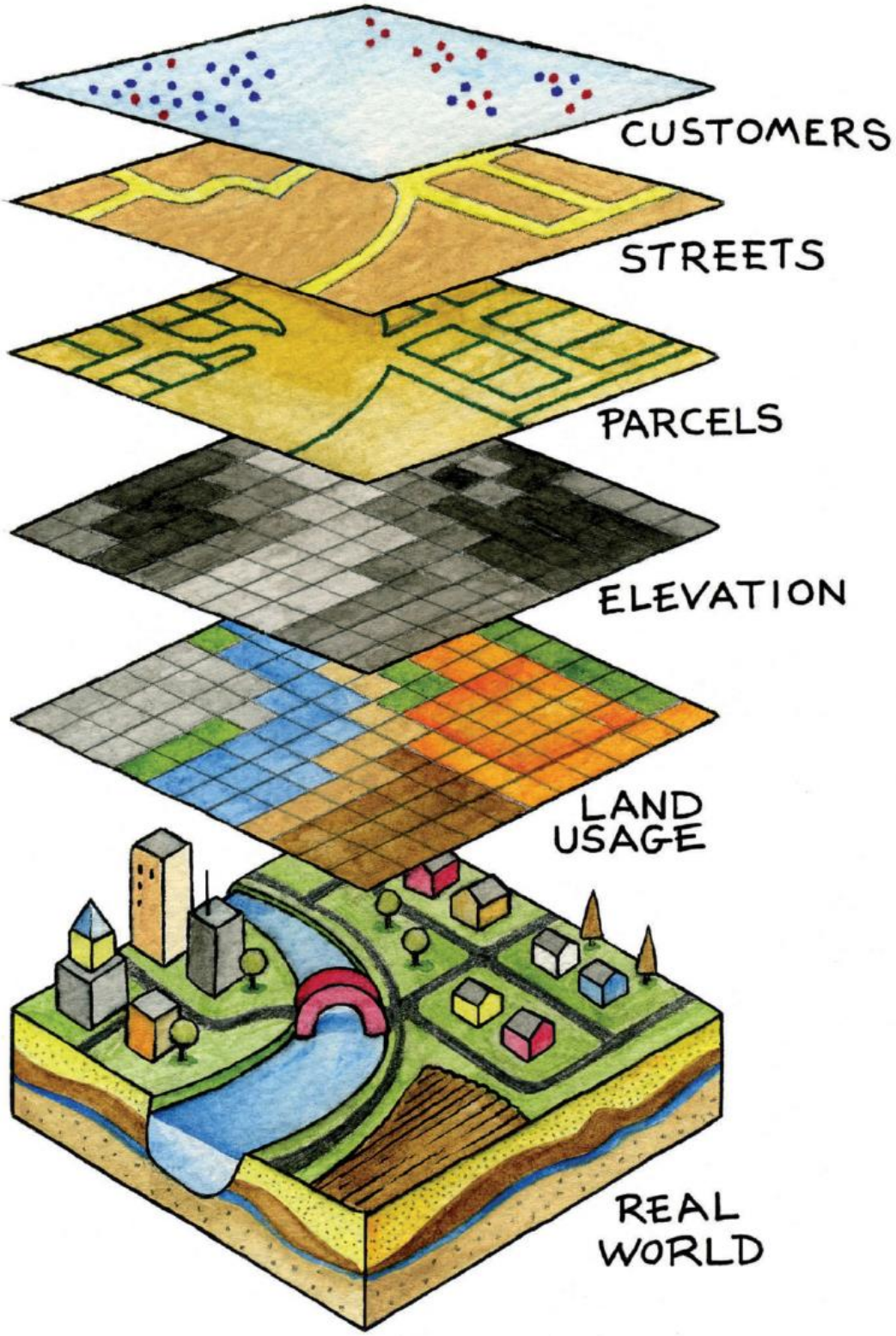


Figure 1.1: Picture showing different layers that may be extracted from the real-world using GIS
Source: Campbell & Shin (2019) (Creative Commons license)

GIS data may be grouped into two broad categories, i.e. vector data and raster data. Vector data represent features on the earth surface as points, lines, or polygons. Points are used to represent a single location; lines connect to two or more points and are used to represent features with similar geometry such as roads, railways, or river courses; while polygons are used to represent features that have boundaries, e.g. cities. This representation depends on the user as well as on the scale. For example, a city may be represented as a polygon when working on a project that covers only the city (i.e. small scale), but as a point when working on a project that covers the whole country (i.e. large scale). Raster data are generally photos of the earth's surface taken using satellite imageries or aerial photographs. Raster data may also be processed from of photos that embed several location-specific spatial data.

1.6.3 Multi-criteria decision analysis (MCDA)

The fact that decision-makers, whether in the public or private sector, may often need to make decisions to achieve multiple and sometimes conflicting objectives, which may also require compromise in some areas, has led to the development of multiple criteria decision analysis (MCDA). MCDA is a sub-discipline of operations research that is concerned with integrating mathematical tools to support the evaluation of decision alternatives. MCDA methods provide useful techniques for arriving at a compromise option among several other alternatives to achieve a defined objective, where the array of options may be evaluated under an equivalent or similar set of criteria. In some cases, the array of options may be evaluated under different sets of criteria (Ishizaka & Nemery, 2013, p. 8).

1.7 Structure of Thesis

This thesis is structured into seven (7) chapters. Chapter One is the Introduction where we provide the background to our study, highlight the problem, set our objectives and research questions, and provide the limitations to the study. In Chapter Two, we provide a conceptual framework for our study. We provide an overview of some theories that our

work may be situated in as well as other concepts relevant to our work. Chapter Three is the Review of Related Literature. In Chapter Four, we present an overview of the road transport sector in Nigeria, including the institutions, policies, and laws that are relevant to road transport development. In Chapter Five, we present our Methodology. In Chapter six we present and discuss our results. Chapter Seven is our Summary, Conclusion, and Recommendations.

CHAPTER TWO

2 CONCEPTUAL FRAMEWORK

2.1 Theoretical framework

This study examines rural road infrastructure from three perspectives: (i) travel mode choices of rural dwellers in the face of poor road infrastructure; (ii) prioritizing rural road infrastructure for upgrading to promote rural accessibility; and (iii) the constraints to rural roads infrastructure development. The first and second research questions may be rationalized from the viewpoints of Utility Theory and/or Decision Theory. Therefore, we present an overview of these theories.

2.1.1 Utility theory

Our first research question seeks to understand the travel mode choices of rural households in the study area. People travel, not necessarily for the sake of travelling, but most often to meet a felt need which may be to work, market, buy groceries, school, etc. The means of transportation used for travelling depends on the availability of different means of transportation as well as on the amount of utility that one is expected to derive from any means of transportation when compared to the utility derived from alternative means of transportation. For example, the choice of using public transportation instead of a personal vehicle suggests that the expected utility that one derives from using public transportation is higher than that of personal vehicle. Several factors may influence the utility: income level, availability of the transportation service, characteristics of the transportation service (e.g. speed, reliability, level of comfort, safety, etc.), cost of transportation, and other personal tastes and preferences which may be difficult to estimate. Based on this, our first research question may be understood using utility theory.

In economics, utility is used to describe the level of satisfaction received by a person from the consumption of a good or service. The underlying assumption is that a rational person will usually strive to maximize his/her utility at any point. From the point of view of Utility Theory, every individual has a utility function associated with the means of transportation one chooses at every material time. The challenge then is on how to model

such a utility function. Earlier studies that have provided methods for modeling this travel choice include Pratt (1970) and Golob & Backmann (1971). We will present additional details on travel mode choice in Section 3.1.3.

2.1.2 Decision theory

Decision-making is a central part of living and decisions are intrinsically part of human existence. Every aspect of living is about decision-making - from the basic decision of what to eat or wear, to more complex decisions such as whether to declare war or not. Decision theory seeks to understand the rationale for people making a decision and whether the decisions are based on anecdotal considerations or logical and rational considerations. The second objective of our study seeks to provide a framework for prioritizing rural road infrastructure for development. This problem may be rationalized from a Decision Theory point of view. Decision theory is very similar to utility theory. Decision theory may be divided into two categories: normative and descriptive. Normative decision theory seeks to understand how decisions ought to be made, while descriptive decision theory seeks to understand how decisions are actually made (Hansson, 1994). Normative decision theory assumes that decision-making is a rational process and is often used in Economics.

2.2 Rural road infrastructure planning: a subset of Transport Economics

Rural road infrastructure planning may be viewed as part of road transport planning which in turn is part of Transport Economics. Therefore, one of the theoretical backgrounds of our research is derived from Transport Economics. Transportation is an inherent feature of human societies (Rodrigue *et al*., 2013). People move from one place to another for the purpose of meeting different types of needs ranging from the basic needs of getting food, clothing, and shelter to other less-basic needs. People also move goods from production centers to markets. Because people need to move from place to place, they decide *how* they move given the options available. The available option may be by

walking, use of animals, or through mechanical means which may include 2-wheelers, 3-wheelers, or 4-wheelers. The decision-making process may be influenced by the means of transportation available at the material place and time, the efficiency of these means of transportation, the time spent on transit, the level of comfort, the transport cost, and the whole "transit experience" which depends on individuals' preferences and inclinations. The aggregate of all the human needs to move from one place to another using any mode or means of transportation, and the need to move goods and services from one place to another makes up "transport demand". Particularly, "transport demand" is regarded as a *derived demand* (Levinson *et al*., 2016, p. 6) because people do not travel just for the sake of travelling, but to achieve a purpose such as going to work, school, farm, market, holiday, or to visit family or friends. On the other hand, the process, resources, materials, and infrastructure required for meeting these needs make up "transport supply".

From the foregoing, it is possible to generate a demand curve as well as a supply curve for a transport service, for any means or mode of transportation, at any particular time, t (Figure 2.1). The price paid for the transport service may be made up of several components such as cost of fuel, fares, tolls, etc. (Levinson *et al*., 2016). There are other intangible "costs" of using the transport service such as total time spent on transit, comfort, and other "transit experiences" (e.g. going through a route along the countryside to view natural features).

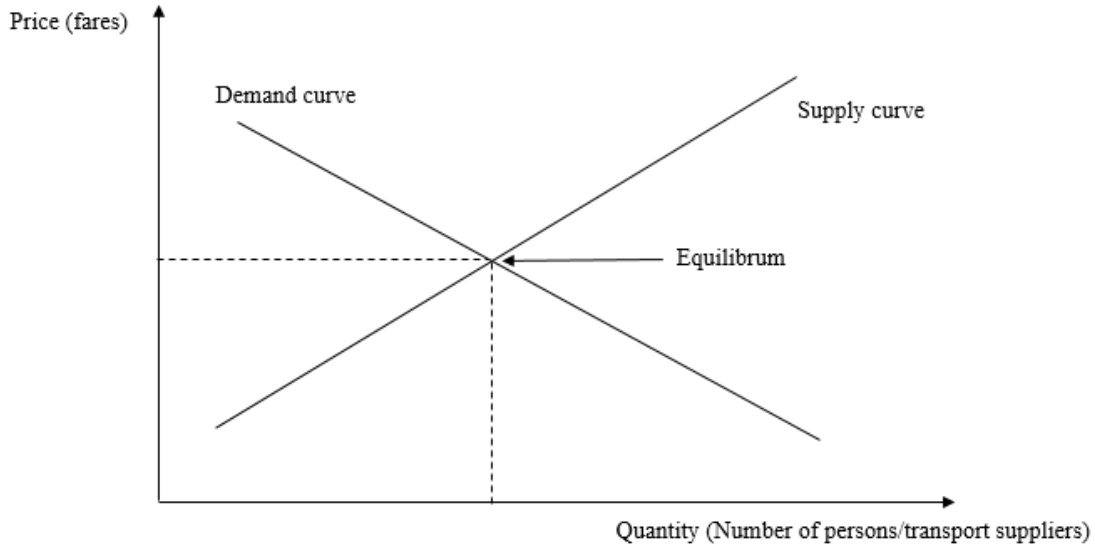


Figure 2.1: Schematic representation of transport demand, transport supply, and equilibrium
Source: Adapted from Levinson *et al*. (2016), p.9.

Figure 2.1 represents the transport demand and transport supply curves as linear. In reality, these are seldom linear but curved. The curve may be convex or concave for demand or supply. The nature of the curve depends on several factors affecting demand and supply, such as the availability of alternatives means or modes of transportation, cost, travel time, time of the day, day of the week, season, etc. In addition, the elasticities of the curves against these variables may also be analyzed.

The market for transport services is not a perfect market because it suffers from several market failures (Levinson *et al*., 2016). For road transport infrastructure, these include:

(i) Negative externalities: the present configuration of the transport sector is captive to fossil fuels. This means that fossil fuels, in form of gasoline, diesel, aviation fuel, etc. are used to power most mechanized forms of mobility (Bhattacharyya, 2011). This poses an environmental cost to society in the form of air pollution. The mechanical systems in most means of transport create noise pollution and there are risks of transport accidents. The impact of transport infrastructure on environmental assets such as forests and natural habitats is also a form of negative externality (Verhoef, 1994). Other negative externalities imposed by road transport are noted by Santos *et al*. (2010).

(ii)

(iii) High investment costs for transport infrastructure: The fixed cost of building most road infrastructure is generally high with a long lead time of potential returns. This makes road infrastructure to be considered as a natural monopoly.

(iv) Welfare distribution and socio-economic impacts: The objective of a government is to ensure the security, welfare, and prosperity of its citizens. Governments control road infrastructure because it is used by all citizens and is crucial to their welfare and prosperity.

(v) Public good: In most jurisdictions and countries road infrastructure are categorized as public goods: it is difficult to exclude people from using or benefiting from a road and the benefits that one user derives from a road does not diminish the benefit that other users derive from the same road (Kallhoff, 2014).

(vi) Strategic Asset: Road infrastructure is viewed as a strategic asset in most countries which implies that it should not be in the hands of private owners but should be controlled by the government. Notwithstanding, the government may allow some form of private sector involvement in the design, construction, and maintenance (Levinson *et al*., 2016, p. 9).

The existence of market failures has necessitated the involvement of the government in the road transport sector, and the development of road infrastructure in most developing countries is often done by government. However, they may be different forms of private sector involvement in the deployment, maintenance, and management of road infrastructure (Levinson *et al.,* 2016, p. 14).

Road Transport planning is the process of ensuring transport supply meets transport demand in an efficient manner presently and in the future, and in a manner that ensures long-term sustainability. Road transport supply refers to the supply of road transport services. These services include infrastructure such as asphaltic or gravel roads. For countries where public/mass transportation is promoted and supported, the infrastructure

may also include bus stops, bus stations, and other technological services that ensure that these infrastructures operate efficiently. Beyond infrastructure, the supply of road transport services also includes the management of transport services with respect to categories of services (personal or freight), whether the services are to be publicly or privately supplied, the type of services that are available in the different modes (e.g. dedicated lanes for walking or cycling, whether or not 3-wheelers may be needed, the types of buses that may be needed for public transportation, etc.). Underpinning all these is how these services will be organized and operated.

On the other hand, the demand for road transport services refers to the ability of users to pay for the transport services to meet their travelling needs.

2.2.1 Overview of rural road transport planning[9]

The aim of rural road transport planning is to match the demand for the transport services in rural areas with the supply of the services in a manner that will ensure efficiency, maximize the transport experience and other benefits, and minimize the transport cost, in any given time period. The demand for transport services often has to do with the travel patterns of end-users as well as the number (volume) of people using the roads. The travel pattern includes the preferred mode of travel, time and days of travel, purpose of travel, and distance of travel.

On the supply side, planning involves the provision of holistic services that reduce the barrier of rural accessibility in rural areas. This generally goes beyond the transport infrastructure: it includes ancillary services that support the infrastructure (including maintenance and repairs) as well as the location of quality facilities (Lebo & Schelling, 2001). Therefore, efforts to improve rural transport services need to consider all these aspects, and not just physical infrastructure (Porter, 2007). Within this context, the provision of rural road infrastructure is the necessary first step towards improving rural transport services and rural accessibility, but is not sufficient. The level of positive impacts that may be attributed to improvements in the quality of rural roads is contingent on the level of economic opportunities created by such roads as well as the level of

[9] This segment draws extensively from Connerley & Schroeder (1996) and Lebo & Schelling (2001)

response of users to these opportunities. The extent to which the construction of a rural road infrastructure creates opportunities depends on the quality and quantity of resources in the area which the road is linked to, while the level of response to such opportunities depends on the awareness of such opportunities and the attitudes toward economic change and incentives.

Hine (2014) notes that to be able to plan for the development of rural transport infrastructure and services, the first step is to have a holistic understanding of the state of rural transport. Furthermore, for rural road planning, the primary objective is usually to achieve basic vehicular access in form of an all-season road especially in situations where communities are already cutoff. According to the study, other objectives of improving rural road infrastructure include:

> "Maximize welfare; Promote economic growth and regional balance; Increase agricultural output; Reduce crop losses and improve food marketing and distribution; Provide access to basic facilities, taking into account the needs of the poor, isolated and marginalized groups; Minimize the time, costs and effort of the community in accessing facilities; Improve health and educational outcomes; Promote mobility and social interaction; Increase employment and develop local skills; …" (Hine, 2014, p. 42).

The study further notes that different planning and prioritization frameworks may be adopted depending on the specific objective as well as on other location-specific features such as availability of experts, quality of institutions, and dedicated funding for rural transport development.

"Rural access" generally refers to the minimum level of rural transport services necessary to sustain socio-economic activities (Lebo & Schelling, 2001). Within this context, rural transport may be viewed as a part of the broader concept of rural access (Connerley & Schroeder, 1996). This is generally viewed in terms of the quality of roads that will permit all-season and all-weather usage. In the tropical region like the southern part of Nigeria where annual rainfall is usually between 2000mm and 4000mm, such roads need to be constructed keeping in mind the underlying geotechnical conditions of soil and in such a

manner that excessive rainfall does not cause it to be flooded or sodden to prevent human and vehicular movement.

Starkey *et al*. (2002) notes that there are several stakeholders involved in the delivery of rural transport services who influence several aspects of the transport services, including supply and demand, price, quantity, quality of the means of transport and other ancillary services that support transportation. These stakeholders include:

(i) the users: differing by type of user, i.e. individual or institutional. Individual users may be further disaggregated by sex, age, wealth, occupation, ethnicity, etc.

(ii) Operators: transport companies, taxi-operators, owner-drivers, users of intermediate means of transportation (IMT)

(iii) Regulators: government agencies, traffic police, transport unions.

Other key stakeholders in rural transport include suppliers of vehicles and spare parts, artisans and mechanics, contractors, professional organizations, etc. A schematic representation of stakeholders in rural transportation is presented in Figure 2.2.

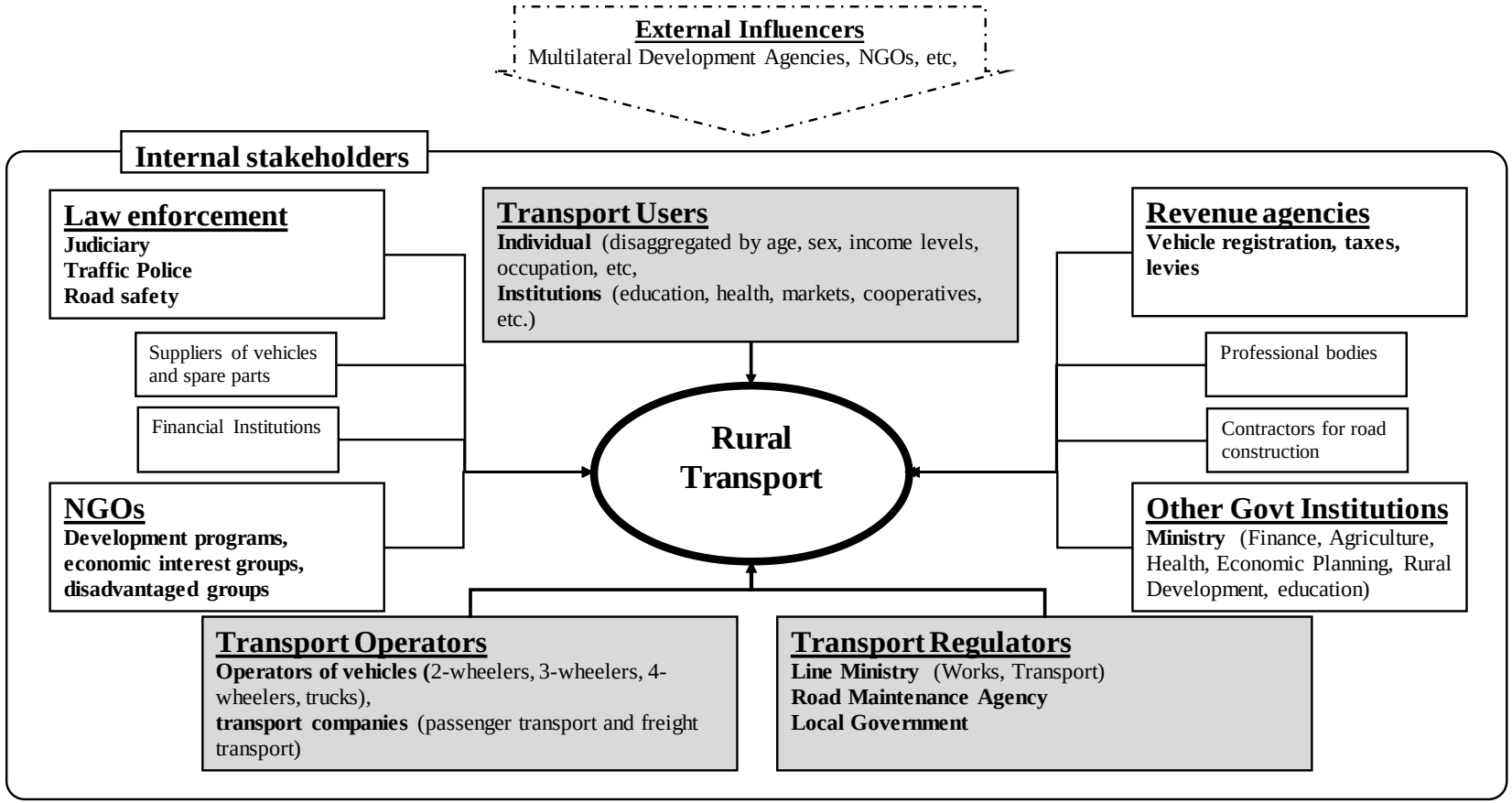


Figure 2.2: Stakeholders in Rural Transport System
Source: Adapted from Starkey *et al*. (2002)

Connerley & Schroeder (1996) suggests that rural transport planning needs to take cognizance of the fact that rural transport is composed of several kinds of input such as (i) source of energy (human, animal, mechanical); (ii) the means of transportation (animals, bicycles, motorcycles, rickshaws, 4-wheelers); (iii) rural transport infrastructure (roads, tracks, paths). Thus, the objective of the planning should take into account all the components of the transport system so as to optimize the desired benefits at a reduced cost. An important thing to know is that rural transport infrastructure may include paved roads, as well as all-weather earth roads, tracks, trails, and walking paths. The need for a particular type of rural transport infrastructure varies depending on the economic activities in a rural area. The infrastructure required for providing rural access to some areas may be paved roads, while for some other areas, providing all-weather earth roads will be sufficient. This implies that planners need to carry out some form of "travelling needs assessment" or understand the travelling purpose and patterns in the rural areas as part of the planning process.

Transport interventions may be done in different ways: (i) by developing new roads in the road network to open up new areas or shorten the distance to rural areas; (ii) by upgrading the quality of existing road infrastructure; (iii) by developing improved transport services, such as public transport; (iv) promoting the increased use of intermediate means of transport (IMT). Planning and prioritization of rural roads usually involve a number of steps: collecting and analyzing relevant data (expected traffic volume); identifying constraints (financial, technical, manpower, etc.); development and evaluation of alternative scenarios (using cost-benefit analysis, cost-effectiveness analyses, or multi-criteria analysis); deployment of resources and implementation; and monitoring of outputs, outcomes, and impacts (Hine, 2014). Given the huge resources involved in building efficient rural transport services, roads with the best returns on investments are usually prioritized. Beyond improvements in rural transport infrastructure and other ancillary support services, successful rural transport planning activities may also be achieved at a lower cost by making careful decisions on where to site services that are related to rural access. For example, siting of markets and agro-

logistic hubs may achieve desired rural development outcomes at a lower cost than upgrading some rural roads.

2.3 Rural Accessibility

There is no precise definition of rural accessibility. The term is used loosely to refer to the level of accessibility of rural dwellers to good quality roads, effective transport services, social services such as health and education, economic opportunities, etc. The concept of rural accessibility started appearing in the academic literature in the 1950s. Hansen (1959) examined accessibility within the context of the relationship between residential development and accessibility to commercial and industrial locations. The study defined accessibility as the "*potential* of opportunities for interactions". Moseley (1979) highlighted the challenge of rural accessibility in the rural parts of England especially as it affects the provision of transport services. This author defined accessibility as a combination of three factors: (i) the people living in rural areas; (ii) the regular activities that they need to live their lives such as health care, education, work, groceries and other goods, economic opportunities, markets, etc.; and (iii) the link required by the people to gain access to these activities. Building on this, Cloke & Edwards (1985) noted that the challenge of rural accessibility differs depending on the frequency of daily activities and the importance of such activities, and this has implications on transport service planning. The study presented a 2x2 classification framework of daily activities as shown in Figure 2.3

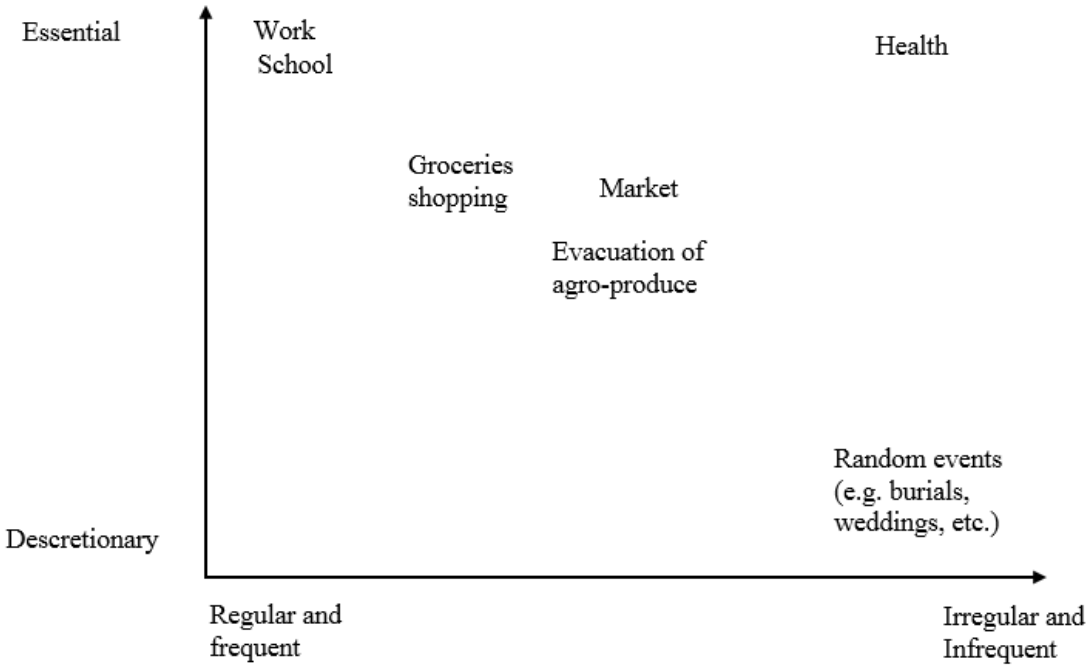
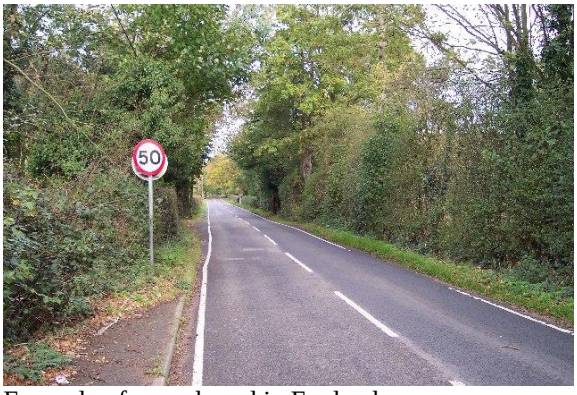


Figure 2.3: Classification of activities
Source: adapted from Cloke & Edwards (1985)

Nutley (1985) examined the planning options that may be used to improve rural accessibility in a specific area of rural Wales. The study adopted a "time-space approach" which involved evaluating different planning options and estimating the costs and benefits of these different options for comparison. The study defined optimum standard of accessibility as having access to every one of a set of necessary services and identified twenty-seven of such services. The population of the study area was then disaggregated into different social groups (e.g. elderly, children) with an understanding that different social groups have different accessibility needs.

From the foregoing, one may observe that accessibility may be examined relative to specific services or may be relative to specific user groups. This point is also noted by (Roberts *et al*. 2006). Parolin *et al*. (1994) considered how rural accessibility in Australia can be modelled using GIS techniques. Other studies that have examined how rural accessibility in developed countries may be improved include Brovarone & Cotella (2020) and Frank *et al*. (2021).

Even though the concept of rural accessibility is relevant to "rural areas" in developing and developed countries, the contemporary use of rural accessibility seems to portray the situation in developing countries. One primary difference in how the term is applied to developing and developed countries is that the quality of rural roads plays an important role in its application to developing countries. As may be observed from the studies highlighted above, rural accessibility in developed countries tends to focus on the availability of efficient transport services to support the mobility needs of people living away from cities and urban areas. For the developed countries, good quality roads linking rural areas to urban areas is not a problem as these roads exist. In contrast, developing countries are yet to overcome the barrier of having good quality rural roads. By "good quality rural roads", we refer to roads that are in fairly good and motorable conditions all year and all season.



Example of a rural road in England
Source: Online (creative commons license)


An example of a rural road (an undisturbed earth road) in the study area
Source: Author

Plate 2.1: Examples of rural roads

Roberts *et al*. (2006) had introduced the concept of Rural Access Index (RAI) which is aimed at providing a consistent indicator for measuring the level of rural accessibility in developing countries. The RAI "measures the number of rural people who live within two kilometers (typically equivalent to a walk of 20-25 minutes) of an all-season road as a proportion of the total rural population". The study notes that the RAI presents a

conceptual shift with respect to expected development outcomes from investments in improving the quality of rural roads. The RAI shifts the focus of investment in rural roads from the civil engineering perspective (which measures the characteristics, length, and size of roads) to a social perspective that examines how the improvement in a rural road provides access to social services to the people who reside close to the roads. RAI has been listed as an indicator (i.e. indicator 9.1.1) for tracking one of the SDGs (Goal 9 and Target 9.1) and has been described as one of the most important development indicators for tracking process in the transport sector in rural areas (Iimi *et al*. 2016). The method of computing RAI has been refined by recent studies (Iimi *et al*., 2016; Workman & McPherson, 2019).

2.4 Informal transportation services

The poor quality of rural road infrastructure in many developing countries has made it difficult for people to meet their mobility needs using transport services such as buses or regular sedans. This is because the roads are sometimes impassable and will impose a huge maintenance/repair cost on such sedans or buses. Moreover, there is seldom a well-organized or planned public transport service in most urban and rural areas. In response to this situation, rural dwellers have found other measures to meet their mobility needs through the use of motorcycles or tricycles. Porter (2014) notes that the expansion of motorcycles in rural areas in several countries in sub-Saharan Africa was fueled by the availability of cheap Chinese-made motorcycles coupled with the expansion of mobile telecommunication services which made rural dwellers to be able to call up motorcycle operators on demand. The use of these means of transportation in rural areas serves diverse purposes from the supply and demand sides of transportation services. From the demand side, motorcycles and tricycles help commuters to meet their daily mobility needs given the prevailing quality of rural road infrastructure. Motorcycles can ride on very narrow roads or tracks and can reach doorsteps of passengers (Olubomehin, 2012). From the supply perspective, it provides a means of livelihood and employment for hundreds of unemployed youths in rural areas (Porter *et al*., 2007). The means of livelihood is usually not limited to riding the motorcycles, but also do include sales of spare parts and

repairs of the motorcycles (Porter, 2014). It also provides a source of secondary income for people who own and rent their motorcycles either on temporary basis or as hire-purchase (Porter, 2014).

This category of transport services is not limited to rural areas - it is also pervasive in many urban areas, conurbations, and informal settlements (Olvera *et al*., 2016). For example, in Kampala (Uganda), motorcycles (called *boda bodas*) provide for the mobility needs of the majority of people in the suburbs and are a major employer of labor for young unskilled people (Evans *et al*., 2018). Hagen *et al*. (2016) observed that people in six Latin American urban areas (Barranquilla, Bogotá (Colombia), São Paulo, Recife (Brazil), Caracas (Venezuela), and Buenos Aires (Argentina) preferred motorcycles because of lower travel time due to its ability to navigate across traffic congestion in spite of the higher risk of accidents. Motorcycle is a major means of transportation in Lomé, Togo (Olvera *et al*., 2016); in Lagos (Nigeria), Douala (Cameroun), and Kampala (Uganda) (Kumar, 2011); in Liberia (Jenkins *et al*., 2020); and in several other cities in sub-Saharan Africa (Ehebrecht *et al*., 2018; Olvera *et al*., 2020). These forms of mobility have been described as "informal transportation" by different studies. Cervero & Golub (2007) defined informal transportation as transport services operating "without official endorsement", and that usually such "vehicles and operators do not have appropriate licenses, permits, or registration papers from public authorities to provide collective-ride services to the general public" (Cervero & Golub, 2007, p. 446). Other characteristics of informal transport services as espoused in Cervero & Golub (2007) are presented in Table 2.1.

Table 2.1: Characteristics of informal transport services as espoused in (Cervero & Golub, 2007, p. 446)

Legal/ regulatory status	No appropriate permits, licenses, or registration papers. Vehicles may not be insured to meet road fitness standards.
Types of vehicles	Small-sized vehicles such as motorcycles or tricycles owned and operated by individuals
Routes	Depending on the type of vehicle, services may be door-to-door or flexible enough to enter different routes that formal transport services may not cover. Service providers may stop anywhere to board or drop passengers. For some vehicles (e.g. mini-buses), the services may have semi-fixed routes
Schedules	No fixed schedules. Different service providers choose whatever time and route may be profitable for them
Pricing	There may be no fixed price. Service providers often compete for customers. In places where service providers organize themselves into an association for some cities or routes, such associations may turn into cartels and may be begin fixing prices.
Passenger capacity	The number of passengers depends on the specific type of vehicle
Cervero & Golub (2007)	

The definition of "informal transport services" seems to be biased against what may be described as a "modern city" where there is extensive and efficient planning and operations of public transport services on one hand, and the existence of non-licensed operators on the other hand. However, studies have noted that the informal sector or informality is gradually becoming the new normal given the seemingly ubiquitous nature of informality across several developing countries (Ezeibe *et al*., 2017).

Even though this category of transport services has several advantages, they are not without their challenges. For example, several studies have observed a high incidence of road accidents amongst motorcycle riders (Kumar, 2011; Ehebrecht *et al*., 2018; Kitamura *et al*., 2018). Policymakers sometimes view the existence of this category of transport services as a deviation from the ideal, where the ideal is the transport system in developed countries (Ezeibe *et al*., 2017). Olvera *et al*. (2016) reports that in some countries, the operators of motorcycle services have a negative public image in the eyes of the general public who often associate them with acts of aggression, violence, and delinquency. In some cases, where the operators of this category of transport services have been able to organize themselves into associations, they are sometimes regarded as threats to established political orders (Olvera *et al*., 2016). Furthermore, due to the non-functional and inefficient state of public transportation and the over-reliance on these individualized means of transportation by a large percentage of the population, any disruption in their usual operations affect the majority of people and is widely reported in the media (Kumar, 2011). Based on these reasons or some other localized reasons, governments in different countries and sub-national regions have sought to have greater control of the informal transport services. In some cases, governments have attempted to restrict their operations in different areas or times of the day, even when there are no feasible alternatives (Kumar, 2011; Oteng-Ababio & Agyemang, 2012; Evans *et al*., 2018; Agheyisi, 2021; Ezeibe *et al*., 2017).

Tricycles are also playing increasing roles in meeting transportation needs in rural and urban areas in developing countries. Tricycles seem to be within the midway between motorcycles and sedan-taxis. Guillen & Ishida (2004) reviewed the evolution of motorcycles and tricycles as a means of public transport in a city in The Philippines and observed that tricycles are becoming the dominant means of public transportation in the study area. The study compared the motorcycles and tricycles as means of public transportation as shown in Table 2.2.

Table 2.2: Comparison of motorcycles and tricycles by (V. Guillen & Ishida, 2004)

"Description	Tricycles		Motorcycle taxi
	Standard-Design	Center-cab-Design	
Local Name	Tricycles	Motor-cab	"Habal-habal"
Period of Emergence	Late 50's	1994	1999
Type of Motorcycle used	Small and low-powered Utility Motorcycles	Utility Motorcycles	Utility motorcycles:
Design Innovations	Motorcycles with attached steel covered roof side-cab	Motorcycle is in the centre and attached side cab is designed like a mini-jeep	Extended seats of motorcycle with extra shock absorber
Role in Transport System	Feeder mode/short-haul journey	Feeder mode/short-haul journey	Feeder mode/urban-rural journey
Service Coverage	Residential areas	Residential areas/market place	Market, shopping areas /residential and school areas;
Road Description	Concrete/paved/ asphalted roads	Concrete /paved/asphalted roads and some uphill	Rough/unpaved roads Poor road network
Ave. Distance per trip	1-5km	1-5km	3-5km
Type of Service	Door-to-door	Door-to-door	Door-to-door
Carrying Capacity (Driver and Passenger)	1-5; Two passengers in the side cab and one to two more at the	1-10; the passengers are seated face-to-face; can accommodate 6-7 persons	1-4"

	back of the driver are possible

Source: Guillen & Ishida (2004)

Tricycles were first introduced in Nigeria in Lagos State between 1996 and 1999 by the then government of Lagos State as a means to complement urban transportation (Agheyisi, 2021). The aim was to address the problem of high unemployment rate while simultaneously solving urban transportation problems. The tricycles were called *keke Marwa* (*keke* is a Yoruba word for bicycles or motorcycles while Marwa is the name of the military administrator that introduced the tricycles) (Agheyisi, 2021). This idea of addressing the problems of youth unemployment and urban transportation was adopted by the then federal government of Nigeria and implemented in the nation's capital (i.e. Abuja) in 2001 under the National Poverty Eradication Programme (NAPEP) and an inscription *Keke NAPEP* was written on them (Agheyisi, 2021). Thereafter, the use of tricycles spread across different parts of Nigeria driven by the private sector as business people started importing them (Agheyisi, 2021). Several studies have been carried out in Nigeria to address this means of informal transportation as they relate to diverse economic and social issues. Ajıboye *et al*. (2020) examined the operation of tricycles as a means of public transportation in Minna (Nigeria) from the perspective of the operators and observed that it provides a means of livelihood for several young people. Specifically, the study observed most operators acquire their tricycles through a hire-purchase arrangement and there are usually high maintenance expenses. Nwaogbe *et al*. (2012) carried out a similar study in Aba (Nigeria) but extended its scope to cover the views of customers of the tricycles. The study observed that a large percentage of the customers were relatively comfortable using tricycles but were concerned about safety.

Agheyisi (2021) examined the operations of tricycles in Benin City, Nigeria with respect to accessibility of different neighborhoods. The study reports that the government of the state where Benin City is located (i.e. Edo State, Nigeria) placed a ban on motorcycles from operating in the city and instead allowed tricycles to operate in the city, albeit

restricted to certain parts of the city dominated by residential areas. The study observes that tricycle riders are organized into several units with each unit covering a clearly delineated area in the city. A new rider is required to pay a specified amount to the unit to enable him to ply the routes covered by the unit. The units regulate fares for the different roads covered by the units taking cognizance of the length of a trip, quality of roads, price of petrol, among others. The study also highlights other dimensions of tricycle operations including routes, speed, rhythm, experience, etc.

Oviedo *et al*. (2021) identifies another form of informal transport service prevalent in Port-Au-Prince, Haiti, called "Tap-Tap" which is made up of modified pick-up vans or buses.

2.5 The Political Economy of decision making in rural transport infrastructure development

As noted previously, transport infrastructures play very important roles in promoting accessibility and facilitating economic activities in an economy – whether rural or urban. One of the main challenges of transport infrastructure development is the availability of financial resources to build and maintain them. Given that these infrastructures are considered as public goods in most countries, the decision on which road to build or upgrade is usually done by the government. Within the context of this study, the decision on selecting a rural road to upgrade is actually an investment decision that will involve committing scarce financial resources. The final decision on which road should be upgraded will be a culmination of a series of smaller decisions which may include the location of the road, quality of upgrade, level of maintenance, cost of upgrade and maintenance, etc. which adds up to the budgetary requirement. Depending on the economic and political system in a country, the item will have to be included in an annual budget which will be reviewed by different institutions. The highest decision-making authority in most countries or sub-national administrative regions is usually political actors who have political interests to protect and advance. This implies that decision-making for transport infrastructure development may be regarded as political.

From a political perspective, and given the paucity of financial resources, the decision of upgrading a road is sometimes made to benefit a clearly defined set of electorates, while the other electorates who are perceived by political actors not to constitute any form of threat to their political aspirations may be left without transport infrastructure (Blimpo, et al., 2013). The same study notes as follows:

> "following the recognition that politicians' incentives may vary over different types of goods, we might also expect that the under-provision of goods to politically marginalized citizens should be particularly severe with regard to more visible or attributable goods; since politicians gain credit for providing visible goods, they have an incentive to target them towards voters who have influence over electoral outcomes, rather than to politically marginalised citizens. In many African countries, one such visible good is transport infrastructure, and in particular roads, the presence of which has an enormous impact on the daily lives of all citizens."
>
> Blimpo *et al*. (2013), p. 61.

Public spending on capital projects may be targeted at specific locations, interest groups, or constituencies in exchange for campaign finance or political support (Vergne, 2009). Mani & Mukand (2007) presents a very comprehensive analysis on how the level of perceived visibility of public goods influences the interest of governments in providing such goods. The study notes that governments are usually inclined to invest in infrastructures that are visible and tangible such as roads, rather than less-visible ones, and are more inclined to provide these public goods to areas that have more influence on political outcomes. Khemani (2010) examined the political-economy of infrastructure spending in India. The study noted that public expenditure on capital projects (water, electricity, and roads) are often used for political rent extraction and dominate political

rhetoric during election. Also, welfare spending on education and other pro-poor services may also be used for political gains instead of the desired development outcomes. Banerjee & Somanathan (2007) also observes that in India, the historically marginalized social groups who mobilized themselves to become politically relevant benefited better from government's investment in rural infrastructure. Keefer & Khemani (2005) examined the political incentives for the government to provide public goods in different countries. The study highlighted the likelihood of politicians to divert resources to political rents and to concentrate public investments in activities that are visible which they can point to when they need support – such as on infrastructure or jobs creation, rather than on social services like health or education.

In developing countries with nascent democracies, there are notably (and sometimes significant) changes in the expenditure outlay in years preceding elections (Schuknecht, 1996; Shi & Svensson, 2006; Brender & Drazen, 2005). This phenomenon is sometimes referred to as "political business cycles". The changes in the expenditure outlay may be in terms of an increase in expenditure, or changes in the sectoral composition of expenditure which reflects the preference for different policies and programs which will be appealing to voters during elections. The political business cycle seems to be minimal in countries with advanced democracies where the institutions are strong and independent from political actors, and where electorates are informed on the economic implications of having fiscal deficits (Shi & Svensson, 2006; Brender & Drazen, 2005).

Another dimension of the political-economy of roads infrastructure investment in developing countries is that of abandonment of projects. Politicians are usually cautious in completing infrastructure projects started by their predecessors (Wagner, 2012). They usually want to initiate and complete any project so that the attribution and/or credit of such project(s) goes solely to them. This happens even when the predecessor is from the same political party. The economic cost of the abandonment of road projects is generally huge (Ezenekwe & Uzonwanne, 2017).

Another political-economy aspect of rural roads upgrade is the lack of institutional capacity for maintenance of the roads. Multilateral development agencies have invested several billions of United States dollars on building new roads in developing countries. However, these roads fail faster than those in developed countries because of lack of maintenance (Kaiser & Streatfeild, 2016). This study notes that "[p]olitical leaders often espouse public commitment to maintaining roads, but there is great variation regarding available resources and the systems and processes in place to fulfil this commitment" (Kaiser & Streatfeild, 2016). Furthermore, Streatfeild (2017) argues that due to the fact that roads are visible infrastructure, building new roads has more political value than maintaining the existing roads, even though the long-term economic cost of preventive maintenance is much lower than the economic cost of rehabilitation of the roads. The study described this scenario thus:

> "…bucket of sand with holes in the bottom. Donors put more sand in the 'bucket' when they build new roads because that is an immediately visible way to demonstrate a successful project and, therefore, politically popular. However, without fixing the maintenance flow—the holes—the sand will continue to deteriorate at the same rate as before." (Streatfeild, 2017, p. 79).

The low levels of maintenance of roads cut across developing countries in all the regions of the world. The major factor responsible is the lack of sufficient financial resources. However, Kaiser & Streatfeild (2016) notes that the problem of road maintenance goes far beyond finances, and includes the lack of institutional capacity to maintain roads over a long period of time.

Wilson (2004) examined the political-economy of roads, sharing experiences from Peru. The study questioned the notion that the outlook of rural communities towards having roads that open up their areas is usually positive and observed that there are cases where rural communities prefer not to be connected for different reasons, some of which may

be political. It argued that while rural transport infrastructure helps in improving accessibility and reducing the cost of spatial transactions such as transportation cost, the assumption in several development literatures that transport infrastructures are socially and politically neutral was not consistent with realities. It noted that rural transport infrastructure development should be situated within the context of political power and political-economy. The study raised important political-economic questions as follows, given the importance of roads "Who decides how/where connections are made and how/where movement is channeled? What kinds of routes/roads emerge under different kinds of political economy?" (Wilson, 2004, p. 526).

Based on the questions posed by Wilson (2004), additional questions may also be raised such as, what is the primary purpose of upgrading a specific rural road? Or, is the purpose of upgrading a rural road economic, social, or political? If economic, who are the intended beneficiaries - the rural communities or some external entities? The list of possible political-economic questions can go on. These questions are important from the political-economic perspective because some studies have reported that the upgrading of rural roads has sometimes resulted in negative development outcomes from the perspective of the rural area which was presumed to be benefiting from the roads. For example, the negative impacts of rural road development in the Amazon rainforest and Congo Basin vis-à-vis deforestation and conflicts are well documented in the literature (van Solinge, 2010; Simmons, 2004; Damania & Wheeler, 2016).

Furthermore, the fact that road transport is one the most "visible" investments that can be done by a politician, implies that it is usually susceptible to a whole lot of corruption. Porter (2007), p. 252 reports that "politics, corruption and the mystique of the paved road continue to encourage a roads focus in national transport strategies". Naimanye (2015) suggests that there is "convoluted corruption" in the development of road transport in developing countries. Porter (2007) also notes that the corruption in road infrastructure provision manifests itself in different dimensions such as the selection of routes to be constructed, disparities between the specifications in the actual road constructed and what was in the contract, etc. In its report on "Curbing Fraud, Corruption, and Collusion in the Roads Sector", World Bank (2011) highlighted different forms of corruption pervasive

in the road transport sector. The study noted that sharp practices in road transport development start from the point of tendering for a road project. Sometimes, even when the procurement process may be deemed transparent and fair, the construction phase of road projects is often plagued by the reduction in specifications. For example, the use of aggregate particles below specified sizes, making the bases of roads thinner than required, use of less cement than specified, concrete that is weaker than specified, etc.

CHAPTER THREE

3 REVIEW OF RELATED LITERATURE

3.1 Review of literature on travel patterns and/or behavior

There is a strong relationship between the travel patterns of people and their needs (Handy, 2005; Acker *et al*., 2010; Cui *et al*., 2017). People travel, not for the main purpose of travelling, but to meet an end which may be to visit, go to work, buy groceries, sell merchandise, or any other purpose. Therefore, travel demand is a means to an end, or "derived demand".

Travel behavior examines how people move physically to meet their mobility needs; their purpose for moving; and the personal, social, and environmental conditions which influence their decisions to move (Acker *et al.*, 2010). Several factors influence travel behavior: socio-economic and demographic characteristics of people such as age, sex, income, family size, etc. (Porter, 2011; Porter *et al*., 2013; Foley *et al*., 2021; Dėdelė *et al*., 2020); the travel options available to people (Porter *et al*., 2013); cost of travel (Porter *et al*., 2013; Foley *et al*., 2021); built environment and land use factors (Ramezani *et al*., 2021; Wee *et al*., 2019; Li *et al*., 2018); social affiliations and networks (Carrasco *et al*., 2008; Kim *et al*., 2018); ownership or access to technologies (Fadare & Salami, 2004; Porter, 2016; Gwaka, 2018); religious and cultural factors (Xu *et al*., 2009; Badawi & Farag, 2021); health conditions (Olawole, 2017; Porter *et al*., 2013; Cochran, 2020; Dėdelė *et al*., 2020); and a combination of these factors. In recent times, the COVID-19 pandemic has affected the travel behavior of people (Brough *et al*., 2021; Irawan *et al*., 2021; Brinkman & Mangum, 2021; Anwari *et al*., 2021). Due to the COVID-19 pandemic, several categories of workers regarded as non-essential workers were required to work from home which inadvertently influenced some changes in travel behavior (Balbontin, *et al*., 2021). Travel behavior may manifest itself in terms of ownership of vehicles, number of trips, length of trips, travel mode choices, etc.

3.1.1 Travel patterns and behavior in developed countries

There are several surveys and literature on travel patterns in developed countries. For example, Santos *et al*. (2011) presents the summary of travel patterns of households in the United States of America (USA) from the 2009 National household travel survey while the UK Department for Transport (2019) presents a report of UK National Travel Survey for England[10]. Tal & Handy (2010) examines the relationship between immigrant status and travel behavior using the US 2001 National Household Travel Survey while Kuhnimhof *et al*. (2012) examines the travel behavior of young adults in six developed countries (USA, Norway, Japan, Great Britain, France, and Germany) using data from National Travel Surveys conducted in each of these countries. Conferences on travel surveys have also focused mainly on developed countries (Bonnela & Munizaga, 2018).

From the foregoing, it is clear that most developed countries conduct periodic national household travel surveys which provide insights on travel behaviors/patterns and help in planning. Several individual surveys have also been conducted in developed countries to examine different dimensions of travel behaviors. For example, Carrasco *et al*. (2008) examines the role of social networks in travel decision in Canada; Kuhnimhof *et al*. (2012) examined the mode of transport used by young adults in Germany; while Frändberg & Vilhelmson (2011) examined personal mobility trends in Sweden with a focus on gender.

3.1.2 Travel patterns and/or behavior in developing countries

National surveys on transport patterns in sub-Saharan Africa countries are scarce. Except for South Africa (Statistics South Africa, 2013) and Ghana (Ministry of Roads and Highways, 2012), we have not seen reports on national surveys in the public domain[11].

[10] Different stylized versions of the report may be seen via https://www.gov.uk/government/statistics/national-travel-survey-2018 (Accessed on November 6, 2019).
[11] In the Anglophone countries in sub-Saharan Africa.

Salon & Aligula (2012) reports a household travel survey that was conducted in Nairobi, Kenya.

3.1.2.1 Travel patterns and/or behavior in developing countries: urban areas and informal settlements around urban areas

Some studies have attempted to understand the travel behaviors of people in urban areas. For example, Afolabi *et al*. (2017), Osoba (2012), and Idrisu & Osoba (2015) examined the travel behavior of public transport passengers in Lagos, Nigeria. Amoh-Gyimah & Aidoo (2013) examined the mode of transportation adopted by government employees in Kumasi, Ghana. Behrens (2004) sought to understand the travel needs of the poor in Cape Town, South Africa, using an activity-based household travel survey method, with a view of improving the practice of travel analysis in the country. Particularly, the study sought to understand whether the structure of the travel system in Cape Town is a good representation of the complexity of the travel needs of people in the city. The study found that some travel occurs by non-motorized means during off-peak period for non-work purposes, and also reported results for daily travel behaviors, route choices, etc. Salon & Aligula (2012) sought to understand the travel behavior, patterns, and stated preferences of residents of Nairobi, Kenya. The study found that the key factors influencing the means of transportation chosen by residents were physical access to the means of transportation and affordability.

Andreasen & Møller-Jensen (2017) examined the mobility patterns and challenges faced by people residing in the outskirts of Dar es Salaam (Tanzania) with respect to access to social and economic opportunities in the city. Venter *et al*. (2007) examined how the residential location within a city affects the travel behavior of men and women in Durban, South Africa. The study observed that there were significant differences between the travel experiences of men and women, depending on where they live. There were non-remarkable differences between the experiences of men and women for persons who lived in central locations. Whereas for those who resided in the outskirts, the differences were

remarkable. Furthermore, the study observed that persons who resided in the outskirts had a larger travel burden and the burden was even higher for women.

Porter *et al*. (2021) examined the mobility and transport-related challenges faced by women in the outskirts of three African cities (Abuja, Cape Town, and Tunis) as well as the impact of COVID-19. The study noted that the patriarchal cultural situations in the study areas limit women's participation in transport the sector which in turn limits the transportation options available to women and the economic opportunities thereof. Women were more vulnerable to sexual harassment. The onset of the COVID-19 pandemic and the attendant lockdowns in the different countries exacerbated the situation because the women in the outskirt of these cities are generally low-income earners who survive on daily wages and needed to leave home every day to earn a living. Behrens, (2021) examined how low-income women in Cape Town (South Africa) cope with the challenges of transportation in the study area. Other studies in this category include Mahadevia & Advani (2016) who focused on Rajkot, India, and Salon & Gulyani (2010) who focused on slums around Nairobi, Kenya.

Oviedo *et al*. (2021) examined and documented the walking experiences of people living in informal settlements in Freetown, Sierra Leone. The study examined the physical conditions of the routes that residents often used as well as what residents do to reduce risks and improve their walking experiences. The walking experiences were classified into three categories: accessibility, safety, and pleasurability. Accessibility was used to represent the characteristics of the built environment with respect to distance and ease of accessing social, economic, and recreational services by walking; safety represented road and personal safety when walking; while pleasurability represented the comfort and aesthetics (such as greenery) experiences by people when walking. The result of the study showed that residents of the study area had engaged in several self-help strategies to improve their walking experiences.

Jain *et al*. (2018) examined the determinants of the commuting patterns between rural and urban areas in India and observed that the location of the residents, the availability of infrastructure, gender, and level of education played important roles in determining commuting patterns. Similarly, Sadhu & Tiwari (2016) examined the factors that determine the choices of travel destinations of urban poor in informal settlements in Delhi, India using a survey of 1669 households.

3.1.2.2 Travel patterns and/or behavior in developing countries: rural areas

Several studies have examined the travel behaviors of rural dwellers in developing countries. Bryceson & Howe (1993) examined rural household travel patterns and focused specifically on the gender perspective. Khayesi (1993) examined the rural household travel characteristics in the Kakamega district of Kenya using household surveys. The study sought to understand the purpose of trips, preferred routes and modes, length of trips, etc., and to establish whether there is a relationship between these factors. Airey & Cundill (1998) examined rural household travel behavior in a rural area in Kenya before and after a rural road was constructed. The survey examined the socio-economic characteristics of households (including size and composition), number and type of vehicles owned, number and sizes of farms owned and farmed, range of crops produced and sold, and other income sources. The household heads were asked to record the purpose of trips, destinations, travel mode, fare, etc. Oyeleye *et al*. (2013) categorized rural travel needs into "on-farm" (i.e. trips for meeting basic household needs such as water, firewood, etc.) and "off-farm" (trips for accessing markets or other social services). Porter *et al*. (2013) examined the mobility constraints faced by older people in rural Tanzania and how this affected their health, income and livelihoods. Porter *et al*. (2007) examined how mobility challenges in rural areas affect the youth and their livelihood options. The study considered the role of daily mobility options on the livelihood opportunities available to young people in rural areas. Similarly, Porter *et al*. (2010) examined how physical mobility and access to affordable transport services affect livelihood opportunities for youths in a rural area in South Africa.

Afukaar *et al*. (2019) carried out a comprehensive assessment of rural transport service in Ghana using mixed methods. The study highlighted the means of transportation often used in rural Ghana depending on the purpose of travel and destination to include saloon cars, large buses (with up to 40 seats), midi-buses (up to seats), mini-buses or "tro-tros", as well as intermediate means of transportation which includes motorcycles and tricycles. In terms of the frequency of travel services and how predictable the travel services are, the study observed that public transport services were generally unpredictable and limited. However, the frequency of travel services was higher on market days and lower in the rainy season. Most of the public transport opportunities were offered by motorcycles, even though there were larger vehicles that offer travel opportunities. The preference of motorcycles to larger means of transportation was due to time savings as motorcycles could depart for the journey whenever any passenger was ready, whereas the larger vehicles will have to wait till full occupancy. Fares were not uniform and varied across different means of transportation. Other aspects of rural transport services examined by the study included safety and regulation. Adom-Asamoah *et al*. (2020) examined how investments in rural road improvement in Ghana under the "Road Sector Development Project (RSDP)" of the Government of Ghana impacted households and examined how this impact affected both genders. The study observed that the impact was more beneficial to women.

Studies that focus on Nigeria are few. Olawole (2017) examined how the limited availability of travel services and options affected the quality of life of elderly people in a rural area in Nigeria. The study observed that elderly people had unmet travel needs due to poor conditions of roads, unreliable and irregular transport services, among others and these unmet travel needs affected their opportunities to meet their health needs. Adetunji (2020) examined the travel behavior of women to markets in rural communities in South-Western Nigeria.

A good number of literature on travel patterns in rural areas are part of the DFID-funded Research for Community Access Partnership (ReCAP) or the World Bank-funded sub-Sahara African Transport Project (SSATP)[12]. Willilo *et al*. (2015) carried out a baseline study on rural transport service indicators using Kidabaga-Boma La-Ng'ombe Road in Kilolo District of Tanzania which is a 20km road with parts being earth road and other parts being gravel road. The result showed that the dominant mode of transportation was motorcycles while trucks were used for evacuating agricultural produce. Some medium-distance travels were done by foot. The survey also revealed that the average commute time on regular days is about 45 minutes by bus and motorcycle and 1hour by truck, yielding an average speed of 25km/hr and 20km/hr respectively. Other indicators related to the cost of travel, reliability of travel modes, etc. are also reported.

Starkey *et al*. (2013) carried out a survey to ascertain rural transport service indicators in Tanzania, Kenya, and Cameroon. The study observed that motorcycles were the dominant (and sometimes the only) means of transportation in rural areas but the mode of operation in terms of how fares are determined (i.e. pricing), loads, routes, and frequencies was quite different across the roads that were surveyed. The study noted that people often used motorcycles for short distance trips but will prefer buses or mini-buses for trips that are longer or trips that will terminate in urban areas. A downside to the preference for motorcycles is that motorcycles are perceived to be more prone to accidents and seldom conform to regulations. The study noted that "Users of rural transport services would like services to be available, affordable, safe, convenient, predictable, timely, comfortable, clean and integrated."

Starkey *et al*. (2019) presents a summary of a similar survey in Ethiopia covering four regions (Amhara, Tigray, SNNP, and Benishangul-Gumuz). The survey showed that the highest number of trips were to markets, religious centers, and farmlands; 99% of trips to farmland was by walking, 98% of trips to school was by walking, while 67% of trips to

[12] http://www.ruraltransport.info/RTSi/resources/project_outputs.php (Accessed on 29th October, 2019)

hospital was through bus/minibus. Further, the study reports a reduction in time taken to access social amenities in areas where there was an improvement in road quality. Similarly, Bishop *et al*. (2018) found that motorcycle was the dominant means of transportation in the rural areas of four countries (Ghana, Kenya, Tanzania, and Uganda). Motorcycles were used mainly because they are readily available even in emergencies, provide employment opportunities, and can easily navigate bad roads and tracks.

3.1.3 Travel mode choices

Travel mode choice is a subset of travel behavior that seeks to understand the factors that influence people's preferences for different modes of transportation at any given time. Numerous studies in the literature have been carried out to examine travel mode choices and these studies focus on diverse travel-related themes including gender (Scheiner & Holz-Rau, 2012; Salon & Gulyani, 2010); work (Bhat, 1997; Amoh-Gyimah & Aidoo, 2013); school (Mitra *et al*., 2010; Mitra & Buliung, 2015; Zhang *et al*., 2017), etc. Most of these studies are in developed countries or urban areas in developing countries.

3.1.4 Vehicle Ownership

Vehicle ownership plays a role in determining travel patterns especially in places where public transportation is non-existent or inefficient. In Nigeria, the National Demographic and Health Survey of 2018 included a segment on household durable goods which included a question on ownership of means of transportation. The result is shown in Table 3.1. The report also notes that motorcycles and scooters are the most common means of transportation to health facilities for delivery.

Table 3.1: Ownership of means of transportation in Nigeria

Means of transportation	Urban (%)	Rural (%)	Total (%)
Bicycle	9.4	15.2	12.5
Animal-drawn cart	0.7	5.2	3.1
Motorcycle/scooter	21.3	32.9	27.5
Car/truck	13.9	5.2	9.3
Boat with a motor	0.5	0.7	0.6
Canoe	1.1	2.7	1.9
Keke Napep (auto rickshaw)	1.2	0.6	0.9

Source: National Population Commission (2019)

Comparing this with that of other countries in sub-Saharan Africa shows huge similarities in terms of the pattern of ownership of means of transportation. We present in Table 3.2. the ownership of different means of transportation in other African countries as reported in the National Demographic and Health Surveys of the respective counties.

Table 3.2: Ownership of means of transportation in Ghana, Kenya, and Uganda

Means of transportation	Ghana			Kenya			Uganda		
	Urban (%)	Rural (%)	Urban (%)	Rural (%)	Total (%)	Total (%)	Urban (%)	Rural (%)	Total (%)
Bicycle	17.4	30.7	16.2	24.8	21.2	23.4	21.2	37.0	32.9
Animal-drawn cart	0.7	1.4	1.1	2.5	1.9	1.0	0.6	0.4	0.4
Motorcycle /scooter	6.9	11.1	6.0	8.2	7.3	8.8	12.3	10.5	10.9
Car/truck	13.2	4.4	7.2	2.7	4.6	9.2	9.6	2.0	3.9
Boat with a motor	0.3	0.4	0.2	0.2	0.2	0.4	0.4	0.4	0.4
Boat without a motor							0.3	1.2	1.0

Source:	Ghana Statistical Service (2014)	Kenya National Bureau of Statistics, (2014)	Uganda Bureau of Statistics (2016)

3.2 Discrete Choice Model

The discrete choice model has been used extensively to examine travel mode choice problems (Ben-Akiva & Lerman, 1985; Ben-Akiva & Bierlaire, 1999). The model assumes that the travel choice made by a person is dependent on the attribute of the person (e.g. socio-economic characteristics) as well as the attributes of the different means of transportation available to the person at a particular time. Since travel mode choices are discrete and qualitative, statistical models for estimating categorical dependent variables are commonly used to analyze travel choice problems. Specifically, the multinomial logit model is commonly used (Ben-Akiva & Lerman, 1985; Muller *et al*., 2008; Thrane, 2015) due to its simplicity and ease of estimation and interpretation. However, Forinash & Koppelman (1993) highlights a major weakness in using the MNL which is that it reduces the relative probabilities of alternatives if a new mode of transportation that is similar to one of the existing modes is introduced (i.e. the condition of independence of irrelevant alternatives). To overcome this challenge, other advance models such as nested logit (Dissanayake & Morikawa, 2002), multinomial probit (Can, 2013); etc. are used. In addition to discrete choice modeling, machine learning tools such as random forest (Cheng *et al*., 2019; Sekhar *et al*., 2016), decision tree (Lindner *et al*., 2017), and Neural Networks (Golshani *et al*., 2018) have been applied to address travel choice problems.

3.3 How (Improvement in the Quality of) Rural Roads can unlock Economic Opportunities

Several studies have been carried out to highlight how rural road transport infrastructure can unlock economic opportunities and lead to rural socio-economic transformation. Most of these studies focus on specific indicators. To have a holistic view of the

contribution of rural road transportation to rural transformation, there is need to present a compendium of these impacts, thus the need for a literature review. There are several previous studies that have been done to review the impact of transportation on economic development (Kessides, 1996; Ajakaiye & Ncube, 2010; Ayogu, 2007; Calderón, 2010). However, these studies focus on transport infrastructure in general, and not specifically on rural road transport infrastructure. There are recent studies that have examined the impact of rural roads (Hine *et al*., 2016; Sieber & Allen, 2016). In this section, we review literature to synthesize evidence on the impact of rural road infrastructure. We focus on **the results** of studies but **do not discuss the methods** used by these studies. This is deliberate and is done because the primary objective of our study is **not** to examine the impact of rural roads improvement. Section 3.3 is included in this Chapter to demonstrate and emphasize the role of rural road infrastructure improvement in promoting socio-economic development. The literature on how rural road planning has been carried out previously and the methods that may be adopted to answer our research question is reviewed in Section 3.4.

3.3.1 Positive Impacts

3.3.1.1 Agricultural development and market integration

Most rural communities depend on primary sector for their food and livelihoods. Farmers therein are mainly smallholder farmers and commercialization of agriculture depend on the efficiency of collation and aggregation of produce, and evacuation of the produce to markets (Njenga, et al., 2014, 2015). Good quality rural road infrastructure contributes to enhancing this efficiency in three areas: (i) improvement in accessibility to farms in terms of cost and time; (ii) improvement in accessibility to markets in terms of cost and time; and (iii) reduction in the cost of maintenance of vehicles (Jacoby, 2000). Studies[13] by Njenga *et al*. (2014) show that due to unavailability of good quality road, farmers rely on motorcycles or other non-motorized means of transportation and the cost of transporting

[13] These studies are part of the "First mile transport challenges" for smallholder farmers, a project funded by the United Kingdom's Department for International Development (DFID) under the Africa Community Access Program (AfCAP).

produce to collation points is up to 16 times more than lorry cost on ton per kilometer basis. The corollary will be that the availability of good quality rural infrastructure has the potential of reducing the "first mile" transportation cost for rural farmers by up 16 folds, where the first mile means the distance from the farms to the collation points of farm produce (Bradbury *et al*., 2017).

The contribution of rural road transport to agricultural development in rural areas is also highlighted by Banjo *et al*. (2012) who adds that poor quality rural road infrastructure limits the spread of information and increases risk to rural farmers. Inoni & Omotor (2009) found that in a part of Nigeria, improvement in the quality of rural road led to about 12% increase in agricultural output and 2.2% increase in household income, and also promoted linkages between the agriculture and non-farm sector resulting in income diversification among rural households. Beyond crop production, improvements in rural roads also has substantial benefits to rural fishing communities as reported by Olsson (2009).

The impact of improvement in the quality of roads on agriculture is two ways. On one hand, a community gets improved access to markets and on the other, goods from outside the community easily reaches the community. This situation fosters improved economic integration. Aggarwal *et al*. (2017) finds that farmers are more likely to adopt improved agricultural inputs such as seedlings or fertilizers if there is improved road infrastructure since it will be easier for these inputs to reach the farmers. Aggarwal (2018) found an increase in the variety of goods consumed by households. Specifically, the study finds that there was a decrease in non-perishable food items and an increase in substitute food items that can last longer. Mu & van de Walle (2011) also finds that improvement in rural access has significant average impacts on the development of local markets in Vietnam. Asomani-Boateng *et al*. (2015) examined the socio-economic impact of Ghana's Transport Sector Program Support (TSPS I & 2) based on before and after comparison of indicators over a five-year period. The study grouped impacts into three categories: impact on productivity, access to social and economic services, and market network

efficiency. On agricultural productivity, the study found that there was a significant increase in the level of production for most food crops as a result of road improvement. Also, due to access to higher order markets as a result of road improvements, farmers were able to sell their food crops for better processing, and had more disposable income. Iimi *et al*. (2015) examined the socio-economic impact of rural road improvements in the State of Tocantins, Brazil. The study found that rural accessibility (in terms of reduction in time travelled to the nearest populated areas and municipal center) had improved. The choice of mode of transportation also changed as more people moved from non-mechanized modes of transportation to mechanized modes. Lindsay & Kongolo (2014) also finds that improvement in rural roads resulted in substantial agricultural benefits in Swaziland. Shamdasani (2021) examined the impact of a large rural roads development program in India and observed that farming households who gained improved accessibility had diversified their crop portfolio and adopted modern agricultural technologies. Takada *et al.* (2021) observed that the improvement in the quality of rural roads in some rural areas in Cambodia led to an increase in the number of times people went to local markets which in-turn contributed to improvement in household income.

3.3.1.2 Increase in access social amenities (education and health), Human Wellbeing and Reduction in Poverty

A good access to social amenities, especially health and education facilities is necessary to produce healthy workforce that have at least basic education, and it is vital for poverty reduction. Good transport infrastructure and services contributes to this. Poor quality of roads may be a disincentive to teachers and health workers from working in rural areas which re-enforces the difficulty of rural dwellers to access good health care. Asomani-Boateng *et al*. (2015) reports an increase in the percentage of persons travelling less than 30 minutes to school as a result of improvement in rural roads, as well as a slight increase in access to health and education facilities. Aggarwal (2018) finds that there was an increase in school enrolment as a result of improvement in rural access in India among other positive impacts. Bell & Dillen (2018) reports that providing access to rural communities contributed to reduction in morbidity due to increased access to health

facilities. Porter (2014) highlights other impacts of improved rural access on education and health.

The linkage between improvement in rural roads and human wellbeing is multidimensional as it transmits through improvement in household income and access to social amenities. Several studies have used diverse methodologies to access the impact of improvement in rural access on poverty reduction. Bucheli *et al*. (2018) found that the improvement in the rural access led to reduction in deprivation and contributed to poverty reduction. Asher & Novosad (2016) observed that improvement in rural roads improved household earnings and increased access of rural workers to other labour markets thereby creating a structural transformation. Aggarwal (2018) found that improvement in rural roads led to an increase in households' consumption basket due to reduction in the cost of bringing in goods produced in other places. Charlery *et al*. (2016) found that the upgrading of rural road contributed to increasing environmental income (i.e. income generated from extract of forest and other environmental goods), remittances and other income. Good quality rural road infrastructure contributed positively to employment in and income from non-farm enterprises in rural Indonesia (Gibson & Olivia, 2010), has several direct and indirect positive impacts on rural communities in the Philippines (Olsson, 2009), improves per capita income and working hours of households in Viet Nam (Cuong, 2011). Other studies that have highlighted how improvement in rural access contributes to poverty reduction include Hettige (2006), Warr (2010), Najman *et al*. (2010), Banjo *et al*. (2012).

3.3.1.3 Sense of Political Inclusion and Gender Dimensions

Some developing countries are made up of different clusters of people from different ethnic and religious backgrounds forced into the country through artificial borders constructed by colonialists (Amadife & Warhola, 1993; Gbenenye, 2016). Consequently, the improvement in the quality of rural road infrastructure also has some political-economy dimension because in helps foster the sense of political inclusion for communities that may feel isolated. This is evident in the studies by Demenge (2012) and

Dennis (2017) in the Himalaya region of Nepal. These studies found that the failure of the government to improve the quality of roads made citizens to infer that the abstract and intangible concept of nation building will not succeed if the tangible reality of having good rural access through roads is not in existence.

Improvement in rural road infrastructure have also been beneficial to women and has promoted gender inclusion as reported by Adom-Asamoah *et al*. (2020)

It is important to highlight that the evidence of the contribution of improvement in rural access to socio-economic development as presented in this brief review cut across developing countries in different regions as presented in Table.3.3

Table.3.3: Studies on rural road infrastructure improvement and country of focus

Study	**Country of focus**	**Summary of findings: Improvement in the quality of roads contributes to:**
Njenga *et al*. (2014)	Kenya	reducing the transportation cost for rural farmers
Asomani-Boateng *et al*. (2015)	Ghana	significant increase in the level of production for most food crops as a result of road improvement
Jacoby (2000)	Nepal	improvement in accessibility to farms in terms of cost and time (ii) improvement in accessibility to markets in terms of cost and time; and (iii) reduction in the cost of maintenance of vehicles
Bucheli *et al*. (2018)	Nepal	reduction in deprivation and contributed to poverty reduction
Inoni & Omotor (2009)	Nigeria	Increase in agricultural outputs and household incomes

Aggarwal (2018)	India	increase in the variety of goods consumed by households
Aggarwal *et al*. (2017)		farmers are more likely to adopt improved agricultural inputs since it will be easier for inputs to reach farmers
Charlery *et al*. (2016)	Nepal	increasing environmental income (i.e. income generated from extract of forest and other environmental goods), remittances and other income
Bell & Dillen (2018)	India	reduction in morbidity due to increased access to health facilities
Lindsay & Kongolo (2014)	Swaziland	substantial agricultural benefits
Iimi *et al*. (2015)	Brazil	Reduction in travel times
Mu & van de Walle (2011)	Vietnam	Creating significant average impacts on the development of local markets
Demenge (2012) and Dennis (2017)	Nepal	sense of political inclusion

Source: Compiled by Author

3.3.2 Negative impacts of improved rural access

3.3.2.1 Socio-economic

It is also important to note that some of the positive impacts attenuate over time. For example, Khandker & Koolwal (2011) observes that the impact of rural road improvement in terms of the increase in household per capita expenditure, schooling enrollment, and transport costs reduced considerably over time.

There are also negative results from the improvement of the quality of rural road infrastructure (Hine *et al*., 2016). For example, while studies have identified that improvement of rural roads generates employment for youths in the rural areas (Porter,

2012), such employments are usually short term and will seize at the completion of such projects thereby exposing the youths to another period of unemployment with its attendant problems. Iimi *et al*. (2015) found that the impact of road improvement on transport demand was unclear because the number of travels increased in some regions and decreased in other regions in Brazil. Also, impacts on education and health were unclear. Furthermore, Asomani-Boateng *et al*. (2015) found that improvement in the quality of roads in Ghana increased the price of average passenger and freight cost per kilometer contrary to expectations, although the reason adjudged for this was the increase in the price of petroleum products. Wagale *et al*. (2019) found that even though newly constructed rural roads have promoted agricultural activities, it has suppressed diversification to other sectors. The upgrade of rural roads resulted in unintended negative environmental impacts because the environmental safeguards were not embedded in the designs. For example, Ledec & Posas (2003) observes that the construction of some rural roads led to the loss of natural habitats and biodiversity, while Wilkie *et al*. (2000) reports unsustainable exploitation of forest resources as a result of increased accessibility to rural areas due to improvement in rural road quality.

Porter (1995) examined the impact of road construction on women's trade in two states in Northern Nigeria (Plateau and Borno). The study sought to know how off-road markets used by people to sell their merchandise have been influenced and finds that road construction led to the reorganization of these markets which acted as primary or secondary collations centers for agro-produce. The impact of this market reorganization on male and female traders was then assessed keeping in mind the historical, social, and cultural peculiarities of both study areas. The study found that the reorganization of the market created improved opportunities in both study areas. However, due to cultural and religious reasons, it impacted differently on male and female traders. In Plateau, which was a multi-ethnic and multi-religious area, both males and females benefitted from the re-organization of the markets. In contrast, several cultural barriers prevented females in Borno State because of religious factors.

3.3.2.2 Environmental Impacts

Beyond the socio-economic impacts, road construction and/or improvement also create negative environmental impacts. For example, several empirical studies have shown that the construction of new roads is one of the main drivers of deforestation (Angelsen & Kaimowitz, 1999) and by extension, some consequences of deforestation such as the. increase in the rate of zoonotic diseases (Gallice *et al*., 2019). This is because roads are constructed to improve rural access and access to environmental resources. However, due to other factors such as the weak regulations and lack of titles to land, areas that were hitherto inaccessible to trucks and loggers become more accessible. This reduces the cost of logging and exploitation of forest goods thereby making deforestation an inadvertent consequence of road construction. Another unintended consequence of improving rural access through the construction or upgrading of rural roads has been the initiation and formation of gully erosion (Jungerius *et al*., 2002; Nyssen *et al*., 2002). Jungerius *et al*. (2002) notes that erosion problems occur as a result of road construction due to the combination of several factors: (i) during road construction, natural drainage may be disrupted and several small streams directed to pass through the road in some specified culvert position to reduce construction cost. This increases the velocity and shearing capacity of water; (ii) trampling on the verge of the roads by humans and cattle thereby making the bare soil erode; and (iii) concentration of water due to reduced infiltration. Moreover, poor design and implementation of projects (e.g. poor termination of storm-water drainages) has been identified as a major cause of gully erosion in Nigeria (World Bank, 2012). This is exacerbated by the low institutional capacity to enforce environmental safeguards.

In their study, Greiner *et al*. (2021) acknowledged the positive impact of roads in terms of improved accessibility, but also observed that the upgraded of roads in a Baringo community in Kenya was a source of conflict primarily as a result of governance of land. Alamgir *et al*. (2017) identifies the negative effects of road development in the tropics to include: loss of biodiversity, the collision of vehicles with wildlife, reduced reproductive

capacity of species that are sensitive to noise, soil erosion, increased physical access for poachers, reduced quality of water for livestock, promotes illegal logging, etc.

3.3.3 Theory of Change: How rural access contributes to poverty reduction

It is possible to deduce the "theory of change" for how improvement of the quality of rural road transport infrastructure unlocks economic opportunities. This is shown in Figure 3.1.

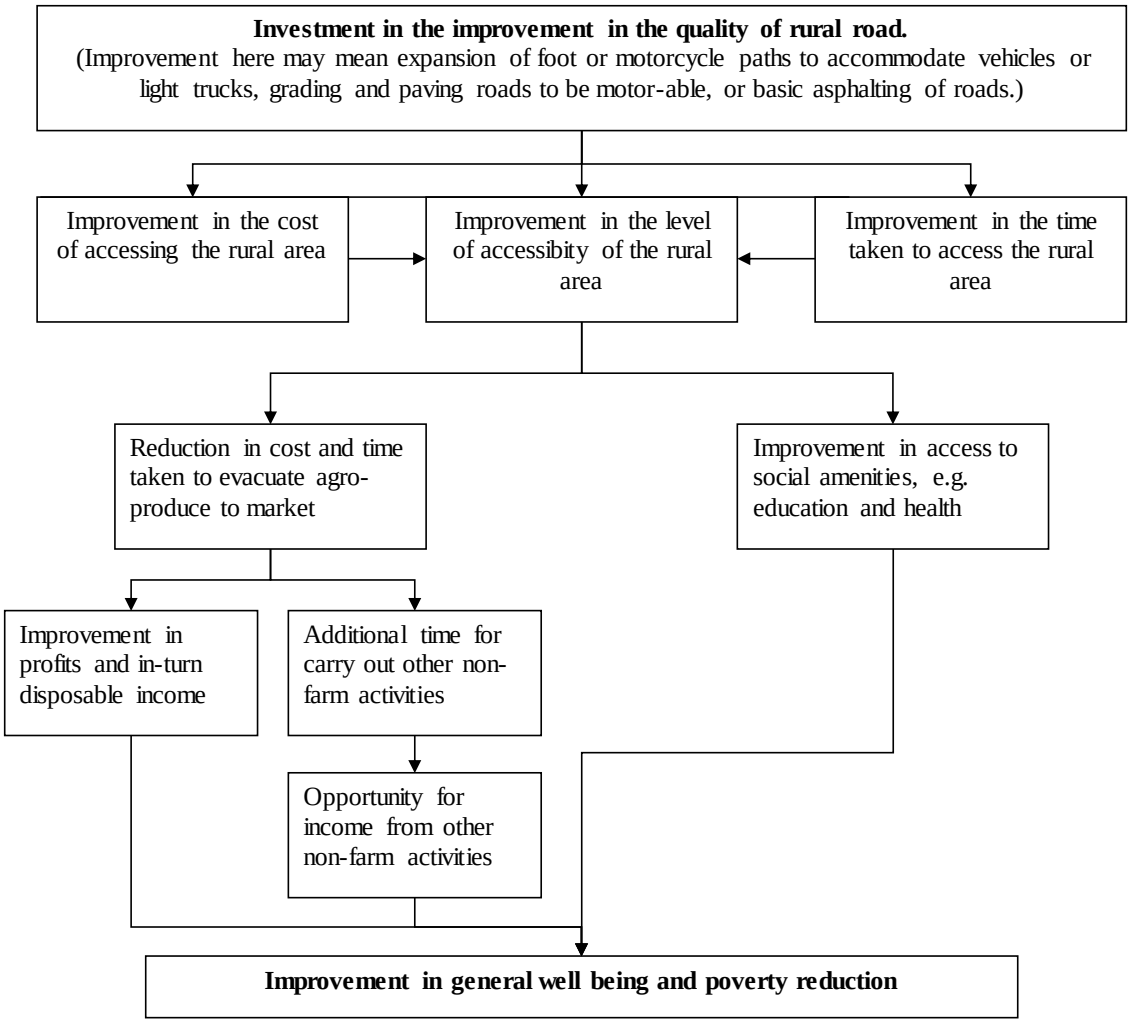


Figure 3.1: Theory of change: Improvements in the Quality of Rural Roads unlock Economic Opportunities

Source: Author

3.3.4 Conclusion

From our brief review, we have observed an improvement in the quality of rural roads has several positive effects with regards to socio-economic transformation and poverty reduction in rural areas. Some of the studies have found that the effects are very significant while others have found that they are not significant. There are also negative effects generated alongside these positive effects. We can infer that an improvement in rural road quality is a necessary instrument to drive rural transformation but may not be sufficient. The ability of the roads to drive the desired economic transformation is contingent on the level of economic opportunities that can be unlocked. This point of view is also shared by (Bryceson *et al*., 2008). Moreover, issues of maintenance of the roads and other negative impacts need to be managed properly.

3.4 Review of methodologies used in rural road prioritization

Several studies have been conducted on the prioritization of rural roads. These studies have different specific objectives and have applied diverse methodologies. Given the renewed interest in the development, planning and prioritization of rural road infrastructure, especially as it relates to the attainment of sustainable development goals, there is a need to revisit the approaches adopted by previous studies to provide researchers with a concise document that summarizes such approaches.

3.4.1 Cost-Benefit Analysis

Cost-benefit analysis (CBA) is a technique that has been widely used as part of the appraisal of the feasibility of a project, and also to compare and select the most beneficial project from a suite of similar investment projects (Jones *et al*., *2014*; World Bank, 2004). CBA involves estimating the potential economic costs and benefits of a project, or that will accrue to a project by the end of the project's life, by aggregating estimates of monetary values of the expected costs and benefits over a given period. The costs and benefits may include financial cost, social cost, environmental cost, etc. of the project

(World Bank, 2004). The actual method of estimating these costs and benefits differs and usually involves different forms of social and environmental valuation (using shadow prices), the opportunity cost of not embarking on the project, or the opportunity cost of alternatives.

In other cases, the consumer surplus is considered (Jones *et al*., 2014). van de Walle (2002) observed that road projects funded by the World Bank were usually selected by examining the benefits that may be obtained from the computations of consumer surpluses on the amount of savings that road users are expected to have in terms of the reduction in the operating cost of vehicles and the travel time. Producer surpluses in terms of the estimated reduction in the cost of inputs have also been used to estimate the potential benefits (van de Walle, 2002). In situations where the budget for road improvement is fixed, cost-effectiveness analysis has been used to examine the most viable road option among a set of possible options (van de Walle, 2002). The applicability of CBA has been nearly universal in the appraisal of public sector projects (Mackie *et al*., 2014). The European Union made the use of CBA for appraisal of investment projects mandatory for all member countries and included the basic rules of conducting CBAs in the secondary legislation that is binding to all member countries (European Union, 2014). Other countries and multilateral or bilateral development agencies also adopt CBA in investment appraisal.

Even though the CBA has been used extensively in the appraisal of (mega) projects in the transport sector, several studies have criticized it for not being adequate to address the diverse factors involved in decision making to select projects (Beukers *et al*., 2012). CBA is carried out using assumptions on the expected costs and benefits of a project to society. Therefore, its performance is dependent on the correctness of such assumptions, the monetary estimates used in those assumptions, and the extent to which the assumptions deviate from realities (Jones *et al*., 2014). For example, in the application of CBA to the appraisal of transport projects, the potential of a project to reduce traffic is commonly overestimated (Jones *et al*., 2014; Beukers *et al*., 2012), and cost overruns are commonly

underestimated leading to lower cost estimates (Salling & Banister, 2009). Where projects involve the potential for saving lives, there are huge discrepancies in the estimation of the value of life because of the different methods that may be used to estimate the value of life. This also applies to estimates of the value of time, safety, and improved security (Jones *et al*., 2014). It is also difficult to estimate other potential benefits of a proposed project such as the impact of the proposed project on the local economy given the diverse interaction between the transport sector and the economy (Mackie, 2010, p. 19). Jones *et al*. (2014) also notes that there is no consensus on how the residual value of a project should be treated. It is also difficult to estimate the distributional aspect of a project and therefore the distributional aspects of projects are not explicitly included

3.4.2 Multi-criteria Decision Analysis (MCDA)

The fact that decision-makers, whether in the public or private sector, may often need to make decisions to achieve multiple and sometimes conflicting objectives, which may also require compromise in some areas, has led to the development of multiple criteria decision analysis (MCDA). MCDA is a sub-discipline of operations research that is concerned with integrating mathematical tools to support the evaluation of decision alternatives. MCDA methods provide useful techniques for arriving at a compromise option among several other alternatives to achieve a defined objective, where the array of options may be evaluated under an equivalent or similar set of criteria. In some cases, the array of options may be evaluated under different sets of criteria (Ishizaka & Nemery, 2013, p. 8). Decisions on planning and prioritization of rural roads may be considered from this perspective. On one hand, the upgrading of rural roads has the potential to unlock economic opportunities with attendant impact on the society, can improve rural access in general, and may be used as an instrument for political inclusion. This means that there are criteria based on potential economic impact, social impact, and political impact respectively. On the other hand, the number of rural roads to be upgraded, or communities to be provided rural access, is usually so large and far beyond the financial

capacity of governments. Hence, there is a criterion on cost or economic viability. There may also be some considerations based on environmental impacts.

In line with this, several studies have been carried out that have applied MCDA to the planning of road transport in general, and rural road transport in particular. These studies have adopted various MCDA methods such as the Analytic Hierarchy Process (AHP), The Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETREE), ELimination Et Choix Traduisant la REalité (ELimination and Choice Expressing REality) (ELECTRE), Multi-Attribute Utility Technique (MAUT), The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), etc.

Despite the inherent advantages of MCDA, there are several disadvantages or weaknesses highlighted in the literature (Annema *et al*., 2015). For example, Macharis & Bernardini (2015) highlights that the method for determining the weights of the various criteria is often subjective. This implies different expert panels may arrive at different outcomes and priorities based on the method they adopt for determining the weights of the criteria even if the performance matrices are identical.

Studies that have applied MCDA to rural transport infrastructure planning include (Bhandari *et al*., 2014; Dalal *et al*., 2010; Kanuganti *et al*., 2017; Bhandari *et al*., 2016; Ndume & Mlavi, 2017). Zietsman *et al*. (2006) examined decision making of a transport corridor using MAUT. The study used three methodologies: the net present worth of investment and two variants of MAUT to demonstrate that the outcome of a decision will differ from single-objective methodology (i.e. cost-benefit analysis) used in transport sector planning. Macharis & Bernardini (2015) carried out a review of 260 studies that have applied MCDA in the transport sector. Bhandari *et al*. (2014) used the AHP to obtain the ranking of diverse criteria to be used in the prioritization of four rural roads in Nepal. The rural roads were between 9.9km and 15.2km and of different qualities. The study grouped the criteria into three groups: economic cost, social aspect, and

environmental aspect. The economic cost was further divided into financial cost and indirect economic (social) cost. The direct financial cost included the cost of construction, cost of maintenance, and vehicle operational cost; while the indirect economic (social) cost covered travel time cost, road accident, and pollution. The social aspect included the population to be served by the road (per km), access to educational facilities, and access to health facilities. The environmental aspect included encroachment on historical, cultural, or any unique eco-system; the possibility of landslide or flooding; or impact on natural stream. The summary of these factors is presented in Table 3.4. Bhandari & Nalmpantis (2018) extends the work of Bhandari *et al.* (2014) and uses three multi-criteria methods (i.e. TOPSIS, MOORA, and PROMETHEE) to compare the result.

Table 3.4: Criteria used in prioritization of roads by Bhandari et al. (2014) and Bhandari & Nalmpantis (2018)

Main category		**Sub-category**
Economic Cost	Financial Cost	cost of construction, cost of maintenance, and vehicle operational cost
	Indirect (social) cost	travel time cost, road accident, and pollution
Social Aspect		population to be served by the road (per km), access to educational facilities, and access to health facilities
Environmental Aspect		encroachment on historical, cultural or any unique eco-system; possibility of landslide or flooding; or impact on natural stream

Ndume & Mlavi (2017) used a dynamic multi-criteria analysis model to support decision-making on investment in road infrastructure in Tanzania. The study considered seven criteria: economic factor, population, production centres, social services, connectivity, road class, and tourism. The economic factor is an aggregation of road agency cost (construction cost and maintenance cost) and road user cost (vehicle operation costs, passenger and cargo time cost, and accident cost). Dalal *et al*. (2010) applied two-stage

AHP to aid in the prioritization of 178 rural roads in two districts of Orissa, India. The study created a block around each road and obtained data on several indices within each block. The study considered four broad criteria with several sub-criteria as presented in Table 3.5

Table 3.5: Criteria used in prioritization of roads by Dalal *et al*. (2010)

Main Criteria	**Sub-criteria**	
Social	Education	Number of educational institutions within the block of each road (including schools, colleges, or professional institutes)
	Health	Number of different levels of health services within the block of each road (including primary health centers, dispensaries, hospitals, maternities and child care centers, etc.
	Law and order	Incidence of different types of crime reported within the block of each road
Economic	Financial Institution	Number of financial institutions within the block of each road (including banks, agricultural and non-agricultural credit cooperatives, etc)
	Employment	Percentage of people employed within a block
	Agriculture	Total production of paddy
	Disaster	Vulnerability of each block to natural disasters
Demographic	Backwardness	Extent of "backwardness" of a block. Where "backwardness" was defined as "the ratio of the total number of scheduled caste and tribal population to the total population in a block"
	Population Density	Population density of a block
	Urban Population	Percentage of urban population in the district where the block is located

Infrastructure	Power	Percentage of villages in a block with access to electricity
	Water	Ratio of total number of villages with drinking water to total number of villages in a block
	Communication	Availability of postal services or telegraph, bus services, and level of connectivity to an all-weather road.

3.4.3 Combination of MCDA and CBA

Some studies have adopted approaches that combine CBA and MCDA. The rationale for combining CBA with MCDA is that it builds on the advantages of each approach. For example, the score of the CBA may be used as one of the criteria in the MCDA as reported in (European Commission, 2001). Guhnemann *et al.* (2012) also developed an approach that allowed CBA results to be integrated into MCDA. On their part, Barfod *et al*. (2011) developed a composite model for assessment based on the combination of CBA and MCDA called COSIMA to assess the strategic impacts of transport projects and applied the model in the north-eastern part of Zealand, Denmark. The approach proposed by the study aimed at adding non-monetary MCDA criteria to monetary CBA impact and achieves this through a weighted sum of results from CBA and MCDA. Annema *et al*. (2015) examined the view of politicians regarding the use of MCDA or CBA for appraising transport projects and proposed a possible combination of both methods in line with previous studies by Guhnemann *et al*. (2012) or Barfod *et al*. (2011).

3.4.4 Integrated Rural Accessibility Planning

The Integrated Rural Accessibility Planning (IRAP) is a multi-sectoral, integrated planning tool developed by the International Labour Organization to support rural access planning. The tool is designed to reflect the travel demand needs of rural population, the locations of basic social amenities, as well as the transport infrastructure in different sectors. The tool adopts a participatory approach to planning and involves communities in all the stages of the planning process (International Labour Organization, 2000). The

IRAP process as highlighted in International Labour Organization (2000) involves ten steps: (i) data collection; (ii) data processing; (iii) data analysis; (iv) mapping; (v) validation workshops; (vi) compilation of access profiles; (vii) setting accessibility targets; (viii) prioritization and formulation of interventions; (ix) implementation; and (x) monitoring and evaluation.

Sarkar & Ghosh (2000) developed a method of quantification of accessibility levels using the IRAP approach. Sarkar & Ghosh (2008) applied the IRAP approach in a rural area in the Indian state of Rajasthan. The participatory approach used helped the study to obtain data on accessibility needs for water sources, education, and health care for 13 villages. The study then applied a prioritization framework to prioritize the villages according to their needs for accessibility. Sarkar & Dash (2011) also applied the IRAP to a cluster of villages in Neemrana Block in Alwar District of Rajasthan (India). ReCAP (2018) notes that the main limitation to the IRAP is that it requires strong institutions to implement, especially given the level of community involvement and data requirement. This strong institution is often not available in developing countries and there are other challenges in terms of managing community expectations.

3.4.5 Application of GIS in Planning and Prioritization of Rural Roads

Due to the advancement in information and communication technologies (ICT) and spatial science, geographic information systems (GIS) is now being used as an improvement to the traditional management information system (MIS) because GIS integrates spatial data into MIS and can be very useful in analyzing data and making inference from data that are spatial. GIS represents real-world concepts in a computer just as maps represent the real world in paper. GIS has been applied extensively in the planning of infrastructure projects ranging from power, telecommunication, rails, and transport infrastructure. The contribution of GIS to the planning process is multi-fold as it helps in virtually all phases of planning. In line with this, some studies have integrated GIS into the process of planning and prioritizing rural roads for upgrade (Rao *et al*., 2003;

Sanchez & Bania, 2002; Garg, 2008; Poerwoningsih *et al*., 2016; ReCAP, 2018; Kanuganti *et al*., 2017; Castro & Vistan, 2020). Through GIS, planners may easily visualize the spatial locations of different features that influence the prioritization of rural roads and carry out different spatial analyses to obtain useful results.

Rao *et al*. (2003) applied GIS to rural road network planning in the Bihar State of India. The first step of this process was the development of a village and rural road inventory system (V&RIS) using spatial and non-spatial data. The non-spatial data used are grouped into five categories as follows: (i) road reference data: serial number, name of the road, unique code, category of road, length, list of habitations; (ii) road geometry details: road land width, roadway formation width, carriageway width, number of lanes, width of shoulders; (iii) road pavement condition and surface type: the extent of cracking, extent of potholes, road thickness, etc.; (iv) terrain type and traffic: type of soil, average annual daily traffic, etc. (v) other parameters. The study applied a prioritization framework using the "functional accessibility approach" for providing single connectivity taking into consideration already developed network patterns as well as the socio-economic features of the areas covered by the road network. The result is then presented in tables and maps.

Modinpuroju *et al.* (2016) carried out facility-based planning for rural roads in India using GIS techniques. The methodology employed was divided into phases. The first phase was to identify roads to be considered for upgrade based on the "Pavement Condition Index" or PCI. The PCI rated roads using a 1-5 ordinal scale based on the average speed that a vehicle can travel on a road given the condition of the road. The highest rating of PCI (i.e. 5) was assigned to a road that the maximum speed was more than 40km/hr while the lowest rating (i.e. 1) was assigned to a road that the maximum speed is less than 10km/hr. Data on the road and the PCI are then digitized in the GIS environment. In the second stage, the study prepared a "facility index" by obtaining data on the spatial location of habitations and those of facilities, and thereafter estimating the distance of facilities from habitations using the GIS. Other primary data collected and used in the study include length of each road link, average travel time, condition of the road, type of road,

population to benefit directly from each link, locations of facilities, etc. The third stage of the study was the development of a spatial database to manage spatial and non-spatial data collected. Thereafter, a "village facility index" was prepared to have a measure of the relative importance of each community vis-à-vis the upgrade of roads. Finally, the study carried out the prioritization of the road network

Kanuganti *et al.* (2017) developed a needs-based approach for rural road network planning in India to compare with a demand-based connectivity network. The data requirement for both methods is similar to those used by Rao *et al*. (2003) and Modinpuroju *et al*. (2016). The result of the study showed that the need-based network provided better accessibility and linked more communities, albeit with the length of the road being higher. The study concluded by suggesting that different types of roads (earth road, gravel, asphalt) may be considered for different communities given the need of each community.

Castro & Vistan (2020) demonstrates the development of a spatial decision support system for rural road infrastructure planning in The Philippines. The approach used is very similar to those of previous studies highlighted above. The first phase is the development of the GIS database to hold spatial and non-spatial data related to road planning. Thereafter, the study applied the multi-criteria decision analysis method of AHP to obtain weights for different criteria used in prioritization. Finally, based on the prioritization, the study categorized roads to be considered for an upgrade in different time horizons as follows: roads for immediate improvement or repair; roads for improvement in the short term; roads for improvement in the medium term; and roads for improvement in the long term.

Shrestha *et al*. (2017) proposed an approach for rural road infrastructure planning in hilly regions and applied the approach in Nepal. The study focuses solely on hilly areas. It qualifies the term "accessibility" as "geographic accessibility" and defines this as the ease

of reaching a given hilly destination to reflect that fact the real distances between communities are usually far higher than Euclidean distances due to the rugged terrain and topography of the study area. The methodology adopted in the study was divided into three phases. First, the study defined political boundaries of settlements and obtained a "distance matrix" as well as a "shortest distance matrix". The study then defined nodal points in-between communities. Second, the study obtained a comprehensive spatial location of nodal points such that a minimum spanning tree can be developed to connect the points. Third, the study used a minimum spanning tree (Prim's algorithm) to obtain backbone links across the study area. A notable feature in this study is the procedure for obtaining the nodal points which are developed to reflect the rugged terrain of the study area.

3.4.6 Graph Theory[14]

The Graph Theory has been applied extensively in transport studies in general (this includes transport planning, network analysis), and rural transport planning in particular. Graph theory is the study of graphs which are mathematical representations of structures used in measuring the pairwise relationships between objects. A simple graph is made up of points (or nodes or vertices) that are connected by lines (or edges or links). The degree of a point is the number of lines with that point as the endpoint, and the whole representation is called a graph (see Figure 3.2) (Wilson, 1996). A "walk" is a way of moving from one point to another through the lines. A graph is said to be "directed" if the walk from one point to another is only unidirectional, and "undirected" if the walk is bidirectional. A walk that no point appears more than once is called a "path" (e.g. A → B → C → H) and a walk that returns to a point is called a cycle (e.g. A → B → F → E → A).

[14] This segment draws mainly from (Wilson, 1996)

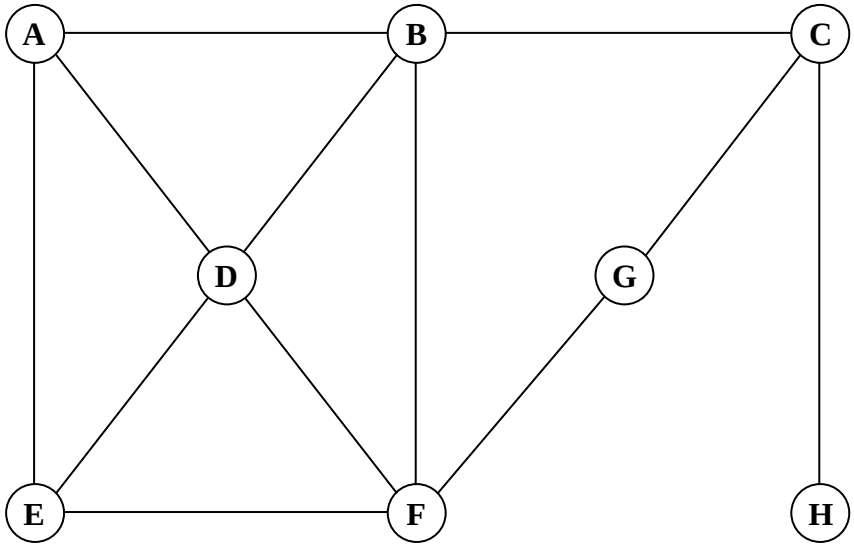


Figure 3.2: A Simple Graph. A - H are points; a line connects any two points; degree of A, C, E =3; degree of B, D, F = 4; degree of G = 2; degree of H = 1

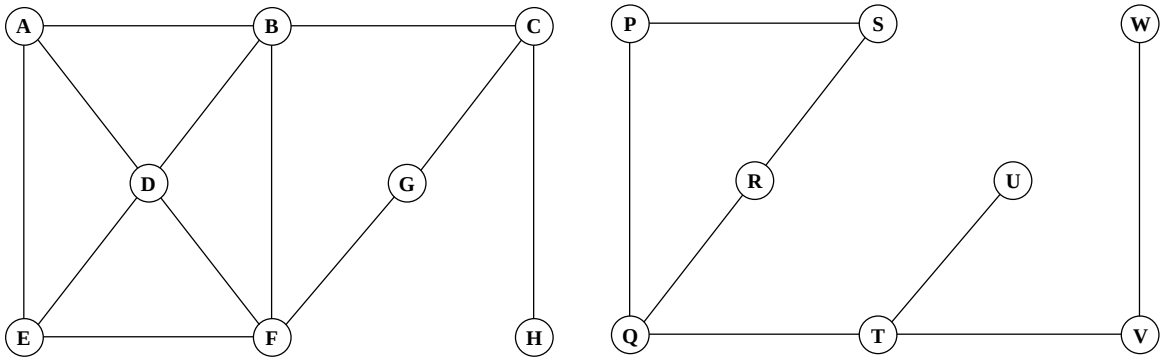


Figure 3.3: Unconnected Graphs

A “connected graph” is a graph that is in one piece such that any two points are connected with a line. An “unconnected graph” is a graph that is in separate pieces (Figure 3.3). A “tree” is defined as a connected graph with no cycle (analogous to a family tree) (Figure 3.4). A “spanning tree” of an undirected graph, G, is a sub-graph created from G, such that the sub-graph forms a tree that includes all the points of G. There may be more than one spanning tree made from G (Figure 3.5). A minimum spanning tree (MST) is a

spanning tree that has the minimum number of lines connecting the points or the sum of the weights of the lines connecting the points is minimum.

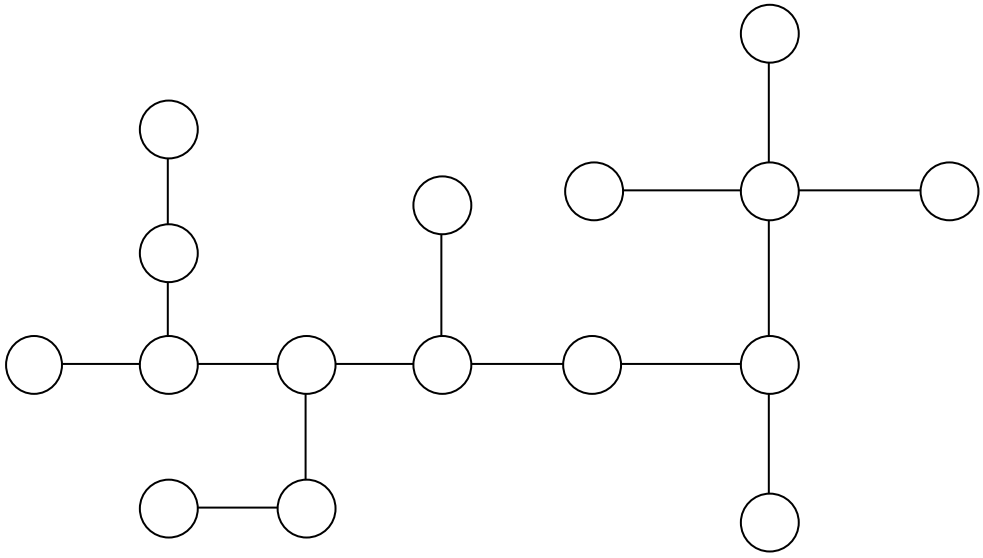


Figure 3.4: Representation of a tree

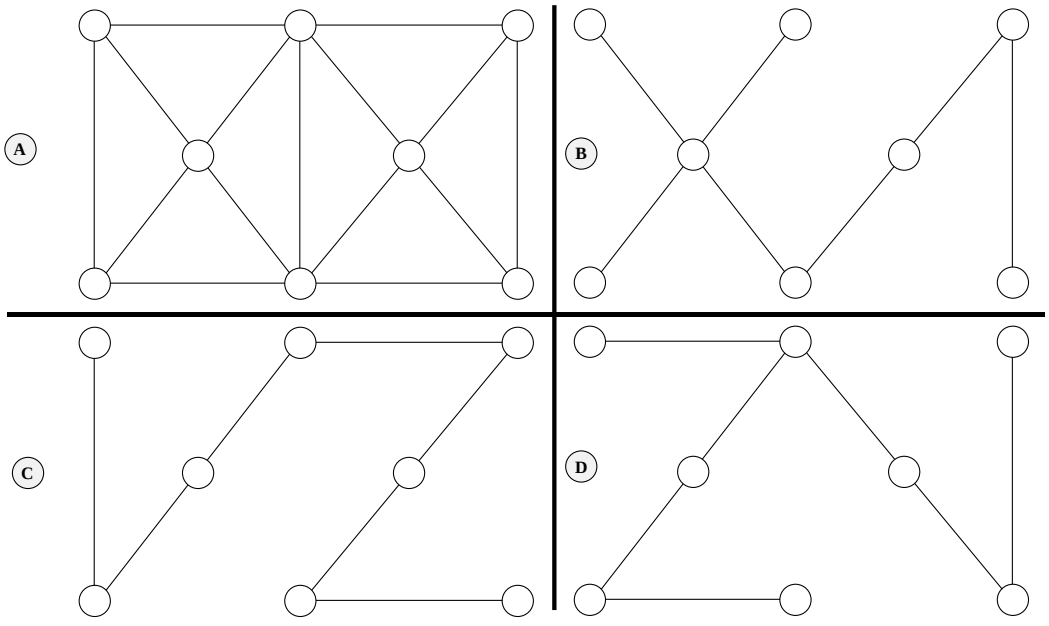


Figure 3.5: Representation of spanning tree: A: undirected graph; B, C, D: Possible spanning trees that can be gotten from A

An abstraction of the graph theory has been used extensively in transportation planning in general and in rural road infrastructure planning in particular. Cities, towns, villages, communities, etc. are represented by the points while the existing and/or planned roads may be represented by the lines. The weights assigned to the line may be derived from the combination of distances, the population of the points, road quality, terrain, economic and social facilities along the pathway, etc. The spanning tree is the possible combination of roads that will connect all the towns/villages, while the minimum spanning tree is that combination that yields the best possible outcome. Studies that have employed graph theory in rural road infrastructure planning include Thomson & Richardson (1995); Arogundade *et al*. (2011); Shrestha *et al*. (2013). Arogundade *et al*. (2011) examined how local road networks covering 88 villages in the Odeda local government area of Ogun State, Nigeria may be improved. The study used GIS software to map the villages, digitized the roads linking the villages, and then obtained the distances between pairs of villages which was used to construct an undirected distance graph. Prim's algorithm (of minimum spanning tree) was then applied to find the best way of connecting the villages. Shrestha *et al*. (2013) adopted a similar approach and also used Prim's algorithm.

3.4.7 Other Tools developed

The Road Economic Model is a software/tool developed by the World Bank for the appraisal of rural roads, or other low volume roads with traffic of fewer than 200 vehicles per day (World Bank, 2001; Archondo-Callao, 2004). REM adopts a consumer surplus approach to estimate the benefits that will accrue to a low-volume road that is upgraded. The tool disaggregates benefits into different categories, namely: normal benefits, generated benefits, induced benefits, and benefits due to traffic that are not diverted. The tool also takes into account changes in the length of a road, overall road quality, and accidents. The tool is designed to work on MS Excel. It is important to state here that the main function of the REM is not for planning and prioritization of rural road infrastructure but for the economic appraisal of roads.

3.4.8 Rationale for Selecting MCDA

The different methodologies that have been applied to planning and prioritization of rural road planning are appropriate in different situations. We select the multi-criteria decision analysis because of several reasons. First, the MCDA is relatively easy to use and does not require complex modelling, unlike the graph theory. In terms of data requirement, cost-benefit analysis requires several data and estimation of several potential costs and benefits. This would have required staying in the field to collect primary data on several variables (such as traffic count on each road) as required in the road economic model (RED). Given that the study covers rural areas in a sub-national territory, the number of roads to be considered will be relatively large. Consequently, it would not be feasible to collect these data for all the roads. Furthermore, with the availability of secondary data on spatial locations of educational and health facilities, population count, etc. it is easier to link the selection of roads for construction with the promotion of accessibility to health and education facilities. As highlighted in Section 2.5, political considerations play an important role in the selection of roads for upgrade/construction and it is important to recognize this reality and reflect it in the decision-making process. Reflecting the political considerations in other methods may be very difficult, whereas, it is possible to reflect political considerations in the MCDA. Keeping all these in mind, we consider the MCDA to be the most preferred method to address our research question. It is also useful to mention that in its comparison of different approaches that may be used to address rural transport planning, Hine (2014) identifies the multi-criteria approach as a possible option for use in different scenarios and our study fits within one of such scenarios.

3.5 Constraints to effective rural transport services

Several constraints are militating against the provision of good quality rural road infrastructure and several studies have examined these constraints. For example, Ali (2013) examined the factors that were responsible for the poor rural transport infrastructure in Enugu State, Nigeria, using data from a sampling survey. The study identified 24 possible socio-economic and environmental factors that may hamper the development of rural transport services. These include: inadequate capacity to manage

rural transport infrastructure; inadequate equipment and machinery to construct and maintain rural transport infrastructure; inadequate maintenance of rural road infrastructure; inadequate skilled manpower for construction; poor quality of road design; nature of soil (topography or geotechnical properties); multiple stakeholders with overlapping responsibilities on rural transport infrastructure; high cost of construction and maintenance; conflicts and unreasonable demands from communities; non-availability useful data to aid decision-making in rural transport development; Low motivation of staff of public works department due to poor remuneration; etc. Agumba (2016) identified challenges such as lack of financial capital to construct and maintain roads, inadequate capacity of institutions, poor planning of rural transport services, among others. Samanta (2015) identified some of the challenges to rural road infrastructure development in India as lack of clear government policy on rural road development, non-availability of dedicated funds, lack of adequate maintenance, etc.

Badu *et al*. (2013) grouped the challenges of rural road infrastructure development into different categories: institutional; engineering, economic; and natural. Institutional challenges include the capacity to plan and prioritize rural roads for development, capacity to maintain and upgrade rural roads, availability of requisite technical and managerial capacity in public works departments; the political will to ensure that rural road infrastructures are developed; etc. The engineering capacity includes the ability to design and construct durable roads; the development and use of appropriate construction materials; etc. Economic challenges include the availability of funds for rural road development and maintenance; price fluctuations in road construction contracts; etc. The challenges in the natural category include the nature of soils (topography and geotechnical characteristics); local weather patterns (e.g. heavy rainfalls on tropics), etc.

CHAPTER FOUR

4 OVERVIEW OF ROAD TRANSPORTATION IN NIGERIA

The transportation sector is very important in any economy since transportation is interlinked with every other sector. In this chapter, we will present an overview of the transportation sector in Nigeria. We will pay more attention to road transportation. We intend to highlight the institutional, legal, and governance framework of the sector as it relates to our study.

4.1 Structure of the Transportation Sector

The transportation sector in Nigeria is administered and governed by the Federal Ministry of Transportation which oversees activities in the maritime, inland waterways, rail, and road transport subsectors. The mandate of the FMT is "to ensure fast, safe, efficient, affordable, convenient, integrated and inter-modal transport system that facilitates Nigeria's socio-economic developmental needs and enhances the quality of life of the public"[15]. The ministry also supervises several other specialized agencies responsible for different aspects of the transportation sector. The Federal Ministry of Aviation oversees air transport and different specialized agencies supporting air transportation. A schematic diagram showing the structure of the transport sector in Nigeria is shown in Figure 4.1. The maritime subsector focuses on ensuring that the infrastructure and services required for shipment and clearing of goods to and from Nigeria are efficient. The in-land waterways focus on passenger and freight transportation within the waterways inside Nigeria. Rail transport focuses on passenger and freight transport using railways while road transport focuses on making policies that govern road transportation. **It is important to note that even though the FMT formulates policies on road transportation, it is not responsible for the construction, maintenance, or upgrading of the roads.** Organizations responsible for the construction and maintenance of different roads are discussed later on.

[15] https://www.transportation.gov.ng/index.php/about-us (visited on 4th December, 2019)

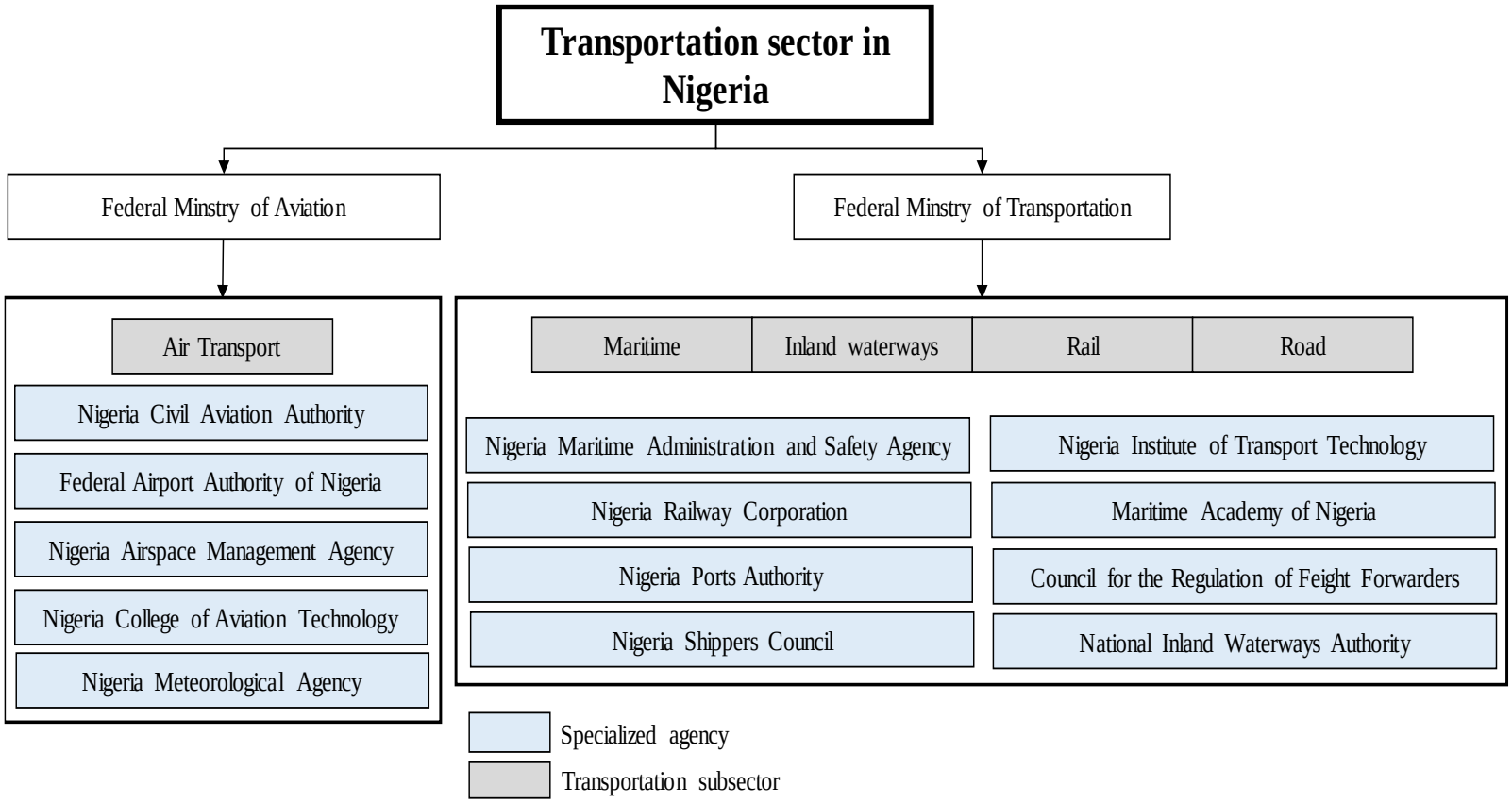


Figure 4.1: Governance Structure of Transport Sector in Nigeria
Source: *Author*

4.2 Road Transport Sector in Nigeria

Road transportation is the predominant means of transportation in Nigeria. Roads are usually classified based on several factors: location & function, traffic volume, materials used for construction, etc. In Nigeria, the primary classification of roads is based on location and function. Hence, roads are grouped into:

(i) Trunk A or Federal Roads: These are roads that are under the supervision and management of the federal government. They form the core of the road network in Nigeria and other categories of roads are built around them. They are roads that connect a town or city in one state to those in other states or connect to important national assets such as airports or seaports. Roads that connect to neighboring countries and important roads in the federal capital territory are also regarded as federal roads

(ii) Trunk B or State Roads: These are roads that connect two towns or local government areas within a state or connect to an important facility in a state. They also serve as major arteries within a state to link up different parts of a state. Major streets in the state capitals are also regarded as state roads. This category of roads is constructed and maintained by the state governments.

(iii) Trunk C or Local Government Roads[16]: These are roads that connect to communities or villages.

In 2017, it was estimated that the total length of roads in Nigeria was between 193000 and 195000 km. This is made up of 32000 km of federal roads, 31000km of state roads, and 130,000 to 132,000km of local government roads (World Bank, 2019). This implies that about 67% of roads in Nigeria are local government roads. Most of the local government roads are rural roads. The same study also reported that 40% of federal roads, 78% of state roads, and 87% of local government roads were in poor condition. Similarly, Oni & Okanlawon (2006) reported that the total length was about 194,000 kilometers, with the federal, state, and local governments being responsible for 17%, 16%, and 67% of the road network respectively. The draft national transport document reports thus

[16] Nigeria is a Federation made up of 36 states and a Federal Capital Territory. Each of the 36 states is further divided into local government areas (LGAs) and each of the LGAs is then divided into wards.

"Nigeria has a total of 193,200 km of roads, made up of 34,123km of Federal roads, 30,500km of state roads and 129,577km of local government roads." (Federal Government of Nigeria, 2010). Most of the local government roads are rural roads. In addition, a report by the World Bank states that only less than 10-15 percent of states and local roads can be considered in good to fair condition (World Bank, 2017c).

4.3 Road Infrastructure Management

The management of road infrastructure usually involves not only the physical infrastructure but also all other appurtenances. It includes the upgrading, rehabilitation, operation, maintenance of existing roads as well as the development of new roads. It also includes the management of all complementary structures that ensure that road transport is efficient and safe. These include pavements, bridges, signage, lighting, and street furniture.

4.3.1 Federal Roads

4.3.1.1 Federal Ministry of Works

The Federal Ministry of Works is responsible for the overall management of all federal roads. The Ministry is responsible for planning, award, and execution of contracts for new roads or rehabilitation of existing roads. It is also responsible for developing highway codes and operating manuals for all roads in the country.

4.3.1.2 Federal Roads Maintenance Agency

The Federal Roads Maintenance Agency (FERMA) is an agency established through the FERMA (Establishment) Act 2002 and FERMA (Amendment) Act 2007 to ensure the effective and timely maintenance of all federal roads. The Agency is supervised by the Ministry of Works.

4.3.1.3 The Federal Road Safety Commission

The Federal Road Safety Commission (FRSC) is an agency of government responsible for making and implementing policies and programs to ensure the safety of road users. Such programs may include driving codes and licensing, educational and public

awareness programs, etc. The agency was established through Decree 45 of 1988 and Decree 35 of 1992 as well as the FRSC (Establishment) Act of 2007.

4.3.2 State Roads

4.3.2.1 State Ministry of Works

All the states in Nigeria have a ministry that carries on the functions and responsibility of a constructing, rehabilitating, or managing state roads. The actual nomenclature of these ministries differs from state to state based on the peculiarities of the different states.

4.3.2.2 State Roads Maintenance Agency

In some states, some agencies have been established and assigned the responsibility of maintaining roads. For example, there is the Akwa Ibom State Road and Other Infrastructures Maintenance Agency (AKROIMA) which is established by an Act of the State legislature.

4.3.3 Local Government Roads

Local government roads are managed by each local government area through the Department of Works in the LGA.

4.4 Transport Policy in Nigeria – Road Transport

Given the importance of the transportation sector, countries usually develop policies to convey their plans and aspirations, and revise same regularly to reflect global and local trends. The Draft National Transport Policy of 2010 presents the aspiration of government to "…develop an adequate, safe, environmentally sound, efficient and affordable integrated transport system within the framework of a progressive and competitive market economy". The document sets out the plans and targets in the different subsectors of the transport sector (i.e. maritime, inland waterways, rail, air, roads). For road transportation, the document identifies the key challenges facing roads as follows: lack of adequate and routine maintenance of roads; poor design and construction of roads; misuse of roads by heavy vehicles due to absence of railways thereby causing damage to the roads. Underlying all these is the lack of funds. In response, the document set the policy objective of the road transport sector as follows: (i) to ensure that there is adequate, efficient, and timely maintenance and rehabilitation of existing road network; (ii) to

promote public-private partnerships in the maintenance of roads. The first objective was to be achieved by strengthening FERMA to discharge its mandate better and by building the rail sub-sector to ensure a shift in freight transport from roads to rail. To achieve the second objective, the document expressed the desire of government to partner with the private sector through concessions of roads. The private partner will be responsible for maintaining the roads and users will be charged fees as tolls.

4.5 Challenges facing the road transport sector in Nigeria[17]

Given the importance of the transport sector to the economy of a country and the fact that transportation in Nigeria is dominated by road transportation, the subsector is facing different types of challenges which have further affected the efficiency of the sub-sector.

(i) Inadequate funding

Primary among the challenges facing the road transport subsector is inadequate funding for rehabilitating, upgrading, and maintaining roads. Given the level of decay of roads, the amount of funds required to upgrade roads is seldom available. In some cases, even when there are funds approved for the rehabilitation of roads, there are bureaucratic bottlenecks in the process of releasing the funds, and funds may sometimes not be released at all, or may be diverted to other uses after release. The general climate of corruption and graft in the Nigeria public service also affects the implementation of road rehabilitation projects.

(ii) Excessive pressure on roads

The non-functioning of the rail and inland waterways subsector means that freights that would have been transported using these alternative means are now being transported via roads. Indeed, road transportation accounts for over 90% of passenger transportation (Adetola *et al*., 2011) and nearly 100% of freight transportation in Nigeria. This creates undue pressure on the roads. Cases abound where trucks conveying goods create congestion on roads and cause undue delays to passenger movement

[17] This section refers mainly to federal roads.

(iii) Inadequate maintenance

Resulting from (i) and (ii) above, the excessive pressure on roads in Nigeria has caused rapid deterioration of the roads and due to inadequate funding, most of the roads are not maintained adequately. The result of this is that most of the roads are in bad condition and keep on worsening yearly.

4.6 Rural accessibility in Nigeria: an overview

4.6.1 Rural Road Infrastructure development in Nigeria between 1960 and 1985

The state of road infrastructure development in Nigeria since independence in 1960 was abysmal. As part of the strategies to set the country on an economic development path, the political leaders at independence developed the first national development plan for Nigeria for the period 1962-1968. The focus of the plan was primarily to improve economic growth, manpower development, reduce dependence on external capital by promoting savings and local revenue generation, and infrastructure development (Iheanacho, 2014). The excessive involvement of politics in economic decisions as well as the political crises in the country which culminated in the Nigeria Civil War in 1967 have been identified as some of the setbacks to the implementation of this plan (Iheanacho, 2014; Ugwuanyi, 2014). At the end of the Nigeria Civil War in 1970, there was the need for reconstruction, rehabilitation, and economic recovery which necessitated the second national development plan for 1970-1974. The third and fourth national development plan was from 1975 – 1980 and 1981-1985 respectively (Iheanacho, 2014; Ugwuanyi, 2014). Filani (1993) noted that the first, second, and third national development plans did not make any statement on rural transport development and achieved very little in the area. The reason for this was that most of the resources in the plans were allocated to urban areas even though a greater percentage of the population resided in areas that were considered rural. Specifically, budgetary allocations to rural areas were 4.9%, 8%, and 4.1% in the first, second, and third national development plans respectively (Filani, 1993). The fourth national development plan highlighted the need to

develop rural transport to stimulate agricultural development in the country (Filani, 1993). The political leadership in Nigeria addressed the issue of rural development in general and rural infrastructure development in particular in 1985 by establishing various agencies and programs focused on agricultural and rural development, one of which was the Directorate of Foods, Roads, and Rural Infrastructure (DFRRI) (Filani, 1993).

4.6.2 Directorate of Foods, Roads, and Rural Infrastructure (DFRRI)

In response to the poor state of agricultural development and rural infrastructure in Nigeria, the government of Nigeria established the Directorate of Foods, Roads, and Rural Infrastructure (DFRRI) on 7th February 1986, and tasked it with the responsibility of transforming rural areas into habitable environments (Filani, 1993). Specifically, the duties of DFRRI included "the provision of roads, basic facilities and increased food and industrial raw material output; the encouragement of agricultural activity and any other activities that will facilitate an improved quality of life in the rural areas of the country" (Udeh, 1989). In the area of rural road transport development, DFRRI had a target to construct or rehabilitate all rural roads in Nigeria disaggregated into four phases. At the end of 1991, 55% of this target was achieved (Filani, 1993). The momentum of upgrading feeder roads reduced as the cost of construction increased in the early 1990 as a result of the devaluation of the local currency (i.e. Naira) due to the implementation of the Structural Adjustment Programme (SAP) (Porter, 1997). Successive governments were unable to build on this achievement and the gains made by DFRRI in rural roads development had since been reversed due to lack of maintenance of the roads.

4.6.3 The current state of rural roads in Nigeria

A report by the World Bank estimated that in 2017 the total road network is estimated at 193,000km to 195,000km. These are categorized as federal (32,000km), state (31,000km), while the remaining 130,000 to 132,000 are local government roads (World Bank, 2019). Most of the roads are in poor condition: 40%, 78%, and 87% for federal, state, and local government roads respectively (World Bank, 2019). The local government roads are generally regarded as rural roads and some of the state roads may also be regarded as rural roads. Road infrastructure challenge has been a problem in

Nigeria since independence in 1960 and the country seems to have performed poorly in addressing this challenge. We compare the status of roads in 2017 with that in 1983 in Table 4.1. We may observe from Table 4.1 that the percentage of rural roads in Nigeria in fair condition has not improved substantially between 1983 and 2017.

Table 4.1: Distribution and quality of roads in Nigeria, 1983 Vs 2017

	1983			2017	
	Total length (km)	Length in fair condition (km)	Percentage	Total length (km)	[a] Percentage in fair condition
Federal roads	29100	16400	56.36%	32000	60%
State roads	24000	8500	35.42%	31000	22%
Local government roads	60000	0	0%	130,000 to 132 000	13%
Overall	113100	24900		193000-195000	
Source: Ezeife & Bolade (1984)				Source: World Bank (2019)	

a. Subtracting the percentage in poor condition from 100%

4.6.4 Studies on rural infrastructure development in Nigeria

Many studies have examined the challenges and impact of poor road infrastructure from different angles. We review these studies to highlight their objectives. This will help in further identifying research gaps in rural transport development in Nigeria.

4.6.4.1 Studies on the impact of rural road infrastructure upgrade

Several studies in Nigeria have focused on examining the impact of rural road infrastructure development on agricultural sector. One of the earliest studies in this regard is Obiechina (1986) who examined the impact of the improvement in rural roads on the

production of oil palm in Imo State, Nigeria. The study found that the intensity of agricultural management practices of farmers reduced for farmers who resided farther from the roads that were improved. Ogunsanya (1987) observed that the poor state of rural roads had a negative effect on the willingness of farmers in Kwara State to increase the acreage of land cultivated and to evacuate produce to markets. Amadi (1988) examined the impact of rural road construction on agricultural development in Anambra State, Nigeria. The study observed that the construction of rural roads eased the evacuation of farm produce to the market to earn higher prices and also contributed to the enlargement of farm sizes. Another impacts observed was that the construction of rural roads induced the development of other infrastructures such as electricity and water.

Porter (1993) examined how rural road development affected the physical accessibility of rural periodic market system in Plateau State and Borno State. In Borno State, the improvement in road quality led to an increase in the activities of some markets which were located on the roads that have improved, while the markets on other roads declined over time. The trend was similar for markets in Plateau State. Porter (1995) examined how the decline in some of the off-road markets impacted women. The study observed that the decline of off-road markets had a significant negative impact on female traders and women in general in Borno because they were unable to travel far from their homes due to their low income and other cultural factors. Porter (1997) further examined the challenges faced by off-road communities in Plateau State, Nigeria.

Omotoso *et al*. (2020) examined how rural road infrastructure influences food crop farmers in Ogun State, Nigeria, and observed that the availability of infrastructure did not have a significant contribution to agricultural output. Rather, other agro-related variables contributed more to crop output. Osumgborogwu (2016) examined accessibility to social infrastructures in rural areas in Imo State focusing on health, educational and recreational facilities. The study observed that there was a strong correlation between access to social infrastructure and income levels. Olorunfemi (2020) examined and observed how the lack of good quality rural road infrastructure has affected agricultural development in Idanre

LGA of Ondo State. Adeniyi *et al*. (2018) examined the impact of road transport on economic development in Akure LGA of Ondo State. Similarly, Ale (2013) observed that the poor quality of rural roads in Akoko South West LGA of Ondo had a significant negative impact on farmers. Adedeji *et al*. (2014) also observed that poor quality of road in Obokun LGA of Osun State had a negative impact on agricultural activities. Olorunfemi (2018) examined the challenges of rural transportation in Ekiti State and how these challenges impact food security. Tunde & Adeniyi (2012) examined the impact of road transportation on agricultural development in Kwara State and concluded that improvement in the quality of roads will have a positive impact on agricultural outputs. A similar study was carried out by Inoni & Omotor (2009) in Delta State, Nigeria.

Using the premise that a poor state of rural transport system may impede having economic opportunities and entrepreneurial activities, Seedhouse *et al*. (2016) examined how rural transportation system affects female entrepreneurs in Nigeria. The study focused on winners of the Youth Enterprise with Innovation in Nigeria (YouWiN) project in Nigeria who are females. The study carried out phone interviews with respondents and followed up with qualitative interviews. The interview examined several transport-related issues including the use of transport, expenditure and time spent on public transport, challenges faced by female entrepreneurs, and potential solutions to these challenges. The result of the study shows that public transportation plays a vital role in business-related trips. The respondents also noted that the poor quality of roads increased the cost of trips and the time taken to complete a trip. In some cases, the low reliability of the transport services exacerbated the difficulties in trip planning.

4.6.4.2 Other aspects of rural road transport development

As noted previously, rural transport development goes beyond the development of road infrastructure but also covers the organization of the transport system in terms of the providers, patterns of travel, maintenance, etc. Several other studies have examined these other aspects of rural road transport development.

Sumaila (2014) examine rural mobility problems in Jos, Plateau State, Nigeria. The study recommended that the problem be addressed using social welfare planning approach. Umoren *et al*. (2009) identified the need to develop rural infrastructure to facilitate economic growth in Ibiono Ibom LGA of Akwa Ibom State and recommended that there should be greater participation of rural communities in road development. Adedayo & Sulyman (2013) examined how different rural communities in Niger State, Nigeria develop based on the availability of different categories of infrastructure and concluded that the availability of infrastructure is crucial to the development of rural communities. Aderamo & Magaji (2010) examined how rural transport infrastructure affects the distribution of public facilities in rural areas with a focus on Edu LGA of Kwara State. Okafor (2020) examined the factors that affect road infrastructure development in Akwa Ibom State and observed that the major challenge of road infrastructure development is the over-dependence on the government for financing road projects. Ali (2013) examined the constraints to rural road infrastructure development in Nigeria, focusing on Enugu State. Usman (2014) analyzed the condition of rural roads in Kwara State, Nigeria and concluded that the level of accessibility and the quality of transport services were generally poor.

Beyond upgrading rural roads, the maintenance of roads is equally important. Road maintenance involves correcting defects caused by wear and tear on the roads. The prevalence of potholes on roads in Nigeria is well documented. In this direction, Ipingbemi (2008) recommended a labour-based approach for rural roads maintenance in a manner that involves the active participation of communities where roads transverse.

4.6.5 Donor-funded programs on rural road infrastructure improvement in Nigeria

4.6.5.1 Rural Access and Mobility Project

The Rural Access and Mobility Project (RAMP) was a project of the Federal Government and Cross River State Government, Nigeria with financial and technical support from the African Development Bank (AfDB). The objective of the project was to "Improve access to transport services for the rural population in Cross River State". (AfDB, 2007). Specifically, the project set out to rehabilitate 474km (increased to 477.5km as a result of realignment) of feeder roads and to strengthen institutions relevant to the upgrade and maintenance of road roads (AfDB, 2016). A similar project was developed called Rural Access and Mobility Project (RAMP) 1 which focused on Kaduna State of Nigeria and received financial and technical support from the World Bank. The objective of RAMP 1 was to "provide improved rural transport infrastructure in support of rural economic development activities and for better access to socioeconomic amenities by rural communities in Kaduna State and assist Kaduna State to manage the State road assets in a sustainable manner" (World Bank, 2008). RAMP 1 was further scaled up to RAMP 2 and also expanded its coverage to Adamawa, Enugu, Niger, Osun, and Imo States. The duration of RAMP was from 2008 to 2016.

The project completion report of RAMP 1 in Cross River State (funded by the African Development Bank) rated the project as satisfactory. Specifically, the project was successful in upgrading 406.7km of roads in the project area amounting to 87% of the target (477.5km) while also improving the institutional capacity to design and maintain rural roads. Based on this achievement, average travel time was reduced from a baseline value of 1hr 30 minutes to 16 minutes; vehicle operating cost per vehicle-kilometer was reduced from US$0.35 to US$0.20km; while average speed on rehabilitated roads increased from 25km/hr to 80km/hr (AfDB, 2016). These resulted in several positive impacts in terms of the development of the agricultural value chain, access to health and education facilities amongst others (AfDB, 2016).

On the other hand, the project completion report RAMP 1 in Kaduna State (funded by the World Bank) rated the project as "moderately satisfactory" (World Bank, 2017). Specifically, the project was successful in rehabilitating 475km of roads in the project area while also improving the institutional capacity to design and maintain rural roads. (World Bank, 2017). Based on this achievement, the number of trips per day for selected roads increased from a baseline value of 37 trips to 76 trips; the unit cost of transportation reduced from NGN232 in 2008 to NGN185 in 2016; the number of persons with increased rural accessibility (i.e. "rural population in project areas with access to an all-weather road within 2 km") increased from 1million in 2008 to 1.5million in 2016; amongst others (World Bank, 2017).

4.6.5.2 Rural Access and Agricultural Marketing Project (RAAMP)

The Rural Access and Agricultural Marketing Project is a project of the federal government of Nigeria in collaboration with implementing states and with financial and technical support from the African Development Bank (AfDB), the World Bank, and *Agence Francaise de Developpment* (AFD). Thirteen states (Abia, Akwa-Ibom, Bauchi, Kano, Katsina, Kebbi, Kogi, Kwara, Ogun, Ondo, Oyo, Plateau, and Sokoto) are supported by the World Bank and AFD while six states (Benue, Borno, Anambra, Cross River, Gombe, and Taraba) are supported by the African Development Bank. RAAMP is a successor project of RAMP following the closure of the latter (FMARD Nigeria, 2019). The objective of RAAMP is to "improve rural access and agricultural marketing in participating states while strengthening the financing and institutional base for effective development, maintenance and management of the rural road network" (World Bank, 2020).

4.6.6 Rural Accessibility in Government's Policy

The Draft National Transport Policy 2010 highlights a rural transport policy to address rural accessibility. The objective of the rural transport policy is to: "

(i) Open up the rural areas for local and regional markets

(ii) Improve the institutional framework for rural road construction, maintenance and operation, for a more focused development; and

(iii)Ensure sustainable funding for rural road construction and maintenance. ”

In line with this, the document states the plan of government to strengthen the Works or Transport department in the local government areas to be able to plan and maintain rural roads within their respective domains.

CHAPTER FIVE

5 RESEARCH METHODS

5.1 Study location

This study was carried out in Nigeria. Administratively, Nigeria is a federation made up of 36 states and a Federal Capital Territory. Each state is further divided into local government areas (LGAs) (there are 774 LGAs in all) (see Figure 5.1). Within each local government area, the subdivisions may differ. For purpose of elections, the LGAs are divided into electoral wards which may be considered as a 4th administrative level in Nigeria. However, for cultural and traditional administration, the LGAs may be divided into clans and villages. The total landmass of Nigeria is 923,763 km². The sizes of states range from 3,345 km^2 (i.e. Lagos) to 76,363 km^2 (i.e. Niger) while the sizes of the LGAs range from 8.71 km^2 (i.e. Lagos Island LGA in Lagos State) to 11,579.77 km^2 (i.e Borgu LGA in Niger State) (National Population Commission, Nigeria, 2006).

A B C

Figure 5.1: Administrative divisions in Nigeria. A : Nigeria (outline); B: 36 States + Federal Capital Territory; C: LGAs in Nigeria.

The study focuses on only one state in Nigeria, i.e. Akwa Ibom State (see). The reasons for selecting Akwa Ibom State are: (i) the state is relatively small in size and has a good mix of urban and rural areas[18] (ii) we had prior knowledge of the area which made data collection easier.

[18] The smallest state in Nigeria i.e. Lagos is completely urban.

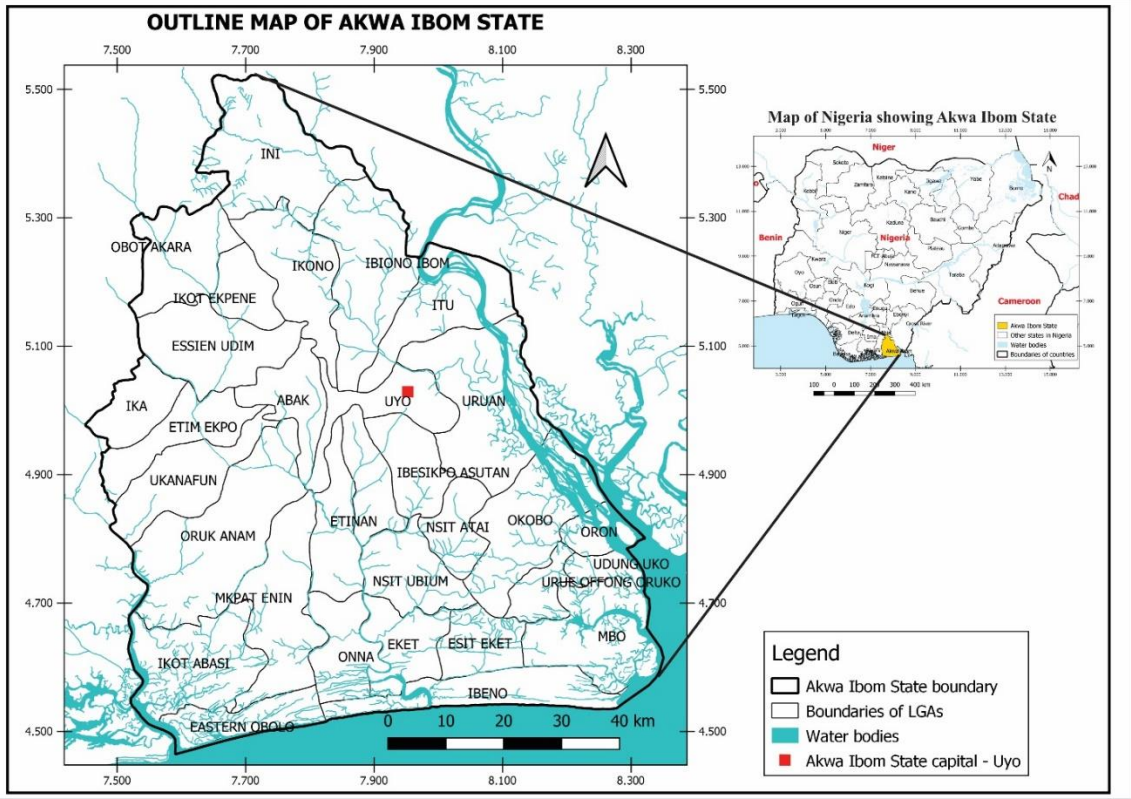


Figure 5.2: Map of Akwa Ibom State (digitized from the official map of Akwa Ibom State provided by the office of the Akwa Ibom State Surveyor General, dated 2016)[19].
Source: Author

Akwa Ibom State[20] is one of the 36 states in Nigeria located in the Niger Delta region of the country, and lies between latitudes 4^{o} 32.1' and 5^{o} 33.1' North, and longitudes 7^{o} 25.1' and 8^{o} 25.1' East. The state is bordered by Rivers State in the South West, Abia State in the Western and Northern part, Cross River State in the North East, and the Atlantic Ocean in the South-Eastern and South. The state has a landmass of 7,081 km^{2} and is made up of 31 local government areas (LGAs) of which six (6) adjoin the Atlantic Ocean. The 2015 population of the state was estimated at 5.27 million (Government of Akwa Ibom State, 2014) and the state falls within the agro-ecological zones of tropical

[19] It is important to note that the shapefile obtained using the official map of the study area is slightly different from the publicly available shapefiles for the second administrative level (i.e. states) in Nigeria.
[20] This paragraph draws largely from the official website of Akwa Ibom State (https://akwaibomstate.gov.ng/about-akwa-ibom/ , visited on 20th February, 2020).

rain forest and mangrove swamps. Its vegetation is mainly green foliage of trees and shrubs.

The climate of the state is influenced by maritime and continental tropical air masses and these make the state to be characterized by two seasons: the wet and dry seasons. The wet or rainy season begins in March-April and lasts for eight months until November in the southern parts of the state which borders the Atlantic Ocean, but slightly less in the northern parts of the state. The total annual rainfall varies between 2,000mm in the hinterland and 4,000mm in the coastal areas. The remaining part of the year is considered as the dry season because of the reduced frequency and intensity of rainfall. Daytime temperature is relatively high all year round and varies between 26ºC and 36ºC. (Amos *et al*., 2015). Farming and fishing are the predominant economic activity in the rural areas in the hinterland and coastal areas respectively. There are several other non-agro micro-scale enterprises like raffia/mat/broom making, carpentry, grocery retailing, etc. which also thrive in rural areas (Amos *et al*., 2015). Not all the 31 LGAs in Akwa Ibom State may be considered as rural. Indeed, the state capital is considered to be one the fastest growing and developed cities in Nigeria (Ukpong & Udofia, 2011; Essien & Cyrus, 2019; Usanga *et al*., 2020).

5.1.1 Road transport infrastructure in the study area

The public transportation system in the study area is generally non-functional. Transport services consist mainly of private operators operating buses, mini-buses, saloon car taxis, tricycles (auto rickshaws or *keke*), or motorcycles depending on the coverage area or distance to be covered. Bicycles are mostly privately owned and used. Buses and saloon car taxis operate mainly for inter-LGA transportation which is generally longer; mini-buses and tricycles (*keke*) operate along the major roads in the state capital while motorcycles operate along minor streets; and tricycles and motorcycles operate in other urban areas. In rural areas, the common transport services are motorcycles and tricycles, even though bicycles are owned and used by individuals. The entry requirement for

operating any commercial transport service involves registration of the means of transportation, paying acceptable fees to be allowed to ply certain routes, and paying for daily tickets. In terms of fares, there is no fixed fare for motorcycles – fares are negotiated for every journey and may depend on the distance to be covered, road quality, time of the day, whether or not the passenger has luggage, etc. The fares for tricycles, mini-buses, and taxis are relatively fixed for any defined route but may fluctuate in response to an increase in the price of petrol or the time of the year (for example, the fares in December are usually higher). In terms of departure and destination points, tricycles, mini-buses/buses, and saloon car taxis have specific departure and final destination points. However, passengers are usually at liberty to drop off at any point before the final destination but will be required to pay the full fare. A summary of the characteristics of transport services in the study area is presented in Table 5.1

Table 5.1: Characteristics of informal transport services in the study area

Type of vehicle	**Routes**	**Schedules**	**Passenger capacity**	**Pricing (fares)**	**Service coverage**
Motorcycle	Variable	Variable	1-2	Variable (always negotiated)	Rural/ Urban
tricycle (*keke*)	Variable	Variable	3-4	Semi-fixed	Rural/ Urban
Mini-bus/bus	Fixed	Semi-fixed	10-16	Semi-fixed	Mainly urban / inter-LGA transportation
Saloon car taxis	Fixed	Semi-fixed	4-6	Semi-fixed	Mainly urban / inter-LGA transportation

Source: Field observation conducted from 3rd to 28th December, 2020.

5.2 Methodology

This study intends to answer three broad questions related to rural road transportation in Nigeria:

(i) what are the travel choices of rural households in Nigeria in the face of poor rural road infrastructure?

(ii) Which rural roads should be improved to yield the maximum socio-economic benefits in rural areas in Nigeria?

(iii) What are the constraints to the improvements of the quality of rural road infrastructure?

In this section, we will describe the method we adopted to address each research question.

5.2.1 Travel behavior of rural households in the face of poor rural road infrastructure

Our first research question examined the travel behaviors of rural households in the face of poor rural road infrastructure.

Agriculture plays a very important role in stimulating the rural economy. Over 80% of farmers in Nigeria are smallholder farmers[21] who reside in areas considered to be rural, and are responsible for over 90% of agricultural output in Nigeria (Anderson *et al*., 2017; Sabo *et al*., 2017). These smallholder farmers contribute substantially to food security at local and national levels (Oluwatayo, 2019). Improvement in their incomes is contingent on selling produce in nearby markets or agro-collation centers which supply food to the expanding urban centers (Dennis & Pullen, 2017). However, the non-availability of efficient transportation system and limited transport options poses a challenge to the transportation of inputs to farm and produce to markets (Berg *et al*., 2018). Consequently, understanding the travel behavior of rural smallholder farmers, based on the available transport options, is important because of the contribution of this category of rural dwellers to the economy, especially in terms of food security. Consequently, we narrow our focus from rural households to rural smallholder farmers.

[21] Farmers who own less than 2hectares of land

5.2.1.1 Survey Design and Data Collection

5.2.1.1.1 Sampling frame

We used an existing sampling frame of smallholder farmers from *Fadama III* project in Akwa Ibom State. *Fadama III* was a project of the Federal Government of Nigeria that benefited from financial and technical support from the World Bank. The objective of the project was to improve the income and agricultural productivity of rural smallholder farmers and was implemented using a community-driven approach (World Bank, 2016a). The project was to be implemented in 20 of the 31 LGAs in the study location but the actual implementation was in 18 LGAs (see Figure 5.3).

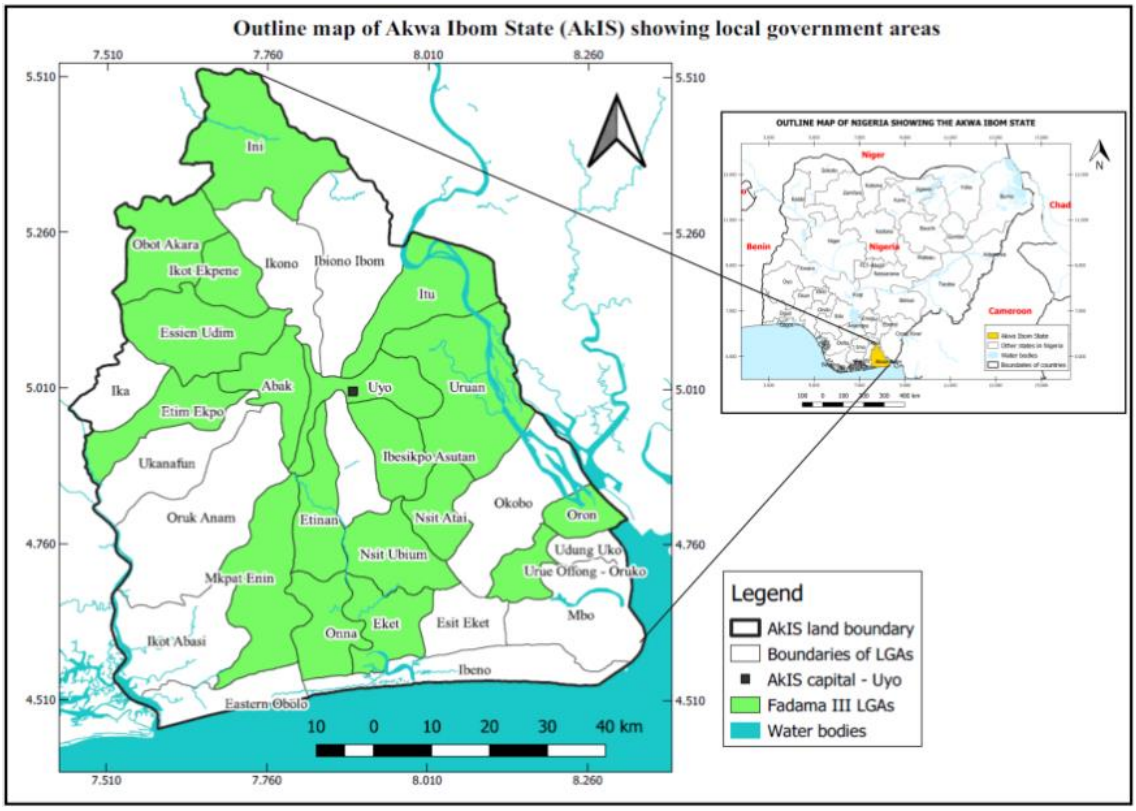


Figure 5.3: Map of the study area showing LGAs that implemented Fadama III

The smallholder farmers in *Fadama III* were selected from each participating LGA following laid down guidelines and they included farmers in crop production, animal

production, agro-processing, agro-marketing, among others (FMAWR Nigeria, 2009, p. 19; World Bank, 2016a). There was no restriction in terms of gender or age, and farmers were grouped into cooperative societies of between 10-25 persons called "Fadama User Groups" (FUGs). The FUGs were further grouped into "Fadama Community Associations" (FCAs). In all, the total number of FCAs was 88, the total number of FUGs was 1218, and the total number of beneficiaries (i.e. smallholder farmers) was 33,674 (18,629 females and 15,089 males) (Akwa Ibom State FCO, 2016). The structure of the database where the sampling frame is obtained is presented in Figure 5.4.

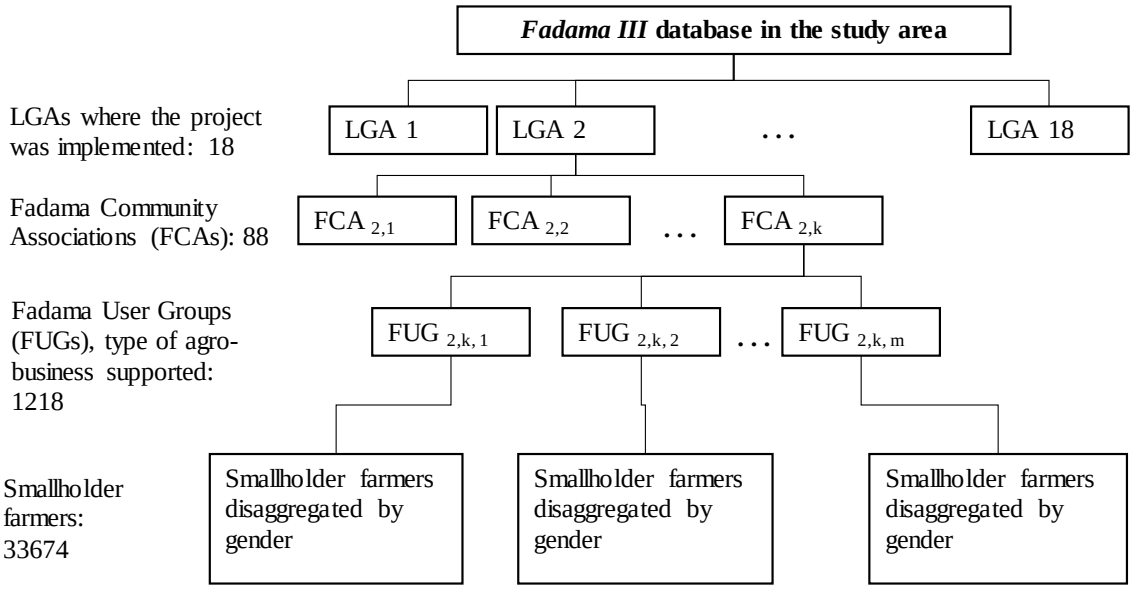


Figure 5.4: Structure of Fadama III database used as the sampling frame

We elected to use this sampling frame because: (i) the geographic spread of the smallholder farmers across rural areas in the study location is fairly even as a result of the due diligence put in place in the course of implementing the *Fadama III* project; (ii) the beneficiaries are a good reflection of rural smallholder farmers; (iii) the smallholder farmers therein are generally literate; (iv) it is easier to locate them for data collection. The sampling frame contains the name of the smallholder farmers and the agricultural value chain they are involved in. The addresses of some of the farmers are also included.

It is important to mention that the use of this sampling frame introduces some sampling biases. First, the sampling frame is only a proportion of smallholder farmers in study area because not all LGAs were included; (ii) the sampling frame may not cover all smallholder farmers even in those LGAs where the project was implemented; (iii) the smallholder farmers of *Fadama III* project had benefitted from technical support from the project in form of training on methods to improve agricultural productivity and in agro-business development, as well as financial support. The technical and financial support had led to improvement in their income (World Bank, 2016b). Therefore, they may not have the same socio-economic status as those not represented in the sampling frame. It was not possible to ascertain the proportion of smallholder farmers covered by the sampling frame in any LGA. Consequently, the findings from this study may not be generalized to cover all smallholder farmers in the study area, but may cover only those smallholder farmers in the sampling frame.

5.2.1.1.2 Data Collection

The study adopts multi-stage sampling procedure. In the first stage, we selected 7 LGAs randomly from the 18 LGAs where the *Fadama III* project was implemented as shown in Table 5.2. Thereafter, we adopted systematic sampling and our target was to obtain data from 10% of smallholder farmers in each selected LGA. We followed the list of smallholder farmers by FCAs and FUGs as they appear in the database. However, we were unable to get data from all the smallholder farmers for several reasons: contact details of beneficially not included, some of the smallholder farmers had died, were ill, changed address, were not reachable, declined the questionnaire, etc. In all, we were able to get data from 620 smallholder farmers as shown in Table 5.2.

Table 5.2: Summary of Sampling frame and sample size

Summary of Sampling frame				LGA selected from simple random sampling	Expected number of respondents (using systematic sampling with 10% sample size)	Actual number of respondents
LGA	**Female**	**Male**	**Total**			
Abak	515	277	792	Selected	79	73
Eket	431	474	905			
Essien Udim	902	788	1680	Selected	168	102
Etim Ekpo	2489	1384	3873			
Etinan	1742	1329	3071			
Ibesikpo Asutan	1314	858	2172	Selected	217	110
Ikot Ekpene	1163	992	2155			
Ini	427	463	890			
Itu	1025	1136	2142	Selected	214	113
Mkpat Enin	707	640	1347	Selected	135	93
Nsit Atai	1053	713	1766			
Nsit Ubium	1563	1332	2895	Selected	290	105
Obot Akara	893	667	1560			
Onna	1016	1049	2065			
Oron	1273	1123	2396			
Uruan	359	171	530	Selected	53	24
Urue Offong/Oruko	438	385	808			
Uyo	1319	1308	2627			
Grand Total	**18629**	**15089**	**33674**		**1156**	**620**

Source of sampling frame data: Akwa Ibom State *Fadama III* Coordination Office

Primary data were obtained from the respondents using a questionnaire configured in a mobile data collection application called *kobocollect*. The only mode of transportation available in the study area is road. The transportation options (excluding walking) are: bicycle, motorcycle, auto-rickshaw or tricycles (popularly called *keke*), mini-buses, and regular saloon cars. A summary of the questionnaire is presented in Table 5.3

Table 5.3: Summary of questionnaire

Segment	Sub-questions	Description
Socioeconomic characteristics of respondents	Age	Age of respondent. Data type = numeric.

	sex	Sex of respondent. Data type = dummy (1=male, 0=female).
	income	(i) Monthly income of respondent (from "less than ₦20,000" to "above ₦100,000.00"[22]. Data type = ordinal (ii) Primary source of income (options are "farming", "trading", "agro-marketing and sales", "public servant", and "others". Data type = categorical
	household size	Household size. Data type = numeric
Ownership of means of transportation, preference, and rationale	number and type of the various means of transportation owned	A table which lists the means of transportation is provided and respondents are requested to fill in the number of each means of transportation owned. Data type = numeric.
	Frequency of using different means of transportation	A table which lists the means of transportation is provided and respondents are requested to select the frequency of using each means of transportation. Options range from "Never" to "Very often". Data type = categorical.
	most used means of transportation	A list of all the means of transportation is provided and the respondent is required to select only one option. Data type = categorical.
	rationale for using the means of transportation most used	A table which lists the means of transportation is provided and respondents are requested to select the rationale for using the different means of transportation.

[22] At the time of carrying out this study, monthly minimum wage in Nigeria is ₦30,000.00 while exchange rate is US$1 = ₦ 379.5

		The options are: “it is safe”, “it is affordable”, “It is comfortable”, “It is readily available”, “It is suitable for the type of road available in the area”, and “It is fast and reduces the travel time”. Data type = categorical
	Most frequent travel days: weekdays or weekends	Between weekdays and weekends, when do you move around more often? Data type = categorical
	Why do you travel out of your home most?	Options are: “To farm (If farming is the main source of income)”, “To market”, “To work (if farming is not the main source of income), “To church”, and “To drop or pick children from school”. Data type = categorical.

Previous studies on travel mode choice obtained data on several other variables. For example, travel time for different means of transportation (Can, 2013; Aloulou, 2018); travel cost (Can, 2013; Aloulou, 2018); questions related to the built environment (Masoumi, 2019; Ding *et al*., 2017; Ye & Titheridge, 2017; Munshi, 2016); etc. Even though these variables are very important in understanding travel choice, we were unable to obtain data on them. This is because the pre-test indicated that respondents may find it difficult to provide reliable answers to these questions. The survey was conducted between 8th January and 6th February 2021.

5.2.1.2 Analytical technique

This study aims to examine the travel choices of rural smallholder farmers. We focus on a single mode of transportation, i.e. road transport. The available means of road

transportation within the study area (excluding by foot) are: bicycle, motor-cycle, auto-rickshaw (popularly called *keke*), mini-buses/buses, and saloon cars. Consequently, we adopt the multinomial logit model (MNL). We note that the nested logit model is preferred to the MNL if any of the discrete options is considered a close substitute of another. In our case, none of the options is a close substitute of another therefore we assume that the condition of independence of irrelevant alternatives will not be violated. The travel choice model is described as follows:

Let U_{ik} represent the utility derived by an individual i if s/he chooses an alternative k from a set S of possible discrete alternatives, where k = 1, …, K; i= 1, …, n. Then,

$$U_{ik} = F\left(Y_{ij}, Z_{ikm}\right) + \varepsilon_{ik}$$

Where:

Y_{ij}, $j = 1,\ldots, J$ represents jth socio-economic characteristics of the ith individual (i = 1,…., n) which influences the choice of the kth means of transportation as the most used means of transportation; Z_{ikm}, k = 1,…, K, m = 1,…., M, represents the value of the mth characteristic of the kth means of transportation most used by the ith individual; ε_{ik} is the random error term. If an individual i uses means of transportation k most frequently, it implies that the utility that i derives from that means of transportation is generally higher than the utility from other means of transportation. Therefore, the probability that individual i uses means of transportation k most frequently is the probability that the utility of k is higher than the utility of other available means of transportation.

$$p_{ik} = P\left(U_{ij} > U_{i1}, U_{ij} > U_{i2}, U_{ij} > U_{im}\right),\ j \neq m$$

The probability that an individual will choose any of the kth alternative is given as:

$$p(k) = \frac{\exp(\beta_{0k}+\beta_{1k}X_{1i}+\beta_{2k}X_{2i}+\beta_{3k}X_{3i}+\cdots+\beta_{jk}X_{ji}+\varepsilon_{ik})}{1+\sum_{l=1}^{L-1}\exp(\beta_{0l}+\beta_{1l}X_{1i}+\beta_{2l}X_{2i}+\beta_{3l}X_{3i}+\cdots+\beta_{jl}X_{ji}+\varepsilon_{il})};\quad k, l \in \text{S, where S is the set of}$$

categorical dependent variables with K elements.

5.2.2 Multi-Attribute Utility Theory

The general objective of this work is similar to that of Castro & Vistan (2020) in the Philippines and ReCAP (2016) in Bangladesh. Therefore, we adapt the methodologies used by these studies. We examine how rural roads may be prioritized for an upgrade in a manner that maximizes access to social and economic facilities in rural areas. The selection of a rural road from a pool of potential roads for an upgrade is a decision-making problem. Decision-making problems may be classified as "Choice Problems", "Sorting Problems", "Ranking Problems", or "Description Problems" (Ishizaka & Nemery, 2013, pp. 3-4). Our study may be considered a ranking problem. In this regard, we adopt the Multiple Attribute Utility Theory (MAUT) because it is more appropriate to use than the Analytical Hierarchical Process (AHP) when the number of alternatives to be ranked is large (Guarini *et al*., 2018). MAUT provides a procedure for selecting an alternative from a set of alternatives such that the selected alternative is the one that maximizes a utility function. MAUT has been used extensively in the literature for ranking problems in diverse fields including health (Claudio *et al*., 2014); maritime transport (Lagoudis *et al*., 2006); international investment (Canbolat *et al*., 2007); pavement management (Dabous *et al*., 2020); selection of diplomats (Taufik *et al*., 2021); flood risk prioritization (Leal da Silva *et al*., 2020); etc. Our problem is presented in a hierarchical structure in Figure 5.5.

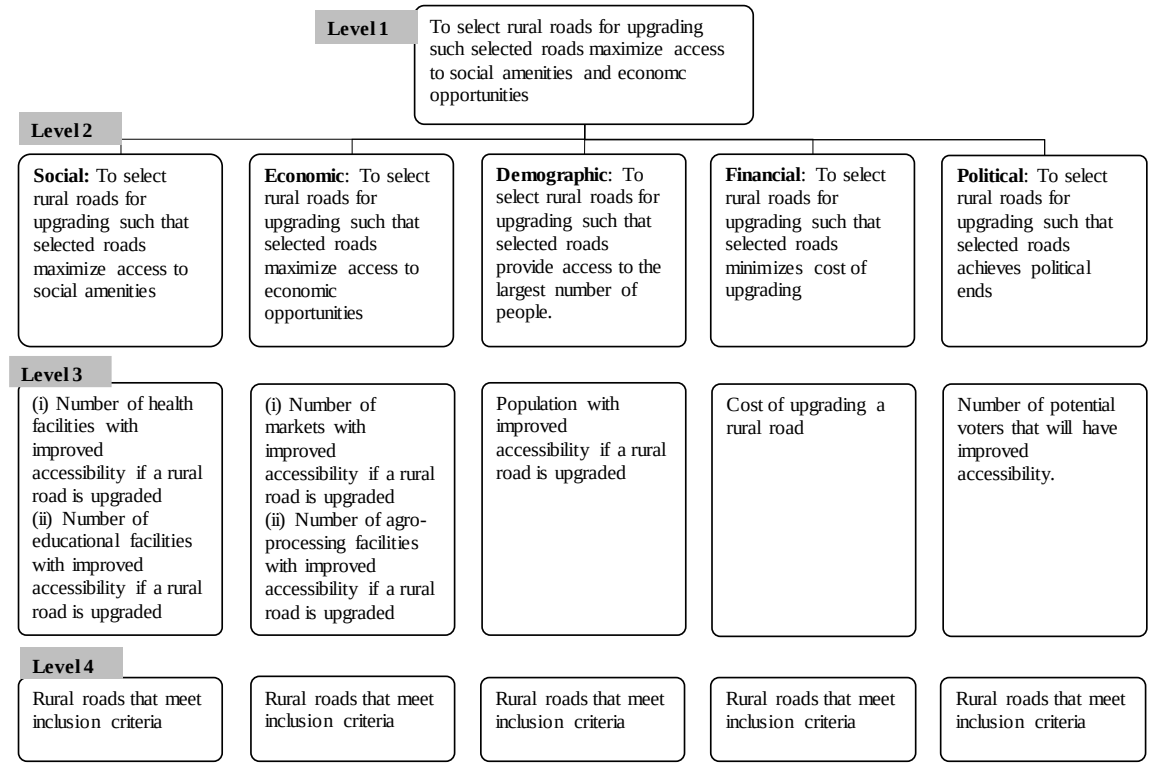


Figure 5.5: Hierarchy of decisions to be made

5.2.2.1 Step 1: Development of the performance matrix

We define the terminologies that will be used in the succeeding segments as follows:

(i) Criteria: These are the different factors that need to be taken into consideration in decision making

(ii) Alternatives: These are the different options available to be considered

(iii) Marginal utility function: this is a way of measuring the degree of performance of different alternatives under each criterion

(iv) Marginal utility score: this is the performance of an alternative under each criterion.

(v) Utility function: the method of aggregating the contributions of the marginal utility scores

(vi) Utility score: the degree of wellbeing provided by each alternative, obtained from the application of the utility function to the marginal utility scores.

Let C denote a set of n criteria $c_1, c_2, \ldots, c_n$ i.e. C = $\{c_1, c_2, \ldots, c_n\}$, where the scales and units of measurements for each criterion c_i may differ significantly. Let A denote a set of m alternatives $a_1, a_2, \ldots, a_m$ i.e. A = $\{a_1, a_2, \ldots, a_m\}$. The performance of each alternative under each criterion may be denoted as $c_j(a_i)$, for i = 1, 2,…, m and j = 1, 2,…, n. The performance matrix may be presented as shown in Table 5.4.

Table 5.4: Representation of Performance Matrix

		Criteria				
		c_1	c_2	c_3	…	c_n
Alternatives	a_1	$c_1(a_1)$	$c_2(a_1)$	$c_3(a_1)$	…	$c_n(a_1)$
	a_2	$c_1(a_2)$	$c_2(a_2)$	$c_3(a_2)$	…	$c_n(a_2)$
	a_3	$c_1(a_3)$	$c_2(a_3)$	$c_3(a_3)$	…	$c_n(a_3)$
	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
	a_m	$c_1(a_m)$	$c_2(a_m)$	$c_3(a_m)$	…	$c_n(a_m)$

5.2.2.1.1 Collection of Data and Development of GIS for Rural Road Infrastructure Planning in the study area

The first step in MAUT is to develop a performance matrix. The candidate roads for upgrade are the alternatives while the criteria are: social (educational and health facilities), economic (nearness to markets), financial (cost of road upgrade), demographic (population), and political.

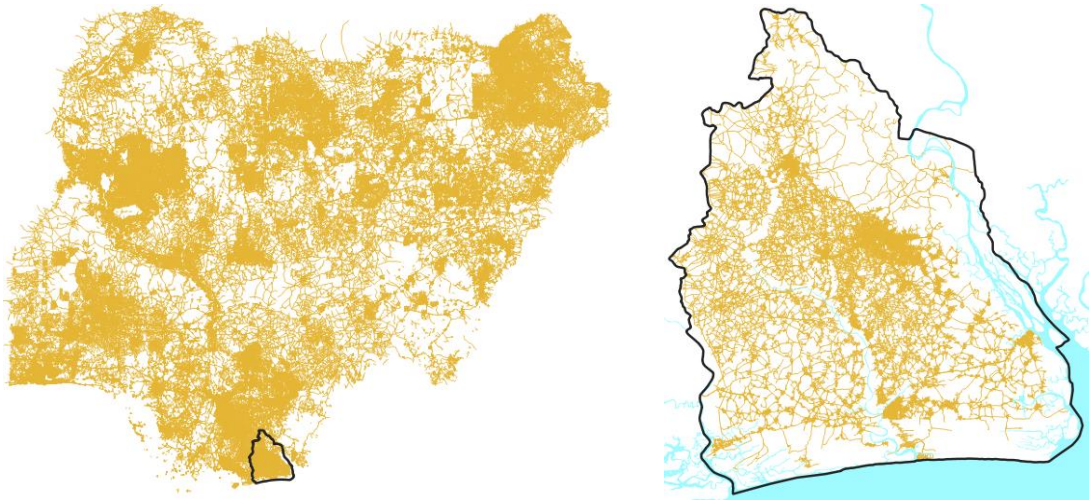
Alternatives

The rural roads in the study are the alternatives. To identify all candidate roads, we note that the definition of "rural road" varies significantly depending on the country and environment. In this direction, a working definition of "rural road" is necessary to facilitate the development of inclusion/exclusion criteria. Roads in Nigeria are categorized as federal, state, or local government roads. A report by the World Bank states that only less than 10-15 percent of state and local government roads in Nigeria can be

considered in good to fair condition (World Bank, 2017b). Therefore, our focus will be on these categories of roads. The criteria for selecting rural roads for this study are:

(i) the road is not a federal road (i.e. may be a state or local government road)
(ii) the length of the road is greater than 5000m;
(iii) the road is not an asphalt road, that is, the road may be described as "undisturbed earth road" or "lateritic earth road"

To obtain the rural roads, we use secondary data of road network in Nigeria obtained from Open Street Map using an online tool[23] . Using the *Intersection* geo-processing function in QGIS, we extracted the road network in Akwa Ibom from that of Nigeria (see Figure 5.6). This yielded a total of 33628 entries in its Attribute Table. A frequency distribution of these entries shows that 27,849 are less than 500m; 3383 are between 500m and 1000m; a total of 2,113 are between 1000m and 5000m; while 283 are above 5000m (Figure 5.7). We carried out further assessment of the 283 roads greater than 5000m and a total of 126 roads met our inclusion criteria. The roads are re-labelled as they appear in the attribute table as Rural Road 001, Rural Road 002, …, Rural Road 126



A **B**

Figure 5.6: ***A:*** *Display of Nigeria roads shapefile showing the outline of Akwa Ibom State. B. Road network in Akwa Ibom State obtained from the intersection of Akwa Ibom State outline map and road network in Nigeria.*

[23] https://www.geofabrik.de/data/ (accessed on February 22, 2020)

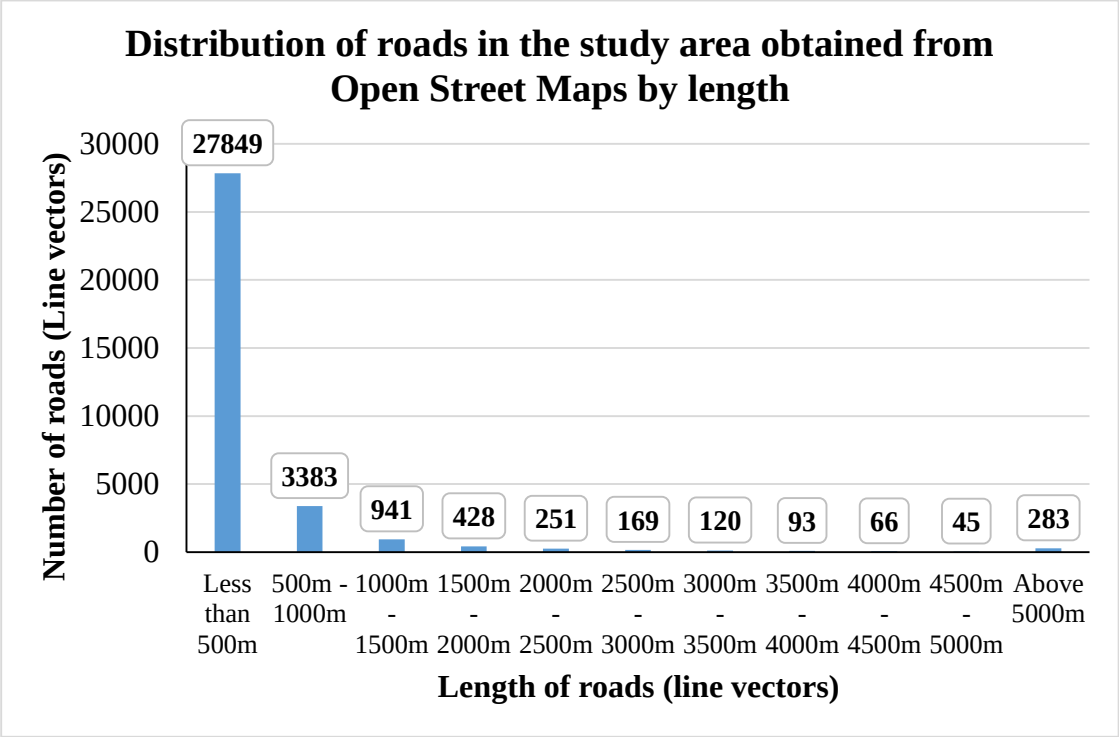


Figure 5.7: Distribution of roads in the study area obtained from Open Street Maps by length

Data on criteria

(i) **Social: health and education**

The social variables to be used in the study are informed by those used in previous studies such as Kanuganti *et al*. (2017), Castro & Vistan (2020), Modinpuroju *et al*. (2016). For our study, we use the numbers of educational and health facilities within 1000m buffer[24] area of each rural road respectively. The data on the spatial locations of educational and health facilities (point vectors) are obtained from the Geo-Referenced Infrastructure and Demographic Data for Development (GRID3) programme in Nigeria[25]

[24] Buffering is a process in spatial analysis
[25] https://grid3.gov.ng/ (accessed on April 19, 2021)

(ii) **Economic**

(a) Number of markets within 1000m buffer area of each rural road. Data on spatial locations of markets (point vectors) are obtained from GRID3.

(b) Number of agro-processing facilities with 1000m of each rural road. spatial locations of agro-processing facilities within the study area are obtained from the Rural Access and Agricultural Marketing Project (RAAMP)

(iii) **Demography**

The demographic variable refers to the population within 1000m radius of each selected road. To obtain the population, we used the raster data of population distribution for Nigeria from World Pop[26]. We downloaded the data for Nigeria and used the "intersection" function on QGIS to clip the data for the study area. We re-projected the road shapefiles to an appropriate coordinate referencing system (CRS) for Nigeria that also allows for buffering operation in meters (i.e. EPSG32632 – Minna 32N), buffered the shapefile at 1000m, then used the "Zonal Statistics" processing tool in QGIS to extract the population within the buffered area for each rural road.

(iv) **Political**

Political considerations are primary in decision making and it will be unrealistic to expect that decision-makers who are mostly politicians will exclude this from the decision-making process. However, unlike social, economic, or demographic criteria, the variables that may be used for political criterion are difficult to quantify objectively. We use the number of polling units within 1000m buffer area of each rural road as a proxy. Data on

[26] Unconstrained individual country data for Nigeria for 2020 (100m resolution).
WorldPop (www.worldpop.org - School of Geography and Environmental Science, University of Southampton; Department of Geography and Geosciences, University of Louisville; Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), Columbia University (2018). Global High Resolution Population Denominators Project - Funded by The Bill and Melinda Gates Foundation (OPP1134076). https://dx.doi.org/10.5258/SOTON/WP00645

the spatial locations of polling units are obtained from the Independent National Electoral Commission (INEC).

(v) **Financial**

We use the cost per km of upgrading a road from an "undisturbed earth road" to a "single carriage asphaltic road with side drains and no median". Obtaining the cost of upgrading roads would have required (i) physical assessment of each road to understand the terrain, (ii) development of an engineering design for each road, and (iii) development of bill of engineering measurement and evaluation (BEME) for each road. This would have been costly and time-consuming. Instead, we obtained the cost per km of an actual rural road awarded for construction in the study area in 2020 from the Ministry of Works in the study area and added a "penalty factor" as follows:

$$Cost_j = A(1 + p_j) * Roadlength_j$$

Where $Cost_j$ is the cost of upgrading road j; A is the actual cost per kilometer of upgrading a rural road in the study area in year 2020; $Roadlength_j$ is the length of road j; and p_j is a positive adjustment factor that is used to adjust A for the different roads to reflect other factors that influence the cost of rural road improvement (e.g. soil type, elevation).

p_js are estimated using the digital elevation map of the study area and it ranges from 0.0 to 0.5. p_j = 0.5, if the average elevation of the road is between 0 and 15m; p_j = 0.3, if the average elevation of the road is above 40m; and p_j= 0, if the average elevation is between 15m and 40m. A higher value is assigned to p_j for elevations between 0 and 15m because it suggests that such roads are in a marshy environment which will require additional construction materials or will likely require a bridge.

Further, we carried out a pairwise comparison of the scores of the alternatives across all criteria to eliminate dominated alternatives. This reduced the number of alternatives from

126 to 59. We did not re-label the roads after deleting the dominated alternatives. This means that the remaining roads used in the analysis will still have the previous labels. The summary of the data in the performance matrix is presented in Table 5.5. while the map showing the selected roads is presented in Figure 5.8. The maps showing the roads after removing dominated alternatives, alongside each criterion are presented in the Appendix.

Environmental criteria

We had envisaged including an environmental criterion in the analysis. The initial plan was to use the digital elevation model for the state as a proxy for terrain. However, we had embedded this information in the financial criterion therefore we excluded the environmental criterion.

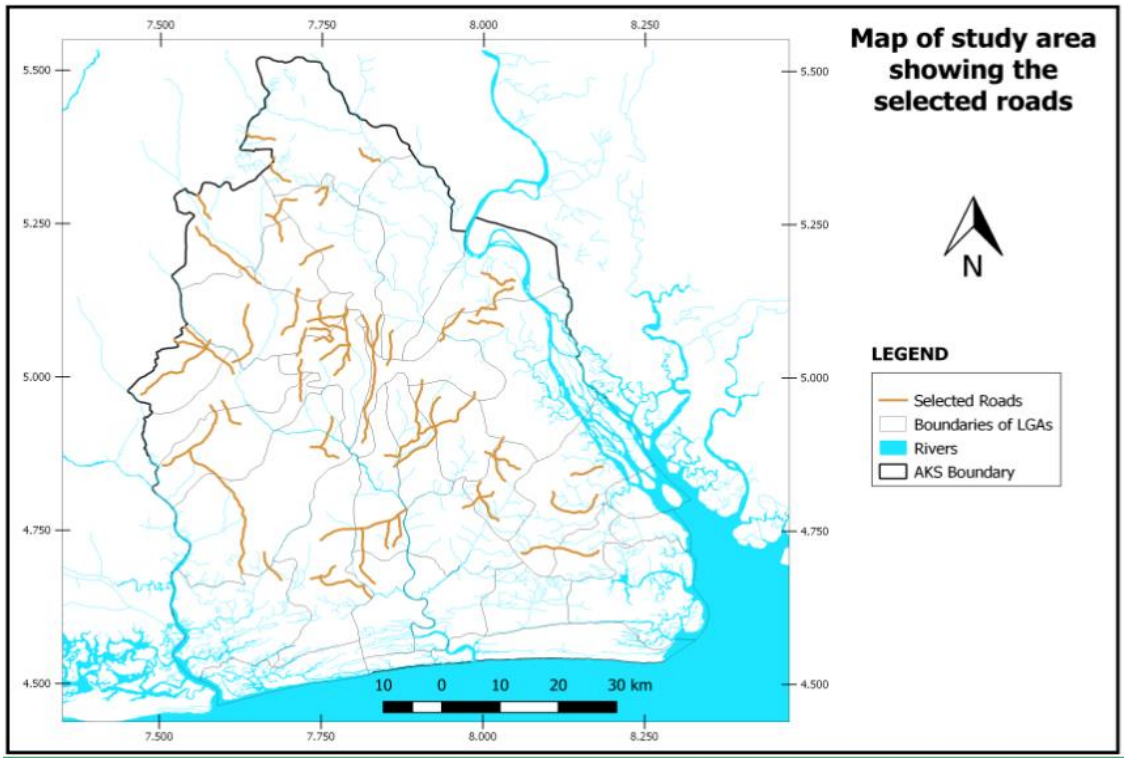


Figure 5.8: Map showing the selected roads (i.e. after removing dominated alternatives)

Table 5.5: The summary of the data used

	Financial	Economic- 1	Economic 2	Social 1	Social 2A	Social 2B	Demographic	Political
	Cost of upgrade (NGN million)	No. of Agro-processing facilities	No. of Markets	No. of Health facilities	No. of primary schools	No. of Secondary schools	No. of persons within 100m x 100m area	No. of polling units
Min	1,144.73	0	0	0	1	0	3085	3
Max	6,069.80	17	16	7	16	12	47899	27
25th percentile	1,321.99	0	3	1	4	1.5	12637	8
50th percentile	1,482.22	1	4	2	6	2	18665	12
75th percentile	2,278.03	2	6	3	8	4	22911	15
Mean	1,837.13	1.76	4.64	2.29	6.42	2.69	19194.14	12.27
St. Dev.	825.50	3.02	3.07	1.34	3.32	2.15	9442.85	5.67

5.2.2.1.2 Summary

We present in Figure 5.9 the summary of the procedure for developing the performance matrix.

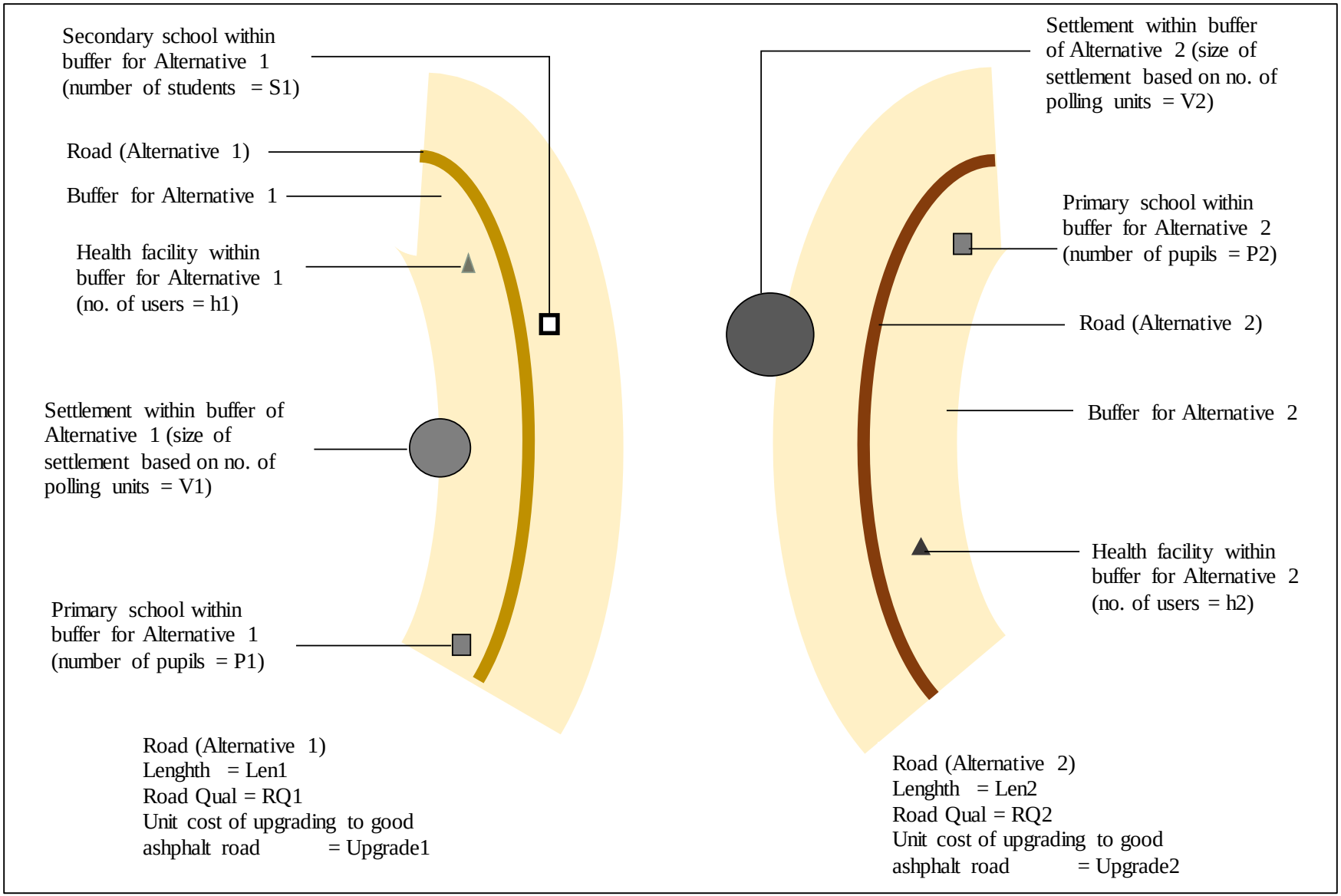


Figure 5.9: Schematic diagram showing how data were obtained to fill in the performance matrix

5.2.2.2 Step 2: Normalization of performance matrix

The unit and scale of each criterion, c_i, may differ significantly, and therefore may not ensure comparability. Therefore, the performance matrix had to be normalized. Normalization is the process of removing units and scales from the different criteria to make the scores comparable. This involves scaling all the scores to be between 0 and 1. In doing this, we keep in mind that for some criteria (e.g. cost), it will be desirable to have lower values than higher values, i.e. people will generally prefer taking decisions that will minimize cost. In contrast, having a higher score will be desirable for others criteria that involve benefits. Therefore, the process of normalizing these two categories of criteria will be different. The normalization is done such that for variables where lower scores are desirable, the lowest score will be normalized to 1 while the highest score will be normalized to 0. Every other score will fall within these extremes. Similarly, for criteria where having higher scores are desirable, the minimization is done such that the lowest score will be 0 while the highest score will be 1. Every other score will fall between 0 and 1. We present the function used in the normalization in equations (1) and (2)

For criteria that need to be maximized (i.e. higher marginal utility scores are desirable)

$$g_{ij} = \frac{c_j(a_i) - Min_j[c_j(a_i)]}{Max_j[c_j(a_i)] - Min_j[c_j(a_i)]} \quad \ldots(1)$$

Criteria that need to be minimized (i.e. lower marginal utility scores are desirable)

$$g_{ij} = \frac{Max_j[c_j(a_i)] - c_j(a_i)}{Max_j[c_j(a_i)] - Min_j[c_j(a_i)]} \quad \ldots(2)$$

Where a_i is the alternative i; c_j is the criteria j; $c_j(a_i)$ performance score of a_i in c_j; g_{ij} is the normalized score for of a_i in c_j and $0 \leq g_{ij} \leq 1$; $Max_j[c_j(a_i)]$ and $Min_j[c_j(a_i)]$ represents the maximum and minimum elements in the column vectors c_js respectively.

5.2.2.3 Step 3: Marginal utility functions of the criteria

We need to specify the marginal utility function for each criterion. We present the shapes of common marginal utility functions in Figure 5.10 and the summary of the marginal

utility functions used for each criterion in Table 5.6. We note that the g_{ij}'s obtained from equations 1 and 2 are linear with respect to each criterion. We use these g_{ij}'s to obtain the marginal utility functions as specified on Table 5.6.

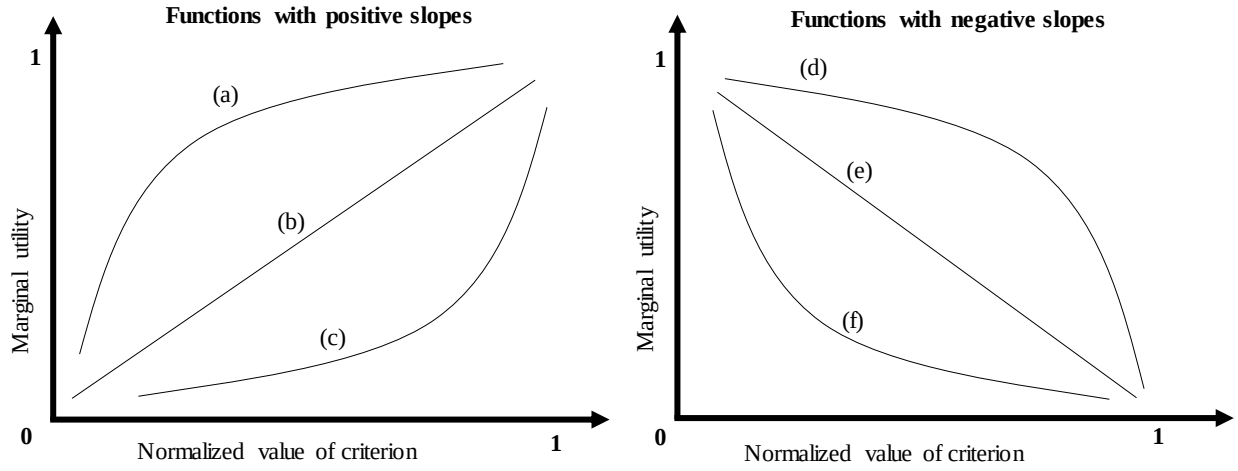


Figure 5.10: Diagrammatic representation of positive and negative linear and non-linear functions considered.

(a) As normalized value of criterion increases, marginal utility increase but at a reduced rate

(b) As normalized value of criterion increases, marginal utility increase at constant rate

(c) As normalized value of criterion increases, marginal utility increase but at an incremental rate

(d) As normalized value of criterion increases, marginal utility decreases but at an incremental rate

(e) As normalized value of criterion increases, marginal utility decreases at a constant rate

(f) As normalized value of criterion increases, marginal utility decreases but at a reduced rate

Table 5.6: Marginal utility functions of the different criteria

Criteria	Marginal utility function (MUF)	Specification
Social-health	The MUF has a positive slope. As the normalized value of criterion increases, marginal utility increases but at a reduced rate. This is based on the assumption that marginal benefits of accessibility to health facilities due to improvement in the quality of rural roads will reduce as the number of such health facilities increases.	$U_{ij} = \frac{100^1 - 100^{1-g_{ij}}}{100^1 - 100^0}$ …(3) $= \frac{100 - 100^{1-g_{ij}}}{99}$ …(4)

Social-education	Similar to above	Same as eqn (4)
Economic (markets)	Similar to above	Same as eqn (4)
Economic (agro-processing facilities)	Similar to above	Same as eqn (4)
Demographic	The MUF has a positive slope. As the normalized value of criterion increases, marginal utility increases but at an incremental rate. This is based on the assumption that roads in places with higher populations will have more marginal utility than those in places with lower populations.	$U_{ij} = \frac{100^{g_{ij}} - 100^0}{100^1 - 100^0}$ …(5) $U_{ij} = \frac{100^{g_{ij}} - 1}{99}$ …(6)
Financial	Negative function with decreasing marginal utility. This is because as the length of roads increases, the unit cost per km tends to decrease.	Same as eqn (4)[27]
Political	We assume that this criterion will have a function with a positive slope with increasing marginal utility. This is because political actors are more likely to nominate roads in areas with higher populations because this will contribute substantially to their popularity	Same as eqn (6)

[27] The normalization carried out using eqn (2) has already made the highest value to be zero and the lowest to be one. Therefore, we retain this transformation. Otherwise, the appropriate transformation would have been, $U_{ij} = \frac{100^1 - 100^{g_{ij}}}{100^1 - 100^0} = \frac{100 - 100^{g_{ij}}}{99}$

5.2.2.4 Step 3: Determination of Weights

The weights for the criteria in MAUT have been a contentious issue for researchers because the method for determining the weights is often subjective (Macharis & Bernardini, 2015). Some studies rely on expert panels which involves the ranking of the criteria (Lagoudis *et al*., 2006) while other studies use AHP (Bhandari *et al*., 2014). We adopt the AHP model to obtain the weights (Saaty, 1980, 1987, 1995; Ishizaka & Nemery, 2013, pp. 13-54).

We prepared an AHP questionnaire that included a pairwise matrix with a 9-point scale. Before completing the pairwise matrix, respondents were asked to rank the criteria from 9-most important to 1- least important (Table 5.7). This ranking is to guide the respondent in completing the questionnaire to minimize the risk of having inconsistencies in the AHP analyses. The sample sizes used by AHP studies differ significantly depending on the number of decision-makers and stakeholder groups. Some studies have used different sample sizes even as low as 5 (Peterson *et al*., 1994; Kil, *et al*., 2016). The respondents were selected purposively and included: (i) senior/management staff of the Ministry of Works in the study area, (ii) staff of donor-funded projects focusing on road infrastructure development, and (iii) development experts in the academia. A total of 12 persons completed the questionnaire. The analyses and checks for inconsistencies were done individually and the weights for all respondents were consistent. We computed the final weight using the arithmetic mean of the individual weights.

Table 5.7: Matrix to show the relative importance of the different criteria

Row/ Column	Social-Education	Social - Health	Economic: Markets	Economic: agro-processing facilities	Demographic	Financial	Political
Social: Education	1						
Social: Health		1					

Economic: Markets			1				
Economic: agro-processing facilities				1			
Demographic					1		
Financial						1	
Political							1

The scale of relative importance to guide in completing the matrix was as follows:

Value	Explanation
1	Equal importance: Criteria A has equal importance as criteria B
3	Moderate importance: Criteria A is moderately more important than criteria B
5	Strong importance: Criteria A is strongly more important than criteria B
7	Very strong importance: Criteria A is very strongly more important than criteria B
9	Extreme importance: Criteria A is extremely more important than criteria B
2,4,6, 8	Intermediate values

5.2.2.4.1 Assignment of Weights

Let W_j be the weight for criteria $c_j, j = 1, \dots, n$, W_j is assigned such that $\sum_{j=1}^{n} W_j = 1$ (Table 5.8)

Table 5.8: Representation of Performance Matrix after normalization and determination of weights.

	Weights	W_1	W_2	W_3	…	W_n
	Criteria	c_1	c_2	c_3	…	c_n
Alternatives	a_1	N_{11}	N_{12}	N_{13}	…	N_{1n}
	a_2	N_{21}	N_{22}	N_{23}	…	N_{2n}
	a_3	N_{31}	N_{32}	N_{33}	…	N_{3n}
	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
	a_m	N_{m1}	N_{m2}	N_{m3}	…	N_{mn}

5.2.2.5 Global Utility Function

To obtain the utility score of each alternative, we aggregated the marginal utility scores of the alternatives across the different criteria. We adopted the additive model which is most commonly used model (Ishizaka & Nemery, 2013, p. 82; Jansen, 2011, p. 106) as opposed to the multiplicative or multi-linear model as follows:

$$\forall\, a_i \in \text{A}:\ U(a_i) = \sum_{j=1}^{n} W_j U_{ij}, \qquad \ldots(7)$$

where $0 \leq U(a_i) \leq 1.$; W_j is the weight for criteria j; U_{ij} is the marginal utility score obtained from the normalize value of the entry for alternative i and criteria j in the performance matrix – computed using the specification of the marginal utility functions in eqns (3) – (6). The analyses are done using MS Excel. The layout of the performance matrix after computation of the utility scores is as shown in Table 5.9. The results of the utility scores are appended to the Esri Shapefile of the selected roads using QGIS.

Table 5.9: Layout of the Performance Matrix after computation of the utility scores

	Weights	W_1	W_2	W_3	…	W_n	Utility score
	Criteria	c_1	c_2	c_3	…	c_n	
Alternatives	a_1	U_{11}	U_{12}	U_{13}	…	U_{1n}	$U(a_1)$
	a_2	U_{21}	U_{22}	U_{23}	…	U_{2n}	$U(a_2)$
	a_3	U_{31}	U_{32}	U_{33}	…	U_{3n}	$U(a_3)$
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	a_m	U_{m1}	U_{m2}	U_{m3}	…	U_{mn}	$U(a_m)$

5.2.2.6 Scenario Building

It is important to examine how the changes in the weights affect the global utility scores of the alternatives. We do this by creating realistic scenarios in which we altered the initial weights used in the base case scenario. The scenarios were as follows:

(i) The main criterion for decision making is financial, i.e. the cost of upgrading the rural roads. This scenario is important because of the dwindling economic fortunes of Nigeria which is affecting every part of the country. In this scenario, the financial criterion takes the largest weight while other criteria share the remaining.

(ii) Social criterion has the highest weight.

(iii) Economic criterion has the highest weight

(iv) Demographic criterion has the highest weight

(v) Political criterion has the highest weight

(vi) The weights are shared equally amongst the criteria.

The summary of the weights for the different scenarios is presented in Table 5.10

Table 5.10: Summary of weights used in the different scenarios

Criteria	Scenarios						
	Base-case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Financial	0.0781	0.4	0.1	0.1	0.1	0.1	0.14286
Demographic	0.1632	0.1	0.1	0.1	0.4	0.1	0.14286
Social-health	0.1821	0.1	0.25	0.1	0.1	0.1	0.14286
Social-education	0.1942	0.1	0.25	0.1	0.1	0.1	0.14286
Economic	0.1599	0.1	0.1	0.25	0.1	0.1	0.14286
Economic_2	0.1163	0.1	0.1	0.25	0.1	0.1	0.14286
Political	0.1062	0.1	0.1	0.1	0.1	0.4	0.14286
Total	**1**	**1**	**1**	**1**	**1**		**1**

N/B for the "Social-education" criteria, our data covers primary and secondary schools. Consequently, we breakdown the weight assigned to the criteria to cover primary and secondary schools as follows: primary school (30%), secondary school (70%).

5.2.3 Constraints to effective rural transport services

5.2.3.1 Survey design and data collection

Our third objective is to identify the constraints to the improvement of the quality of rural road infrastructure in the study area. To address this objective, this study adopts sampling survey. We note that given the nature of the research question, we will require persons who are experienced and knowledgeable about rural road infrastructure development to be the respondents. Consequently, we adopt a purposive sampling technique. We identified institutions and categories of persons who may be included as potential respondents. These included:

(i) Elected/Appointed public office holders

(ii) Senior civil servants in the government at state of local government involved in rural roads developed (e.g. Ministry of Works)

(iii) Contractors who have (or are) working on road construction.

(iv) Engineering design consultants;

(v) Academia/ researchers.

(vi) Employees of donor-funded projects involved in the road transport sector.

5.2.3.2 Survey instrument and data collection

Primary data were obtained from the respondents through the use of a structured paper-based questionnaire. The content of the questionnaire was informed by previous studies (Ali, 2013; Agumba, 2016; Samanta, 2015). The questionnaire had two segments as shown in Table 5.11. The questionnaires were taken round different offices as identified in the previous section. More preference was given to civil servants because this category of respondents help government in the implementation of rural construction projects and we assumed that they will be more knowledgeable. Also, the number of potential respondents from this category is far higher than that from other categories.

Table 5.11: Summary of questionnaire on constraints to effective rural roads development

Segment	Question	Options	Type of response/Data type
Part A: Information about respondents	Category of respondent	(a) Political appointee/elected public officer (b) Senior Civil Servant in LGA or State (serving or retired) (c) Development worker (e.g. in a donor-funded project) (d) Contractor (e) Engineering Design and Supervision firm (f) Researcher/Academia	Categorical data. Respondent may select more than one option
	Years of experience in rural (i.e. state) road construction	Not applicable	Numerical data

	Highest Educational Level	(a) OND/NCE (b) HND/B.Sc. (c) PgD and above	Categorical data. Respondent to select one option
Part B: Kindly select from the options in each category the magnitude of challenge posed by the listed variables	Institutional Challenges	(a) Poor planning for rural road development (b) Non-availability of skilled persons to supervise and implement rural road construction activities (c) Multiple stakeholders with overlapping responsibilities in rural road construction	Categorical data. Respondent may select more than one option
	Engineering/ technical challenges	(a) Non-availability or poor engineering design (b) Use of sub-standard materials for construction (c) Poor supervision (d) Non-availability of suitable materials locally (e) Lack of appropriate equipment	Categorical data. Respondent may select more than one option
	Natural/ Environmental factor	(a) Geotechnical properties of soil in the region which makes construction expensive and difficult (b) Topography of the environment	Categorical data. Respondent may select more than one option

		(c) Extended period of rainy season which makes road construction impossible (d) High vulnerability of existing roads to erosion (e) Non implementation of environmental impact assessment	
	Economic	(a) Non-release of funds to contractors (b) Delay in payments of contractors and consultants (c) Misappropriation and embezzlement of public funds (d) Lack of funds for maintenance of roads (e) Frequent price escalation	Categorical data. Respondent may select more than one option
	Social	(a) Excessive requirements from communities in the process of roads construction (b) Unfavorable cultural requirements (c) Lack of community ownership in the process of construction and maintenance of roads.	Categorical data. Respondent may select more than one option
	Political	Use of rural road project as political tools and abandoning the roads	Categorical data. Respondent may select more than one option

We had planned to generate data from 100 respondents. However, 59 questionnaires were competed and returned. The distribution of respondents by who completed the questionnaires by category of respondents is presented in Table 5.12. We observe from Table 5.12. that the there was a high non-response rate from appointed/elected public officers while the response rate from civil servants was relatively high.

Table 5.12: Number of respondents across different categories

Category of respondent	**Number of questionnaires distributed**	**Number returned**	**Percentage**
Appointed/elected public officers	10	2	20.00%
Senior Civil Servant in LGA or State (serving or retired)	30	22	73.33%
Development worker (e.g. in a donor-funded project)	20	13	65.00%
Contractor	15	9	60.00%
Engineering Design and Supervision firm	15	7	46.67%
Researcher/Academia	10	6	60.00%
Total	**100**	**59**	**59.00%**

5.2.3.3 Data Analyses

Data obtained were inputted into an MS Excel document. The data were then analyzed using descriptive statistics

CHAPTER SIX

6 RESULTS AND DISCUSSIONS

6.1 Travel Mode Choice of Rural Smallholder Farmers

The results will be presented in two parts. In the first part, we will present the summary of the data collected. This is to help the reader have an understanding of the characteristics of the respondents as well as their ownership of means of transportation and frequency of use of the different means of transportation available in the study area. In the second part, we will present the result of the discrete choice model.

6.1.1 Summary of data collected

6.1.1.1 Socio-economic characteristics

The socio-economic characteristics of the respondents are presented in Table 6.1. We observe from Table 6.1 that the modal age of the respondents was 31 to 40 years accounting for 40% of the responses while the extremes (i.e. 0-20 years and 71-80 years) accounted for the least. The sex distribution of respondents was fairly even. The household sizes of about 77% of the respondents were between 5 and 8. The modal income range was ₦20,001 – ₦40,000 and the income of about 77% of the respondents was between ₦20,000 and ₦60,000 per month. Farming was the primary source of income for 47% of the respondents which is not surprising because the respondents are sampled from a sampling frame of smallholder farmers.

Table 6.1: Summary of socio-economic characteristics of respondents

	Category	Number of respondents	% of respondents
Age of respondents	0-20	2	0.32%
	21-30	68	10.97%
	31-40	248	40.00%
	41-50	172	27.74%
	51-60	87	14.03%
	61-70	39	6.29%
	71-80	4	0.65%

	Total	***620***	***100.00%***
Sex of respondent	Male	317	51.13%
	Female	303	48.87%
	Total	***620***	***100.00%***
Household size	Less than 4	98	15.81%
	5 or 6	288	46.45%
	7 or 8	190	30.65%
	9 or 10	34	5.48%
	11 or 12	5	0.81%
	Greater than 12	5	0.81%
	Total	***620***	***100.00%***
Average Monthly income	Less than ₦20,000	55	8.87%
	₦20,001-₦40,000	340	54.84%
	₦40,001-₦60,000	137	22.10%
	₦60,000-₦80,000	56	9.03%
	₦80,000-₦100,000	27	4.35%
	Above ₦100000	5	0.81%
	Total	***620***	***100.00%***
Primary Source of income	farming	292	47.10%
	Trading	122	19.68%
	Agro-marketing and sales	97	15.65%
	Public/civil servant	59	9.52%
	Others	50	8.06%
	Total	***620***	***100.00%***

6.1.1.2 Ownership and use of means of transportation

On ownership of means of transportation, respondents were asked to state the number of means of transportation they own. The options were bicycle, motorcycle, tricycle (*keke*), mini-bus/bus, and saloon car. The result is presented in Table 6.2. We may observe from Table 6.2 (column a) that motorcycle is the means of transportation most owned by respondents which is in line with the findings of National Population Commission (2019).

Table 6.2: Number of respondents who own different means of transport

Means of transportation	(a) No. of respondents who indicated that they owned each means of transportation *.	(b) Number and % of respondents who selected means of transportation as the most used.	(c) Number of respondents who own a means of transportation and selected that means of transportation as most used.	(d) No. of respondents who do not own any means of transportation and selected means of transportation as most used.
Bicycle	109	69 (11.1%)	61	8
Motorcycle	290	388 (62.6%)	253	131
Tricycle (*keke*)	47	101 (16.3%)	9	72
Minibus/Bus	31	48 (7.7%)	20	24
Saloon car	27	14 (2.3%)	13	1
Total		**620 (100%)**		**236**

N/B: Some people own more than one means of transportation

The next question was to know the means of transportation most used by the respondents. We observe from Table 6.2 (column b) that the means of transportation used most often is motorcycle, followed by tricycle. The observation that motorcycle is the means of transportation mostly used by people is a reflection of the rapid increase in reliance on motorcycles in most rural areas in sub-Saharan Africa as a market-driven response to the inefficiencies in the transport systems, especially the non-availability of quality all-weather roads and public transportation. The fact that motorcycle can navigate bad roads, coupled with the availability of relatively cheap and fuel-efficient Indian and Chinese-made motorcycles, makes it an appealing alternative for meeting the transportation needs of people (Jenkins *et al*., 2020). This finding agrees with previous studies in several other countries in sub-Saharan Africa (Jenkins *et al*., 2020; Ehebrecht *et al*., 2018; Porter, 2014; Mustapha *et al*., 2017; Bishop *et al*., 2018). Next, we sought to understand whether the preference for any means of transportation is due to ownership of that means of transportation. In other words, do respondents who use motorcycles most often do so because they own a motorcycle? This information is also included in Table 6.2 (column c). The result shows that a large number of people who selected bicycle, motorcycle, and

saloon cars as their most used means of transportation actually do own that means of transportation respectively. For example, out of the 14 persons that selected saloon car as their most used means of transportation, 13 actually own a saloon car. Interestingly, 27 respondents had indicated that they own at least one saloon car. This means that some respondents own saloon cars in addition to another means of transportation but they use other means of transportation more often than the saloon car. This may also be a consequence of poor road quality. Tricycle is a major exception because out of the 101 respondents who selected tricycle as their most used means of transportation, only 9 actually own a tricycle. This suggests that tricycle is preferred by a sizeable number of people whether they own it or not. We move on to getting insights on the means of transportation most used by people who do not own any means of transportation. This result is also presented in Table 6.2 (column d). We observe that motorcycles and tricycles are still the most used means of transportation for respondents in this category.

Furthermore, we observe that some respondents own more than one means of transportation while some did not own any. Specifically, 236 (38.06%) of respondents did not own any means of transportation; 286 (46.13%) owned only one; 82 (13.23%) owned two; 11 (1.77%) owned three; and 5 (0.81%) owned four or more. For some respondents that owned more than one means of transportation, the vehicle types owned included the different means of transportation.

While motorcycles provide an important means of mobility for the respondents (and indeed rural dwellers in general), studies have shown that the high reliance on motorcycles by rural dwellers also has negative consequences. For example, Jones *et al*. (2016) reported that motorcycles had the highest risks of danger among other means of transportation used in rural areas. This is mainly because motorcycles lack sufficient balance because they have two wheels as well as the poor safety practices of the riders who are often young males (Oginni *et al*., 2007; Olumide & Owoaje, 2015). Motorcycles contribute significantly to the number of road traffic accidents in Nigeria (Oluwadiya *et al*., 2009), and these accidents result in injuries, traumas, or permanent disability

(Oluwadiya *et al*., 2009; Nwadiaro *et al*., 2011) with attendant economic costs. Tricycles (auto-rickshaws or *keke*) is the second most used means of transportation. Incidentally, reports of road crashes with tricycles are very few.

6.1.1.3 Rationale for preferring the most used means of transportation

We now examine the rationale for using the different means of transportation. For the rationale, the options provided were: "it is affordable", "it is safe", "it is comfortable", "it is fast/reduces travel time", "it is readily available", and "it is suitable for the type of road". Respondents were allowed to select more than one option. The results are presented in Table 6.3.

Table 6.3: Frequency and rationale for using different means of transportation

Means of transportation	Number of respondents who selected means of transportation as the most used.	Rationale for using different means of transportation (Number who selected the option, %)					
		It is affordable	It is safe	It is comfortable	It is fast/reduces travel time	It is readily available	It is suitable for the type of road
Bicycle	61	33 (54.1%)	60 (98.36%)	42 (68.85%)	14 (22.95%)	55 (90.16%)	42 (68.85%)
Motorcycle	388	159 (40.98%)	362 (93.3%)	324 (83.51%)	304 (78.35%)	329 (84.79%)	277 (71.39%)
Tricycle	101	21 (20.79%)	101 (100%)	97 (96.04%)	93 (92.08%)	91 (90.1%)	81 (80.2%)
Mini-bus/Bus	48	18 (37.5%)	47 (97.92%)	46 (95.83%)	46 (95.83%)	45 (93.75%)	44 (91.67%)
Saloon Car	14	5 (35.71%)	14 (100%)	14 (100%)	14 (100%)	10 (71.43%)	8 (57.14%)

We may observe from Table 6.3 that out of the 61 respondents who selected bicycle as their most preferred means of transportation, 60 (98.36%) preferred it because they considered it safe while 55 (90.16%) preferred it because it is readily available. Also, out of the 388 respondents who selected motorcycle as their most preferred means of transportation, 362 (93.3%) preferred it because they considered it safe while 329 (84.79%) preferred it because it is readily available. Similarly, all the respondents who

selected saloon car as their most preferred means of transportation did so because they considered saloon car to be safe, comfortable and fast.

6.1.1.4 Travel days and cost of trips

Our result also shows that almost all the respondents travel more on weekdays than weekends and also travel most to work or farm. Further, respondents spend between ₦100 (US$0.26) and ₦500 (US$1.32) per trip depending on: distance, destination, the quality of the road, whether or not they have luggage. While the expenditure on transportation looks small if compared internationally, it actually constitutes a substantial proportion of income given that the minimum wage is ₦30,000.00 (US$79.05) per month which amounts to ₦1000 (US$2.64) per day.

6.1.2 Logistic Regression Result

The means of transportation most used by the respondent is used as the dependent variable. The options are: bicycle, motorcycle, tricycle (*keke*), mini-bus/bus, and saloon car. We use motorcycle as the reference category because it is the modal category. The socioeconomic characteristics of the respondents included as explanatory variables are: age (numeric), sex (dummy), income (ordinal) and household size (numeric). We include a dummy variable to show whether or not the means of transportation most used by respondent is owned by the respondent. The rationale for preferring to use a means of transportation may be viewed as a respondent's perception of the attributes of the means of transportation. The attributes were: "it is safe", "Fare/Cost (it is affordable)", "It is comfortable", "It is readily available", "It is suitable for the type of road available in the area", "It is fast and reduces the travel time". We include additional 30 dummy variables to represent the rationale for using the different means of transportation (i.e. six attributes X five means of transportation). The names of the attribute are appended to the means of transportation for ease of reference. The model is estimated using SPSS V25. The result is presented in Table 6.4 and shows only explanatory variables that are significant. We

also exclude variables where "floating point overflow" occurred while computing some statistic because the values of such statistics were set to blank.

Table 6.4: Result of multinomial logistics regression[28]

Parameter Estimates

Which_means_of_trans_do_you_use_most_often?[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
bicycle	Ownership	1.271	0.544	5.459	1	0.019	3.563	1.227	10.343
	Bicycle_comfortable	1.515	0.609	6.190	1	0.013	4.551	1.379	15.016
	Bicycle_readily_available	1.919	0.628	9.347	1	0.002	6.811	1.991	23.301
	Bicycle_roadtype	2.496	0.997	6.274	1	0.012	12.136	1.721	85.576
	Motorcycle_readily_available	-1.671	0.709	5.560	1	0.018	0.188	0.047	0.754
mini_bus	bus_affordable	4.377	2.064	4.496	1	0.034	79.623	1.392	4553.027
	bus_roadtype	3.408	0.775	19.321	1	0.000	30.219	6.610	138.139
saloon_car	Income	1.547	0.522	8.772	1	0.003	4.698	1.688	13.077
	car_travel_time	2.146	0.939	5.225	1	0.022	8.554	1.358	53.884
	car_readily_available	4.186	1.560	7.201	1	0.007	65.739	3.091	1397.961
tricycle__keke	Ownership	-1.012	0.507	3.991	1	0.046	0.363	0.135	0.981
	tricycle_safe	1.428	0.718	3.956	1	0.047	4.169	1.021	17.025
	tricycle_travel_time	1.184	0.470	6.339	1	0.012	3.267	1.300	8.213
	tricycle_readily_available	1.203	0.484	6.184	1	0.013	3.331	1.290	8.600
	tricycle_roadtype	1.891	0.551	11.786	1	0.001	6.627	2.251	19.510

[a.] The reference category is: motorcycle.

From our result, the coefficient of *Ownership* under bicycle shows that smallholder farmers in the sampling frame who own bicycles are more likely to use them than motorcycles. Also, smallholder farmers who perceive bicycles as comfortable, readily available, and suitable for the type of road respectively are more likely to use bicycles than motorcycles. The negative coefficient of *Motorcycle_readily_available* under bicycle shows that smallholder farmers in the sampling frame who consider motorcycles as being readily available are less likely to use bicycles than motorcycles. For the

[28] Running the model threw up a warning: "Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged. The NOMREG procedure continues despite the above warning(s). Subsequent results shown are based on the last iteration. Validity of the model fit is uncertain". Also, floating point overflow occurred while computing some statistic and the values of such statistics were set to system missing

coefficients of variables under mini-bus, only two explanatory variables (*bus_affordable* and *bus_roadtype*) were significant. The result shows that smallholder farmers in the sampling frame who consider mini-bus/bus as affordable and suitable for the type of road they use respectively are more likely to use mini-buses/buses than motorcycles. For saloon car, *Income*, *car_travel_time*, and *car_readily_available* are significant. Finally, for tricycle relative to motorcycle, the negative coefficient of *Ownership* suggests that smallholder farmers who own tricycles are less likely to use tricycles more often than motorcycles. Also, smallholder farmers are more likely to use tricycles than motorcycles if they consider tricycles as being safe, reduces travel time, readily available, and appropriate for the roads in their areas.

With the exception of the coefficient of *Ownership* under tricycles, every other coefficient presented in Table 7 seems intuitive. For example, it can be expected that smallholder farmers will be more likely to use saloon cars rather than motorcycles if they have higher income or if they perceive that saloon cars will reduce their travel times and are readily available. On the other hand, the negative coefficient of *Ownership* when comparing tricycles with motorcycles seems to be counter-intuitive. This is because it is expected that a smallholder farmer who owns a tricycle will be more likely to use the tricycle than motorcycle. Furthermore, our result shows that almost all socio-economic variables included in the model (age, sex, household size) do not contribute significantly to the preference of smallholder farmers for different means of transportation. The only socio-economic variable that contributes significantly to the preference of a means of transportation is income which contributes to the preference of smallholder farmers for saloon cars.

6.2 Prioritization of Rural Roads using Multi-Attribute Utility Theory

6.2.1 Base-case

The result of the base case scenario is presented in Figure 6.1. Based on the utility scores, the first road that should be prioritized has the following within its 1000m buffer radius: 2 agro-processing facilities, 16 markets, 4 health facilities, 15 primary school, 4 secondary schools, and 17 polling units. The population within 1000m buffer radius of this road is 41866 and the cost of upgrading this road is estimated at NGN3,557.4million. In contrast, the road that ranked last has the following: zero agro-processing facility, one market, zero health facility, two primary schools, zero secondary school, and three polling unit. The estimated cost of upgrading this road is NGN1,145million and the population within 1000m buffer area of this road is 5017. The roads within these extremes perform better on some criteria on worse on others. The fact that upgrading the road with the highest utility score will have impact on different economic and social variables also re-iterates the role of improving rural road infrastructure on achieving the sustainable development goals (SDGs). We present in Table 6.5 the performance scores of the roads that have the top-five utility scores (the table has been transposed for ease of presentation).

Table 6.5: Performance scores of the roads with the top-five utility scores in the base-case scenario

Road	Rural Road 017	Rural Road 046	Rural Road 069	Rural Road 075	Rural Road 021
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	3,557.38	6,069.80	2,735.48	2,555.81	2,305.97
Number of agro-processing facilities	2	0	4	17	1
Number of markets	16	8	7	7	14
Number of health facilities	4	5	3	3	3
Number of primary schools	15	14	12	9	7

Number of secondary schools	4	5	3	4	2
Population	41866	47899	42804	30249	37225
Number of polling units	17	23	14	15	26
Utility Score	0.7146	0.7068	0.7005	0.6844	0.6794
Rank	1	2	3	4	5

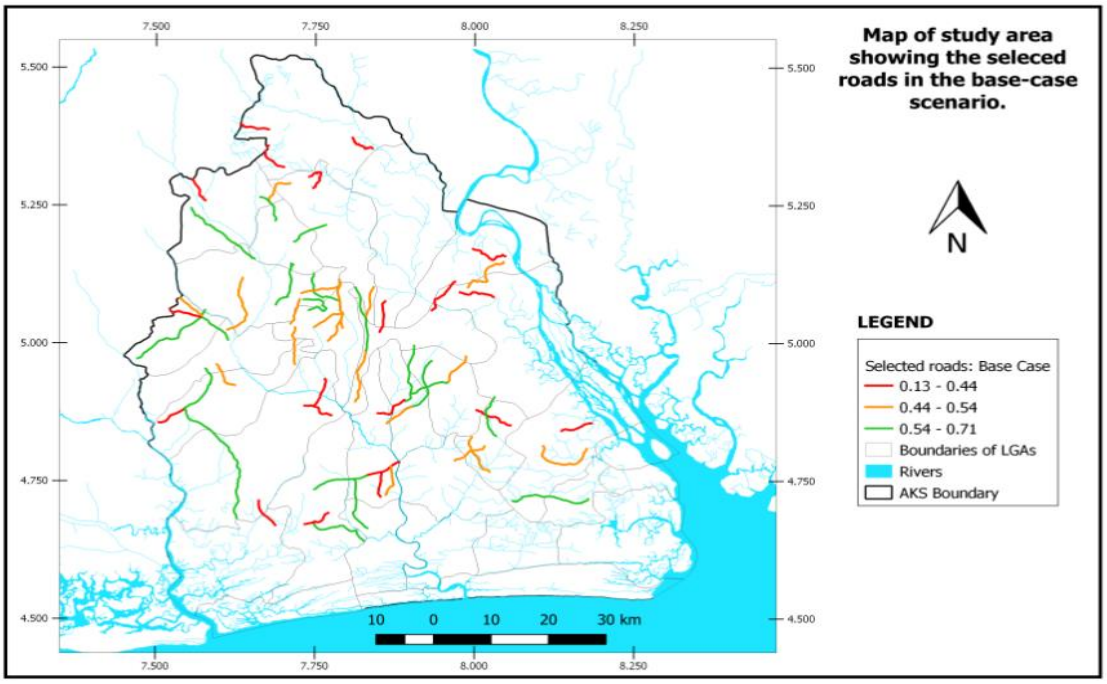


Figure 6.1: Map showing roads that should be prioritized (i.e. those in green cooler) based on assumptions in the base-case scenario (i.e. those in green color)

6.2.2 Alternative Scenarios

6.2.2.1 Political

Based on the utility scores, the first road that should be prioritized in the scenario has the following within its 1000m buffer radius: 1 agro-processing facilities, 7 markets, 2 health facilities, 7 primary school, 1 secondary schools, and 27 polling units. The population within 1000m buffer radius of this road is 25939 and the cost of upgrading this road is estimated at NGN2,515.11 million. In contrast, the road that ranked last has the following: zero agro-processing facility, one market, zero health facility, two primary schools, zero secondary school, and three polling unit. The estimated cost of upgrading this road is

NGN1,145million and the population within 1000m buffer area of this road is 5017. The roads within these extremes perform better on some criteria on worse on others. We present in Table 6.6 the performance scores of the roads that have the top-five utility scores for the political scenario (the table has been transposed for ease of presentation). The summary of the political scenario is presented in Figure 6.4

Table 6.6: Performance scores of the roads with the top-five utility scores in the political scenario

Road	Rural Road 083	Rural Road 021	Rural Road 046	Rural Road 033	Rural Road 017
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	2,515.11	2,305.97	6,069.80	2,343.39	3,557.38
Number of agro-processing facilities	1	1	0	0	2
Number of markets	7	14	8	6	16
Number of health facilities	2	3	5	3	4
Number of primary schools	7	7	14	10	15
Number of secondary schools	1	2	5	8	4
Population	25939	37225	47899	24642	41866
Number of polling units	27	26	23	23	17
Utility Score	0.735	0.731	0.560	0.556	0.519
Rank	1	2	3	4	5

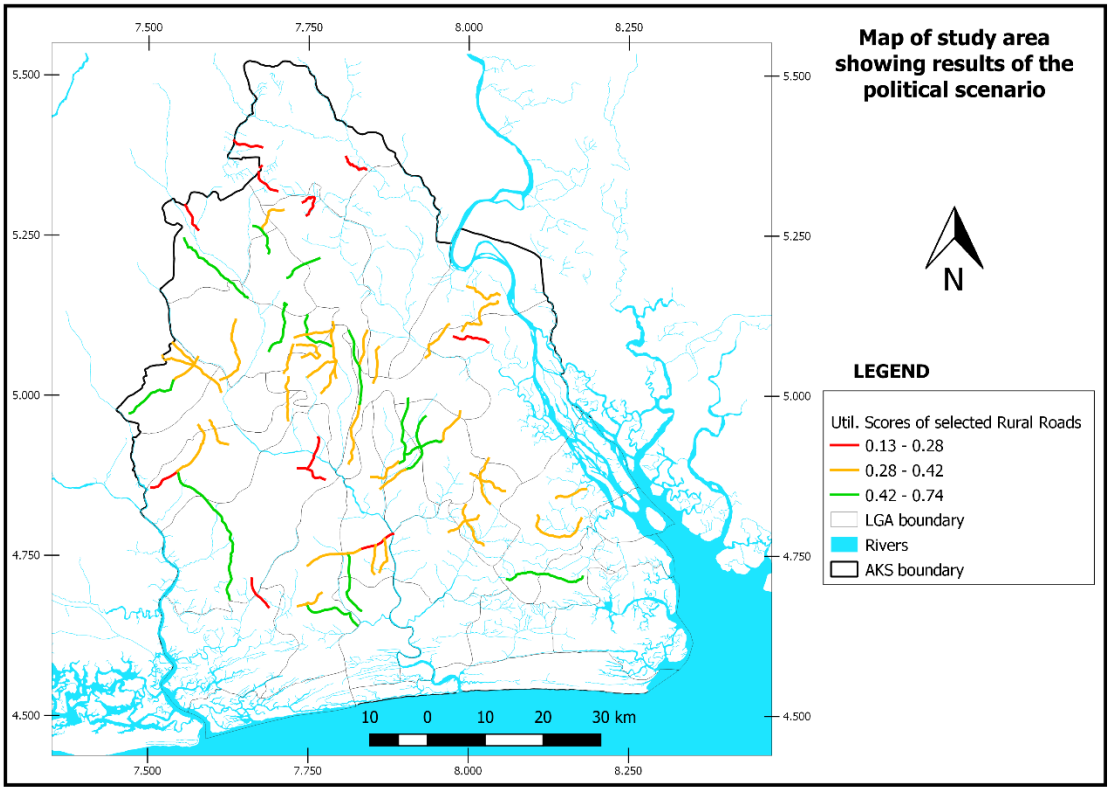


Figure 6.2: Map showing roads that should be prioritized based on assumptions in the political scenario (i.e. those in green color)

6.2.2.2 Social

Based on the utility scores, the first road that should be prioritized in the scenario has the following within its 1000m buffer radius: 2 agro-processing facilities, 16 markets, 4 health facilities, 15 primary school, 4 secondary schools, and 17 polling units. The population within 1000m buffer radius of this road is 41866 and the cost of upgrading this road is estimated at NGN 3,557.38 million. In contrast, the road that ranked last has the following: zero agro-processing facility, one market, zero health facility, two primary schools, zero secondary school, and three polling unit. The estimated cost of upgrading this road is NGN1,145million and the population within 1000m buffer area of this road is 5017. The roads within these extremes perform better on some criteria on worse on others. We present in Table 6.7 the performance scores of the roads that have the top-five utility scores for the social scenario (the table has been transposed for ease of presentation). The summary of the social scenario is presented in Figure 6.5

Table 6.7: Performance scores of the roads with the top-five utility scores in the social scenario

Road	Rural Road 017	Rural Road 010	Rural Road 075	Rural Road 069	Rural Road 021
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	3,557.38	1,509.18	2,555.81	2,735.48	2,305.97
Number of agro-processing facilities	2	0	17	4	1
Number of markets	16	7	7	7	14
Number of health facilities	4	7	3	3	3
Number of primary schools	15	15	9	12	7
Number of secondary schools	4	12	4	3	2
Population	41866	39005	30249	42804	37225
Number of polling units	17	18	15	14	26
Utility Score	0.7434	0.7434	0.7314	0.7214	0.7045
Rank	1	2	3	4	5

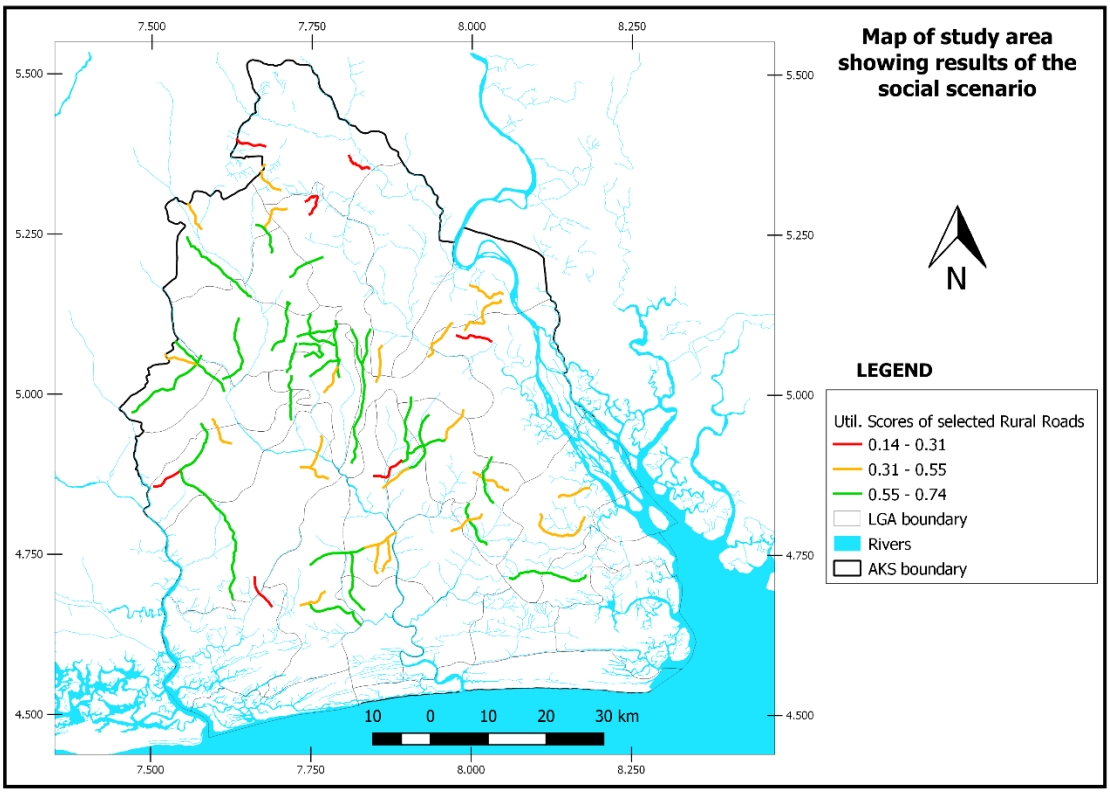


Figure 6.3: Map showing roads that should be prioritized based on assumptions in the social scenario (i.e. those in green color)

6.2.2.3 Demographic

Based on the utility scores, the first road that should be prioritized in the scenario has the following within its 1000m buffer radius: 0 agro-processing facilities, 8 markets, 5 health facilities, 14 primary school, 5 secondary schools, and 23 polling units. The population within 1000m buffer radius of this road is 47899 and the cost of upgrading this road is estimated at NGN6,069.80 million. In contrast, the road that ranked last has the following: zero agro-processing facility, one market, zero health facility, two primary schools, zero secondary school, and three polling unit. The estimated cost of upgrading this road is NGN1,145million and the population within 1000m buffer area of this road is 5017. The roads within these extremes perform better on some criteria on worse on others. We present in Table 6.8 the performance scores of the roads that have the top-five utility scores for the demographic scenario (the table has been transposed for ease of presentation). The summary of the demographic scenario is presented in Figure 6.4

Table 6.8: Performance scores of the roads with the top-five utility scores in the demographic scenario

Road	Rural Road 046	Rural Road 069	Rural Road 017	Rural Road 021	Rural Road 010
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	6,069.80	2,735.48	3,557.38	2,305.97	1,509.18
Number of agro-processing facilities	0	4	2	1	0
Number of markets	8	7	16	14	7
Number of health facilities	5	3	4	3	7
Number of primary schools	14	12	15	7	15
Number of secondary schools	5	3	4	2	12
Population	47899	42804	41866	37225	39005
Number of polling units	23	14	17	26	18
Utility Score	0.7228	0.6553	0.6378	0.5817	0.5620
Rank	1	2	3	4	5

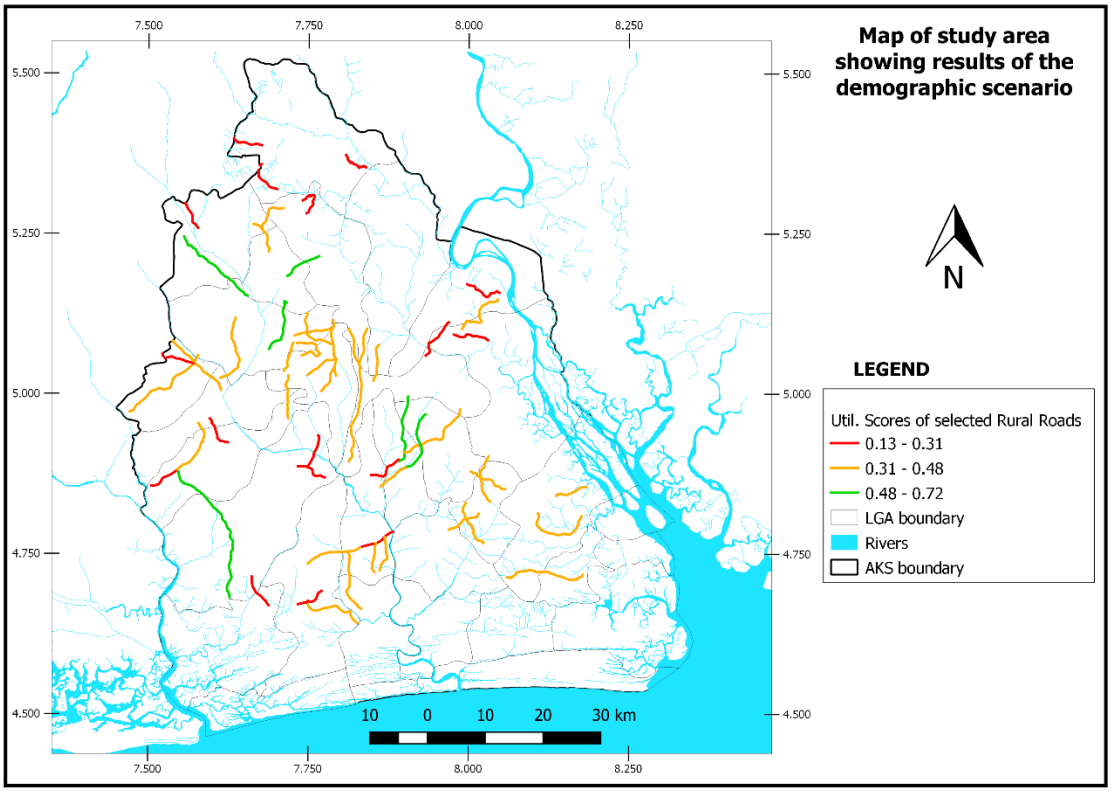


Figure 6.4: Map showing roads that should be prioritized based on assumptions in the demographic scenario (i.e. those in green color)

6.2.2.4 Economic

Based on the utility scores, the first road that should be prioritized in the scenario has the following within its 1000m buffer radius: 17 agro-processing facilities, 7 markets, 3 health facilities, 9 primary school, 4 secondary schools, and 15 polling units. The population within 1000m buffer radius of this road is 30249 and the cost of upgrading this road is estimated at NGN2,555.81 million. In contrast, the road that ranked last has the following: zero agro-processing facility, one market, zero health facility, two primary schools, zero secondary school, and three polling unit. The estimated cost of upgrading this road is NGN1,145million and the population within 1000m buffer area of this road is 5017. The roads within these extremes perform better on some criteria on worse on others. We present in Table 6.9 the performance scores of the roads that have the top-five utility scores for the economic scenario (the table has been transposed for ease of presentation). The summary of the economic scenario is presented in Figure 6.5

Table 6.9: Performance scores of the roads with the top-five utility scores in the economic scenario

Road	Rural Road 075	Rural Road 069	Rural Road 017	Rural Road 097	Rural Road 074
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	2,555.81	2,735.48	3,557.38	3,273.12	1,611.82
Number of agro-processing facilities	17	4	2	9	9
Number of markets	7	7	16	4	5
Number of health facilities	3	3	4	5	2
Number of primary schools	9	12	15	9	7
Number of secondary schools	4	3	4	2	4
Population	30249	42804	41866	27915	20209
Number of polling units	15	14	17	19	12
Utility Score	0.7595	0.7104	0.6912	0.6885	0.6864
Rank	1	2	3	4	5

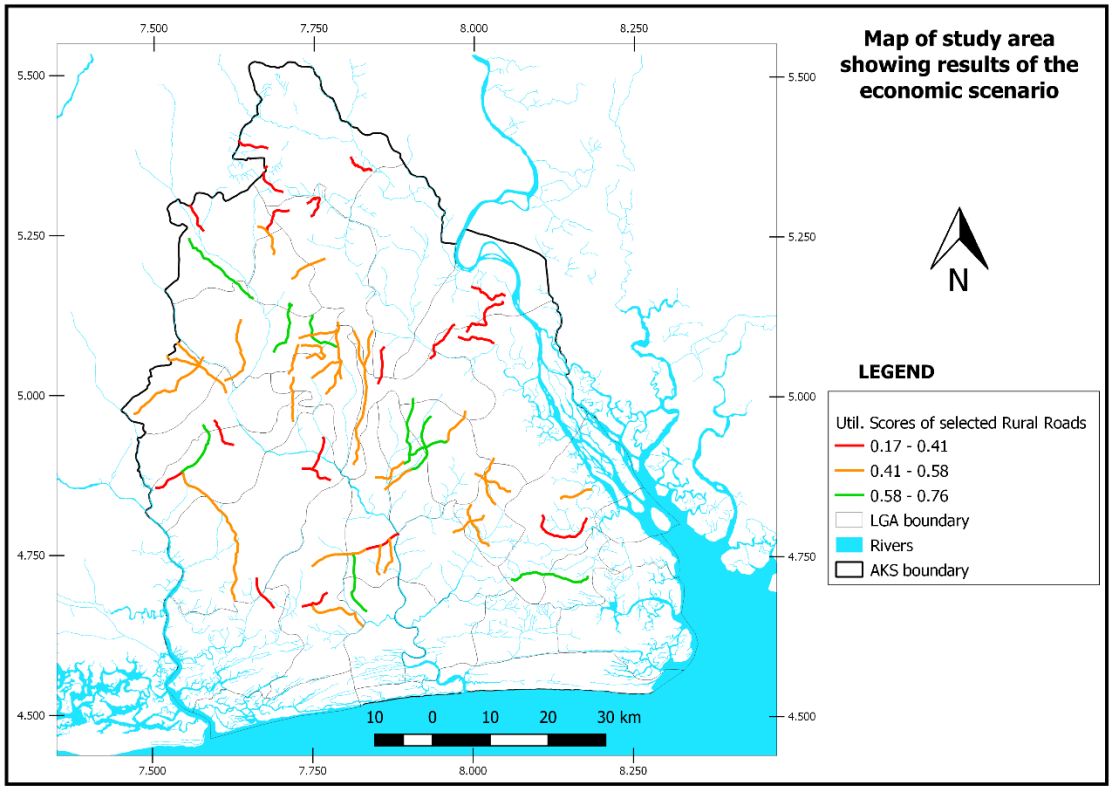


Figure 6.5: Map showing roads that should be prioritized based on assumptions in the economic scenario (i.e. those in green color)

6.2.2.5 Financial

Based on the utility scores, the first road that should be prioritized in the scenario has the following within its 1000m buffer radius: 1 agro-processing facilities, 4 markets, 3 health facilities, 7 primary school, 2 secondary schools, and 26 polling units. The population within 1000m buffer radius of this road is 37225 and the cost of upgrading this road is estimated at NGN2,305.97 million. In contrast, the road that ranked last has the following: zero agro-processing facility, eight market, five health facility, 14 primary schools, five secondary school, and 23 polling unit. The estimated cost of upgrading this road is NGN6,069.80 million and the population within 1000m buffer area of this road is 47899. The roads within these extremes perform better on some criteria on worse on others. We present in Table 6.10 the performance scores of the roads that have the top-five utility scores for the financial scenario (the table has been transposed for ease of presentation). The summary of the financial scenario is presented in Figure 6.6

Table 6.10: Performance scores of the roads with the top-five utility scores in the financial scenario

Road	Rural Road 021	Rural Road 075	Rural Road 069	Rural Road 017	Rural Road 010
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	2,305.97	2,555.81	2,735.48	3,557.38	1,509.18
Number of agro-processing facilities	1	17	4	2	0
Number of markets	4	7	7	16	7
Number of health facilities	3	3	3	4	7
Number of primary schools	7	9	12	15	15
Number of secondary schools	2	4	3	4	12
Population	37225	30249	42804	41866	39005
Number of polling units	26	15	14	17	18
Utility Score	0.7776	0.7699	0.7684	0.7519	0.7423
Rank	1	2	3	4	5

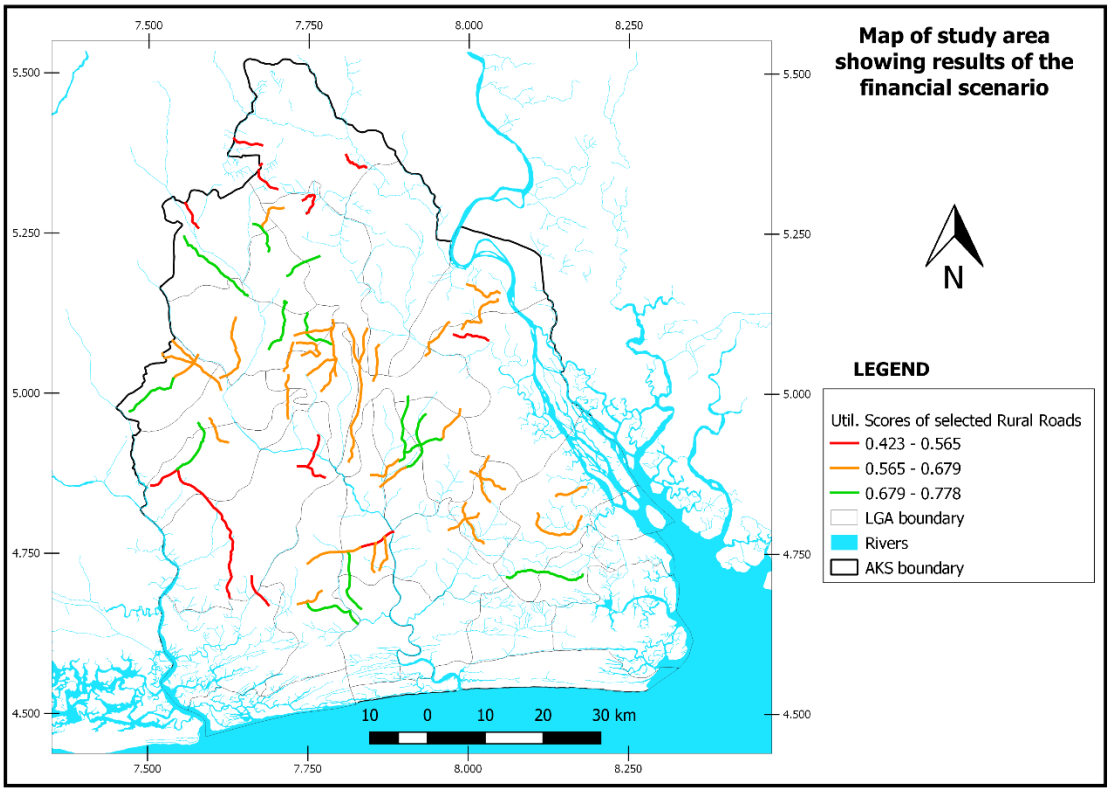


Figure 6.6: Map showing roads that should be prioritized based on assumptions in the financial scenario (i.e. those in green color)

6.2.2.6 Equal weights

Based on the utility scores, the first road that should be prioritized in the scenario has the following within its 1000m buffer radius: 1 agro-processing facilities, 14 markets, 3 health facilities, 7 primary school, 2 secondary schools, and 26 polling units. The population within 1000m buffer radius of this road is 37225 and the cost of upgrading this road is estimated at NGN2,305.97 million. In contrast, the road that ranked last has the following: zero agro-processing facility, one market, zero health facility, two primary schools, zero secondary school, and three polling unit. The estimated cost of upgrading this road is NGN1,145million and the population within 1000m buffer area of this road is 5017. The roads within these extremes perform better on some criteria on worse on others. We present in Table 6.11 the performance scores of the roads that have the top-five utility scores for the "equal weights" scenario (the table has been transposed for ease of presentation). The summary of the "equal weights" scenario s presented in Figure 6.7

Table 6.11: Performance scores of the roads with the top-five utility scores in the "equal weights"scenario

Road	Rural Road 021	Rural Road 069	Rural Road 075	Rural Road 017	Rural Road 097
Cost of upgrade to an asphaltic road with side drains without median (Million NGN)	2,305.97	2,735.48	2,555.81	3,557.38	3,273.12
Number of agro-processing facilities	1	4	17	2	9
Number of markets	14	7	7	16	4
Number of health facilities	3	3	3	4	5
Number of primary schools	7	12	9	15	9
Number of secondary schools	2	3	4	4	2
Population	37225	42804	30249	41866	27915
Number of polling units	26	14	15	17	19
Utility Score	0.6908	0.6840	0.6831	0.6826	0.6380
Rank	1	2	3	4	5

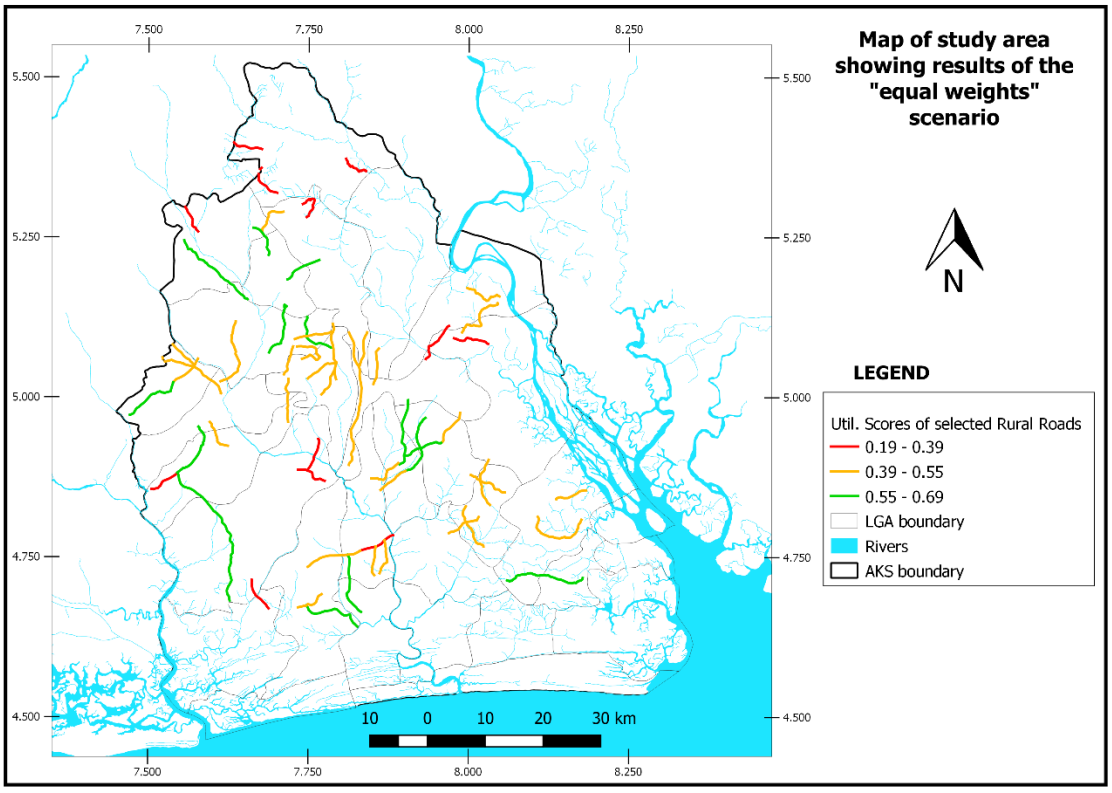


Figure 6.7: Map showing roads that should be prioritized based on assumptions in the equal weight scenario (i.e. those in green color)

6.2.2.7 Summary

We summarize the performance of top ranked road in the different scenarios in Table 6.12. We observe that the roads that rank top in the different criteria differ significantly, with the exception of the "financial" and "equal weights" criteria where the same road ranked highest. Furthermore, with the exception of the "demographic" criteria where the top-ranked road does not have any agro-processing facility, there are social and economic facilities in every other scenario. We may also observe that a particular road (rural road 039) ranks lowest in all the scenarios, with exception of the financial scenario.

Table 6.12: Summary of performance of the top ranked road in the different scenarios

	Cost of upgrade (NGN, million)	Agro-processing facilities (number)	Markets (number)	Health facilities (number)	Schools-Primary (number)	Schools - Secondary (number)	Population (number)	Polling units (number)
Base-case	3557.38	2	16	4	15	4	41866	17
Political	2515.11	1	7	2	7	1	25939	27
Social	3557.38	2	16	4	15	4	41866	17
Demographic	6069.8	0	8	5	14	5	47899	23
Economic	2555.81	17	7	3	9	4	30249	15
Financial	2305.97	1	14	3	7	2	37225	26
Equal weights	2305.97	1	14	3	7	2	37225	26

Further, we compute the average of the utility scores of the selected roads in all criteria (with the exception of the base-case scenario). The rationale for doing this is to identify roads that will yield balanced accessibility, irrespective of scenario. We present the map showing the top-ten roads that should be prioritized based on the average of the utilities scores across the different scenarios in Figure 6.8

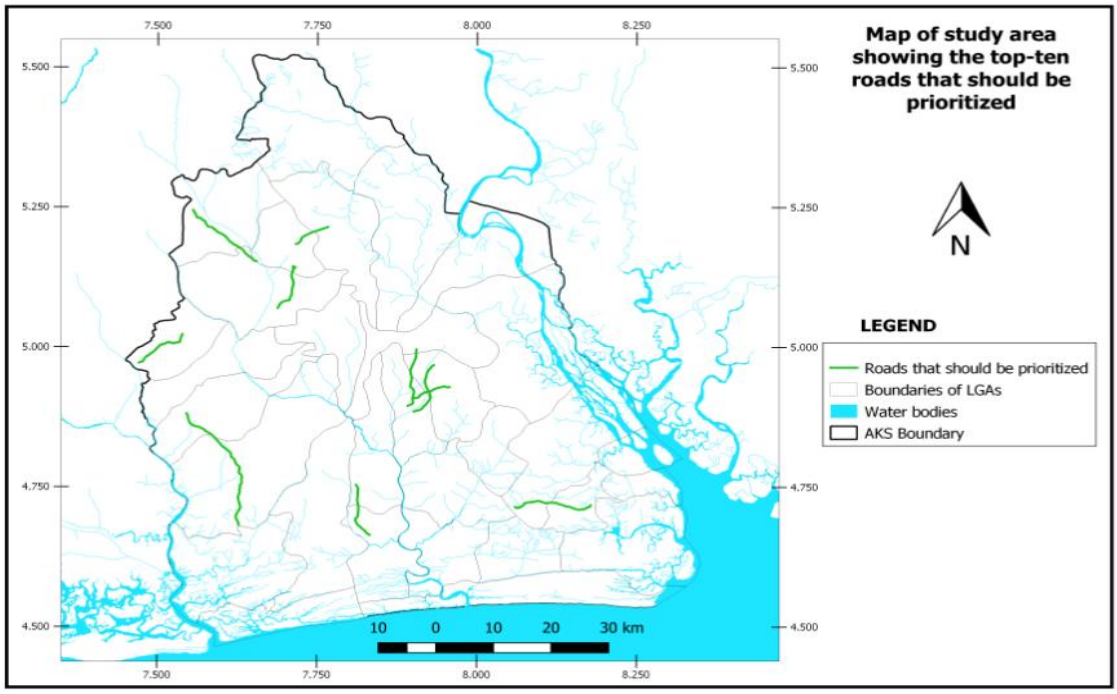


Figure 6.8: Map of the study area showing top ten roads that should be prioritized based on the average utility scores across all criteria

Beyond ranking of the roads, our model also provides answers to other related questions. For example, given a budget of NGN20billion, which road should be upgraded to maximize access to health facilities? From the result of social scenario, 6 roads with cumulative length of 13.8km can be upgraded at a total cost of NGN18.7billion. These six roads have within their 1000m buffer area the following: 24 agro-processing facilities, 59 markets, 25 health facilities, 72 primary schools, 30 secondary schools, 113 polling units, and a population of about 290,000. Our model may also be used to estimate the cost of ensuring that all health facilities or educational facilities in the study area are within 1000m buffer area of an asphaltic road.

6.2.3 Additional Comments

The focus of our methodology is on selecting roads that maximize the potential net economic benefits in terms of promoting accessibility. However, one aspect of development is the prevalence of poverty. Several studies have noted that there is a high correlation between physical isolation and incidence of poverty (Bird, *et al*., 2002; Stifel *et al*., 2003; Bird *et al*., 2010). In other words, locations that are physically isolated tend to have higher incidences of poverty. In this direction, it seems that our model will be unable to address the problems of poverty vis-à-vis physical isolation. This implies that the roads leading to poor isolated communities may not be selected for construction because they will not have high global utility scores. By extension, it also implies that communities living in isolated areas may find it difficult to escape the poverty trap as investment decision will seldom be in their favor.

Furthermore, we note that from the political-economy perspective, investment projects have to be distributed fairly across the different parts of the state. It is possible that this approach identifies rural roads only a certain part of the state. If such result is implemented, it may lead to feelings of marginalization in other parts of the state. One way of avoiding this is to sub-divide the state into other smaller geographic units such as senatorial districts, federal constituencies, or local government areas prior to implementing the MAUT.

6.3 Constraints to rural transport development

6.3.1 Preliminary information

The distribution of the educational levels and years of experience of the respondents are presented in Figure 6.9and Figure 6.10 respectively. We observe from Figure 6.9 that about 85% of respondents had at least a bachelor's degree (or equivalent), while Figure 6.10 shows that 49% of the respondents had more than 12years of experience in the development of rural road infrastructure in the study area.

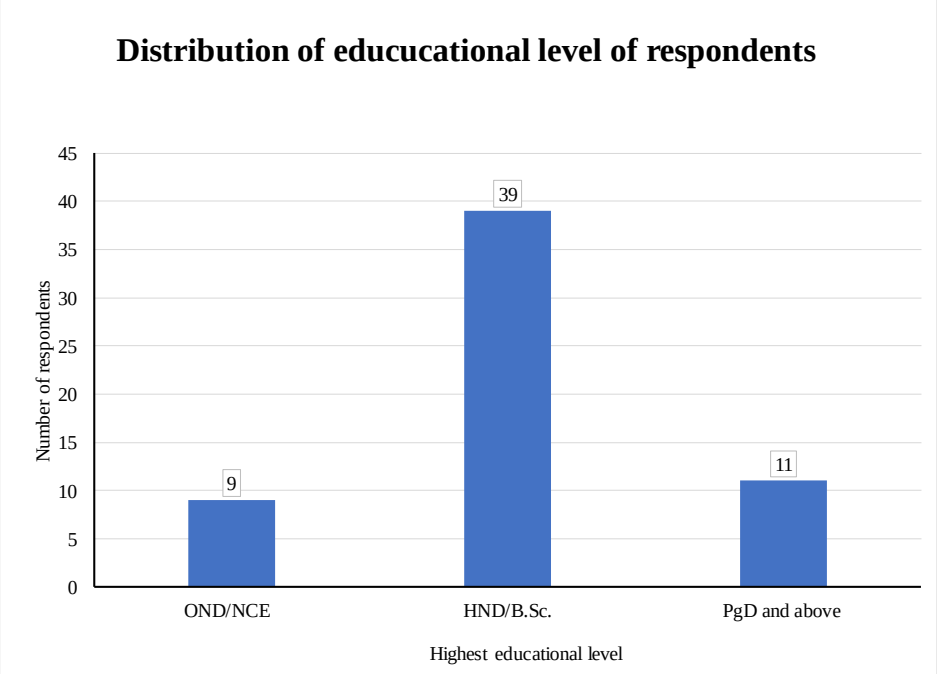


Figure 6.9: Distribution of educational level of respondents

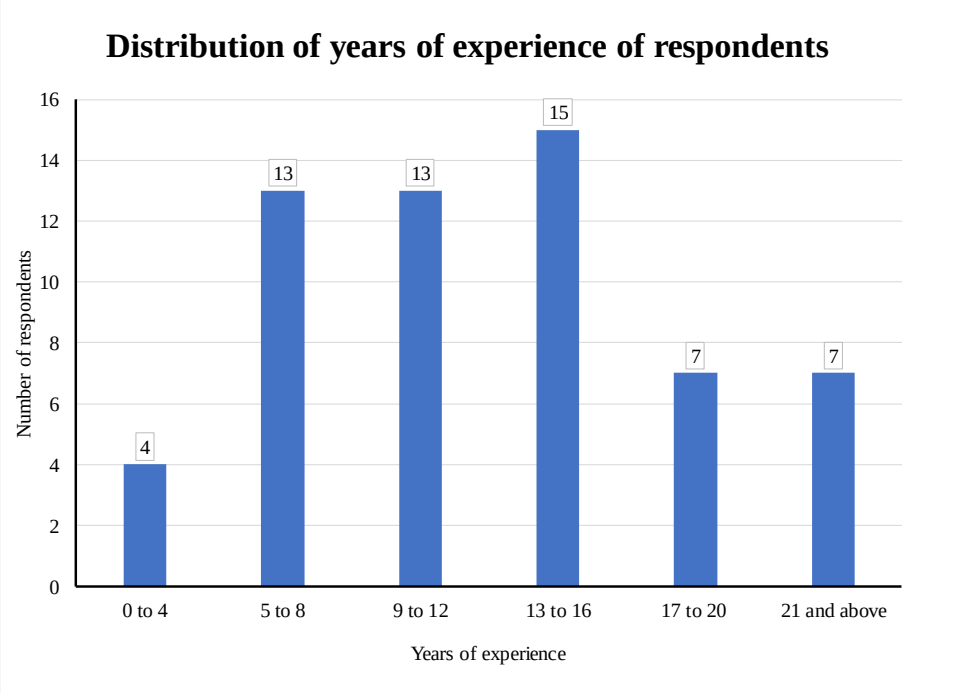


Figure 6.10: Distribution of years of experience of respondents.

6.3.2 Challenges to rural road infrastructure development

6.3.2.1 Institutional challenges

In terms of the challenges to rural road infrastructure development, we recall that a total of twenty-two (22) challenges were included in the questionnaire and these were grouped into six (6) broad categories: institutional, engineering/ technical, natural /environmental, economic, social, and political. For each challenge, respondents were requested to rate the challenges on a 4-point ordinal scale (not a challenge, minor challenge, average challenge, and major challenge). We present details of the responses for the institutional category in Figure 6.11. We observe from Fig xx that a large number of respondents regarded *poor planning for rural roads development* as a major challenge whereas only 1 (1.7%) regarded it as a minor challenge. None of the respondents selected the "not a challenge" option. On the challenge of *non-availability of skilled to supervise and implement rural road construction activities*, 21 of the 59 respondents opined that this is a minor challenge while 11 opined that it is not a challenge. The numbers of persons who selected the other options are also shown in the figure. For the challenge of m*ultiple stakeholders with overlapping responsibilities in rural road construction*, 12 respondents opined that it is not a challenge; 18 opined that it is a minor challenge; 11 opined that it is an average challenge; while the remaining 18 opined that it is a major challenge.

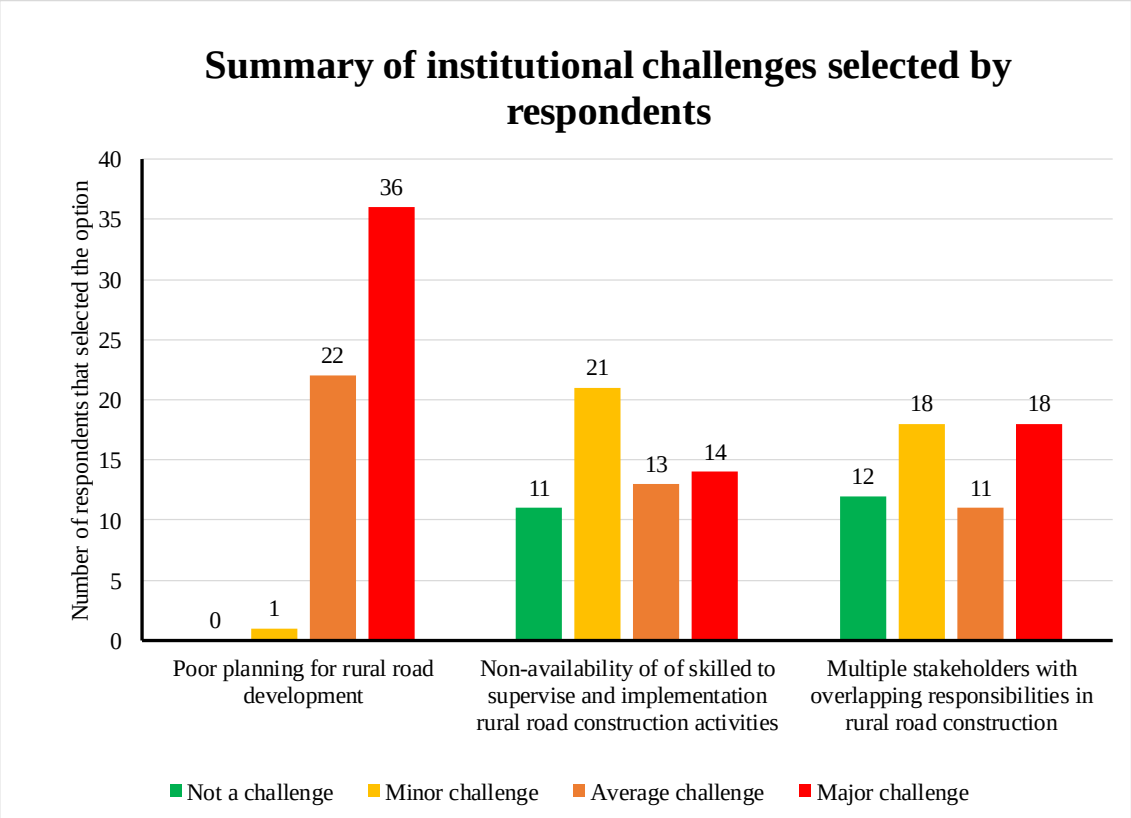


Figure 6.11: Summary of institutional challenges affecting the development of rural road infrastructure in the study area as selected by respondents

6.3.2.2 Engineering and Technical Challenges

Five challenges were identified in the engineering and technical category: non-availability or poor engineering design; use of sub-standard materials for construction; poor supervision; non-availability of suitable construction materials locally; and lack of appropriate equipment. All the respondents opined that *non-availability or poor engineering design* is a challenge, albeit at varying severity. Three respondents noted that it is a minor challenge, 26 noted that it is an average challenge while the remaining 30 noted that it is a major challenge. For the challenge of the *use of sub-standard materials for construction*, 6 respondents opined that it is not a challenge; 12 respondents opined that it is a minor challenge; 11 respondents opined that it is an average challenge; and 30 respondents opined that it is a major challenge. The responses of the respondents on the *poor supervision* were as follows: not a challenge: 0; minor challenge: 12; average challenge: 14; and major challenge: 33. For *non-availability of suitable construction*

materials locally, the responses were as follows: not a challenge: 14; minor challenge: 19; average challenge: 18; and major challenge: 8. For the challenge of *lack of appropriate equipment*, all respondents opined that it is a challenge albeit at varying degrees. The summary of these responses is presented in Figure 6.12.

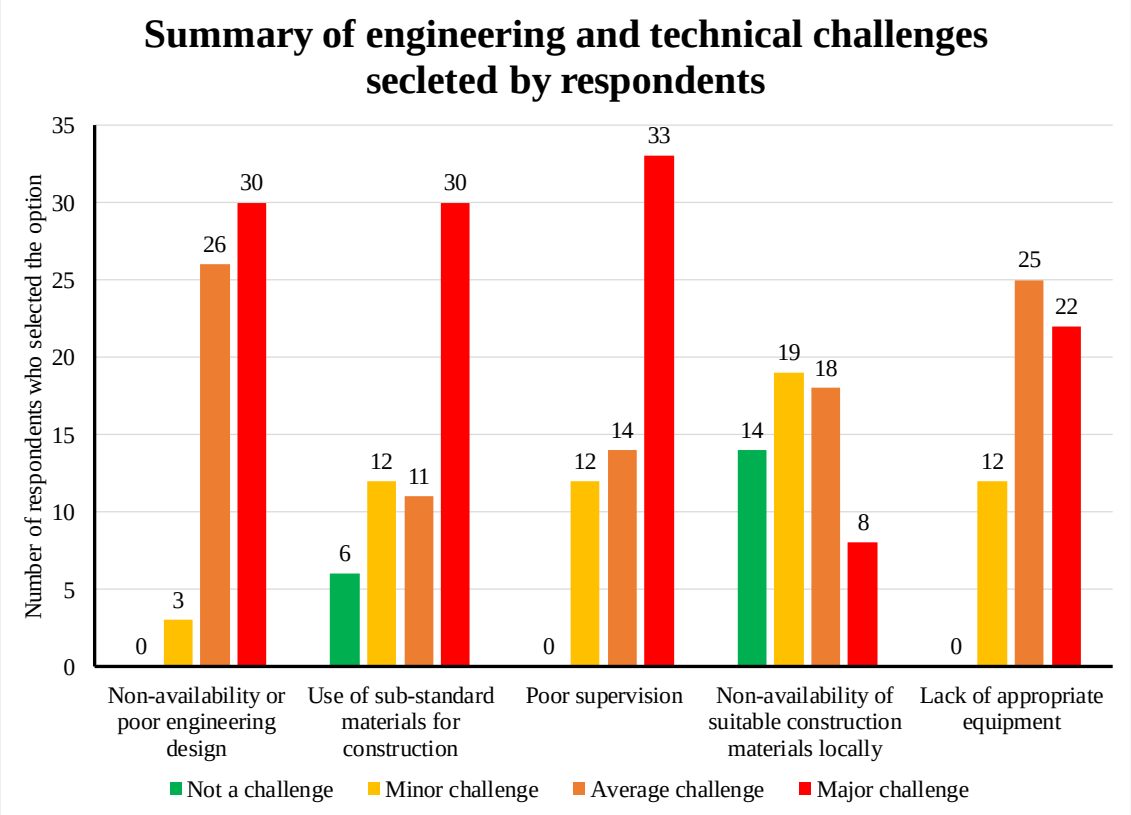


Figure 6.12:: Summary of engineering and technical challenges affecting the development of rural road infrastructure in the study area as selected by respondents

6.3.2.3 Environmental and natural challenges

Five challenges were identified in the environmental and natural category: geotechnical properties of soil in the region which makes construction expensive and difficult; topography of the environment; extended period of the rainy season which makes road construction impossible; high vulnerability of existing roads to erosion; and non-implementation of environmental impact assessment. All the respondents opined that *geotechnical properties of soil in the region which makes construction expensive and difficult* is a challenge, albeit at varying severity. 33 respondents noted that it is a minor challenge, 30 noted that it is an average challenge, while the remaining 7 noted that it is

a major challenge. The responses of the respondents on the *extended period of rainy season which makes road construction impossible* were as follows: not a challenge: 11; minor challenge: 13; average challenge: 27; and major challenge: 8. For *high vulnerability of existing roads to erosion*, the responses were as follows: not a challenge: 10; minor challenge: 9 average challenge: 18; and major challenge: 27. For the challenge of *non-implementation of environmental impact assessment*, all respondents opined that it is a challenge albeit at varying degrees. The summary of these responses is presented in Figure 6.13

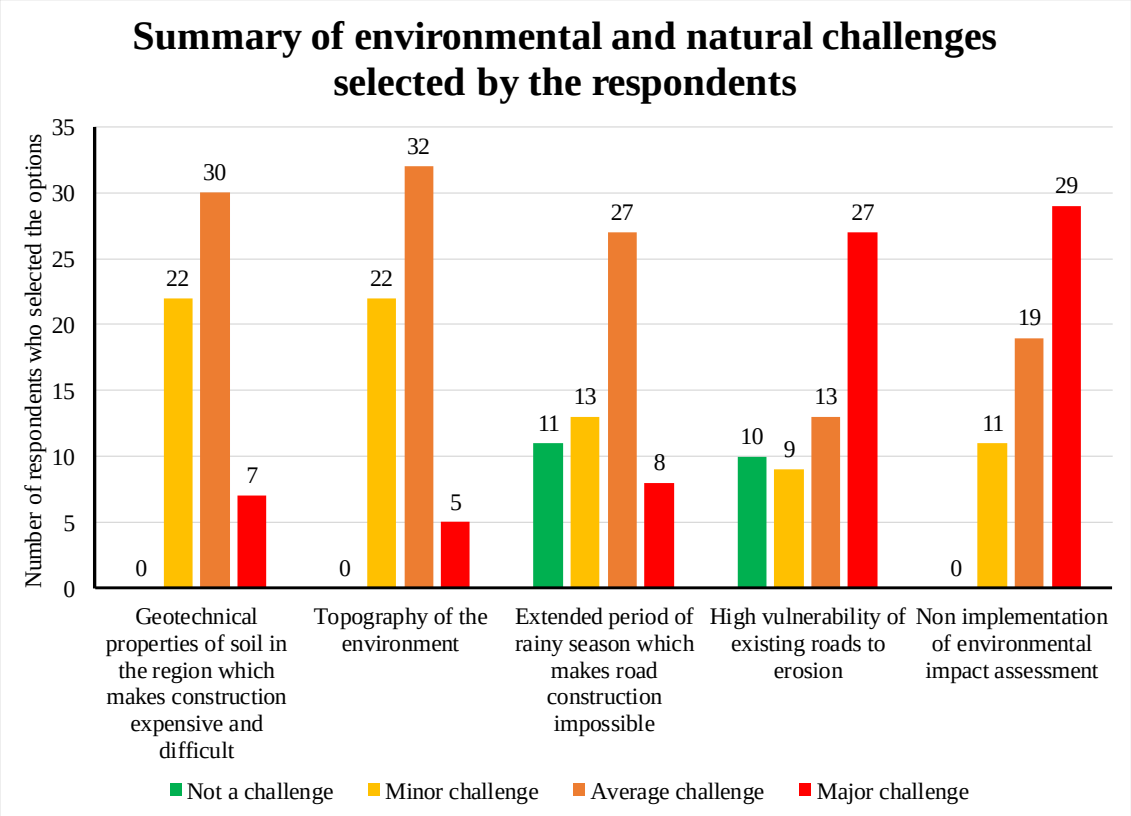


Figure 6.13: Summary of environmental and natural challenges affecting the development of rural road infrastructure in the study area as selected by respondents

6.3.2.4 Economic Challenges

Five challenges were identified in the economic category: non-release of funds to contractors; delay in payments of contractors and consultants; misappropriation and embezzlement of public funds meant for road construction; lack of funds for maintenance

of roads; and frequent price escalation. The distribution of responses in the first three challenges are similar, i.e. all respondents selected either average challenge or major challenge. For the fourth challenge in this category, most respondents also selected either average challenge or major challenge (only 2 respondents selected minor challenge and no respondent and none opined that it was not a challenge). For the last challenge in this category (i.e. *frequent price escalation*), 7 respondents opined that it is not a challenge; 6 opined that it is a minor challenge; 26 respondents opined that is was an average challenge; while the remaining 20 opined that it was a major challenge. The summary of the responses is presented in Figure 6.14.

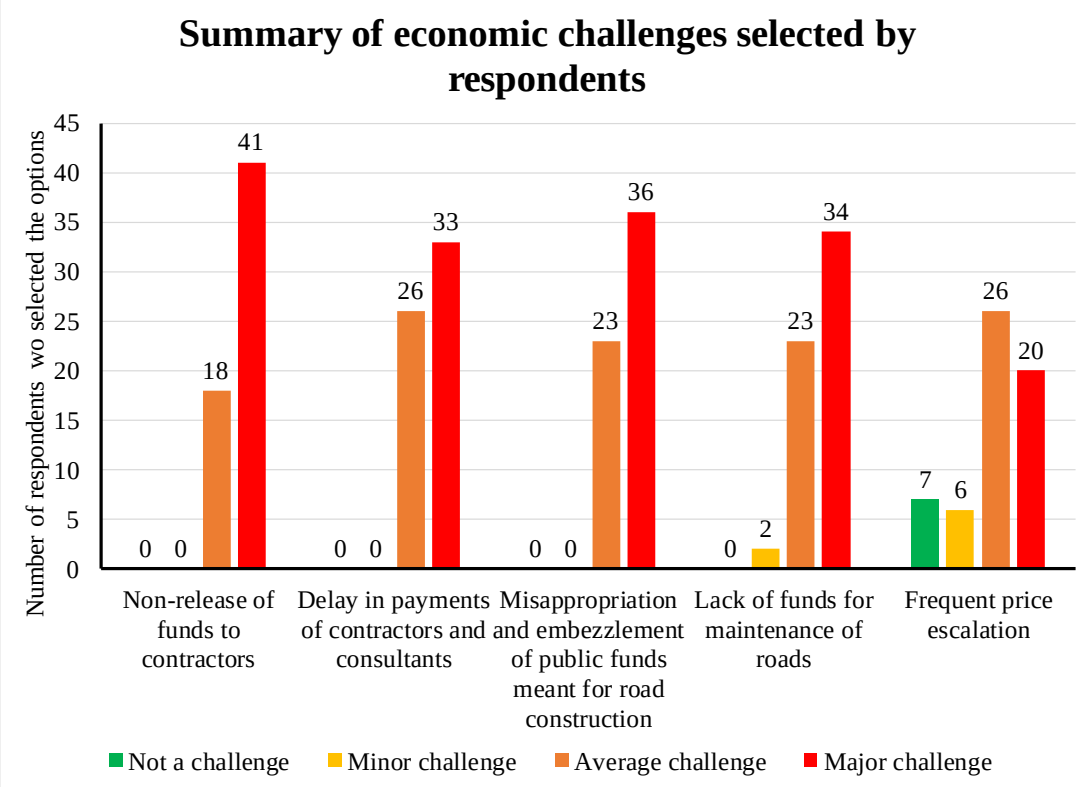


Figure 6.14: Summary of economic challenges affecting the development of rural road infrastructure in the study area as selected by respondents

6.3.2.5 Social Challenges

The challenges identified in the social category are: excessive requirements from communities in the process of roads construction; unfavorable cultural requirements; and

lack of community ownership in the process of construction and maintenance of roads. For *excessive requirements from communities in the process of roads construction*, 12 respondents opined that it is not a challenge; 7 opined that it is a minor challenge; 34 opined that it is an average challenge; while the remaining 6 opined that it is a major challenge. For *unfavorable cultural requirements*, 22 respondents opined that it is not a challenge; 12 opined that it is a minor challenge; 20 opined that it is an average challenge; while the remaining 5 opined that it is a major challenge. For the challenge of *lack of community ownership in the process of construction and maintenance of roads*, only one respondent opined that it is not a challenge, while the remaining noted that it is a challenge but with different levels of severity. The summary of the responses for the social category is presented in Figure 6.15

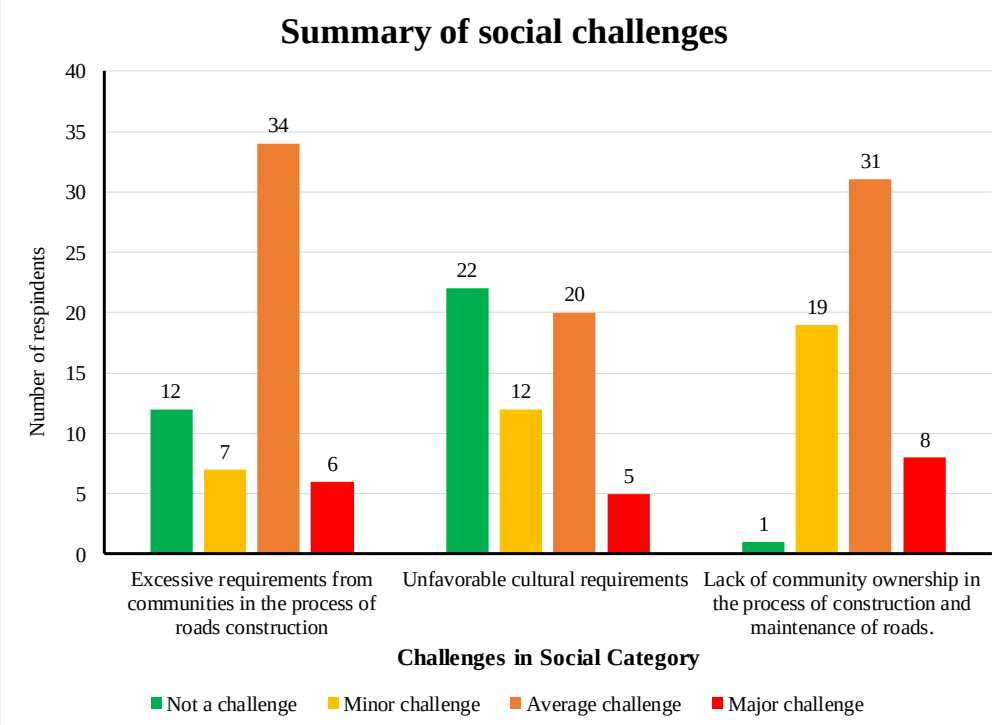


Figure 6.15: Summary of social challenges affecting the development of rural road infrastructure in the study area as selected by respondents

6.3.2.6 Political challenge

There was only one option in the political category which is the *use of rural road projects as political tools and abandoning the roads*. All the respondents noted that this was a challenge. Specifically, 1 respondent opined that it was a minor challenge; 19 opined that it was an average challenge; while the remaining 39 opined that it was a major challenge.

6.3.3 Discussion

The challenges listed above were obtained from previous studies. The responses by the respondents provide very useful insights on the particular set of challenges in the study area. We rank all the challenges using the number of respondents that selected each challenge as a major challenge and present this information in Table 6.13.

Table 6.13: Ranking of all challenges based on number of respondents who selected the challenge as a major challenge

Category	Challenge	Number of respondents who selected it as a major challenge	Percentage (number of respondents = 59)
Economic	Non-release of funds to contractors	41	69.49%
Political	Use of rural road project as political tools and abandoning the roads	39	66.10%
Institutional	Poor planning for rural road development	36	61.02%
Economic	Misappropriation and embezzlement of public funds meant for road construction	36	61.02%
Economic	Lack of funds for maintenance of roads	34	57.63%
Engineering/ technical	Poor supervision	33	55.93%
Economic	Delay in payments of contractors and consultants	33	55.93%
Engineering/ technical	Non-availability or poor engineering design	30	50.85%
Engineering/ technical	Use of sub-standard materials for construction	30	50.85%
Natural /Environmental	Non implementation of environmental impact assessment	29	49.15%
Natural /Environmental	High vulnerability of existing roads to erosion	27	45.76%

Engineering /technical	Lack of appropriate equipment	22	37.29%
Economic	Frequent price escalation	20	33.90%
Institutional	Multiple stakeholders with overlapping responsibilities in rural road construction	18	30.51%
Institutional	Non-availability of of skilled to supervise and implementation rural road construction activities	14	23.73%
Engineering/ technical	Non-availability of suitable construction materials locally	8	13.56%
Natural/ Environmental	Extended period of rainy season which makes road construction impossible	8	13.56%
Social	Lack of community ownership in the process of construction and maintenance of roads.	8	13.56%
Natural/ Environmental	Geotechnical properties of soil in the region which makes construction expensive and difficult	7	11.86%
Social	Excessive requirements from communities in the process of roads construction	6	10.17%
Natural/ Environmental	Topography of the environment	5	8.47%
Social	Unfavorable cultural requirements	5	8.47%

We observe from Table 6.13. that the top-5 major challenges to the development of rural road infrastructure in the study area as noted by our respondents are: non-release of funds to contractors; use of rural road project as political tools and abandoning the roads; poor planning for rural road development; misappropriation and embezzlement of public funds meant for road construction; and lack of funds for maintenance of roads. All of these falls within the economic, political, or institutional categories. Indeed, we point out that it is the political decision makers that determined whether or not funds are approved or released for construction or maintenance of rural roads, or even for the detailed planning for rural road development. This implies that the major impediment to the development of rural road infrastructure is with the political decision makers. Indeed, some the challenges have been highlighted in literature since in 1980s. For example, World Bank

(1988) noted that lack of institutional capacity and funding for maintaining roads constituted the greatest impediment to road transport infrastructure development in developing countries. In spite of the fact that there has been huge budgetary allocation for upgrading of rural roads over the years, as well as donor -funded project targeted at rural road improvement, the percentage of paved rural roads is still low. This seems to suggest that the solution to the challenge is beyond economics. In fact, the solutions seem to be more political than economics, given that most of the economic challenges are subsumed under political factors/actors. Kaiser & Streatfeild (2016) opines that the problem of road maintenance in developing counties goes beyond availability of financial resources and includes public sector capacity and political will. Donor-funded programs, such as the sub-Saharan Africa Transport Project (SSATP), have attempted to reform the public sector capacity to plan, build and maintain rural roads but the results seem to be mixed (World Bank, 2007). This further underscore the role of political will in addressing the constrains to rural road infrastructure development.

CHAPTER SEVEN

7 SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Summary and conclusion

Good quality rural road infrastructure seems to contribute substantially to improvements in several socio-economic indicators in rural areas: increases accessibility to markets, educational and health facilities, and stimulates economic activities. However, about 450 million people in sub-Saharan Africa, or 70% of the rural population have been left without access to good transport infrastructure.

This study answers three broad questions related to rural road transportation in Nigeria: what are the travel choices of rural households in Nigeria in the face of poor rural road infrastructure? Which rural roads should be improved to yield the maximum socio-economic benefits in rural areas? What are the constraints to the development of rural road infrastructure? The study focuses on Akwa Ibom State, Nigeria.

7.1.1 Conclusion for Research Question 1

The objective of this study is to understand the travel choices made by smallholder farmers in the face of poor quality of rural road infrastructure with a view of integrating this knowledge into a broader rural transport policy. The result of this study shows that the means of transportation most owned by smallholder farmers in the sampling frame is motorcycle. Motorcycle is also the most used – even by persons who do not own any means of transportation. This result aligns with findings from several previous studies in different countries in sub-Saharan Africa. The rural transport policy in Nigeria focuses on road infrastructure development. The approach is usually to build all-weather asphalt roads mainly because of the huge political currency that accompanies this. However, the budgetary requirement is usually a major constraint which makes it needful to consider other “low hanging fruits” which may contribute to improving rural transportation and

help rural dwellers meet their transport need in an efficient manner. Given that the motorcycles and tricycles have now dominated the rural transport landscape as an economic response to meeting the transport needs of people, rural transport policy needs to be revised to reflect this reality. The operation of motorcycles and tricycles should be properly mainstreamed into rural transport policy in a manner that is directed at improving rural accessibility. Further, instead of focusing on asphalt roads which seldom have favorable outcome in terms of cost-benefit analysis due to the low traffic in rural areas, gravel roads may be considered. Our result shows that safety is a primary consideration for preferring the means of transportation. Given the propensity of motorcycles to road crashes, it is important to improve safety through consistent public awareness. Since tricycles are less susceptible to road crashes, the use tricycles for rural transportation should be promoted.

This study used a sampling frame which limits the generalizability of the research to cover all smallholder farmers in the study area. In addition, the study was unable to obtain numeric data on some of the variables that influence travel choice such as cost of transportation and travel time. Future studies may be designed to overcome these limitations.

7.1.2 Conclusion for Research Question 2

The selection of rural roads in Nigeria for upgrade is often done by political leaders based sometimes on political considerations, subject to financial availability. This study presents a simple template that can be used to integrate socio-economic considerations in rural road transportation planning such that roads selected for upgrade will unlock the socio-economic potentials of rural areas, promote rural accessibility, while also considering some political goals. We demonstrate how this may be done using one of the states in Nigeria. Particularly, we use geographic information system (GIS) in conjunction with multi-criteria decision analysis (specifically, the multi-attribute utility theory). We have identified 10 roads that should be prioritized out of the 59 rural roads

in the study area that met our inclusion criteria. These identified roads have the highest average utility scores across the different scenarios which imply that they will have the highest net socio-economic benefit if upgraded. It is important that decision-makers adopt a similar approach in selecting rural roads for upgrade.

Other interests of end-users of rural road infrastructure not already captured in the model may be incorporated into the model by including an additional criterion as need arises.

7.1.3 Conclusion for Research Question 3

The top-5 major challenges to the development of rural road infrastructure in the study area as noted by our respondents are: non-release of funds to contractors; use of rural road project as political tools and abandoning the roads; poor planning for rural road development; misappropriation and embezzlement of public funds meant for road construction; and lack of funds for maintenance of roads. All of these falls within the economic, political, or institutional categories. The economic and institutional challenges may also be linked to political factors. This suggests that the solution to the challenge is beyond economics. In fact, the solutions seem to be more political than economic, given that most of the economic challenges are subsumed under political factors/actors.

7.2 Recommendations

(i) **Objective 1:** Motorcycles and tricycles should be mainstreamed into rural road transport policy. Extensive awareness to be created on safety when using motorcycles to reduce the frequency of road crashes.

(ii) **Objective 2:** We consider our methodology to be practical and realistic, especially in developing countries where data on several socio-economic variables that influence rural development are scarce. GIS is used to overcome some of the constraints of data availability. Notable improvements which may be made to the model include the incorporation of data on road quality as well as data on the number of persons using the education and health facilities. These data could not be obtained for all the education and health facilities in

the study area so we had to drop the criteria. Nonetheless, the criteria used are sufficient to provide useful results. The marginal utility functions applied are user-specified. This implies that a different set of specifications for the marginal utility functions may alter the results. This approach may be replicated in other climes if the relevant data are available and with understanding of the local situation which may influence the specification of the marginal utility functions. The approach may further be developed into a decision-support tool for rural road improvement in other states in Nigeria and other developing countries.

(iii) **Objective 3**: The challenges of rural road infrastructure are mainly economic and political. However, the political dimensions seem to dominate. Consequently, political leaders need to be given orientation on how to prioritize investment decision on rural road infrastructure in a manner that maximizes socio-economic benefits.

7.3 Contributions to knowledge

This study answers three broad questions related to rural accessibility: what are the travel patterns of rural households? Which rural roads should be improved to yield the maximum socio-economic benefits in rural areas? What are the constraints to development of rural road infrastructure? The study focuses on Akwa Ibom State, Nigeria.

(i) **Objective 1**: There is a knowledge gap on travel mode choices of rural smallholder farmers in sub-Saharan Africa. This study fills some of the knowledge gap. The study is also unique because it focuses on smallholder farmers because of the contribution of this category of rural dwellers to food security in Nigeria.

(ii) **Objective 2**: This is the first study that has applied Multi-Utility Attribute Theory (MAUT) to the planning and prioritization of rural roads in Nigeria, and specifically in the study area. The specifications of the utility functions of the criteria are also unique to the study and constitute an important contribution to

knowledge. The use of GIS techniques to overcome some of the data constraints is also novel.

(iii) **Objective 3**: By collecting primary on the challenges of rural road infrastructure development in the study area, the study has generated useful insight on location-specific challenges.

7.4 Areas for further research

This study has attempted to fill knowledge gaps in several areas related to rural transportation in Nigeria. However, there are several areas that may be considered for further research to improve on the knowledge stock in the thematic area of this research. We highlight some of these areas for further research below:

(i) **Objective 1**: The travel choice problem in rural areas in the study area is under-researched. The diversity of issues surrounding rural accessibility, rural transport planning, and rural transport services need to be researched extensively. With respect to the specific research question, we note to that study was unable to capture travel times and travel cost of rural households in specific terms because respondents usually do not keep these records. Future studies may be designed to capture the contributions of travel cost and time.

(ii) **Objective 2:** In the Multi-Attribute Utility Theory adopted for the second research question, we provided the specifications for the marginal utility functions of each criterion. Future studies may use alternative specifications for the marginal utility functions of the criteria.

(iii) **Objective 2**: The use of simple additive model in the computation of the global utility in the MAUT does not capture the interaction between the criteria. In reality, it is most likely that places with high population are more likely to have a higher number of social and economic facilities. Future studies may explore the use of the multi-linear or multiplicative models.

(iv) **Objective 3**: In our third research question, we only generated data on the constraints to the development of good quality rural roads in the study area using questionnaires. Future studies may consider supplementing quantitative data with

qualitative data because this will yield more detailed information on the constraints to improving the quality of rural roads.

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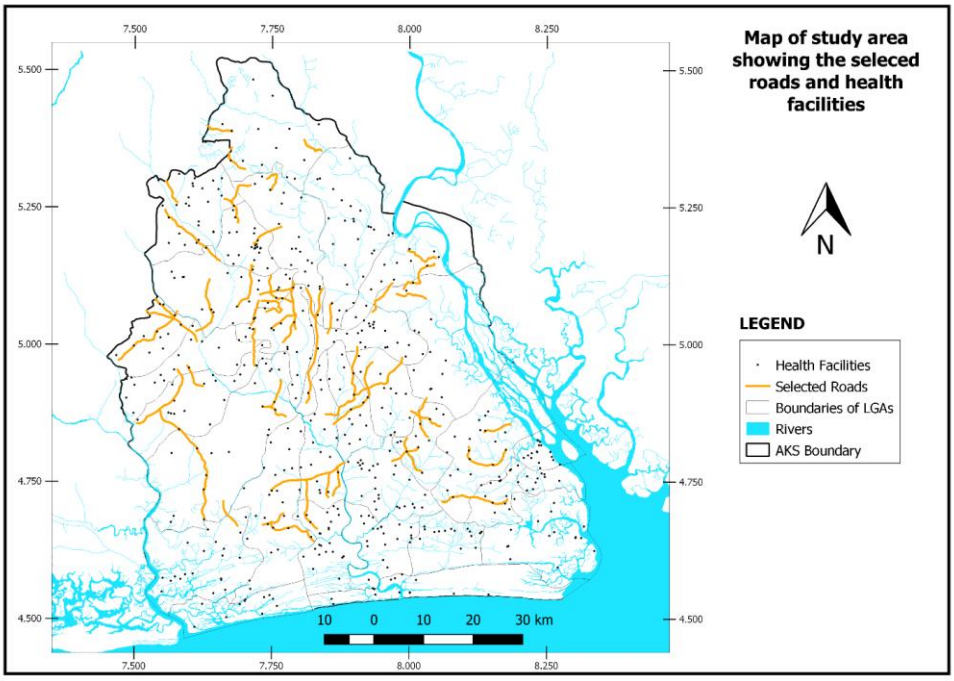
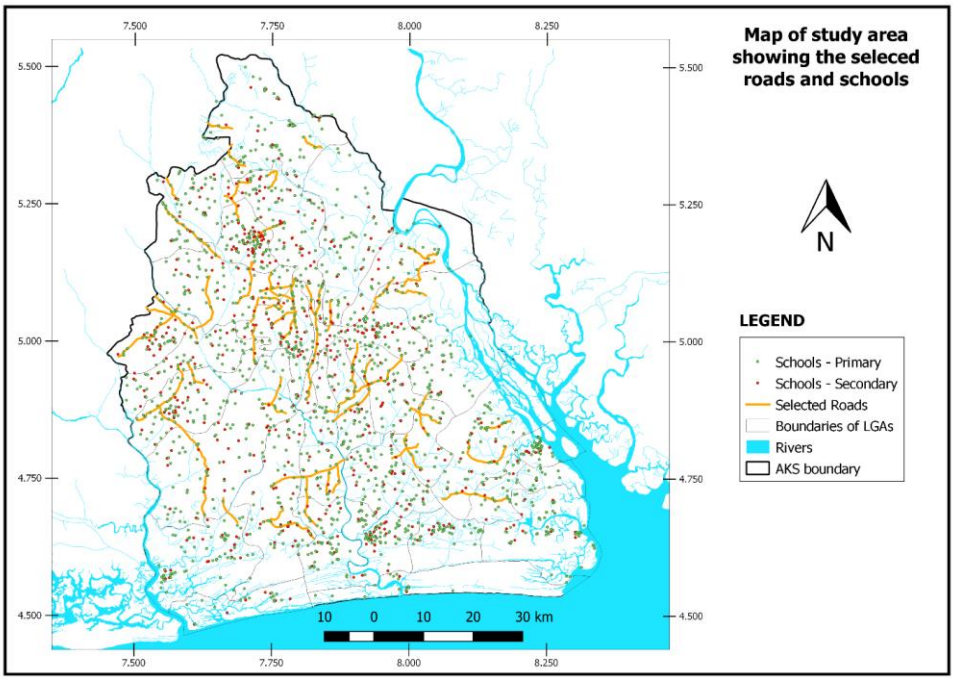
APPENDICES

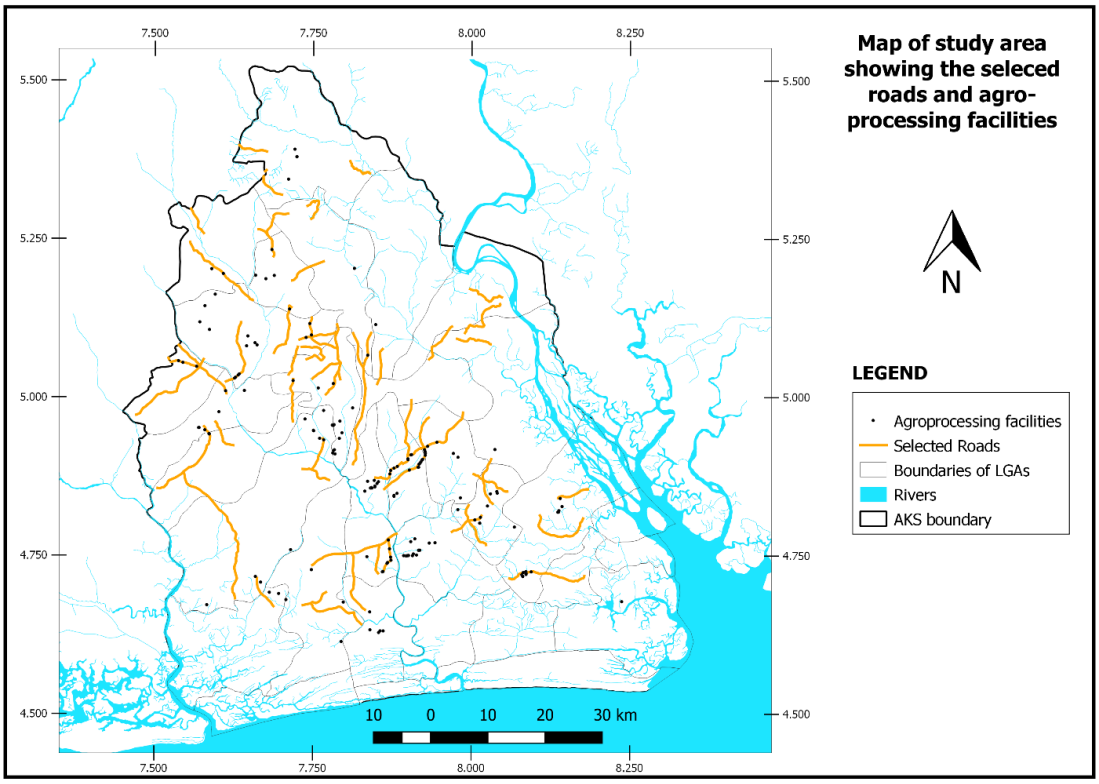
Appendix 1: Maps of study area showing spatial locations of health facilities, educational facilities, etc.



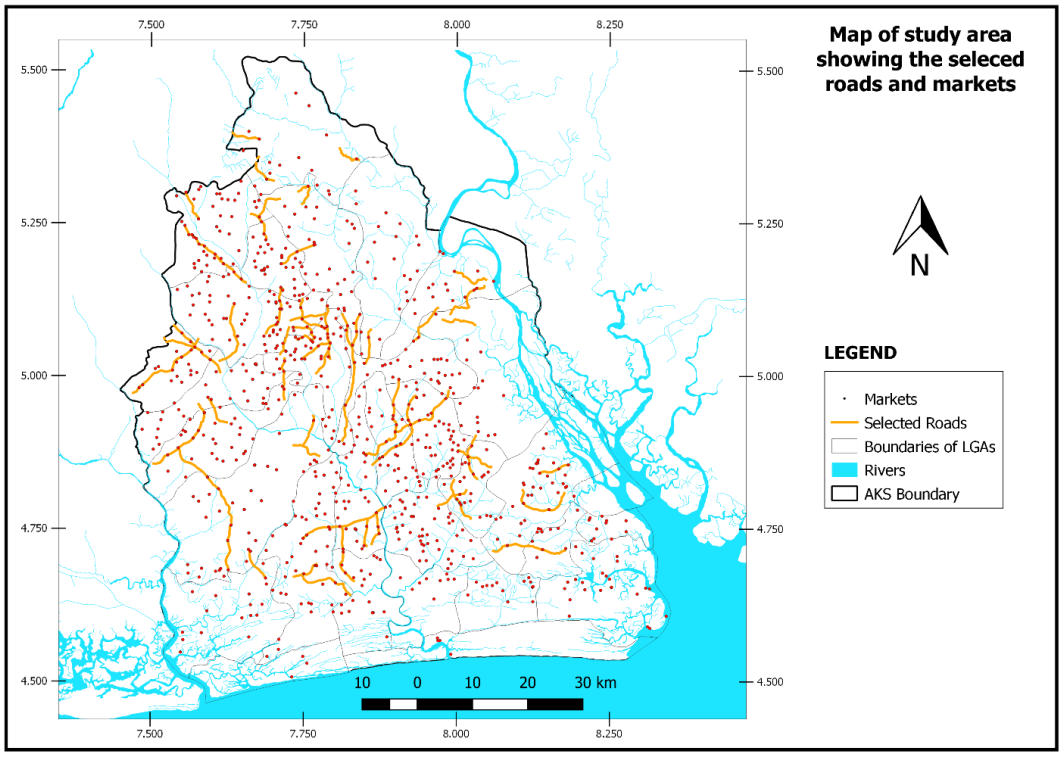
Map of the study area showing spatial locations of health facilities with selected roads ((i.e. after removing dominated alternatives)



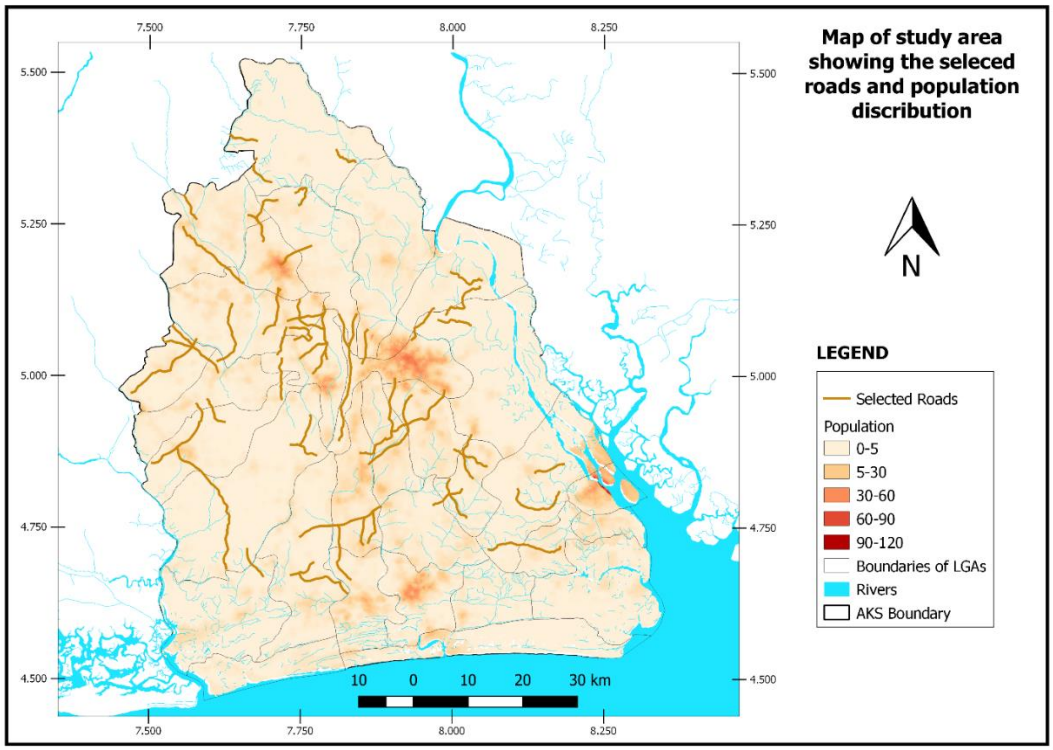
Map of study area showing spatial locations of educational facilities (primary and secondary schools) with selected roads ((i.e. after removing dominated alternatives)



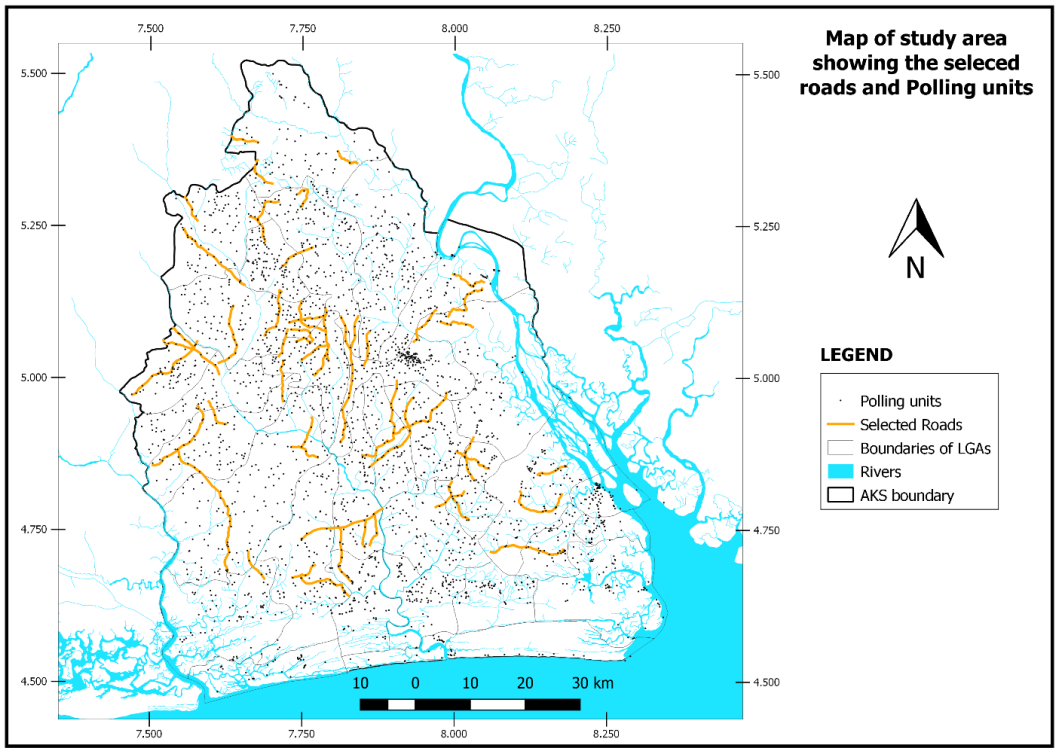
Map of study area showing spatial locations of agro-processing facilities with selected roads (i.e. after removing dominated alternatives)



Map of study area showing spatial locations of markets with selected roads (after removing dominated alternatives



Map of study area showing population distribution with selected roads (i.e. after removing dominated alternatives)



Map of study area showing locations of polling units with selected roads (i.e. after removing dominated alternatives)

Appendix 2: Sample bill of engineering measurement and evaluation (BEME) for construction of 1km of rural road

Type of road: Asphalt road with two side drains and no median

Currency: Nigerian Naira (₦). The official exchange rate at the time of the study was US$1 = ₦ 379.5

Bill of Engineering Measurement and Evaluation (BEME) for a 1km Road					
Project Site: xxxxxxxxx, Akwa Ibom State					
Distance Covered: 1km					
Width of carriage way: 7.3m					
Date: May, 2021					
Activity	**Item description**	**Units**	**Quantity**	**Rate (₦)**	**Amount (₦)**
Site Clearing	Clear site of all bush, shrub, grass and rubbish. Haul to spoil as directed Length: 1000m (1km) Clearing width: 15m Area of clearing = 1000 x 15 = 15,000m2 = 1.5Ha	Area (Ha)	1.5	800,000.00	1,200,000.00
Excavation	Excavate for topsoil to depth not exceeding 300mm and haul to spoil any difference Length: 1000m width: 11m depth:0.3m Volume: 1000 x 11 x 0.3 = 3300m3	Volume (m3)	3300	2500	8,250,000.00

	Excavate unsuitable materials to a firm soil within the carriageway, haul excavated material at a distance not exceeding 2000m to be spread in layers of 150mm in embankment, verge, side slopes behind drains and other locations, or dispose off excess as shall be directed by the Engineer's representative. Length: 1000m width: 7.3m depth:0.6m Volume: 1000 x 7.3 x 0.6 = 4380m3	Volume (m3)	4380	2500	10,950,000.00
Earth works	Provide, spread, and compact t 100% B.S. compaction fill materials in layers of 150mm as filling for building formation. Length = 1000m Width = 7.3m Depth = 0.8m Volume = 1000 x 7.3 x 0.8m = 5840 Amount = 5840 x NGN3000 = NGN17,520,000.00	Volume (m3)	5840	3000	17,520,000.00
Sub-total (Clearing and Earthworks)					**37,920,000.00**
Shaping	Shape and compact subgrade as specified to 100% B.S. compaction Length = 1000m Width = 7.3m Area = 1000 x 7.3 = 7,300m2	Area (m2)	7300	250	1,825,000.00

sub-base	Provide, spread, shape and compact to 100%W.A. compaction naturally occuring material as sub-base to a compacted thickness of 150mm (haulage inclusive) Length: 1000m width: 7.3m depth:0.15m Volume: 1000 x 7.3 x 0.15 = 1095m3	Volume (m3)	1095	3200	3,504,000.00
Stone-base	Provide, spread, shape and compact to 100%W.A. compaction crushed stonebase course material to 150mm thickness Length: 1000m width: 7.3m depth:0.15m Volume: 1000 x 7.3 x 0.15 = 1095m3	Volume (m3)	1095	30000	32,850,000.00
Priming	Provide and lay prime coat using MC1 cutback bitumen at the rate of 1.1 liter per square meter blinded with fine sand Length = 1000m Width = 7.3m Area = 1000 x 7.3m = 7,300m2	Area (m2)	7300	600	4,380,000.00
Surfacing	Prepare surfaces, provide and apply bitumen emulsion tack coat at the rate of 0.5liter per square meter Length = 1000m Width = 7.3m Area = 1000 x 7.3m = 7,300m2	Area (m2)	7300	400	2,920,000.00

Surfacing	Provide, spread, and compact asphalt wearing course to finished thickness of 50mm as directed Length = 1000m Width = 7.3m Area = 1000 x 7.3m = 7,300m2	Area (m2)	7300	6000	43,800,000.00
Sub-total (Pavement and surfacing)					**89,279,000.00**
Excavation	Drainage (0.6m x 0.6m x 1000m; 0.15m thickness Excavate for concrete side drains in any material except rock to any depth including backfilling to 100B.S. compaction and dispose of surplus materials as directed. Length: 1000m width: 1.3m depth: 0.75m Volume = 1000 x 1.3 x 0.75 = 975m3	Volume (m3)	975	1600	1,560,000.00
Blinding	Prepare surfaces of drain excavation to receive 50mm concrete blinding Length = 1000m Width = 0.9m Area = 1000 x 0.9m = 900m2	Area (m2)	900	150	135,000.00
Concrete	Provide, mix and place reinforced concrete grade 25 to form drain. Rate to include blinding and shuttering length = 2000m (i.e. 1000m for two	Length	2000	35000	70,000,000.00

	sides) Amount = 2000 x 35,000 = NGN70,000,000.00				
Access slabs	Provide, mix, and place reinforced concrete pre-cast access slabs average size of o.50 x 1.0 x 0.150 for every 4m entrance to property Total number of slabs = 100 Amount = 100 x 9200 = NGN920,000.00	Number	100	9200	920,000.00
Sub-total (Drains)					**72,615,000.00**
Total 1					**199,814,000.00**
Add Contingency (5%)					9,990,700.00
Total 2					209,804,700.00
Add VAT (7.5%)					15,735,352.50
Grand Total					**225,540,052.50**

Source: Ministry of Works, Akwa Ibom State, Nigeria

Appendix 3: Samples of completed AHP questionnaire

T.T. OSU, AKS

Dear Respondent,

I am a doctoral researcher at the School of Oriental and African Studies (SOAS), University of London, United Kingdom conducting a research on the topic "**Promoting Rural Accessibility through rural roads improvement: An application of GIS and Multi-criteria evaluation**". As part of my research, I am carrying out a multicriteria decision analyses (analytical hierarchy process) to obtain the weights of different criteria that may be used to prioritize rural roads for construction in Akwa Ibom State. As an expert, you are kindly requested to rank the different criteria based on their relative importance following a 1-9 scale of relative importance:

Part A: Information about respondents

(1) Category of respondent
- (a) Political appointee/elected public officer ☐
- (b) Senior Civil Servant in Ministry of Works or any other line ministry (serving or retired) ☑
- (c) Development worker (e.g. in a donor-funded project) ☑
- (d) Contractor/Engineering supervision ☐
- (e) Researcher/Academia ☐

(2) Years of experience in rural (i.e. state) road construction 8 years

Part B: Analytic Hierarchy Process

Table A. Definition of criteria related to Community and its Populations

Criteria	Definitions/Indicators
Social: Education	Number of education facilities that are within 1000 meters of a candidate road which may benefit from the construction of the road
Social: Health	Number of health facilities that are within 1000 meters of a candidate road which may benefit from the construction of the road
Economic: Markets	Number of markets that are within 1000 meters of a candidate road which may benefit from the construction of the road
Economic: agro-processing facilities	Number of agro-processing facilities or cottage industries that are within 1000 meters of a candidate road which may benefit from the construction of the road
Demographic	Number of persons residing within 1000 meters of a candidate road which may benefit from the construction of the road
Financial	Cost of upgrading the road
Political	Number of polling units that are within 1000 meters of a candidate road

Years of experience in rural (i.e. state) road construction

Criteria	Rank (7 is highest while 1 is lowest)
Social: Education	6
Social: Health	7
Economic: Markets	5
Economic: agro-processing facilities/cottage industries	4
Demographic	3
Financial	2
Political	1

Based on your ranking above, kindly provide additional insight regarding the levels of importance of the different criteria above by completing the pairwise matrix below. A guide is provided below to assist you in ra

Value	Explanation
1	Equal importance: Criteria A has equal importance as criteria B
3	Moderate importance: Criteria A is moderately more important than criteria B
5	Strong importance: Criteria A is strongly more important than criteria B
7	Very strong importance: Criteria A is very strongly more important than criteria B
9	Extreme importance: Criteria A is extremely more important than criteria B
2,4,6,8	Intermediate values

Row/ Column	Social-Education	Social - Health	Economic: Markets	Economic: agro-processing facilities	Demographic	Financial	Political
Social: Education	1	2	2	3	~~#5~~ 4	5	5
Social: Health	3	1	3	4	4	5	~~7~~
Economic: Markets	1/3	1/3	1	2	2	4	5
Economic: agro-processing facilities	1/4	1/4	1/2	1	2	4	5
Demographic	1/4	1/4	1/2	1/2	1	2	4
Financial	1/5	1/5	1/4	1/4	1/2	1	2
Political	1/5	1/7	1/5	1/5	1/4	1/2	1

The values in the diagonals will be 1 because each criterion will have "equal importance" with itself. The entries of the matrix in the lower triangle are inverted with those in the upper triangle. For example, if a respondent considers that criteria 2 has a "moderate importance" relative to criteria 1, the value in cell (2,1) will be 3 while the value in cell (1,2) will be $\frac{1}{3}$

A.O., MoWFS, AKS

Dear Respondent,

I am a doctoral researcher at the School of Oriental and African Studies (SOAS), University of London, United Kingdom conducting a research on the topic "**Promoting Rural Accessibility through rural roads improvement: An application of GIS and Multi-criteria evaluation**". As part of my research, I am carrying out a multicriteria decision analyses (analytical hierarchy process) to obtain the weights of different criteria that may be used to prioritize rural roads for construction in Akwa Ibom State. As an expert, you are kindly requested to rank the different criteria based on their relative importance following a 1-9 scale of relative importance:

Part A: Information about respondents

(1) Category of respondent
- (a) Political appointee/elected public officer ❒
- (b) Senior Civil Servant in Ministry of Works or any other line ministry (serving or retired) ❒✓
- (c) Development worker (e.g. in a donor-funded project) ❒
- (d) Contractor/Engineering supervision ❒
- (e) Researcher/Academia ❒

(2) Years of experience in rural (i.e. state) road construction 10 years (2011-2021)

Part B: Analytic Hierarchy Process

Table A. Definition of criteria related to Community and its Populations

Criteria	Definitions/Indicators
Social: Education	Number of education facilities that are within 1000 meters of a candidate road which may benefit from the construction of the road
Social: Health	Number of health facilities that are within 1000 meters of a candidate road which may benefit from the construction of the road
Economic: Markets	Number of markets that are within 1000 meters of a candidate road which may benefit from the construction of the road
Economic: agro-processing facilities	Number of agro-processing facilities or cottage industries that are within 1000 meters of a candidate road which may benefit from the construction of the road
Demographic	Number of persons residing within 1000 meters of a candidate road which may benefit from the construction of the road
Financial	Cost of upgrading the road
Political	Number of polling units that are within 1000 meters of a candidate road

Years of experience in rural (i.e. state) road construction

Criteria	Rank (7 is highest while 1 is lowest)
Social: Education	7
Social: Health	6
Economic: Markets	4
Economic: agro-processing facilities/cottage industries	5
Demographic	3
Financial	2
Political	1

Based on your ranking above, kindly provide additional insight regarding the levels of importance of the different criteria above by completing the pairwise matrix below. A guide is provided below to assist you in the ranking

Value	Explanation
1	Equal importance: Criteria A has equal importance as criteria B
3	Moderate importance: Criteria A is moderately more important than criteria B
5	Strong importance: Criteria A is strongly more important than criteria B
7	Very strong importance: Criteria A is very strongly more important than criteria B
9	Extreme importance: Criteria A is extremely more important than criteria B
2,4,6,8	Intermediate values

Row/ Column	Social-Education	Social - Health	Economic: Markets	Economic: agro-processing facilities	Demographic	Financial	Political
Social: Education	1	2	4	3	4	5	7
Social: Health	1/2	1	3	4	4	5	6
Economic: Markets	1/4	1/3	1	1/2	3	3	5
Economic: agro-processing facilities	1/3	1/4	2	1	3	5	5
Demographic	1/4	1/4	1/3	1/3	1	5	3
Financial	1/5	1/5	1/3	1/5	1/5	1	3
Political	1/7	1/6	1/5	1/5	1/3	1/3	1

The values in the diagonals will be 1 because each criterion will have "equal importance" with itself. The entries of the matrix in the lower triangle are inverted with those in the upper triangle. For example, if a respondent considers that criteria 2 has a "moderate importance" relative to criteria 1, the value in cell (2,1) will be 3 while the value in cell (1,2) will be $\frac{1}{3}$

A. A., RAMP, AKS

Dear Respondent,

I am a doctoral researcher at the School of Oriental and African Studies (SOAS), University of London, United Kingdom conducting a research on the topic "**Promoting Rural Accessibility through rural roads improvement: An application of GIS and Multi-criteria evaluation**". As part of my research, I am carrying out a multicriteria decision analyses (analytical hierarchy process) to obtain the weights of different criteria that may be used to prioritize rural roads for construction in Akwa Ibom State. As an expert, you are kindly requested to rank the different criteria based on their relative importance following a 1-9 scale of relative importance:

Part A: Information about respondents

(1) Category of respondent
- (a) Political appointee/elected public officer ☐
- (b) Senior Civil Servant in Ministry of Works or any other line ministry (serving or retired) ☐
- (c) Development worker (e.g. in a donor-funded project) ☑
- (d) Contractor/Engineering supervision ☐
- (e) Researcher/Academia ☐

(2) Years of experience in rural (i.e. state) road construction 4 years

Part B: Analytic Hierarchy Process

Table A. Definition of criteria related to Community and its Populations

Criteria	Definitions/Indicators
Social: Education	Number of education facilities that are within 1000 meters of a candidate road which may benefit from the construction of the road
Social: Health	Number of health facilities that are within 1000 meters of a candidate road which may benefit from the construction of the road
Economic: Markets	Number of markets that are within 1000 meters of a candidate road which may benefit from the construction of the road
Economic: agro-processing facilities	Number of agro-processing facilities or cottage industries that are within 1000 meters of a candidate road which may benefit from the construction of the road
Demographic	Number of persons residing within 1000 meters of a candidate road which may benefit from the construction of the road
Financial	Cost of upgrading the road
Political	Number of polling units that are within 1000 meters of a candidate road

Years of experience in rural (i.e. state) road construction

Criteria	Rank (7 is highest while 1 is lowest)
Social: Education	4
Social: Health	3
Economic: Markets	7
Economic: agro-processing facilities/cottage industries	5
Demographic	6
Financial	2
Political	1

Based on your ranking above, kindly provide additional insight regarding the levels of importance of the different criteria above by completing the pairwise matrix below. A guide is provided below to assist you in ra

Value	Explanation
1	Equal importance: Criteria A has equal importance as criteria B
3	Moderate importance: Criteria A is moderately more important than criteria B
5	Strong importance: Criteria A is strongly more important than criteria B
7	Very strong importance: Criteria A is very strongly more important than criteria B
9	Extreme importance: Criteria A is extremely more important than criteria B
2,4,6,8	Intermediate values

Row/ Column	Social-Education	Social - Health	Economic: Markets	Economic: agro-processing facilities	Demographic	Financial	Political
Social: Education	1	3	1/4	1/3	~~1/5~~ 1/4	4	5
Social: Health	1/3	1	1/5	1/4	1/5	2	4
Economic: Markets	4	5	1	3	2	7	9
Economic: agro-processing facilities	3	4	1/3	1	1/3	6	7
Demographic	4	5	1/2	3	1	6	8
Financial	1/4	1/2	1/7	1/6	1/6	1	3
Political	1/5	1/4	1/9	1/7	1/8	1/3	1

The values in the diagonals will be 1 because each criterion will have "equal importance" with itself. The entries of the matrix in the lower triangle are inverted with those in the upper triangle. For example, if a respondent considers that criteria 2 has a "moderate importance" relative to criteria 1, the value in cell (2,1) will be 3 while the value in cell (1,2) will be $\frac{1}{3}$

Appendix 4: Samples of completed questionnaires on the constraint to development of rural road infrastructure

(1)

Dear Respondent,

I am a graduate student conducting a research on the topic "**Constraints to rural road infrastructure development in Akwa Ibom State, Nigeria**". The research involves sampling survey on stakeholders in rural road infrastructure development. Kindly answer the questions below as accurate as possible based on your perspective. Your answers will be treated as confidential and will be used purely for the purpose of this research. Please tick the appropriate box in each question.

Part A: Information about respondents

(1) Category of respondent
- (a) Political appointee/elected public officer ☐
- (b) Senior Civil Servant in LGA or State (serving or retired) ☐
- (c) Development worker (e.g. in a donor-funded project) ☐
- (d) Contractor
- (e) Engineering Design and Supervision firm ☐
- (f) Researcher/Academia ☑

(2) Years of experience in rural (i.e. state) road construction 11

(3) Highest Educational Level
- (a) OND/NCE ☐
- (b) HND/B.Sc. ☐
- (c) PgD and above ☑

Part B: Kindly select from the options in each category the magnitude of challenge posed by the listed variables

Institutional Challenges	Not a challenge (0)	Minor challenge (1)	Average challenge (2)	Major challenge (3)
Institutional Challenges				
Poor planning for rural road development				✓
Non-availability of skilled persons to supervise and implement rural road construction activities		✓		
Multiple stakeholders with overlapping responsibilities in rural road construction				✓
Engineering/technical challenges				
Non-availability or poor engineering design			✓	
Use of sub-standard materials for construction			✓	
Poor supervision		-		✓
Non-availability of suitable materials locally				✓
Lack of appropriate equipment			✓	

Natural/Environmental factor				
Geotechnical properties of soil in the region which makes construction expensive and difficult			✓	
Topography of the environment			✓	
Extended period of rainy season which makes road construction impossible				✓
High vulnerability of existing roads to erosion			✓	
Non implementation of environmental impact assessment			✓	
Economic				
Non-release of funds to contractors				✓
Delay in payments of contractors and consultants			✓	
Misappropriation and embezzlement of public funds				✓
Lack of funds for maintenance of roads			✓	
Frequent price escalation				✓
Social				
Excessive requirements from communities in the process of roads construction				✓
Unfavorable cultural requirements			✓	
Lack of community ownership in the process of construction and maintenance of roads.			✓	
Political				
Use of rural road project as political tools and abandoning the roads				✓

(2)

Dear Respondent,

I am a graduate student conducting a research on the topic "**Constraints to rural road infrastructure development in Akwa Ibom State, Nigeria**". The research involves sampling survey on stakeholders in rural road infrastructure development. Kindly answer the questions below as accurate as possible based on your perspective. Your answers will be treated as confidential and will be used purely for the purpose of this research. Please tick the appropriate box in each question.

Part A: Information about respondents

(1) Category of respondent
- (a) Political appointee/elected public officer ☐
- (b) Senior Civil Servant in LGA or State (serving or retired) ☑
- (c) Development worker (e.g. in a donor-funded project) ☐
- (d) Contractor
- (e) Engineering Design and Supervision firm ☐
- (f) Researcher/Academia ☐

(2) Years of experience in rural (i.e. state) road construction 14 Yrs

(3) Highest Educational Level
- (a) OND/NCE ☐
- (b) HND/B.Sc. ☑
- (c) PgD and above ☐

Part B: Kindly select from the options in each category the magnitude of challenge posed by the listed variables

Institutional Challenges	Not a challenge	Minor challenge	Average challenge	Major challenge
Institutional Challenges				
Poor planning for rural road development				✓
Non-availability of skilled persons to supervise and implement rural road construction activities			✓	
Multiple stakeholders with overlapping responsibilities in rural road construction				✓
Engineering/technical challenges				
Non-availability or poor engineering design				✓
Use of sub-standard materials for construction				✓
Poor supervision				✓
Non-availability of suitable materials locally			✓	
Lack of appropriate equipment			✓	

Natural/Environmental factor				
Geotechnical properties of soil in the region which makes construction expensive and difficult			✓	
Topography of the environment			✓	
Extended period of rainy season which makes road construction impossible				✓
High vulnerability of existing roads to erosion				✓
Non implementation of environmental impact assessment				✓
Economic				
Non-release of funds to contractors				✓
Delay in payments of contractors and consultants				✓
Misappropriation and embezzlement of public funds				✓
Lack of funds for maintenance of roads				✓
Frequent price escalation				✓
Social				
Excessive requirements from communities in the process of roads construction				✓
Unfavorable cultural requirements				✓
Lack of community ownership in the process of construction and maintenance of roads.				✓
Political				
Use of rural road project as political tools and abandoning the roads				✓

(3)

Dear Respondent,

I am a graduate student conducting a research on the topic "**Constraints to rural road infrastructure development in Akwa Ibom State, Nigeria**". The research involves sampling survey on stakeholders in rural road infrastructure development. Kindly answer the questions below as accurate as possible based on your perspective. Your answers will be treated as confidential and will be used purely for the purpose of this research. Please tick the appropriate box in each question.

Part A: Information about respondents

(1) Category of respondent
- (a) Political appointee/elected public officer ☐
- (b) Senior Civil Servant in LGA or State (serving or retired) ☑
- (c) Development worker (e.g. in a donor-funded project) ☐
- (d) Contractor
- (e) Engineering Design and Supervision firm ☐
- (f) Researcher/Academia ☐

(2) Years of experience in rural (i.e. state) road construction 6years

(3) Highest Educational Level
- (a) OND/NCE ☐
- (b) HND/B.Sc. ☐
- (c) PgD and above ☑

Part B: Kindly select from the options in each category the magnitude of challenge posed by the listed variables

Institutional Challenges	Not a challenge	Minor challenge	Average challenge	Major challenge
Institutional Challenges				
Poor planning for rural road development				✓
Non-availability of skilled persons to supervise and implement rural road construction activities				✓
Multiple stakeholders with overlapping responsibilities in rural road construction			✓	
Engineering/technical challenges				
Non-availability or poor engineering design				✓
Use of sub-standard materials for construction				✓
Poor supervision				✓
Non-availability of suitable materials locally			✓	
Lack of appropriate equipment				✓

Natural/Environmental factor				
Geotechnical properties of soil in the region which makes construction expensive and difficult				✓
Topography of the environment				✓
Extended period of rainy season which makes road construction impossible			✓	
High vulnerability of existing roads to erosion				✓
Non implementation of environmental impact assessment				✓
Economic				
Non-release of funds to contractors				✓
Delay in payments of contractors and consultants				✓
Misappropriation and embezzlement of public funds			✓	
Lack of funds for maintenance of roads				✓
Frequent price escalation				✓
Social				
Excessive requirements from communities in the process of roads construction			✓	
Unfavorable cultural requirements			✓	
Lack of community ownership in the process of construction and maintenance of roads.				✓
Political				
Use of rural road project as political tools and abandoning the roads			✓	