University of Nairobi

THE INFLUENCE OF ROAD INFRASTRUCTURE DEVELOPMENT PROJECTS ON URBAN LAND USES: A CASE OF EASTERN BYPASS

NAME: OUMA LOICE ATIENO

REG. NO.: W50/87665/2016

Research Project submitted in partial fulfillment for the award of the degree of Master of Urban Management in the Department of Architecture, University of Nairobi.

July, 2022

DECLARATION

I declare that this research project is my original work and that it has not been presented in any other university for academic credit

27.07.2022.

Loice Atieno Ouma

Date

W50/87665/2016

SUPERVISORS' APPROVAL

This research project is submitted for examination with my/our approval as the university supervisors.

26/07/2022

Prof. Jeremiah Ayonga

Department of Urban and Regional Planning

University of Nairobi

Date

27.07.2022

Dr. Margaret Macharia

Department of Architecture

University of Nairobi

Date

DEDICATION

To my grandfather Mr. Asiyo and my parents, Mr. & Mrs. Ouma, I gained confidence and knowledge because you lived out God's word every day, in every way. You taught us how to live, and how to love. To my dear husband, Erick Oluoch, your love, support and inspiration has seen me through the most difficult moments. To my brothers and sisters, thank you for the support and inspiration. And to my fellow classmates who pushed me through and encouraged me throughout this journey, I thank you all. Above all, thanks to the Most High.

ACKNOWLEDGEMENT

I extend heartfelt gratitude to all my lecturers in the Department of Architecture. Sincere thanks to my supervisors, Prof. Jeremiah Ayonga, Department of Urban and Regional Planning, the late Dr. T. Agwanda, Department of Architecture and Dr. Margaret Macharia, Department of Architecture at the University of Nairobi; for relentlessly and patiently guiding me through the writing and compilation of this research work. Your time and constant input are really appreciated.

ABSTRACT

Road infrastructure development in Kenya has risen steadily over the past decade as the need for urban land-use changes becomes a development agenda for economic prosperity. Ruiru is a classic example of a town that has benefited from different land uses. Construction of the Eastern bypass has improved development activities, leading to the region's growth. The impact of urbanization due to the increase in the road infrastructure in town has placed more pressure on the existing land. The current study focused on investigating how road infrastructure projects has an impact on urban land use, a case of the Eastern Bypass. The study specifically (1) investigated the extent to which road infrastructure development affects land use/land cover along the Eastern bypass;(2) established land use conflict driving forces that emerge from road infrastructure development along Eastern bypass; and (3) recommended medium-term urban management framework that will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects. The study was instigated by the bid rent theory, industrial location theory, Central place theory, concentric zone model, and Hoyt's sector model. Conflicts as a result of land use changes that emerge from the road infrastructure development on land use along the Eastern bypass were reviewed. The specific areas by geographical coordinates are 1.1530460S, 36.9271000E to the north-west, 1.1688500S, 36.9775970E to the north-east, 1.1565380S, 36.9251330E to the south-west and 1.1757160S, 36.9727610E to the south-east using land-use data from 2009 to 2021. Descriptive and historical designs were used as the main study design with a target population of residents along the Eastern bypass in the Ruiru sub-county. Stratified sampling was used to get a sample size of 382 respondents for primary data collection data obtained via a structured questionnaire. The findings indicated that vegetation and buildings continuously increased while bare land reduce throughout the study period (from 2009 to 2021). The road overlay length increases in 2021 more than in 2015 and 2009. Questionnaire findings collected indicated that most of the respondents live and work along the eastern bypass. The respondents noted that the most common access service is the electricity supply. Noise pollution, traffic congestion, insecurity, inadequate social amenities and conflict of activities and land uses are the main urban management challenges along Eastern bypass. The residents along Eastern bypass are also not familiar with the development control in the area. Therefore, there is need for land use management framework that will guide planning and enforcement of development controls.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

CBD	Central Business District
CGK	County Government of Kiambu
KCIDP	Kiambu County Integrated Development Plan
KNBS	Kenya National Bureau of Statistics
GIS	Geographical Information System
RSISUDP	Ruiru Subcounty Integrated Strategic Urban Development Plan
RSNIP	Ruiru Sewage Network Improvement Project
RUJWASCO	Ruiru/Juja Water and Sewerage Company
TOD	Transport Oriented Development
UN	United Nations

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Roads, rails, airports, seaports, waterways, and pipelines are examples of different forms of transportation. Roads are the primary mode of transportation from one region to another, within areas, and within localities (Nautiyal & Sharma, 2021). They divide the land into various patterns to provide the best suitable path between destinations. Road networks can be classified based on speed, accessibility, connectivity, directness of routing, and sidewalk continuity (Ewing & Cervero, 2001)

On a global scale, nearly 60 geospatial datasets on road infrastructure were integrated into a global road dataset presented in Figure 1 that shows the Global Roads Inventory Project (Meijer *et al.*, 2018). The dataset covers over 190 countries and includes over 21 million kilometers of road. The highest road densities are associated with densely populated and wealthier countries (see Figure 2). Meijer *et al.* (2018) projected that by 2050, there would be an estimate of 3.0-4.7 million kilometers of additional road length due to future population growth densities.

Road's network grows faster due to urbanization (Pradhan, Arvin & Nair, 2021). Urbanization is a crucial factor in land use change due to its transformative effect on rural areas. An estimate by United Nations shows that more that 55% of the world population live in urban areas, and this will increase to 60% and 68% by 2030 and 2050, respectively (Abuya *et al.*, 2020).

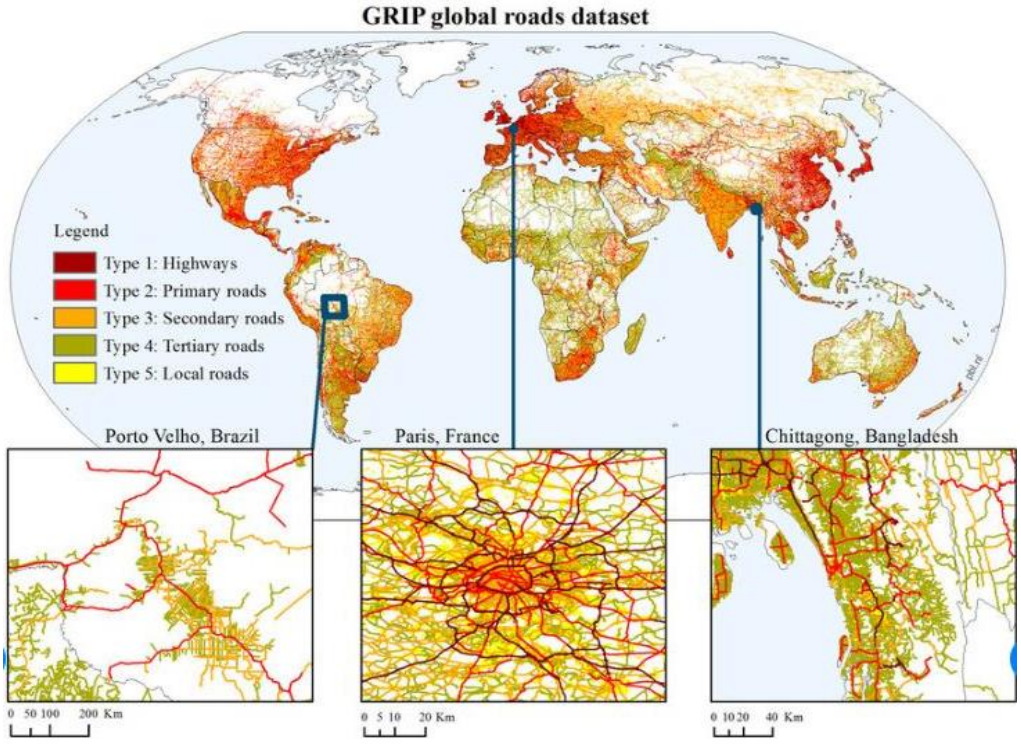

Figure 1: Grip Global Roads Dataset

Source: Environmental Research Letters

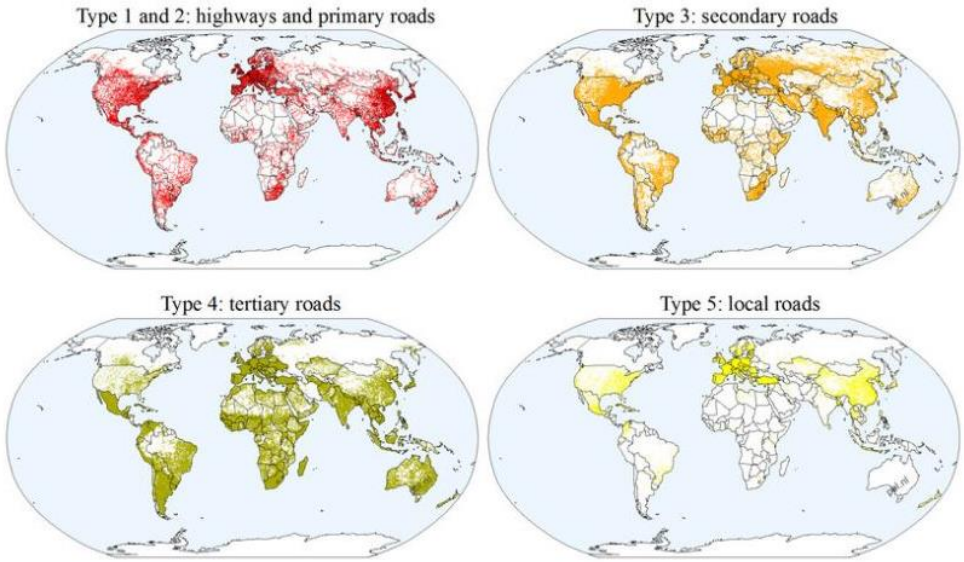

Figure 2: GRIP global roads map

Source: Environmental Research Letters

Landscapes in rapidly urbanizing cities are being transformed by spatial planning and development projects on a large-scale basis. Such large project is used by the governments to enlarge their city's competitiveness within the local and global standards. Investment opportunities are attracted by good roads, which are resultant of restructured road networks. For instance, (Erkul & et al, 2016) argue that large-scale projects, case in point road infrastructure projects, touch on numerous stakeholders, resulting to changes in adjoining locations. They reviewed that this attempt to enlarge the city and make it viable occasionally disregards the wishes of the concerned people during infrastructure development process. Uncertainties also surround long term developments in urban land use. The future of land use is a challenge tasks due to the complexities and interaction leading to everyday life (Kaczorowska *et al.*, 2016). Land use has attracted numerous attentions resulting to several attempts in the 2000s to model land use to better understand land use patterns and mechanisms that change and affect them. Few models have attempted to integrally model all land use categories (Koomen & Dekkers, 2005). The development of infrastructural facilities such as road infrastructure always triggers changes in land use practices and economic growth. The existence of or the adjacency to any transport infrastructure is generally affiliated with population growth, transformation of land to various urban uses such as industrial and commercial uses, increase in employment densities, and ultimately, urban development (Kasraian & Maat, 2016).

Road infrastructure also affect the economic dynamics of a region, spatial policies, and attractiveness of the location. Upgrading of existing roads or construction of new ones both have an impact either positive or negative on the population, economic status, urban form and the environment depending on the situated context (Mackett & Edwards, 1998). The positive impact of new road developments is that it leads to improved neighborhood, living conditions by encouraging economic opportunities, social development, and enhancement of community welfare. Consequently, there is a tendency of roads infrastructure changing major cities operations. This breaks the inner city into minor areas with restricted or no interaction between them and no relationship that permits togetherness and orderliness (Balbo & Navez, 1995). The resultant is an emergence of social and spatial distinctness among people, consequently aggravating segregation, gentrification, and polarization which magnifies the existing inequalities (Manderscheid & Bergman, 2008).

As societies expand, more and more depend on vehicles for transport daily (Geels, 2012). The large network of roads continues to alter the scenery. It can exert influence on the economic growth and

the land use of a region, ultimately shifting the population demographics of an area. They influence the physical and economic growth of towns and cities worldwide, growth and development of human settlements, the location of industrial and commercial activities, and other land uses (Oni, 2010). Rapidly increasing population induces growing cities and increases car ownership. Consequently, road transport and urban land use problems become significant due to their economic effects (Gulhan & Ceylan, 2016). The values of property and land values tend to rise in areas with expansion of road infrastructure networks and increase less rapidly in areas without such advances.

A rapid and sustained rise in housing and land prices are practiced in cities with road infrastructure enhancements and population growth and rapid economic. Population growth is one of the most important driving forces of change in any urban area. If the urban population increases, the city must expand outward to accommodate this increase. Along with economic development and technology revolution, mainly transport and communication, rapid urban growth can be characterized by the development of suburban expansion and redevelopment in the city center (Rui & Bang, 2013)

The impact of road infrastructure on urban land use comes with management challenges such as disruption of existing physical infrastructure like the sewer lines, power lines, water ways, and other social amenities (Giuliano, 2004). There is also forceful land acquisition from private land owners who have to resettle in other areas, breaking social ties within neighborhoods. Land fragmentation into smaller plots becomes a major challenge as it stimulates population growth, this is coupled with urban sprawl towards agricultural land, leading to the creation of intense land uses especially along the available transport corridors. Existing land uses are divided into smaller units that do not conform with the overall zoning regulations resulting to land use conflicts (Batunova & Gunko, 2018). It is therefore important to get mitigation options that will ensure proper planning of the road infrastructure development so that it can be in line with existing urban land use. If not well planned and managed, road infrastructure growth will create pressure and challenges on the existing land uses and ultimately trigger land-use changes.

As a developing country, Kenya is also experiencing rapid growth in its socio-economic systems (Leeson, 2021). Like any other developing country, its growth can be attributed to population growth, especially in the urban areas. Nairobi's population for instance, has increased by approximately 10% between 2009 and 2019 (KNBS, November 2019). The rapid increase in the population of urban areas

through rural-urban migration triggers the expansion of urban centers as urban life promises employment and opportunities for income. This has led to congestion within the cities, especially Nairobi, which is the capital city, and therefore, more people resolve to settle in the metropolitan areas. This prompts the growth and development of road infrastructure in the metropolis, and triggers changes in urban land-use practices in these satellite towns. Therefore, quantifying the influence that road infrastructure has had on urban land use is necessary since land is a major resource for urban development.

1.2 Problem Statement

Road infrastructure development in Kenya has been increasing steadily in the recent past (UN, 2016) thereby scaling up urban land-use changes. The spatial dynamics, economic impact, and urban management components of road infrastructure development projects all affect urban land-use practices and characteristics. Efficient road infrastructure and a good road network generates a competitive advantage in moving goods economically. Conversely, nonexistence road infrastructure or poor road network systems bars agriculture, industry and trade. It may also deter the procedure of urbanization and socio-economic development (Ng, Law, & Jakarni, 2019).

Many cities and towns experience urban sprawl along newly developed highways. Cities and towns experience urban growth, either physically or in population size or both. According to (Mansour, 2004), settlement pattern growth which can be low density leapfrog, strip or linear development along highways and condensed pattern of new developments defines emergence of land use conflicts, which is caused by disorganized & mixed land uses, intense land uses along road networks which creates pressure on available social amenities, land fragmentation and traffic snarl ups due to population increase & construction along road reserves. It is the density, pattern and rate of new urban growth that ultimately determine the extent of urban sprawl as a result of land use changes.

Ruiru is a classic example of a town that developed rapidly to accommodate different land uses. It has been an agricultural area for a long time, with sisal and coffee farms being dominant (UN Habitat, 2017). Construction of roads such as the Eastern bypass has improved the area’s economy considerably with the introduction of residential confines which have profited from the growing call for rented spaces in commercial properties. However, the road design did not consider the incoming

traffic whereby traffic is brought directly to the main highway from the local & collector roads which ideally should be filtered from the local/collector roads to arterial roads and eventually to the highway. Most commercial developments also come after road infrastructure development and this changes the dynamism of development patterns whereby the moment the road is developed, you see linear developments emerging along the road and this brings with it traffic jams. This is the reason why there's the proposal for dualling the highway to avert traffic snarl ups. This is a clear indication of a lack of hierarchy of roads which should actually guide land uses and this emanates from lack of planning.

1.3 Research Objectives

1.3.1 General Objectives

The project investigates the influence of road infrastructure development projects on urban land use, the case of the Eastern Bypass.

1.3.2 Specific Objectives

1. To investigate the extent to which road infrastructure development affects land use/land cover along the Eastern bypass.
2. To establish land use conflict driving forces that emerge from road infrastructure development along Eastern bypass.
3. To recommend medium-term urban management framework that will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects.

1.4 Research Questions

1. To what extent does road infrastructure development affect land use/land cover along the Eastern bypass?
2. Which land use conflicts emerge from road infrastructure development along Eastern bypass?
3. Which urban management framework will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects?

1.5 Justification of the Study

Analysis of road infrastructure development projects plays an important part in the delivery of a better realization of how land use transforms over time as a result of improvement of road infrastructure. While change in land uses in major urban areas are well established, land use variations among geographically smaller regions are largely unexplored yet it has importance in understanding the homogeneity of urban growth. This has resulted to land fragmentation which has encouraged population growth, the development of new settlement patterns and pressure on existing infrastructure, and for this reason the researcher's interest in the area of study. Furthermore, there is a distinguishable knowledge gap in comprehending planning and zoning regulations within the satellite towns. Therefore, for effective urban management, road infrastructure development survey is key for all urban areas especially the satellite and peri urban areas that are undergoing speedy growth in infrastructure development.

The larger Ruiru town is experiencing rapid urban growth, population increase, significant commercial activities, residential and services development which majorly rely on road infrastructure. Construction of the Greater Eastern Bypass brought in another dynamism into the overall growth and evolution of the town with a significant result on the land uses of the surrounding area. This has brought in land use conflicts caused by driving forces such as land fragmentation, disorganized/ mixed land uses, intense land use along road networks and ultimately traffic jams due to construction along road reserves. There is need for planning of this growth that is in tandem with road infrastructure development, but without policy plan to guide, regulate and coordinate these urban activities, there will be loss of urban fabric.

However, there is limited scholarly reviews on the above conflicts and this has necessitated the need to conduct this study. It is also unclear what challenges emerge from the relationship between road infrastructure and urban land use as geo-referenced changes in the land use data are also not available. What is available are the broad land use statistics for most countries (United Nations, 2004) which fails to show the grounds for change in land-use practices. Variable definitions and the lack of consistent urban land-use change data spatially referenced are serious hindrances to, for example, temporal analysis and international comparisons (Clark & et al, 2012). These analyses are difficult

since no consistent datasheet for land-use change would show the important indicators in order to make public policies more effective and conforming to the recipients.

This knowledge is useful if policymakers have to implement useful policy interventions guided by historical surveys and trends in land use intervention of various regions based on key indicators that trigger the change. The analysis that will be presented in this study will convey valuable information for future research that will explore the various impacts of road development projects on land use. Notwithstanding, there is a need to evaluate new methods of managing road infrastructure development projects as a causal effect on land-use changes, specifically to determine the gaps and priorities facing this phenomenon (Moraci et al., 2020). These issues could be improved by developing a collaborative engagement framework between the government and land holders for road infrastructure management, the result of which would be the implementation of useful policy interventions. The research is therefore timely as it will benefit various players in the fields such as the central government and county government in realizing the need for the development of land use management framework that is both transport-oriented and all-embracing land use plans that will promote a sustainable urban growth in our urban areas. Therefore, this study shall fulfill the critical role of providing knowledge in an area hitherto understudied.

1.6 Scope of the Study

1.6.1 Geographical Scope

This study is conducted along the Eastern bypass (see Figure 3), bound by the northern bypass to the west and brookside dairy forestland to the east. The study is limited to 400M distance from the bypass on either side of the road bound by geographical coordinates; 1.153046^0S, 36.927100^0E to the north-west; 1.168850^0S, 36.977597^0E to the north-east; 1.156538^0S, 36.925133^0E to the south-west; and 1.175716^0S, 36.972761^0E to the south-east; and stretches a distance of 13.04 km and covers a total area of $4.57km^{2.}$ The study covered the Eastern bypass and the feeder roads leading to the various land uses. It was conducted both during the weekdays to gather data from key informants and government officials and during the weekends to gather data from household heads and carry out field observations.

Figure 3: Site location map

Source: Google Earth

1.6.2 Variable Scope

This research establishes the correlation between road infrastructure development projects and urban land use by studying the attributes that define and measure the independent variable. The study focuses on the following variables: road infrastructure as the independent variable and urban land use as the dependent variable. This is guided by the following indicators: land use/land cover change, land use conflicts and land use management framework. While the focal point of this paper is the influence of road infrastructure development projects on urban land use, it also considers the interaction between the two and whether road infrastructure follows land use or vice versa. As hypothesized by (Kasraian & Maat, 2016), interminable scrutinization make it possible to compare distinction between various stages in history, providing insight into whether road infrastructure development's impact on urban land use has changed.

The study reviews recent empirical studies on the topic done by researchers worldwide. The research is conducted using the descriptive case study design to establish how road infrastructure development projects have impacted urban land uses, therefore, providing knowledge on policy formulation.

It focuses on the residents living in Ruiru, particularly those who lived along the Eastern bypass and witnessed the road construction, key informants from county government officials, experts and agencies on road infrastructure, private entities, land developers, and the business community within the study area. Questionnaire respondents are selected using the random sampling method.

1.7 Delimitations of the Study

The study focuses on land-use changes that have occurred over time due to road infrastructure development projects, in particular, the case of the Eastern bypass. Studies on the impact of other transport networks such as railways are outside the scope of this research. Though several factors influence land use changes such as social and environmental factors, this study only focuses on the road infrastructure development indicators. This includes expansion of the existing road networks and introduction of new roads in order to establish their role in encouraging land-use changes. In terms of the timelines, the study covers the period before, during and after construction of the Eastern bypass in a time lapse series between 2009, 2015 and 2021 because of availability of data. The study is limited in terms of data availability of similar studies done by scholars, therefore requiring an empirical study.

1.8 Assumptions of the Study

The following assumptions are made in the study: the road infrastructure-land use relationship analysis is a means to resilient development in a metropolitan; The specimen data collected and analyzed from the research area can be used to generalize or approximate the land-use change for the whole stretch of Eastern bypass; We can adopt the recommendations from the study to resolve indistinguishable issues in other parts of the study area along with other areas experiencing the same problems.

1.9 Definition of terms

Land use- these are the activities which land has been given/allocated and practiced at a given place. They include among other residential, commercial, transportation and industrial uses.

Land use change – this is the conversion or modification of land from one activity to another to suite different purposes.

Land cover – this is the overall surface cover of the ground, whether built, vegetated, bare or covered with water, without looking at the specific use of the land.

Land use conflicts -these are the social discords that arises due to diverse interests and ineffective use of land.

Urban sprawl – is the expansion of cities or towns into areas that were initially not populated.

Satellite town – this is a smaller metropolitan area that are located near to, but are independent of major towns.

1.10 Organization of the study

The research project has been divided into eight chapters as follows:

Chapter 1: This chapter discusses the background of the research problem, identifies the research/knowledge gap, outlines the objectives, research questions, study's justification, study's scope, delimitation, and assumptions.

Chapter 2: This chapter covers a detailed literature review from publications written by scholars on the study topic and discusses the theories linked to the study objectives. It also contains the conceptual and legal frameworks related to land use and road infrastructure in Kenya

Chapter 3: This chapter covers the research methods employed for the research design and procedures that were used, data collection tools, data analysis, and presentation methods. It also includes a description of the study area's scope, location, and population.

Chapter 4: This chapter covers results, finding and discussions as per the objectives.

Chapter 5: Conclusion and recommendations- It discusses the implications of the findings and the solutions. It also presents the contribution to knowledge (both theory and practice), recommendations and suggested areas for further investigation.

Appendices-It includes any supplementary information and data such as tables, sample questionnaires, interview questions, and drawings that support the research work.

References-This section introduces the citations that have been used to support the study discussion.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The literature that is reviewed is along the subject of the research project, road infrastructure, and land use; the central themes are spatial dynamism, economic impact, and urban management challenges. The chapter, therefore, provides a basis for analysis of the research questions. The chapter reviews existing literature based on variables of the central themes and the indicators that affect the central theme as a concept of the study.

The major function of the literature review is the provision of detailed accounts of studies that had been done earlier so as to show the gaps that are in existence to be filled by the research project. Emphasis is put on the study of origin, growth & development of road infrastructure, road infrastructure pattern analysis (road accessibility level, road size, road quality, and conditions), and road infrastructure management. All of these are informed by inductive reasoning derived from various theories such as Alonso's bid rent theory, Burgess's concentric zone model, Hoyt's sector model theory, and Weber's industrial location theory which are discussed in this chapter.

2.2 The Study Area

The rapid growth of Ruiru town can be linked to the bid rent theory whereby land rent is affordable as compared to Nairobi town hence affordable housing. Road infrastructure development such as the Thika highway and the Nairobi Eastern Bypass and associated commercial and residential developments that followed the new highways have also led to the growth of the town. Road infrastructure has led to a high concentration of retail and commercial centers in the town, ultimately leading to an increased number of movements along the roads (UN Habitat, 2017). Ruiru town has also experienced urbanization and population increase, leading to high land demand. The town is characterized by strip and nodal physical developments that follow the road networks. The variation in land uses in Ruiru town may be attributed to road infrastructure development, resulting in unplanned urban growth. Thika highway, which cuts through the town, has also promoted trade in the region and attracted more land-use practices. The road infrastructure has created a variation in the land use characteristics by altering the land use density, pattern, and types which have ultimately impacted the general slope of the land, creating a microclimate change in the water capacity and

vegetation cover. Undoubtedly, this advancement in road infrastructure development has come with many challenges and changes in the existing land use patterns. With the existence of such trends establishment of a reliable study and documentation is important because they help predict the trends in land-use patterns resulting from road infrastructure development projects.

Origin, Growth, and Development of Road Infrastructure.

One of the primary factors that affects developmental patterns in both urban and regional levels is road networks. In most cases, new links can lead to agglomeration, activities dispersed, the altercation of the balance between where the households are located as well as the level of aggregation of firms but it is often dependent on the type of change to the network (Iacono & Levinson, 2009).The need for movement of people and commodities has been an everlasting requirement for many centuries. These has been continuous as the need to survive has continues to persist. This has led to continuous improvement on roads network from stone age to the modern day (Mouratidis & Kehagia, 2014). Transportation of commodities is the apparently the main socio-economic activity positively impacting people's welfare.

Road transport is the most common and popular means of transport. The evolution of road networks can be seen through road expansion, road resurfacing, or the construction of new road networks. Therefore, road networks and land-use changes are assumed to have an influence over each other over time mutually. When a new road link is constructed or expanded, it would have a great influence on the choice of household location, developments in the real estate sector, land development and also the density of building. Accessibility and demand for travel would also ultimately be influenced by the changes in land-use.

The improvement and expansion of road networks in an urban area result in urban expansion through the changes in the existing land uses. Burchfield (2006) studied the U.S urban development and expansion and determinants of the spatial differences during expansion. Remote sensing data was used in tracking how land-use evolved. The findings indicated that road networks increase the likelihood of urban expansion. Therefore, the expansion of road networks over time results in more accessibility and thus encourages changes in land-use patterns. Improving road networks play an

important part in the urban landscape by influencing urban land use and guiding changes to the urban environment.

Ogonda (1986) examined the origin, growth, and development of systems of road networks in Kenya and how it is related with socio-economic development factors. He identified the main steps of evolution and compared them with a sequence model that was ideal for the growth of road networks and development. In his study, he assesses and evaluates how network patterns relate and the indices that have been chosen for the development of socio-economic factors in accordance with the units of administration in which those districts are classified in the different levels of development Then they are related to the level of road transport development. Here, a relationship was derived to determine the interrelationships between road networks and development due to various land uses. The study findings showed that there is a close relation between development of road networks and features of socio-economic development.

2.3 Road Infrastructure Pattern and Connectivity

One of the major primary elements of infrastructure that is known to contribute to the economic growth and provision of strength and security to countries is road networks (Al Tarzy, 2003). It consists of many interwoven roads exhibiting many patterns (Zhang & Lund University, 2004) According to (Aderamo, 2003), the road network provides accessibility required by different land uses, therefore they are considered as an important element in urban development. In order for such urban areas to properly function, efficient network of transport should be in place. He argues that the road network analysis should involve recognizing the qualities of the roads and how their patterns.

Road infrastructure is considered a key aspect to the regional growth of an urban area. The huge cost of road development as an infrastructure demands proper utilization, that can be gotten only when the connection and orientation are proper (Sreelekha; et al, 2016). Consequently, organic growth pattern is more predominant in many urban areas hence the need for studies on road network connectivity pattern as connectivity level of the road network influences how land-use patterns develop in a region. More road network connectivity tends to attract competitive land uses and this study will help determine the more dominant use of land in the area of study.

The city's road networks and highways connect one city to another hence they cover a large portion of the urban area. (Ali, 2001) highlights that street are an indication of an areas historical background, topographical layout and economic wellbeing as they take many shapes and forms. Transportation infrastructure is a key activity as its importance can be related to human activities and road networks have to be connected to various regions to achieve the goal of movement (Land Transport Regulatory Commission, 2016).

2.4 Road Infrastructure Accessibility Level

Accessibility is the ease of arriving at opportunities, land use, economic activities, valued destinations, activities such as work, shopping, and healthcare. It is the ease with which land use activity can be arrived at from a location using a particular transport system (Koenig, 1980). It is the main urban quantity to consider from a resource allocation standpoint since it links land use and transportation (Duranton & Guerra, 2017). Accessibility involves transport and land use component, which depends on why an individual is traveling and on how an individual travels. As Chen (2011) states that accessibility involves the attractiveness of destinations weighted by the cost of arriving at that destination (Chen, 2011). Factors such as mobility (physical movement), the quality and affordability of transport options, transport system connectivity and mobility substitutes affect accessibility.

Different approaches to measuring accessibility, as studied by (Garmendia, Moroz, & Rozenberg, 2015), can be grouped into infrastructure-based, location-based, person-based, and utility-based measurements. Infrastructure-based measurements use to transport the quality and quantity of transport infrastructure to evaluate accessibility and emphasize the transport system (Geurs & Wee, 2004). Location-based measurements analyze accessibility based on activities' location and the cost of arriving at those locations. Person-based measurement takes an individual-level perspective on accessibility, incorporating space-time constraints such as scheduling and travel characteristics into the accessibility analysis (Geurs & Wee, 2004). Utility-based measurement calculates the actual economic benefits that the individuals enjoy due to their available opportunities.

2.5 Roads, Urban & Economic Development and Modernization

African investors believed that investments in transport infrastructure positively influenced economic development even though the relationship between road networks and economic development has been contentious (Njoh, 2009). The connection between development and transportation infrastructure seems obvious in most towns and cities. The belief that 'growth will be generated through public investment' has justified resource allocation to the transportation sector, spurring economic growth and development (Njoh, 2009). European colonial authorities were equally convinced by theories connecting transportation infrastructure to economic development and transformation. As mentioned by (Leinbach, 1975), it was generally perceived that 'transportation plays an important part in spreading modernization.' He argued that 'the potentiality to move items and people reliably while joining supply and demand is an essential result of enhanced transportation.'

However, some researchers such as (Dalenberg & Partridge, 2006) have brought out proof questioning the validity of studies suggesting an optimistic relationship between road infrastructure development and economic development. They noted some road networks might negatively impact development, such as unpaved roads. As argued by (Hoyle & Smith, 1992), transportation infrastructure acts as a catalyst for social activities and as a promoter of economic development. It enhances social processes by lowering the cost of movement for especially people, goods and services necessary for improving well-being. To understand road infrastructure as a catalyst of urban and economic development, Njoh (2000) stated that the framework of the transportation sector must be widened so as to help include all activities that may not be traditionally treated as part of the transportation industry, such as supplying construction materials & equipment, operating transportation facilities and managing transportation services. He postulates that by thinking of the transport sector in this broader sense, it is easy to appreciate that the sector attracts a wider component of the economy. Any efforts made to improve the sector directly improve a region's entire economy.

2.6 Influence of Road Infrastructure Development on Land Use

Land use refers to how people utilize the earth's surface (Qtiashat & Makhmreh, 2018). The most important surveys to be carried out by planners before the planning phase is land use studies, which

includes thorough studies on land use types in an area based on land use distribution patterns so as to decide the type of land use to be located in different city parts (Al Khaldi, 2005). Land uses are positioned based on market survey informing where and how much land should be devoted to various uses. Land use may be affected by several factors; the change may involve either conversion from one type of use to another, the changes in the mix and patterns of land uses in an area, or modification of a certain type of land use, changes in the intensity of use, or alterations of its characteristic qualities and attributes (Briassoulis, 2012). Land use patterns have diverse economic, social and environmental impacts: some require less impervious surfaces and preserve more open spaces. Some are more accessible, reducing transportation costs for businesses and consumers (Arabiyat, 2012). There is often a high level of interaction between transportation activities and the planning decisions of land use. The land-use patterns affect the access to different places and destinations, consequently affecting travel needs (Qtiashat & Makhmreh, 2018).

Road infrastructure increases the demand on transportation, which plays a part in dispensing the land use. This creates a reciprocal relationship between road infrastructure and land use (Ghnaim, 1999). Land-use type and road infrastructure is part of the transportation network, and the means of transportation can play a part in assigning the use of land (Shehab & Alladin, 1990). While benefits from an improved road infrastructure may be capitalized into land sale prices, the ultimate land use and land zoning may be compromised. Therefore, changes in the existing land uses may occur, and newer proposed land may be affected.

In their study on the effects of road networks on land use, (Asadi & et al, 2016) analyzed the link between land changes in the northern part of south Iran to estimate the direct influence of roads network development on the agricultural land, and assessing the impact on the west Iran network. The study showed that 3% of the agricultural land changed to other types of uses, where the main changes to the agricultural land took place near the main roads in contrast to areas far from the main roads. The results showed that the agricultural land was mainly shifted to non-agricultural use due to the road network development.

2.7 Change in Land Use Trends

Population growth pressure affects the earth, which is a limited and non-renewable natural resource. It is of importance to be conscious of land-use changes caused by different aspects and how human beings make use of the land, so as to make optimal use of land (Kalkhajeh & Jamali, 2019). Land uses have changed over time based on various historical analyses as indicated with the changes of uses of land, growth and reduction of different land-use categories. A study done by (Delden, Hagen, & Luja, 2008) on the assessment and scenarios of land-use change in Europe showed an increase in residential, industrial, and commercial locations in the period 1990-2000. In contrast, there was a reduction in agricultural areas within the same period. Variables such as proximity to the road network were considered effective parameters in growth and development.

2.8 Conceptualization of Theories on Land Use and Road Infrastructure Development.

Many factors conspire to create different patterns of land use evident in cities. Different scholars have established a strong relationship between different transportation infrastructure (roads, rails, airports, water, pipelines) and land use, which ultimately leads to development (Njoh, 2009). Therefore, this study employs deductive reasoning using theories done by researchers such as Alonso, Weber, Burgess, Hoyt, and Christaller.

2.8.1 The Bid Rent Theory by William Alonso (1960)

William Alonso developed the theory in 1960 (Alonso, 1960). Land uses are classified as residential use, commercial and industrial use, transportation, educational, public purpose, recreational, public utilities, deferred land and agricultural land. These land-use types compete for space in any urban setup, and therefore, they would compete to be located near transportation networks. However, this may not be the scenario for most land uses since the distance from the road determines the cost of land, thereby determining the type of land use that will afford the space. The land-use type which occupies the most accessible site will pay the highest rent. These land uses often generate more income and, therefore, can pay the high rent; hotels, supermarkets, and high-income businesses are competitive in rent payments.

Classical bid rent theory by (Alonso, 1964) highlights the fact that there is a decline in rents outwards from the Central Business District (CBD) to set off the reducing revenue production capacity and higher costs such as cost of moving from one point to another. He attempted to apply accessibility requirements to the city center for various land uses such as residential, commercial, and industrial land use (Narvaez & Griffiths, 2013). He investigated the bid rent theory by studying the relationship between land price and accessibility based on the proposal that distance is not a measure from place to place, rather, it is shaped by the network of streets. The findings established that remote access attracts industries and residential facilities due to the low land value and less disturbance from other activities. He also presumes that due to the relative cost of open land space in locations closer to the CBD, there are chances that higher-income households are located in the suburbs (Watkins, 2000). Alonso further hypothesized that accessibility is an element that can harmonize, disperse and accommodate the generation of movement since distance constructs chances for socio-economic interaction. Therefore, access relates to the quantifiable distance that makes a place with a specific function (land use) located with another.

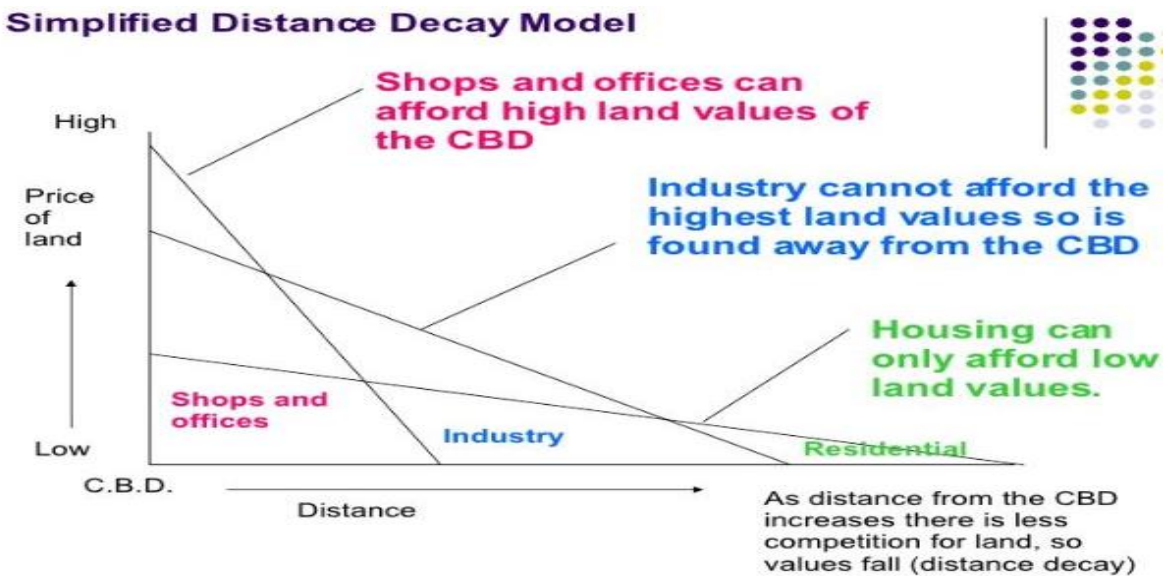

Figure 4: Alonso's Bid Rent Curve Model

Source: Watkins, (2000)

Further studies done by (Oduwaye, 2004) on land price indicators in relatively dense neighborhoods indicated that road infrastructure influences property values. Ease of accessibility creates and

increases land value and subsequently determines the land use type. He further established that high land prices are experienced in well serviced areas that have adequate and good access to roads, water, good drainage and electricity. Therefore, he concluded that upgrading of transportation facilities, especially roads, improves access and subsequently creates a certain pattern of land use.

Against this background, the study analyses Alonso's bid rent theory to establish the influence of accessibility/distance from road infrastructure on land use type in Ruiru town. The theory suggests that distance from road infrastructure determines the land rent. The higher degree of accessibility leads to a higher value of the land. More accessible roads will translate to converting one type of land use to another or modifying certain types of land uses.

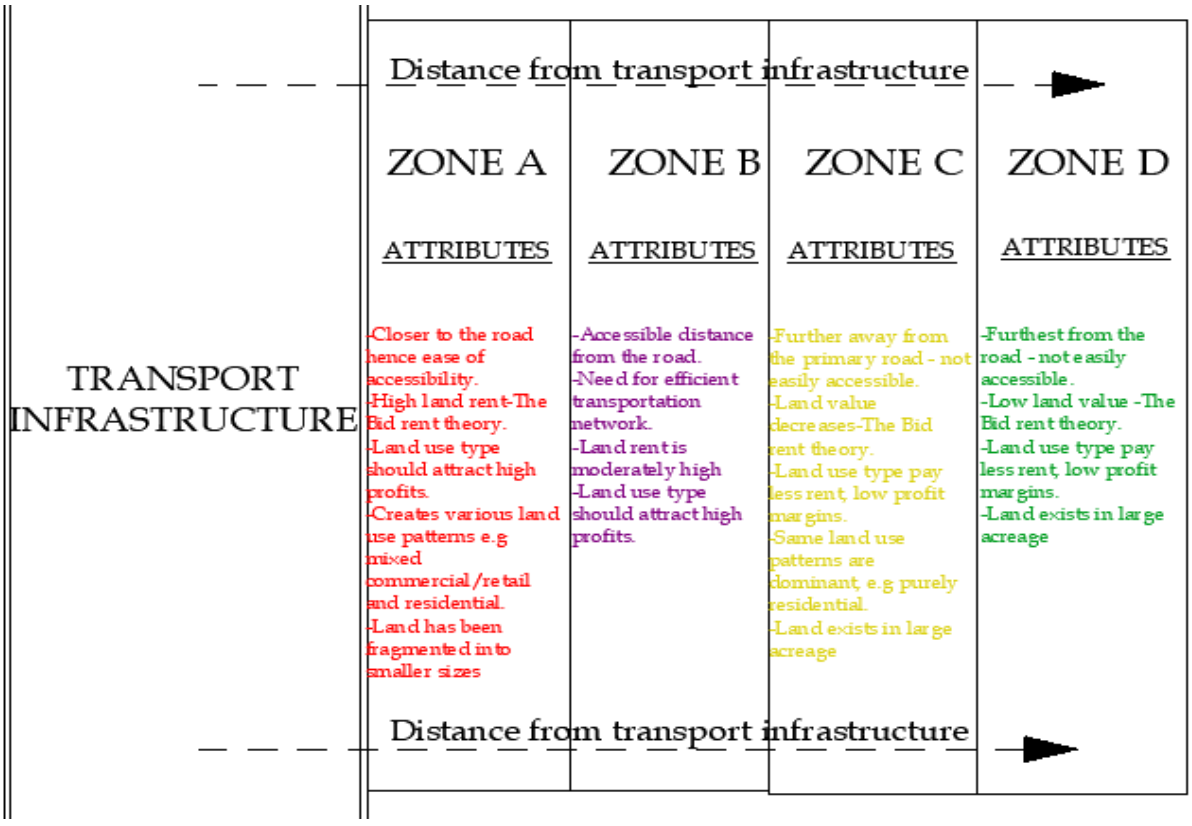

Figure 5: Land use type locational attributes with distance from transport infrastructure

Source: Author's sketch based on Alonso's theory

2.8.2 Alfred Weber's Theory of Industrial Location

Road infrastructure greatly influences the location of various land uses and land covers. It comprises a series of interlinked roads that exhibit different characteristics (Oni, 2010). Alfred Weber developed the industrial location theory in order to construe the relationship between road infrastructure and land-use patterns. He established that three main factors influenced industrial location; transport costs, labor costs, and agglomeration economies. He argued that each industry tries to find a location where transportation charges are minimal, and there is the ease of accessibility, both in terms of availability of resources and place consumption. The premise of his theory is the scrutiny of the general elements that pulls an industry towards different geographical regions (Sandhya, 1999). Weber argued that transport cost depends on assembly cost and marketing cost for transport costs. An industry might be located either at the raw material source or at the marketplace. This depends on the nature of the raw material and the distance traveled.

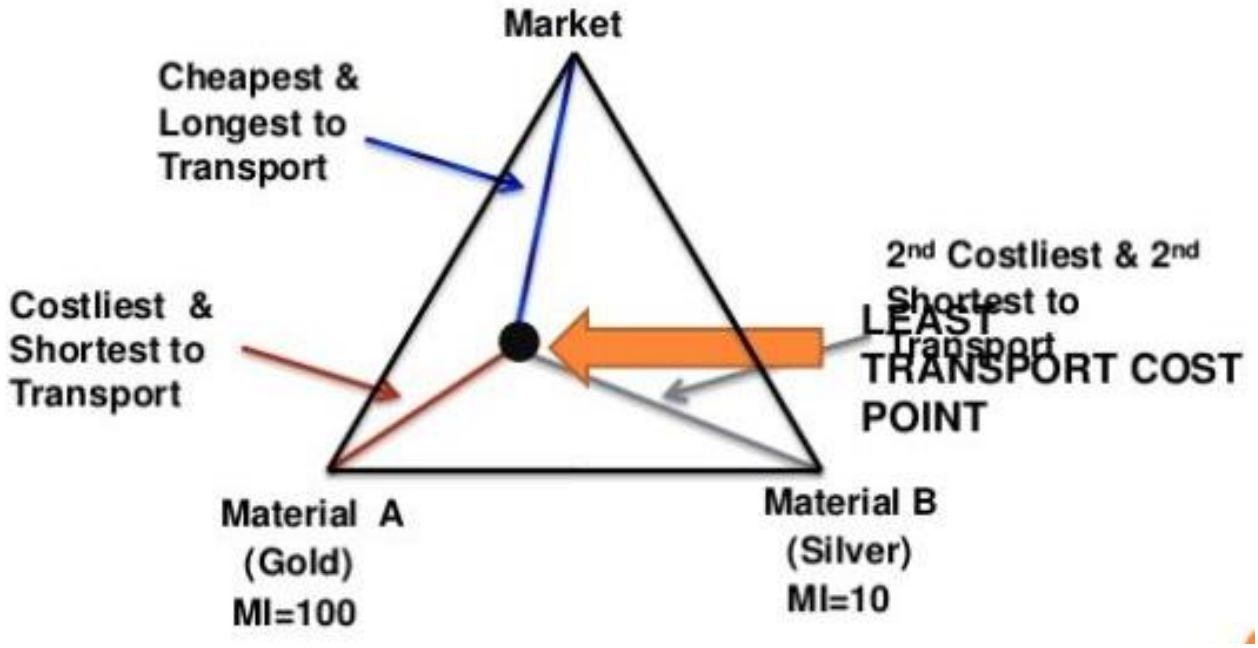

Figure 6: The locational triangle by Weber.

Source: Oni (2010)

With a variation in road infrastructure components, such as the road's physical conditions, the road's width and size, and the type of road surface, we can be argued that the industrial location theory can

be applied to establish the linkage between road infrastructure and land use. Some land uses, such as commercial, will be located next to major primary roads where there is the ease of access to the market and high returns to scale in production. Less intense commercial activities such as small retail shops will tend to locate along with tertiary road networks, where rent is affordable.

The type of road surface also determines the location of land uses. As one moves further from the primary road, the road conditions may vary in surface finish. The change may be gradual from asphalt to bituminous to gravel finish. Some land will tend to be concentrated closer to the primary or asphalt road surfaces as they can easily reach the target market. In contrast, others will be located further away due to the availability of raw materials.

Weber's arguments on industrial location, therefore, highlight the influence of road infrastructure on various land uses, whereby industrial activities will be located in areas with minimal transport charges and on land with minimal rent costs to avoid high manufacturing costs. Good road infrastructure also attracts a high population growth, leading to land fragmentation into smaller units, which eventually leads to change in land-use patterns.

2.8.3 Christaller's Central Place Theory.

The theory was developed in 1933 by Walter Christaller to describe the spatial pattern of urbanization. The spatial arrangement, such as city size, city location, market area, and several settlements within a region, are focal areas for dispensing services and goods to surrounding market areas (Berliant, 2005). The theory states that the local markets in the frontier supply low-cost necessities while the central place provides the hinterland goods and services of high cost. This kind of arrangement creates different zones where the central place is categorized as a commercial zone while the hinterland develops to be a residential zone.

Christaller noted that the central places are arranged using three different principles (see Figure 7): the marketing principle, the transportation principle, and the organizing principle (Berliant, 2005). Using the transportation principle, he postulates that the distribution of central places is most favorable when many important places lie along the same traffic route between two important towns. Therefore, the major places are aligned along a straight traffic route that spreads out from the main point.

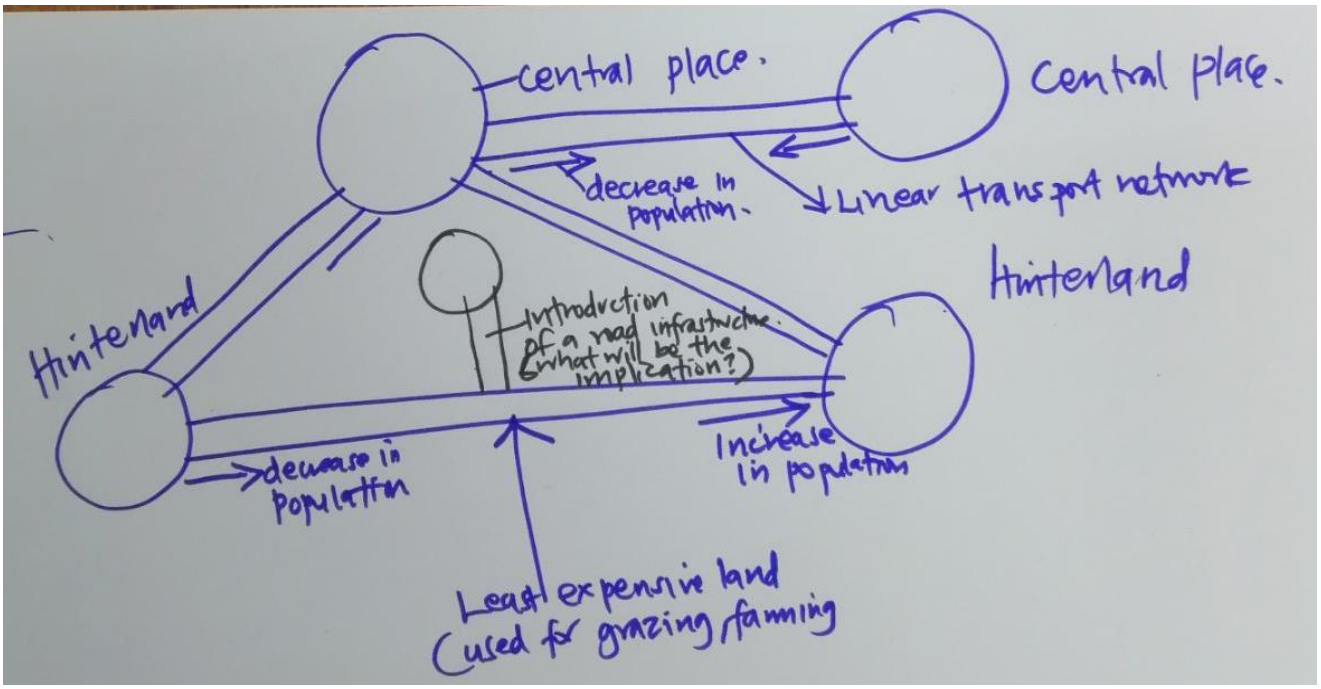

Figure 7: Central Place Theory

Source: Author sketch based on Berliant (2005)

Walter Christaller observed urban hierarchies whereby cities form a ranking based on the location of a linear transport network and heterogeneity in economies of scale across goods. The consumer population is uniformly distributed while firms locate in cities. This theory, therefore, presumes that population distribution decreases as one moves away from the central place. Then it begins to rise as one gets closer to the next central city. The least expensive land will be found at the midway point between the two central cities, and this land was used for grazing and farming. Therefore, this relationship is pegged on the changes in road hierarchy whereby the central place (larger cities) is located along major transportation routes thus. The high-cost commodities can easily be gotten here.

In contrast, the low-cost commodities will be gotten from the hinterland (smaller cities) located along secondary and tertiary transportation routes. The outcome is a collection of hierarchically ordered cities/towns that follow transportation routes. Therefore, the theory will help answer the question, ‘does road infrastructure result in a change in the intensity of activities?

2.8.4 Burgess's Concentric Zone Model

Many scholars like Burgess, Ullman, Hurd, Hoyt, Feiry, McKenzie, and Colby have presented their concept of urban land use models to express city structures and generalize the arrangement of land use regions within a city (Meyer, 2000). These models have been affected by physical, economic, political, and cultural factors of the urban areas in shaping the form and structure of cities over time.

The concentric zone theory was developed by E.W. Burgess in 1925. The model suggested that any urban area expands radially from its central commercial core to the outer periphery. This forms a series of concentric circular zones, including the central business district, the zone of transition, independent workingmen homes, the zone of better residence, and the commuter zone (Mandal, 1992). Burgess noted that each zone tended to expand its area by invading the next outer zone. According to Burgess, this dynamic process of city structure creates economic differentiation among people and land use in the urban centers. The concentric theory postulates that land use varies regularly due to distance from the city center. Therefore, this argument for city growth emphasizes how circulation networks guide the different zones/land uses in the form of concentric rings.

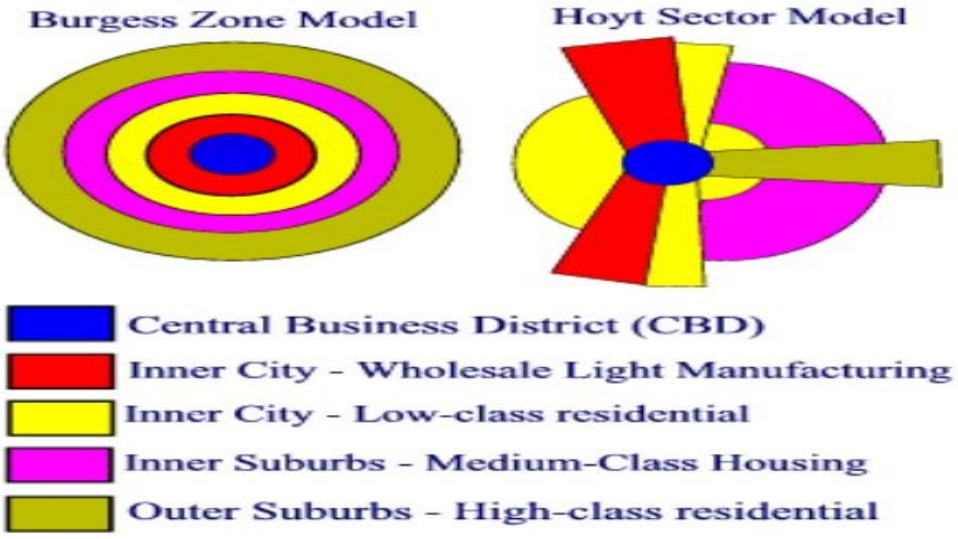

Figure 8: Urban land-use models

Source: Mandal (1992)

2.8.5 Hoyt's Sector Model

The sector model was developed by Homer Hoyt (1939) to explain the correlation between transportation infrastructure and land uses which follows lines of transportation corridors to form a star-shaped city (Singh, 2013). He theorized that cities centered on major transportation routes and they tended to grow in wedge-shaped patterns from the CBD (see Figure 9). In this theory, along a particular transportation axis, similar types of land use follow each other. The direction away from the CBD is the important concentric zone as similar activities are located in the same area and they extend outwards as growth occurs. The Hoyt model registered that transportation and resource access disrupted the concentric zone model. Land use and population pattern tend to develop similarly, outward from the center of the sectors and growing in a sector form. This theory emphasizes how road infrastructure guides the location and arrangement of the different land uses.

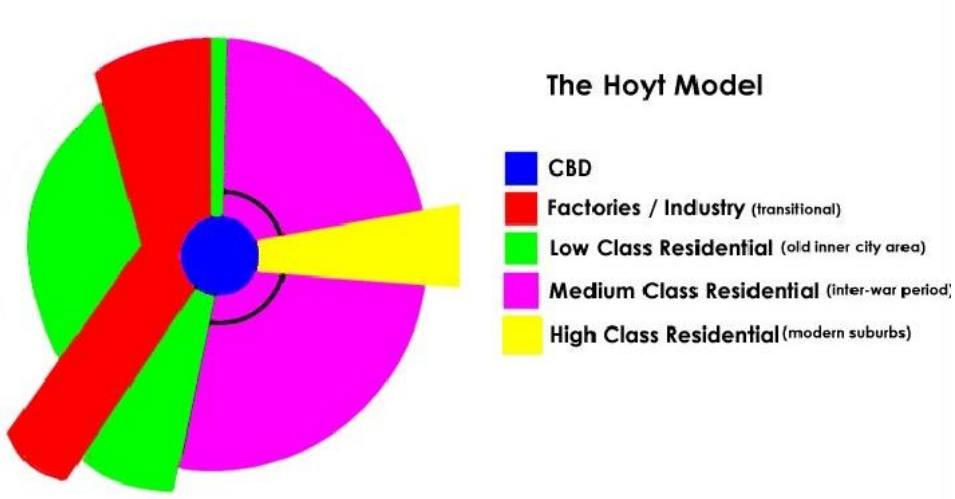

Figure 9: Hoyt sector model

Source: https://slidetodoc.com/the-location-of-industry-and-urban-land-use

As similar land use follows a transportation network, the resultant effect will be a shift in land use characteristics by affecting the change in land use mix and land use patterns. This will affect the activity patterns such as zoning & regulations, land use density, availability of land, and pressure on public utilities and telecommunication infrastructure. An area initially zoned as high-class residential land could experience a paradigm shift to a commercial zone. This eventually will bring management

challenges such as changes in demand for travel which will apply considerable influence on the development of new transport infrastructure. This study, therefore, uses the Hoyt theory to investigate the management challenges that emerge from the road infrastructure-land use nexus by studying the implications on land use density.

2.9 Empirical Reviews

Many scholars have used land use and land cover to investigate the factors driving certain practices on the land. For instance, Alemu et al. (2015) studied the changes in land use and land cover associated with driving factors in the northwestern lowlands of Ethiopia. The study assesses the status of western dry woodlands via analysis of land use and land cover dynamics. Image analysis of the captured GIS images indicated the change in land use and land cover. The study used the findings to recommend suitable sustenance management and development functions that could help improve the livelihood of the locals. The study used remote sensing and GIS to attain the research objectives. This study is similar to the current study in many ways. First, it emphasizes the need to focus on how the population will benefit from the project, which is people-based. The population will be in support of the project if they stand to benefit. The project must also be sustainable to attract interest.

Abuya (2020) studied the management of land-use changes on urban infrastructure capacity using the case of Ruaka town. The study noted that other socio-economic activities are indicated by land change. Specifically, road networks increase land use. Therefore, the study focused on finding the drivers of spatial-temporal land-use changes between 1988 and 2019. The study noted the reduction of vegetation and agricultural activities and increased building activities. The encroachment of human activities on riparian land led to climate change. This is facilitated by a lack of planning policies in place. However, the policies are undocumented, making it difficult for investors to follow. The study's findings noted that the key drivers of land use and cover changes are accessible roads, speculations of land investments, and higher housing demand. Urbanization reduces vegetation and increases building, contamination of water sources, and traffic congestion. The study recommended a need to have management strategies to promote sustainable and resilient urban infrastructure. Unlike Abuya's (2020) study, the current study has one major difference: the focus on place-based and people-based strategies to guide infrastructure development.

2.10 The Role of Actors in Urban Land Use Management and Plan Implementation

Urban areas experience dynamic changes especially in the satellite towns. These changes result in unplanned land conversions and fragmentation, hence the need to emphasize on the importance of various players in urban land use. Information on land use management is also very critical and would give details on ways land owners and developers are able to develop their properties.

Both institutional and non-institutional actors play an important part in urban land use management and plan implementation. The role of the national and county government is key, but the role of other non-governmental institutions cannot be ignored (Thuo, 2013). In order to identify the key players in land use, the actor-oriented approach is used. Key players such as the private and institutional actors, the government, business people, multilateral institutions and organizations are identified. The actor-oriented approach guides in understanding how the key players make decisions which result in the transfer of organizations and tasks played by different institutions over a period of time, even though their mandate may overlap or possibly conflict.

2.10.1 Non-Institutional (private) Actors

The key actors include farmers, residents, real estate agents, developers, businessmen and non-governmental bodies. Residents can be classified as indigenous residents, tenants and new residents. The indigenous residents have subdivided their family land and have been edged out of farming and therefore, converted their portion of land for residential use. Land fragmentation has left these actors with insufficient small land units not viable for commercial agriculture. Real estate agents' role in land use management entails purchase of parcels from farmers or individuals, partition and market them since they are aware of the land business and they have connections beyond the local area (Thuo, 2013). Non-governmental bodies such as religious and environmental organizations supplement the tasks of the national and county government through service provision of education, water and health services.

2.10.2 Key Institutional Actors

The key organizations involved in land use planning are: national government, county government and local community organizations. The national government has a number of actors that are

distributed across different departments and ministries. These departments serve different duties in land use planning & management and they include the Department of Physical Planning under the Ministry of Lands. The Ministry's task in land regulations is to provide information on the value of land, land uses, topographical maps which shows the characteristics of the area. This data helps in establishing the land use trends, land sizes, composition of land use plans and ownership types which is important in establishing and predicting future land uses. The Ministry of Transport & Infrastructure, under the State Department of Infrastructure gives information necessary for road infrastructure planning, road type and existing road network (Thuo, 2013).

2.11 Legal, Institutional and Policy Framework

The legal and policy frameworks that guides land use and land use management includes both the planning agencies (County governments) and the oversight agencies such as National Lands Commission.

Figure 10: Summary of Institutional Framework for ULUPs

Source: National Land Policy

2.11.1 Physical and Land Use Planning Act, 2019

The 2019 Planning Act came into use after the 1996 Act was repealed. The Act was established to help with land development matters by giving guidance on planning, usage and regulation of land. The objects of the Act are to provide: procedures and levels for the preparation and implementation of physical and land use development plans at the national and county level, guidance and oversight of physical and land use planning, strategies for development control and the policing of physical planning and land use, a strategy for the coordination of physical and land use planning by county governments, a strategy for fair and viable use, planning and management of land and a framework to ensure that investments in property benefit local communities and their economies (Kenya Law Reports, The Physical and Land Use Planning Act, 2019, 2019).

2.11.2 Urban Areas and Cities Act 2011 CAP 275

The Act was established as an Act of Parliament for the purpose of categorization, administration and the running of urban areas and cities, to give basis of setting up of urban areas, to contribute to the concept of administration and management of urban areas and involvement of residents in the administration and management of cities.

The Urban Areas and Cities Act Cap 275 Section 12 places the running of cities and municipalities in the County Government. This is to be administered through a Board that has been enacted as per the Act. The board performs other functions such as formulating and implementing plans and, in the process, ensuring the involvement of the users. Section 36 (2) of the Act emphasizes on incorporation of all functions through the integration of city development plan which should be binding, guiding and informing all planning and development decisions. Furthermore, Section 37 of the Act lays down guidance on how an urban area integrated development plan should be in line with the county government's development plans and master plan (Kenya Law Reports, Urban Areas and Cities Act No 13 of 2011, 2011). Section 36 (1) advocates that cities and municipalities set under the Act are to work within a merged development planning framework that will be the premise for development control and provision of services such as water, health, electricity and solid waste management.

This Act therefore outlines the overall oversight role that is to guide the urban development and planning of land uses which also need to be in line with the Kenya Roads Act (No 2 of 2007).

2.11.3 County Governments Act 2012

Section 104 (1-3) of the County Governments Act 2012 requires a county government to plan for the county and ensures that public funds are used appropriately within the planning structure that incorporates physical, economic, social, environmental and spatial planning. The law also indicates that the county government selects county departments, sub-counties and ward representatives as people in charge of planning and that county plans to be obligatory to all sub-counties.

The law indicates that city plans are the instruments for development control within the city and that uses and basis of land use and building plans and placement of infrastructure are to be provided for by the plans. Monitoring and compliance with the plan are an important aspect of execution which the county government has to adhere to and therefore, create land use planning unit to undertake it (Kenya Law Reports, 2012).

2.11.4 National Land Commission Act No 5 of 2012

The commission has been mandated as in Article 67 (2) of the Constitution of Kenya, to keep track of and supervise plan implementation in cities in order to cushion the sovereignty of the users and promote federalism hence, they obtain continuous reports from the county government board and carry out visits to confirm the conditions. The National Land Commission also seeks to promote cities which are intentionally aggressive, habitable, usable, economically vibrant, socially inclusive and environmentally friendly. This is to be achieved through integrated and functional urban transport (National Land Commission, 2016). NLC also ensures that land and land-based resources are well managed and utilized and that an appropriate structures for integration of land use plans are put in place to necessitate execution of the planning proposals and regulations. The Sessional Paper Number 3 of 2009 on National Land Policy recommends that: in order to prepare land use plans at different levels of the government, there is need to adhere to examination of aspects such as the economy, safety, aesthetics, harmony in land use and environmental sustainability.

From the above laws and legislation, it is clear that counties have been given the mandate of developing various land uses within their regions but this should be in line with the national policies and regulations on land use. Therefore, there is need to align the national road development plans with county land use development plans.

2.12 Instruments in Realizing Effective Land Use Planning, Development and Management.

2.12.1 Sectoral Policies

Various policies and institutional arrangements can be implemented to address land use planning, development and management so that compatibility with road networks is achieved. As highlighted by (Riad, 2019), this can be achieved through mandatory and time-bound development obligations for all state granted or sold lands, adoption of mandatory land assets management strategies and policies for public agencies with large real estate portfolio, penalty or fees imposed on vacant lands, impact fees for leap frog developments and centralized planning framework to facilitate coordination.

Land use and spatial planning tools such as Environmental Impact Assessment and Strategic Environmental Assessment are important regulatory approaches to guide in road infrastructure development and land use management. Poor spatial results occurs if there is no mediation between infrastructure and amenities, conflicting land uses in close vicinity to one another such as industries located next to housing. Hence there is a call to traverse multiple interests about land utilization, both currently and in future, and a demand to optimize multiple objectives such as economic rivalry, environmental sustainability and social inclusion through the inclusion of other policy instruments beyond land use planning (OECD, 2017).

2.12.2 Enhanced Legislation

There is need to enhance rules and regulations that guides land use management. Land readjustment technique can be applied in some regions in order to control urban hinterland and promote land for development purposes, upgrading of slums and regularization, arrangement of new residential areas and planning of vacant land for future developments. Laws will be able to facilitate and guide planned city extension or densification through negotiated processes that can lead to a more orderly and proactive supply of land for urban development (Riad, 2019). It also ensures infrastructure and service provision for the land owners.

2.12.3 Practice guidelines/manuals

Land use guidelines and manuals should be developed and enforced. This can include developing timelines on which land development should be done so as not to leave land undeveloped for long period of time, especially land in prime urban areas. This will help in avoiding further subdivision of land for speculative purposes, which will then discourage haphazard and an unplanned development leading to urban sprawl.

2.13 Urban Land Use Management Framework

2.13.1 Transport-oriented development planning (TOD)

TOD is a planning and design strategy that encompasses land use and transport planning and seeks to include walkable and livable neighborhoods with high density of land uses that are mixed so as to achieve sustainable urban growth. It aims at advancing compact, mixed-use, pedestrian friendly urban development that closely intertwines with mass transit by clustering jobs, services and amenities around public transport areas (Cervero & et al, 2004).

Consolidating transport and land use planning contributes to the sustainability of cities and promotes the use of public transport. It is viewed by many as a promising tool for curbing urban sprawl and the automobile dependence it generates (Cervero & et al, 2004) and hence has a particular relevance to integrated development of public transport and land uses. This will allow for goods and services to be readily available and accessible to neighborhoods and therefore minimize the distance of travel to work. This will reduce the impact of traffic snarl ups to the core town and will also promote infrastructure development within neighborhoods. TOD brings many benefits including ease of access to transit, making it easy to move around without a car hence this discourages traffic congestion in urban areas. This strategy allows for better planning of neighborhoods by incorporating all land uses in one area.

Development should be coordinated in advance to avoid inconsistent patterns as it will be difficult to convert land use once land is built-up, hence planning is necessary to harmonize public and private investment decisions. On a smaller scale, this could include the construction of low-density development around a road network, which at later point prevents densification. On a larger scale,

this could entail offices being built far away from public transport nodes therefore leaving the public transport system operating below capacity while creating congestion on roads.

2.13.2 Overarching Land Use Planning

Sectoral issues such as transportation, housing, energy, water, agriculture, tourism and economic development have an effect on the uses of land. Development in one quarter affects another sector (OECD, 2017). The coordination of sectoral issues is complex coupled by the fact that policies in different sectors, rules and regulations cuts across local, regional and national scales. Therefore, there is need to develop a more comprehensive and all-embracive land use plan that includes all aspects of sustainable urban area that considers social well-being, environmental aspect and promotes economic growth and help minimize the unplanned conversion of open spaces and agricultural resources to urban uses.

This will allow for integration of transportation systems, water, environment and housing into land use. Currently, policies on land use are coordinated beyond policy fields and this coordination has to escalate and should include transportation plan. Already, land use policies are often coordinated across policy fields and this coordination will have to intensify and should include transportation plan. Moreover, there is need for close engagement and working relations across government levels and policy sectors to establish frameworks to encourage integrated planning. Amalgamation and harmonization of policies is critical if a broad range of policy instruments is used to propel land use. Without this, it will be impossible to orient diversified set of policies to influence land use effectively.

2.14 Decentralization of Land Use Planning to County Governments

The county government is mandated to carry out land use planning but through the guidance from the national government. It is localized and depends with the context hence it is dependent on high information level on local conditions, which may not be available with the national government. The county government embraces comprehensive land use plans that have zoning regulations and use different ways to regulate land use. They also prepare strategic plans to direct land use decisions on a local level as the national government prepares strategic plans and policy guidelines with spatial implications to harmonize territorial development of the entire nation. These policies may at times be

binding and hence the need for local plans to abide by them and at times the guidelines give only directions for lower-level plans.

It is therefore imperative that there is good coordination between the county and national government in the establishment and implementation of land use plans to allow for uniformity in design. All the necessary stakeholders and agencies such as the roads, water, sewer management authorities should work as a team to allow for a smooth merger of all the land uses without creating room for conflict of land uses.

2.15 Conceptual Framework

A conceptual framework is defined as a systematic way of arriving at a study's anticipated ideal end state, using written or visual representation of the study variables. The reviewed literature highlights the theories that explain the relationship between road infrastructure and land-use/land cover changes, which have guided construction of the conceptual framework. It also establishes mitigation options to resolve the negative outcomes that emerge from the road infrastructure-land use nexus. Figure 11 summarizes the conceptual framework for the study. Road infrastructure development results in changes in the uses of land in terms of increased vegetation, built-up areas, and decreased open/bare land. Land use conflicts such as land fragmentation, irregularity of land use and traffic snarl ups are due to road infrastructure development projects which do not conform or merge with the existing land uses. In order to develop functional road infrastructure, there is need to develop a land use management framework that encompasses both transport-oriented development planning and all-inclusive land use planning.

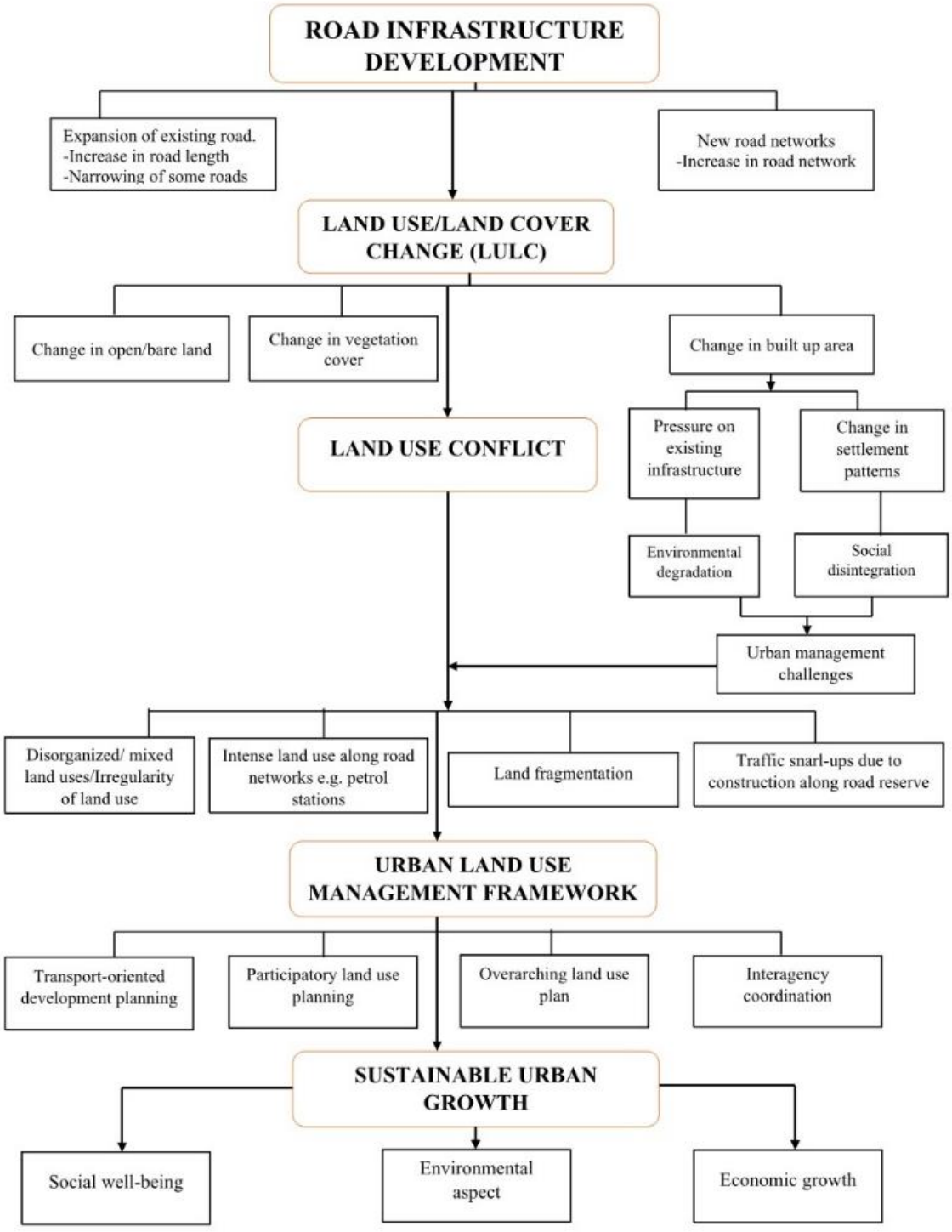

Figure 11: Conceptual framework

Source: Author

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The chapter looks at the methodological framework used in accomplishing the stated aim and objectives of the study. It covers the research design, study area, type and data sources and the procedure employed to accomplish the objectives of the study. The chapter focuses on the sample frame, the sampling technique chosen, data collection instruments, questionnaire design and methods of data measurements, analysis, and presentation and finally on the conclusion and recommendations.

3.2 Research Design

Descriptive and historical designs are used to describe each study variable. Qualitative and quantitative methods are used wherein qualitative method consist of collection of data using questionnaires administered to the study population. It conducts scheduled interviews with key informants such as the county government officers, physical planning officers, town administrators, development control officers, land developers and land selling agencies. A qualitative approach allows the researcher to account for changes in the development patterns within the study area based on first-hand data gathered from respondents and observation.

Quantitative methods involved the use ArcGIS data to generate land cover historical maps from 2009 to 2021 within the study area as it easily classifies various land cover data into appropriate categories for ease of analysis. A spatial model approach using time lapse series of land use/land cover maps is used to reclassify land cover into those classes that represent built up areas, bare land and vegetated areas. It also allows the demarcation of the study area and mapping out of road networks within the study boundary. Neighborhood summary statistics quantify data of the built-up area vis-a vie the circulation networks and explain the growth areas' categorization.

3.3 Study Area

3.3.1 Location of the study

The Eastern Bypass is 39km long and it commences on Mombasa Road at the City Cabanas Interchange (A104) in Nairobi County and ends in Kiambu County at the junction with Ruiru-Kiambu Road (C63). It crosses a rapidly developing urban area, whereby underdeveloped sections have been re-planned for developments such as residential and commercial. This study is conducted along the Eastern Bypass bound by geographical coordinates 1.1530460S, 36.9271000E to the north-west, 1.1688500S, 36.9775970E to the north-east, 1.1565380S, 36.9251330E to the south-west and 1.1757160S, 36.9727610E to the south-east using landcover/land use maps from 2009 to 2021. The study area (see Figure 11) is limited to a 6 kilometers stretch starting from the Kamakis area to the Northern Bypass junction and 400 meters from the road on either side.

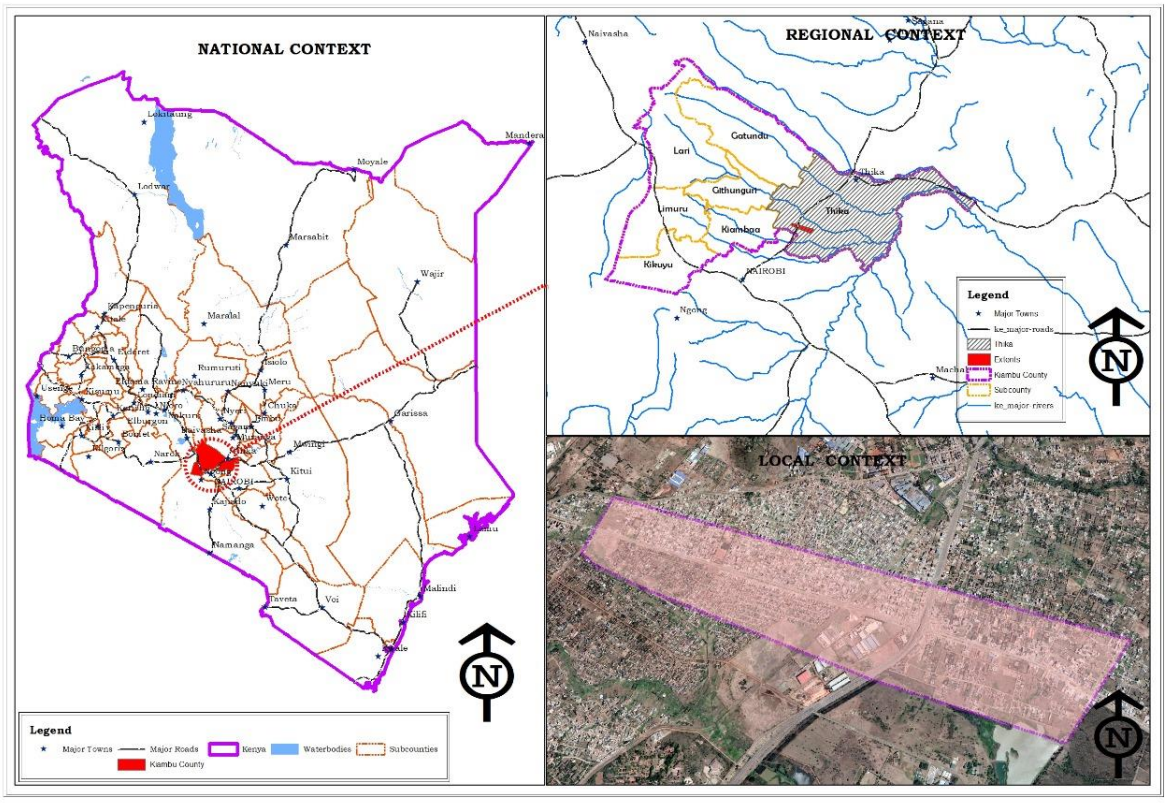

Figure 12: Summary of study area

3.3.2 Physiographic analysis

3.3.2.1 Topography & Slope Analysis

The Eastern Bypass (Figure 12), area which lies in Ruiru Subcounty, lies on the south-eastern edges of the Aberdare ranges that are in the Athi River Drainage Basin (County Government of Kiambu, September 2020). The area is characterized to the western boundary by relatively gentle terrain that slopes from 1,598m above sea level to 1440m above sea level towards the eastern periphery. The topography offers a good environment for residential developments and farming.

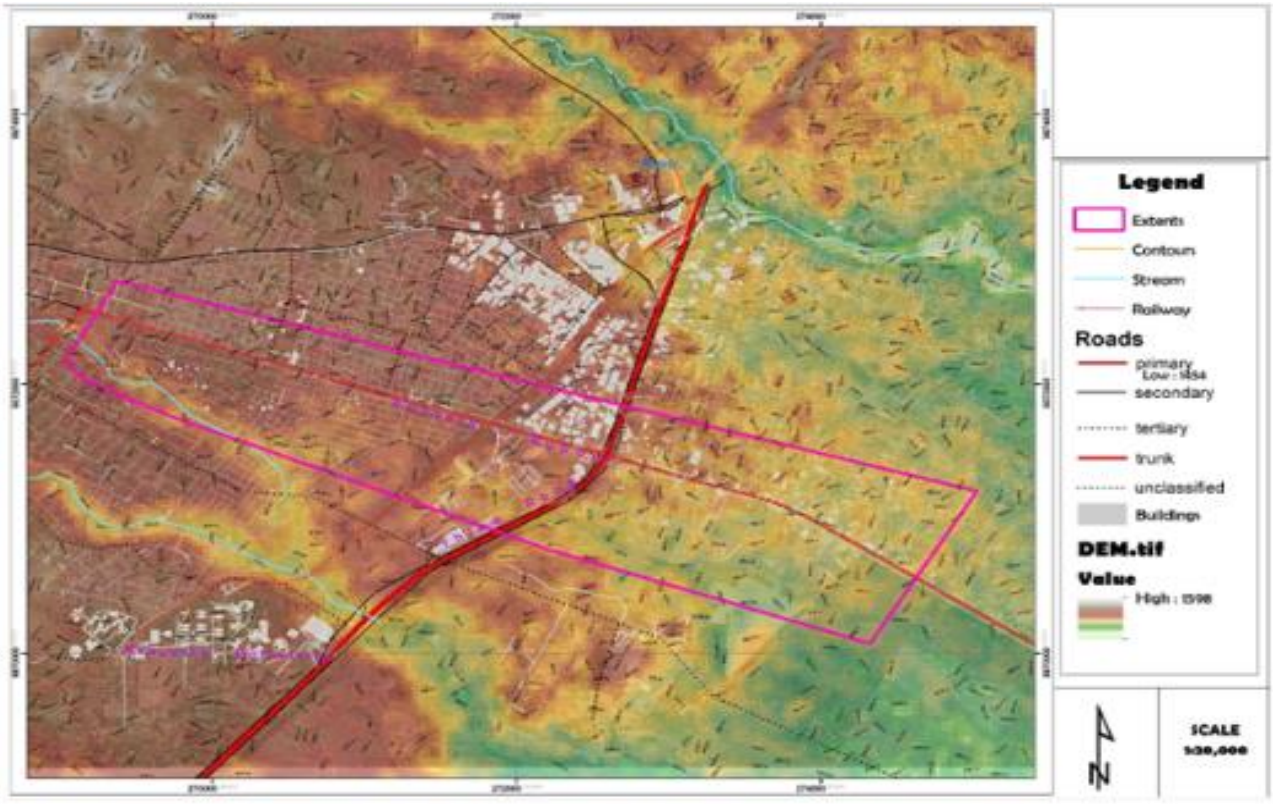

Figure 13: Topography and slope analysis

3.3.2.2 Geology and Soils

Geologically, Ruiru lies on Cenozoic volcanic material overlaying basement system rocks at greater depths. The geology of the Ruiru sub-county provides a good foundation for building construction and rich underground water reservoirs. When associated with adequate recharge, the volcanic rocks have a good water capacity (GoK, 2000). The area has a high prospective for underground water as there are several public and private boreholes within the study area (County Government of Kiambu, September 2020). The soil type is extracted from volcanic rocks that range from shallow to red clay, with patches of black cotton soils. Therefore, the soils have a high safe-bearing capacity, supporting, though at shallow depths, building foundations. The soil type also supports vegetation cover; therefore, advancing the suitability of the area for both agriculture and urban development.

3.3.3 Physical Infrastructure

3.3.3.1 Road networks

A total of 2,033.8 km of roads in Kiambu County are under bitumen standards, 1,480.2 km under gravel surface and 430.1 km under earth surface (KCIDP, 2018-2022). Ruiru Subcounty is well connected to the major national trunk road A3 Thika highway as well as two bypasses; the Northern Bypass and the Eastern Bypass (see Figure 13).

Secondary and tertiary road networks within the study area of the Eastern Bypass have increased in distance overtime with the distance coverage in the year 2009 being 61,186m, year 2015 being 75,446m and the distance increasing to 105,305m in the year 2021 as analyzed from the GIS time lapse series maps. This increase in road networks can be attributed to the subdivision of land to accommodate more development, therefore the need for provision of access to the individual plots.

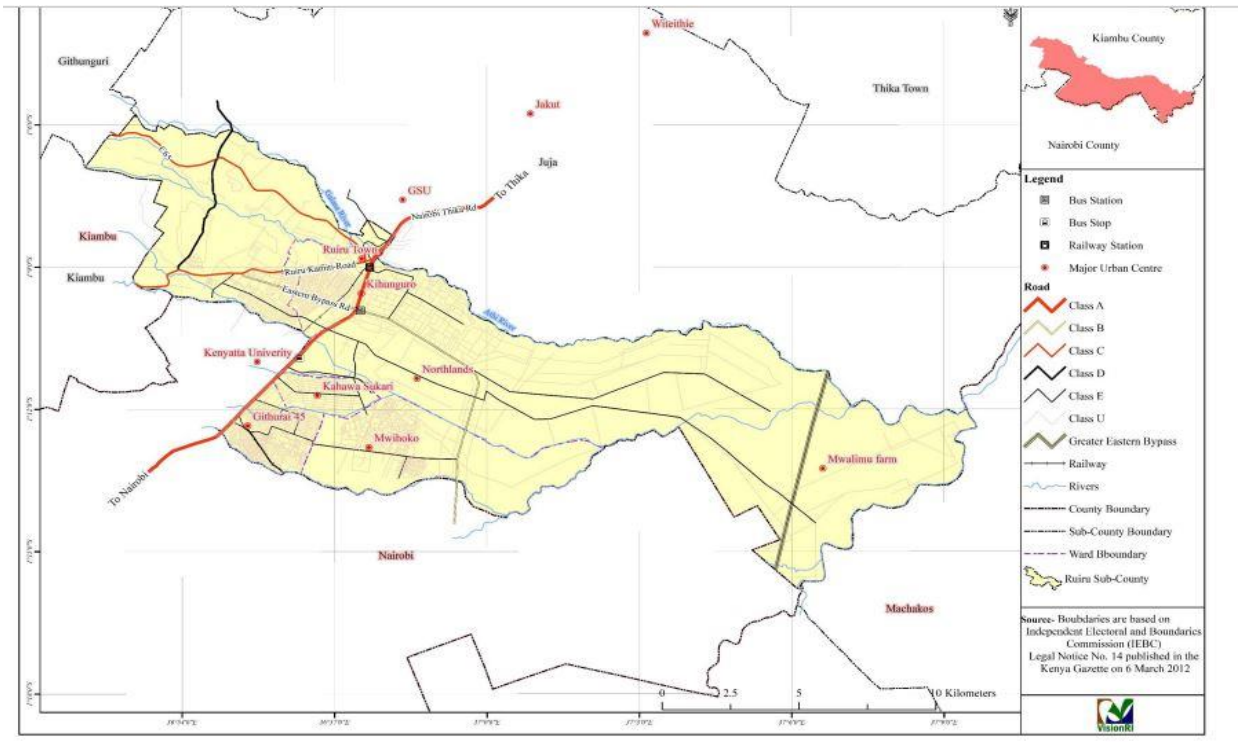

Figure 14: Ruiru Transportation Network

Source: Roads Department Ruiru Sub-County Road Report

3.3.3.2 Water Supply

Water supply within Ruiru Subcounty is from the Ruiru/Juja Water and Sewerage Company (RUJWASCO) at 46% of the households while 39% get water from public water points/water kiosks. Borehole services stand at 11% of the total water supply in Ruiru Subcounty (County Government of Kiambu, September 2020) (see Figure 14 and Figure 15). This is reflected in the study area of the Eastern Bypass as most households indicated that the water supply from the County Government is limited hence most opt for borehole water, whether from public or private suppliers.

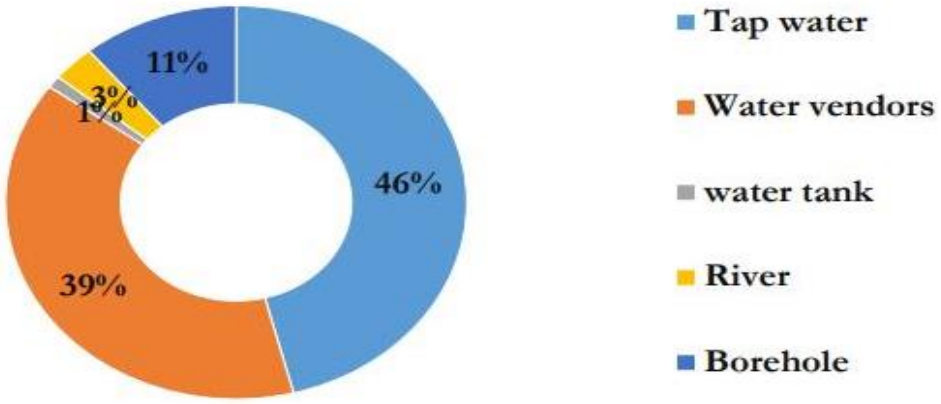

Figure 15: Source of Water

Source: RSNIP, 2017.

Figure 16: Overhead water tanks

Source: Field Survey.

3.3.3.3 Sewerage Services and Liquid Waste Management

The main sources of liquid waste in Ruiru are residential, commercial and industrial areas. The main mode of wastewater and disposal system within Ruiru includes pit latrines, septic tanks, and compost pits. It is reported that only 1% of the population in Ruiru Subcounty are connected to the sewer, 28% use septic tanks and soak pits, while 71% use pit latrines (County Government of Kiambu, 2015). Water pollution is experienced and this has been caused by the fact that clean water pipes have been

connected alongside wastewater pipes which have been connected from different facilities. Stormwater is also a major source of liquid waste (see Figure 16 and Figure 17). With the construction of the Eastern Bypass, the County Government of Kiambu has a proposed reticulation sewer line along the Eastern Bypass, which will be connected to other proposed sewer lines within the neighborhood.

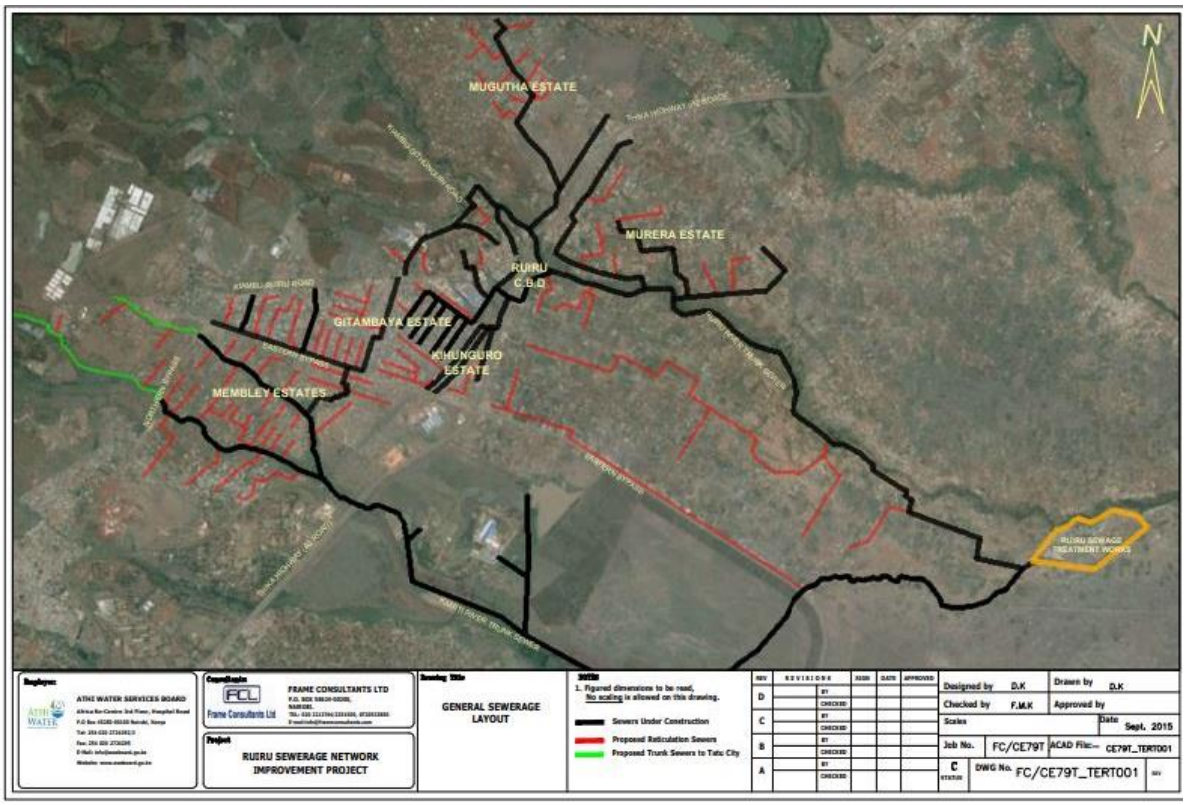

Figure 17: Sewerage layout

Source: Ruiru Sewage Network Improvement Project, 2017

(a) (b)

Figure 18: (a) Open waste disposal (b) Solid waste disposal along a swampy area

Source: (a) Field Survey; (b) Field Survey

3.3.3.4 Land tenure and Land Use

The ownership status of land along the Eastern Bypass is both public and private. In the study area, land use consists of residential dwellings; commercial uses are represented by retail businesses (shops, supermarkets, petrol stations, hardware, fast food cafes) to provide for residential neighborhoods and transit travelers. Entertainment joints are common around the Kamakis area. From a household survey done (see Figure 18 and Figure 19), various social places include malls, conference centers, and family entertainment spots. There are light industries such as Dr. Mattress, NKG Coffee Mills Kenya, and the Cape Business Park, which have attracted both skilled and unskilled labor and increasing traffic of lorries conveying and assembling goods from the industries. This has therefore increased snarl-up into the Eastern bypass.

(a) (b)

Figure 19: (a) Residential land use; (b) Commercial activities

(a) (b)

Figure 20: (a) Public open field; (b) Religious center

Source: Field Survey Source: Field Survey

3.4 Target Population

The study targeted residents along the Eastern bypass in Ruiru sub-county within Kiambu County. Kenya Population and Housing Census 2019 indicated that Kiambu County has a population of 2,417,735, with Ruiru sub-county having the highest population in the county with a total of 371,111 people (KNBS, November 2019). The study area of Ruiru has a population of 105,248 (KNBS, November 2019). This study covered the Eastern bypass and tertiary roads abutting the bypass. Satellite images of the study area are derived using Geographic Information System to reveal the existing land-use changes along the main road networks.

3.5 Sampling Technique

In this study, simple random sampling is used. The study groups the population into strata, that is, Ruiru Sub- County Planning Department, Urban development department, residents, business enterprises, and large-scale real estate developers. Sampling is unnecessary for the road networks, and the land uses because analysis of the road networks will be incomplete if not all the roads within the study area are included. The required data on existing roads is derived from a Geographic Information System and the Planning department based in Ruiru.

The population of Ruiru town in terms of residents is considered finite, and therefore, a sampling technique by the National Education Association is used (Krejcie & Morgan, 1970).

$$s = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

S= required sample size

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size (105,248 Source: KNBS).

P = the population proportion (assumed to be 0.5 since this would provide maximum sample size)

d= the degree of accuracy expressed as a proportion (0.05)

Therefore, the sample size for the study area is as follows;

[3.841x105,248 x0.5 (1-0.5) /0.05^2 (105,248-1) + 3.841^2x0.5 (1-0.5) = 382.71

Required sample size = 382

382 sample population are sampled out of the total population of 105,248 residents of the Ruiru Subcounty.

3.6 Data Collection

Data is collected from both primary and secondary sources. The primary data is obtained directly from respondents through structured questionnaires and accompanied by oral interviews of the Physical Planning Office, residents and dwellers of commercial properties within the study area. The secondary data sources include collecting and analyzing published materials and information from other sources such as publications, reports, institutional records, and government documents, including those from the Kenya National Bureau of Statistics. Details of road infrastructure are derived by analyzing satellite road maps in the study area.

3.6.1 Primary Data Collection Instruments

Primary data is collected using the following tools:

(a) Questionnaires: structured questionnaires in both open-ended and closed formats were used to gather data on the research objectives. Questionnaires were administered to the 270-sample population in the study area. Questions administered included information on access to water supply, solid waste management, sewerage services and access to electricity.
(b) Interview schedules: interviews were conducted with key informants to verify the information provided in the questionnaires. This data was obtained from the Physical Planning office in Ruiru Subcounty. Questions asked included the challenges they face in enforcing development control laws and measures that ensures compliance with the development control guidelines.
(c) Direct observation: this involved the visual study of the behavior of the individuals and the surrounding areas to understand better the physical attributes of the study area, such as the conditions of the road networks. Data was collected on drainage, solid waste disposal, existing power lines, the physical characteristics of the road-type of road finish material which was majorly murram, storm water drainage channels and pedestrian access.

3.6.2 Pilot Testing and Reliability of the Instrument Process

20 residents, who had been randomly selected a week before the study was done, took part in the pilot study. This allowed for scrutiny of the research instruments beforehand. However, the data collected

from the pilot survey were not part of the data analyzed. The pre-test helped the researcher identify the most likely source of error and respond to them before the actual study was done. The researcher used the delayed response technique, whereby the instruments were given to the respondents, and a follow-up question was asked to verify the same question. The researcher then compared the responses.

3.6.3 Data Collection Procedure

One-on-one assessment through observation of the physical characteristics of the road infrastructure, such as the conditions of the road and whether the roads are tarmacked or not and photographs were used to store the evidence for further analysis. Six trained research assistants helped in administering questionnaires to the sample population. Face to face interviews were used in gathering qualitative data from the key informants.

3.7 Ethical Considerations and Confidentiality

While conducting this research, the researcher considered various ethical issues that were of most significant concern and highly considered. The researcher declared that individuals participating in the research are treated as anonymous agents to preserve respect for persons. The researcher indicated that the interviewees receive full disclosure of the nature of the study and alternatives with an extended opportunity to ask questions. Regarding issues of justice, the researcher ensured that there is fairness in all the data collection processes in terms of the selection of participants.

3.8 Data analysis and Results Presentation

Data collected from household questionnaires are both quantitative and qualitative. Qualitative data is coded and converted to quantitative data for analysis. Quantitative data is subjected to descriptive statistics and the findings presented in frequency tables, pie charts, histograms, bar, and line graphs. Two sets of data are collected, namely, data on road infrastructure networks and data on land cover/land use. In analyzing the data, several techniques are used; line density estimation model, road network expansion rate, graph-theoretic approach, descriptive analysis and spatial statistics model.

3.8.1 Road Network Line Density Estimation Model

A road network density map is generated to help estimate road network spatial distribution and concentration with the type of land use found in the area of study. Line density estimation model describes the solidity of the linear features in the study area. The study involves the spatial distribution of the road networks, whether the road networks are distributed evenly across the study area, and where the aggregation points are. The length of all the road networks that falls within the study boundary is established and it is divided by the land area, and the various land uses neighboring the area are determined. This helps predict the relationship of the road infrastructure networks in terms of density visa vis the land-use practices. The calculation formula by (Shi & Shan, June 2019) is as follows:

$$LD_i = \frac{\sum_1^n L_k}{A}$$

Where LD_i is the road network line density in year i

L is the length of the portion of roads that falls in the unit k

A is the area of total unit

3.8.2 Road Network Expansion Rate

The road network expansion rate of the study area is calculated by measuring the total change of the road network in the study area. If the road expansion network rate is beyond zero, the corresponding research period is experiencing an expansion time. If the value is below zero, it is experiencing a loss period. This therefore indicates the relationship between road infrastructure growth and expansion with the changes in land use. This also includes the rate of modification of a certain type of land use, that is, change in intensity of land use activities within the study area and helps predict the growth rate of road infrastructure and, therefore, better planning of the land use activities. The calculation formula by (Shi & Shan, June 2019) is shown below:

$$ER = \frac{RL_{n+i} - RL_n}{i}$$

Where *ER* is the road network expansion rate from year *n* to year *n* + *i*

RL_{n+i} is the total length of road network in year *n* + *i* in kilometer

RL_n is the total length of road network in years *n* in kilometer

3.8.3 Overlay Analysis Model

In order to establish whether the land has been converted from one use to another, that is, change in the mix and patterns of land use, temporal studies were carried out using digital satellite imagery to determine the various land cover/land-use changes, and the data tabulated to establish the area percentage within a range of time with relation to road infrastructure. Remote sensing techniques and Geographical Information Systems (GIS) were used in this study to track various land-use changes over 14 years period. This was done using Landsat Data to establish a relationship between the two variables and if they can be represented in a predictive context. This relationship can be used to estimate land-use responses to road infrastructure. Spatial overlays of superimposed data sets were done using GIS to extract information on urban expansion within the study area to understand the relationship between the variables.

3.9 Methods of Measuring and Analyzing Data

Table 1: Summary of techniques & modes of measurements of study objectives

S/N	Objective	Indicators to measure	Intervening parameters	Mode of Analysis
1.	To investigate the extent to which road infrastructure development affects land use/land cover along the Eastern bypass.	Land use/land cover	-Change in vegetation cover -Change in the built-up areas -Change in open/bare land	-Land Use/Land Cover GIS images. -Field observations. -Survey maps, interviews & questionnaires.
2.	To establish land use conflict driving forces that emerge from road infrastructure development along Eastern bypass.	-Land fragmentation. -Disorganized /mixed land uses -Traffic snarl-ups	-Change in road length. -Change in road network expansion rate.	-Land Use/Land Cover GIS images. -Road Network Expansion Rate -Site survey -Key Informant Interview -Household questionnaires
3.	To recommend medium-term urban management framework that will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects.	People-based and place-based policies and frameworks	-Policy framework on land subdivision -Development policy of inter-regional homogenous land use management framework. -Land use conversion policies	-Studying of existing policies and framework. -Comparison Analysis

CHAPTER FOUR: RESULTS, FINDINGS & DISCUSSIONS

4.1 Introduction

The purpose of this chapter is to present the findings from the collected data using ArcGIS time series data on land use/land cover changes and Road Network Expansion Rate analysis from ARC 1960 on time series and road overlay lengths within the study period. Data collected from administering household questionnaires, checklists, key informant interviews, and observations are also presented. The data that was already collected is then analyzed to ensure that the findings are in line and are able to respond to the objectives of the study as well as the main study questions It demonstrates results, findings and discussions on: extent to which road infrastructure development affects land use/land cover along the Eastern bypass, land use conflict driving forces that emerge from road infrastructure development and it recommends medium-term urban management framework that will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects along the Eastern Bypass.

4.2 The extent to which road infrastructure development affects land use/land cover along the Eastern bypass.

Land cover time lapse mapping was done for the period of 2009, 2015 and 2021 in order to determine the extent to which road infrastructure development affects land use/land cover along the Eastern bypass. Data was collected on the built-up areas, vegetation cover and bare land for the three-time lapse series. Most of the changes that were witnessed on land use within the specific area that was under study can be attributed to the road infrastructure development as per data collected on the time lapse series. This is due to the fact that people want to settle and develop near road networks due to ease of access to goods and services.

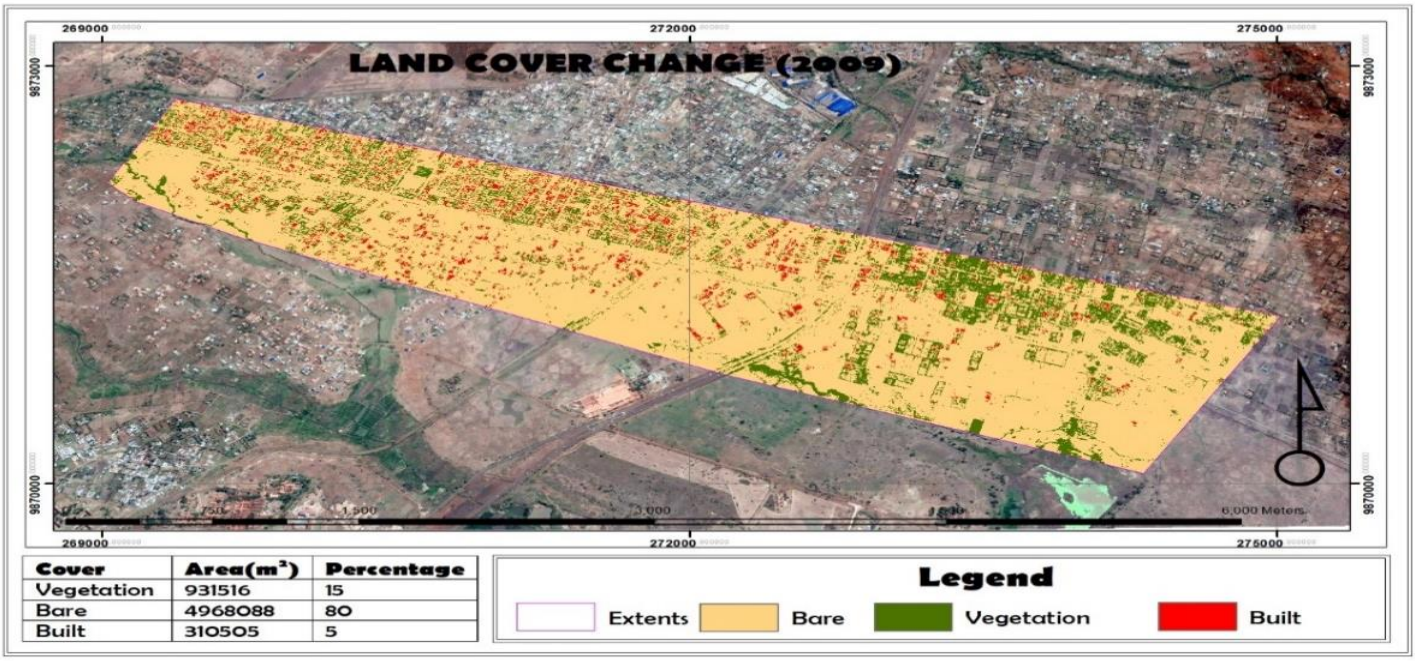

Figure 21: Land cover change for 2009

For the year 2009, the built-up area covered 5% of the whole area that was under study while vegetation cover and bare land covered 15% and 80% respectively as shown in Figure 20. This is the period when the Eastern Bypass construction commenced in the year 2009 and commissioned in 2013. The settlements are more scattered within the study area.

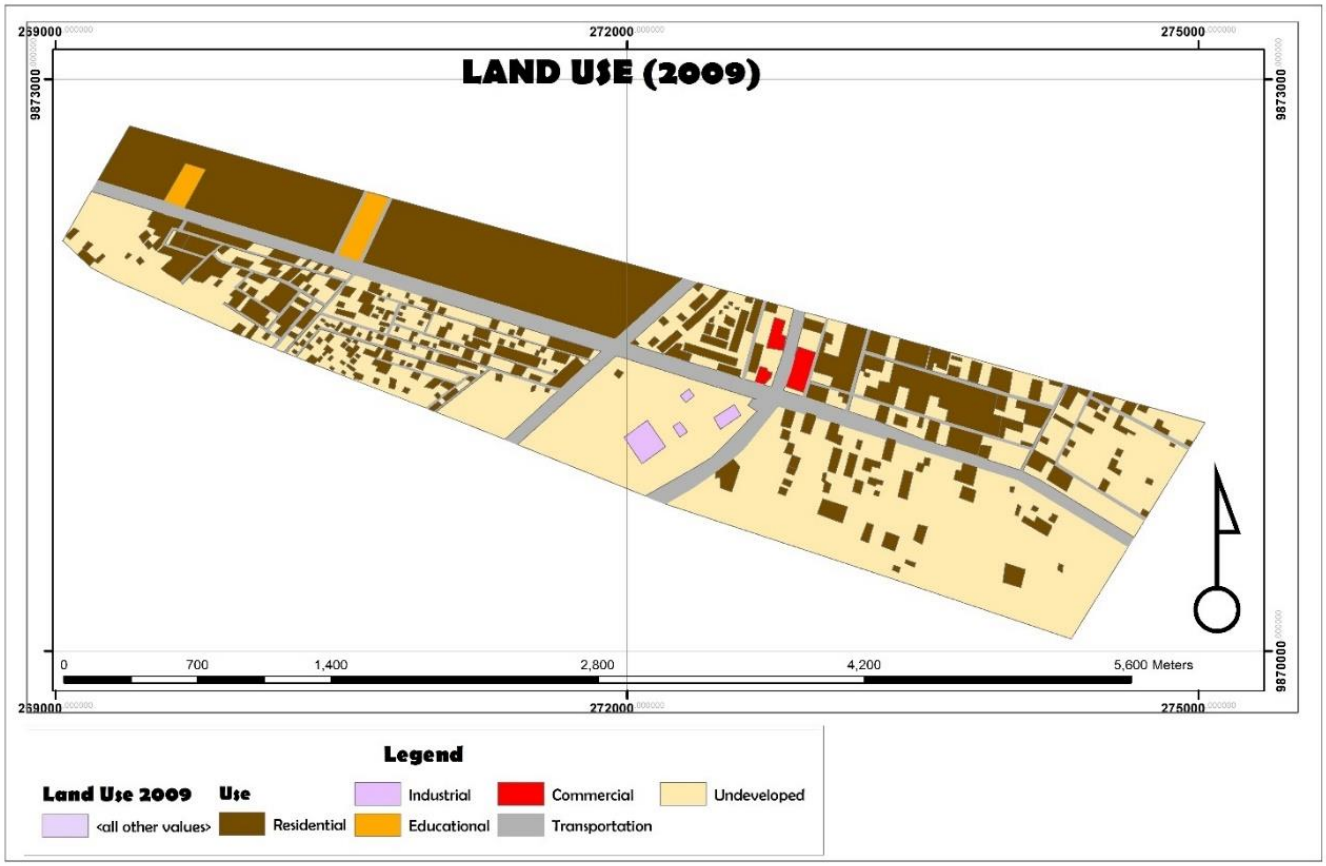

Figure 22: Land use change for 2009.

The existing land use for the year 2009 is in tandem with the land cover for the same period as indicated in Figure 21 whereby the most predominant land use is residential areas with minimal commercial land use and more open/undeveloped land.

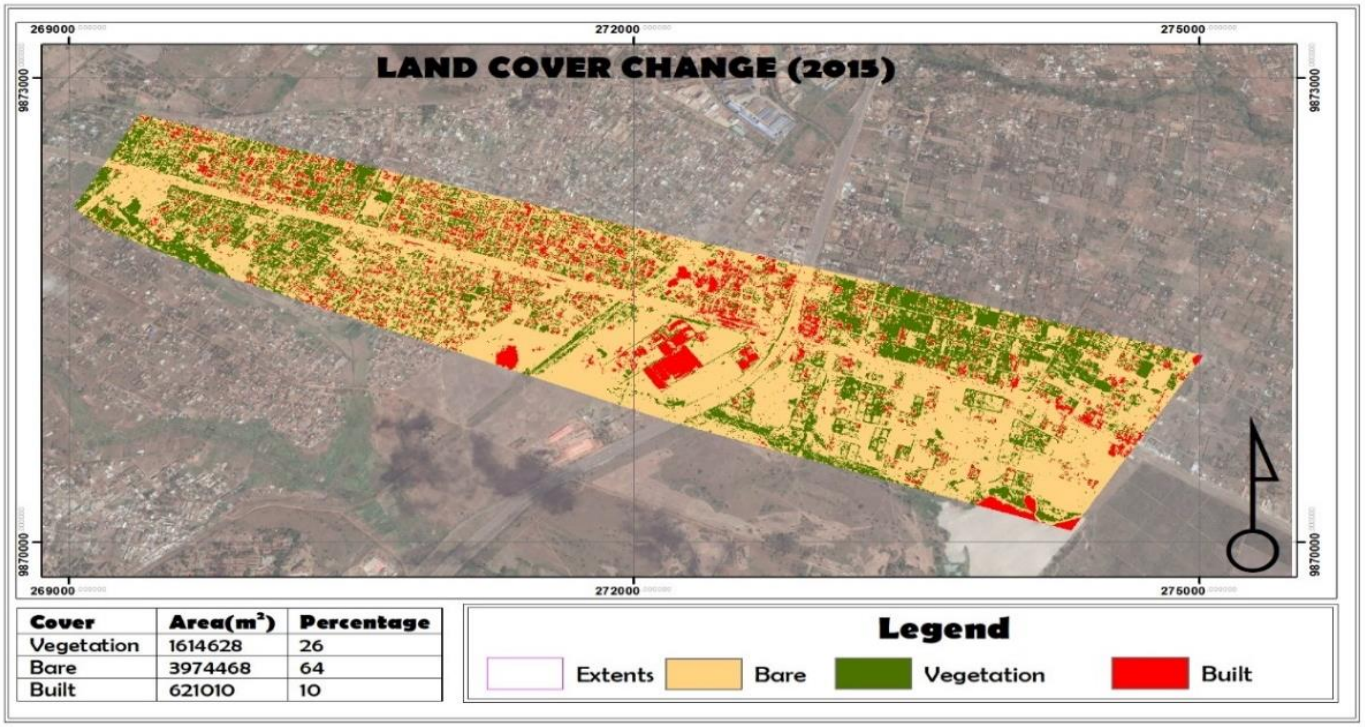

Figure 23: Land cover change for 2015

The study findings for the year 2015 established that the built-up area covered 10%, the vegetation cover constituted 26% while the bare land covered 64% of the total study area as shown in Figure 22. This is an indication of an increase in the built-up area from the previous year of study as well as the vegetation cover while the bare land reduced in 2015 compared to the year 2009. This can be attributed to the fact that the Eastern Bypass was already in use and therefore it attracted more human settlements and therefore, the bare land that was initially available was converted to built-up areas, and this also encouraged an increase in vegetation cover as people desire to live in areas with green cover hence plant trees in their various plots. The map shows a more concentrated linear pattern of development in various points along the Eastern bypass.

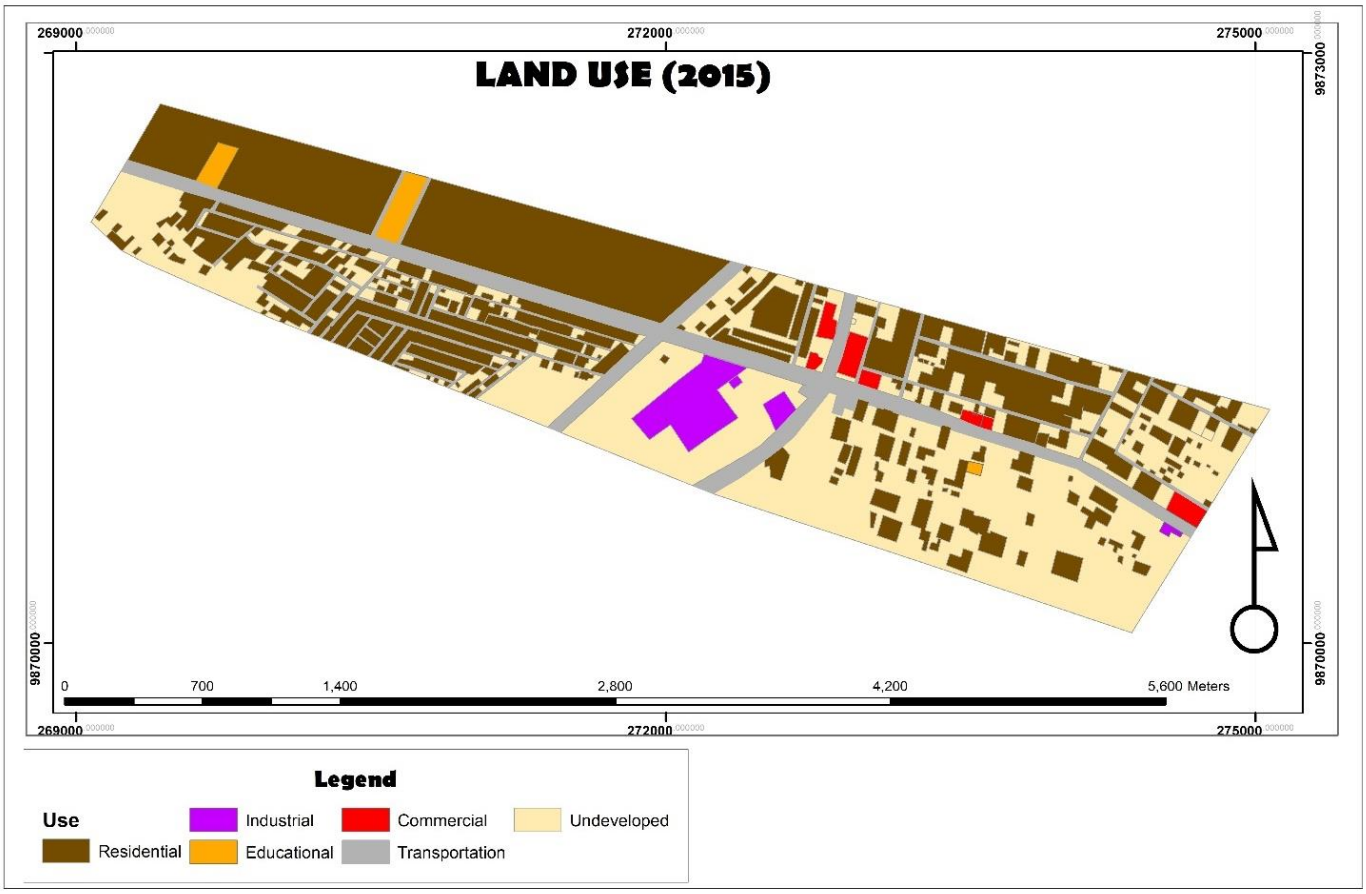

Figure 24: Land use change for 2015.

Figure 23 shows the land use mapping for the year 2015 also indicated a change in the trend of the land uses as more areas were developed and there is a clear indication of land fragmentation as the developments followed a linear pattern along the road networks. Apart from the initial residential land use, more land uses are becoming predominant during this period such as industrial and commercial land uses which are seen to follow the Eastern bypass.

Figure 25: land cover change for 2021

In the year 2021, there was a substantial increase in the vegetation cover which constituted 44% of the total area of study, built-up areas also increased to 16% while bare land decreased to 40%, a significant dwindle which is attributed to more buildings that were constructed on the initially bare land (see Figure 24). Significant urban growth is seen to occur as the clustered built-up areas that were there in the year 2009 are seen to conglomerate and are almost joining. Urban sprawl is experienced in all directions as more development patterns follow the road networks.

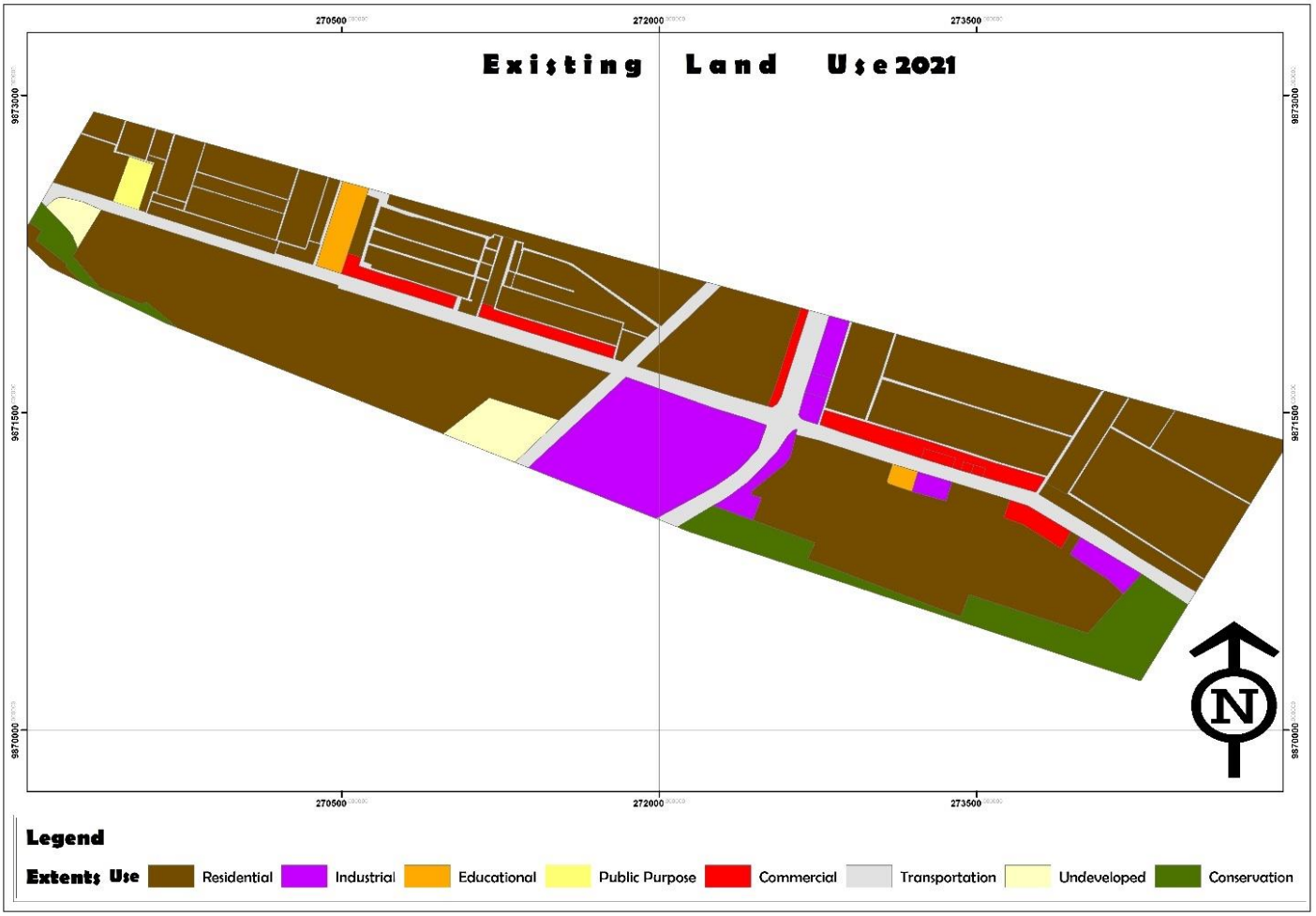

Figure 26: Land use change for 2021

Land use change for the year 2021 is characterized by more intense development along the road networks as shown in Figure 25. As a result of land fragmentation, everybody wants to buy land next to the road and this creates a linear development along the road corridors. Commercial businesses are seen to develop on land along the road networks as they can afford the value of land in these areas. Industrial land uses are also seen to be predominant along the Eastern bypass as compared to 2009 when the industrial activities were very minimal. The percentage of residential developments also increases in 2021 as well as educational facilities.

Discussions

Figures 20, 22 and 24 shows the summary of changes in land cover between 2009, 2015, and 2021. The findings for the study period of 2009, 2015, and 2021 indicated a change in land cover due to the development of road infrastructure projects. This can be seen by the projected increase in the built-up area from 5% to 10% and eventually to 16% during 2009, 2015, and 2021 respectively. This is an indication that as road infrastructure development increases, the need for construction also increases. This increase in the built-up area is inversely proportional to the bare land, whereby the study findings indicated that bare land has decreased from 80% to 40% between the years 2009 and 2021. This implies that built-up areas increase as the road network increases and the bare land reduces. This indicates that people converted their bare land to accommodate buildings due to the increase in businesses (leading to an increase in buildings for businesses and residents) as this was when the Eastern Bypass was in use, hence taking advantage of the new road infrastructure. Vegetation cover also increased from 15% in 2009 to 26% in 2015 and 44% in 2021. This increase is attributed to the fact that humans desire to live in a vegetated area; thereby, as the built-up area increases, the green cover also increases since they plant trees within their properties and also due to the need to put the land to productive use if there is no capital for erecting buildings. These observations are visible in Figures 21, 23 and 25.

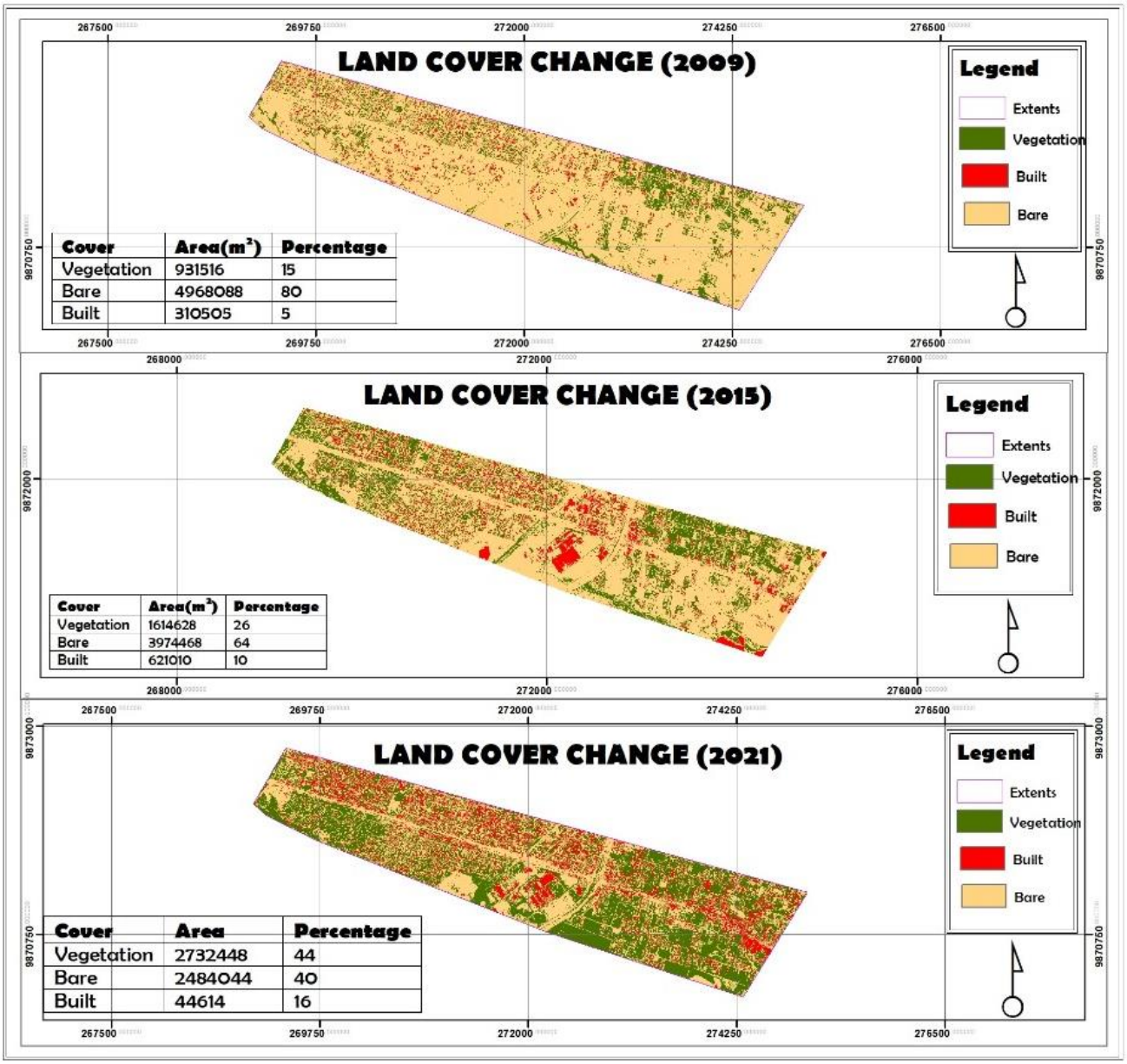

Figure 27: Summary of extract of land cover.

Table 2, Table 3, Figure 27 and Figure 28 indicate the summary for the land cover change between the year 2009, 2015 and 2021. The vegetation and built graph show increments throughout the study period. This implies that the road network increases the bare land reduces. This is due to the increase in businesses (leading to an increase in buildings for businesses and residents). The vegetation also increases due to the need to put the land to productive use if there is no capital for erecting buildings. It is common practice to have every developer try to green an area they are settling on, and therefore vegetation growth is directly related to human settlement. This significant growth in the built-up areas between 2015 and 2021 is influenced by infrastructure improvement which occurred within the same period in the region.

Table 2: Summary of land cover analysis

		2009 land cover		2015 land cover		2021 land cover	
Land Cover	Code	Area(ha)	%	Area(ha)	%	Area(ha)	%
Vegetation	1	931516	15	1614628	26	2732448	44
Bare	2	4968088	80	3974468	64	2484044	40
Built	3	310505	5	621013	10	993617	16

Table 3: Average percentage growth rate of land cover

	Change between 2009 and 2015	Change between 2015 and 2021	Change between 2009 and 2021
Vegetation	73.33	69	193
Bare	-20	-37	-50
Built	100	108	220

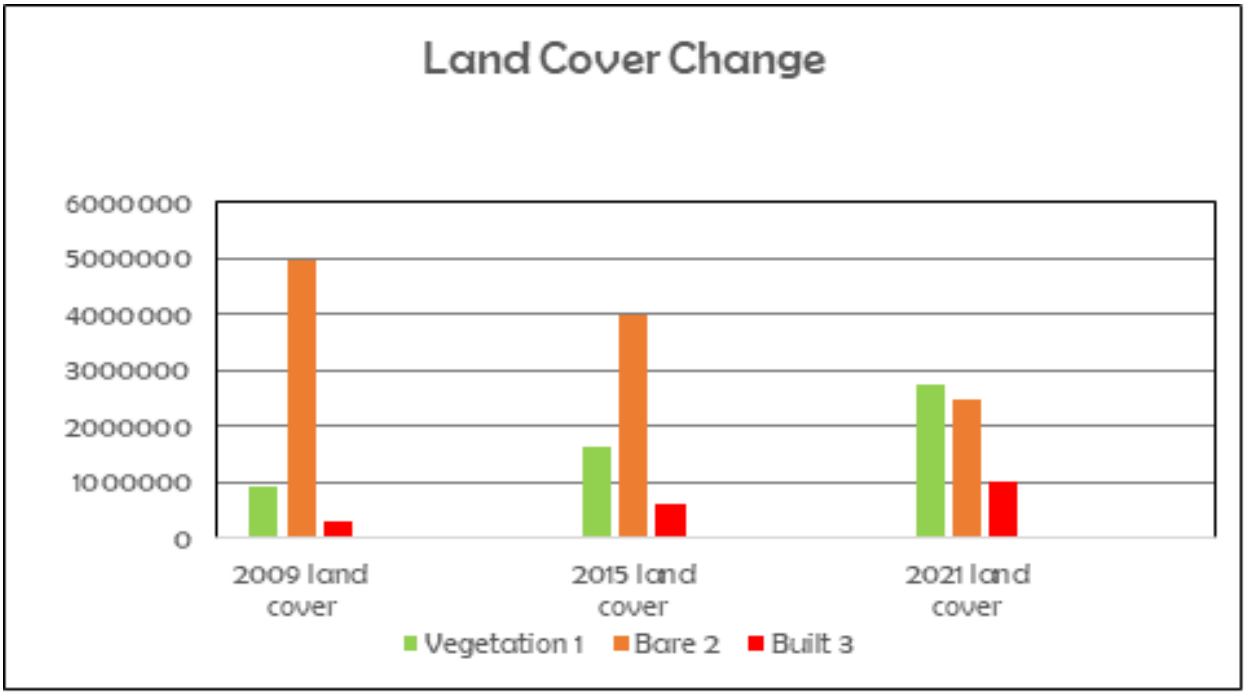

Figure 28: Graphical representation comparing Land Cover Change in 2009, 2015 and 2021.

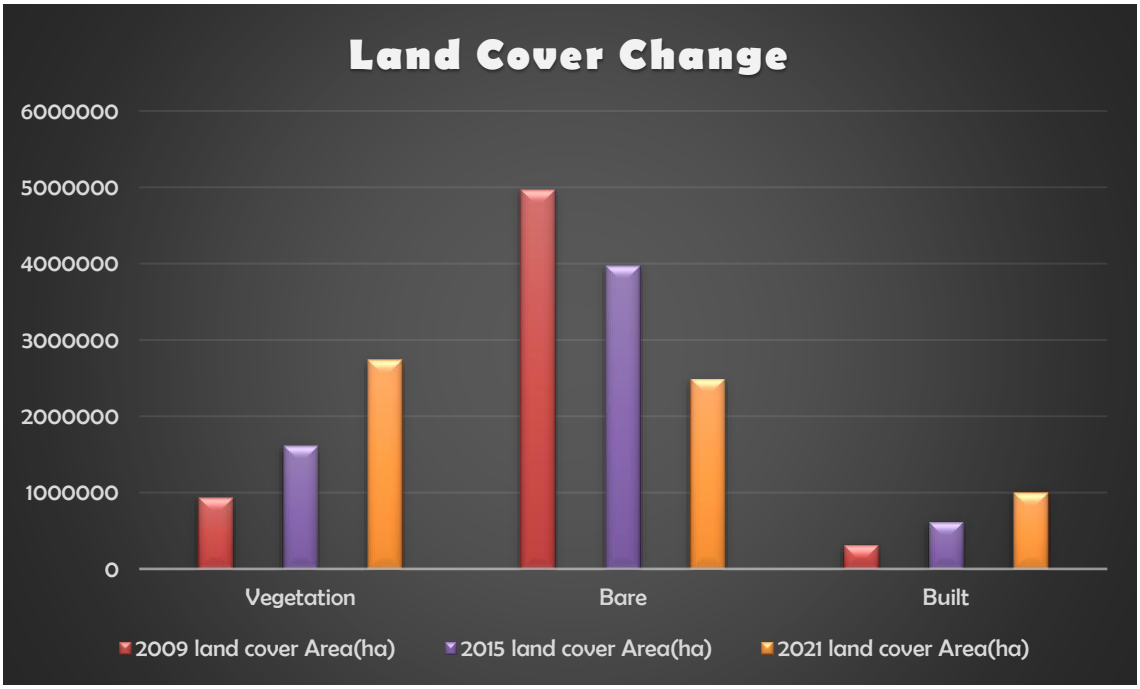

Figure 29: Graphical comparison of land cover change based on vegetation, bare and built area in 2009, 2015 and 2021.

4.3 To establish land use conflict driving forces that emerge from road infrastructure development along Eastern bypass.

The study area is well served by inter-county road linkages that include the Eastern By-pass which starts from Mombasa Road to Ruiru. This links with the Northern By-pass which starts from Ruaka to Ruiru where it meets the Eastern By-Pass. Thika Superhighway also traverses the site. The site has grown over the past few years in terms of infrastructure development with the Eastern bypass and Thika road being constructed in 2010. This has had a major effect on the land use changes and development patterns with people rushing to develop residential and commercial properties along this trunk road infrastructure.

There has been a major growth in the road infrastructure in the area of study over time. Within the period of study, the stretch of the road networks within the area of study was estimated to be 61,186m in 2009. This increased in 2015 to 75,446m and further to 105,305m in 2021 as shown in Table 4. This significant increase on the road networks has added to the land use changes within the study area as the road networks attract various activities and therefore, their improvement ultimately triggers changes to the land use. The general physical state of the roads are in a good condition, with most of the all-weather road having been graded and with well compacted murram finish and drainage.

Table 4: Road networks and its change over time

Year	Roads (metres)
2009	61186
2015	75446
2021	105305

Table 4 summarizes the roads growth patterns between 2009, 2015 and 2021. The graphs show the increase in roads growth pattern from 2009 to 2021. The average percentage growth rate between 2009 to 2015 is 48%. This rate reduces to 39% between 2015 to 2021, but still depicts growth in the road lengths. The increase in the lengths of the road networks between 2009 to 2021 is 72% which is a significant change. With such growth, land use conflicts emerge as urban sprawl is experienced in the study area.

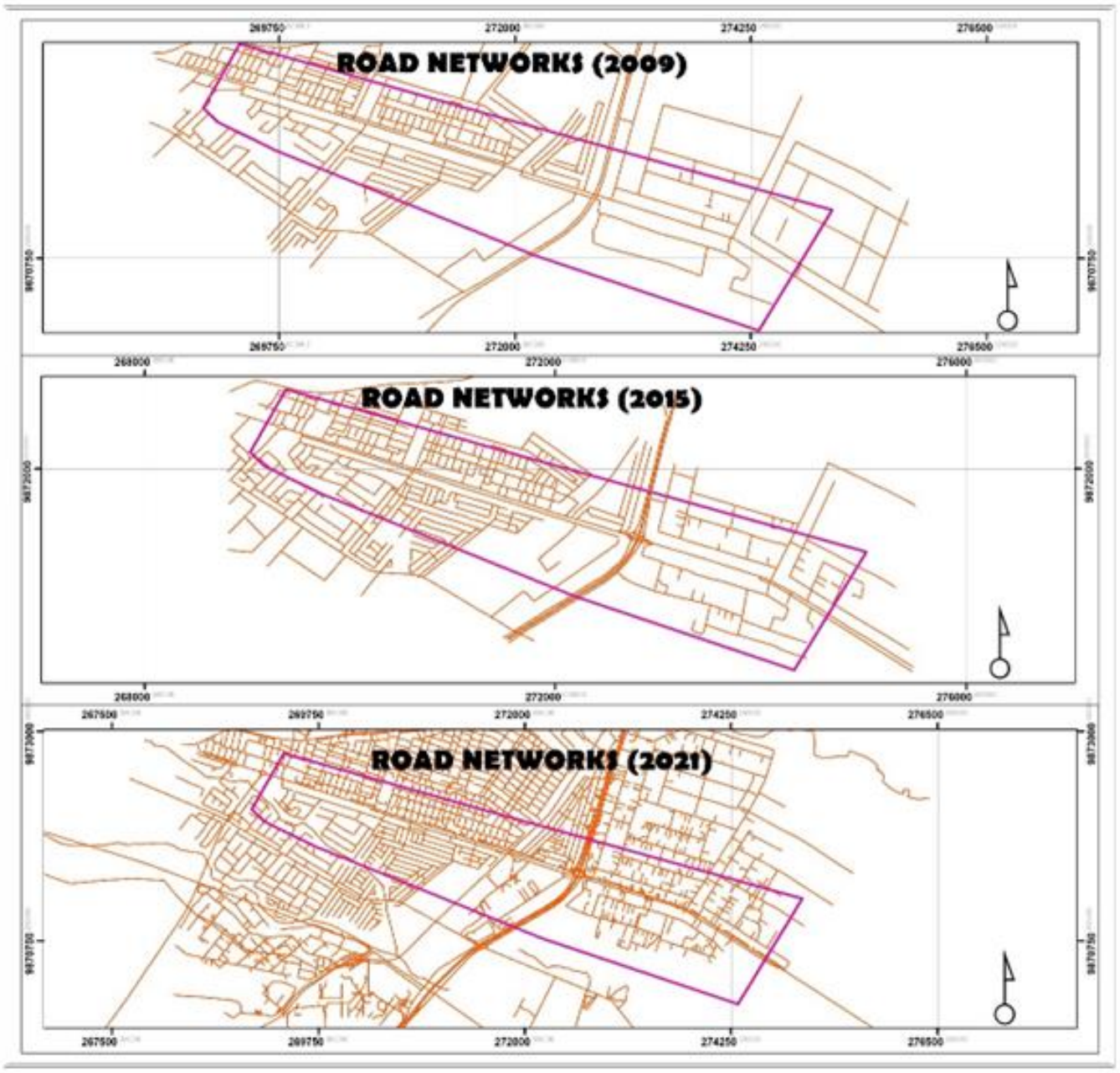

Figure 30: Comparison of roads network.

Figure 29 indicates the road network growth patterns between 2009, 2015 and 2021. There is an increase in the stretch of the road networks through the period of study. The road networks form a linear pattern which encourages linear development.

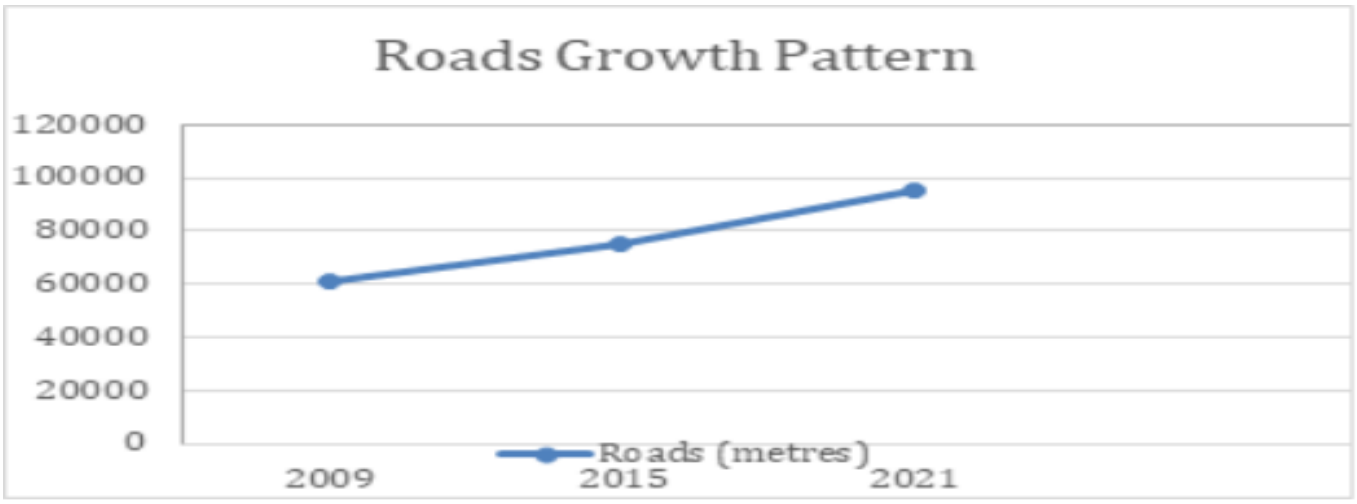

Figure 31: Road's growth pattern.

A road network overlay was done in order to visually understand the transformation of the road infrastructure in the area of study within the specified period as shown in Figure 31. The black lines represent the road networks in the year 2009, orange lines represent the year 2015 and the blue lines represent road networks for the year 2021. From the road overlay, there is a significant change in the length of the road networks within the period of study, a clear implication of the impact of the Eastern Bypass on the development of other tertiary roads, hence changing the land uses within the study area.

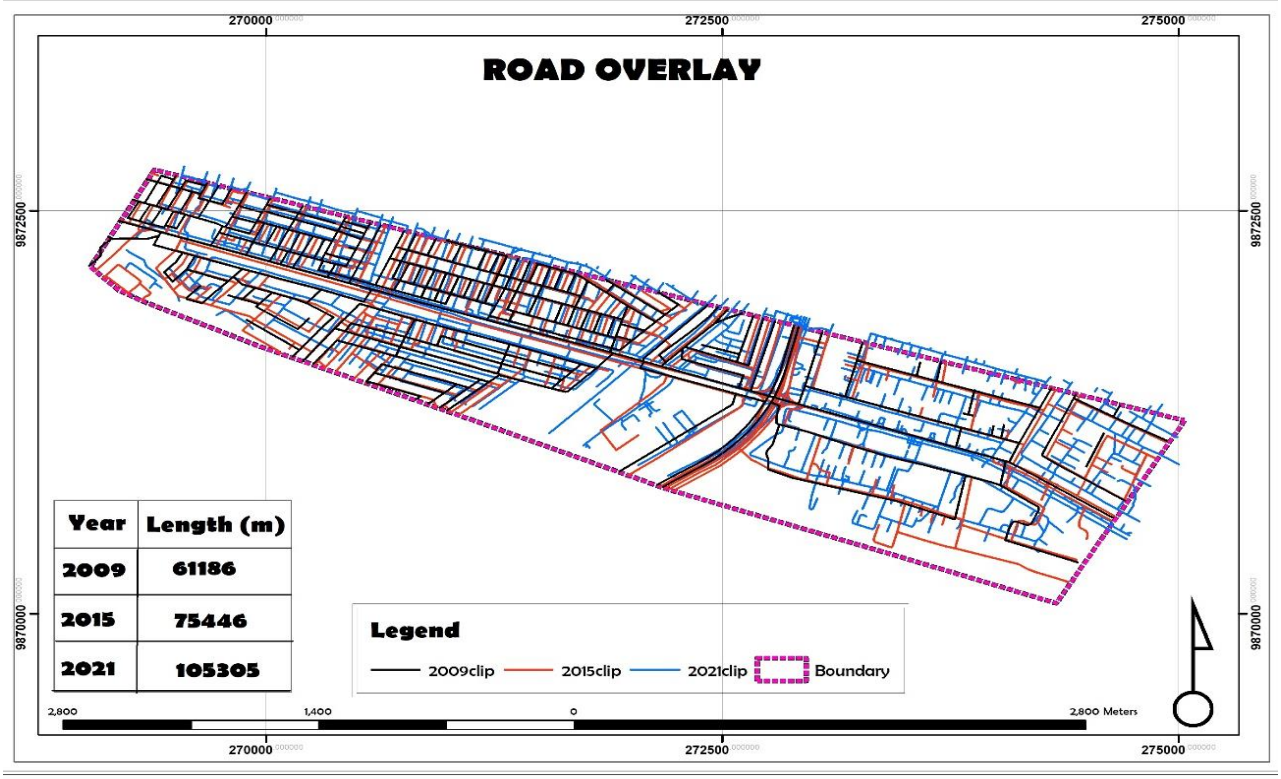

Figure 32: Summary of roads overlay.

From the maps, there is a clear indication of road network growth. This growth has encouraged development within the study area hence the urban area has sprawled towards agricultural land.

Figure 33: Up-close view into the development pattern around the road networks.

An up-close view into the road network growth in the year 2009, 2015 and 2021 indicates an increase in the built-up areas and this is in tandem with the road networks which has also increased throughout the study period as shown in Figure 32.

Household findings

Household data was collected from 382 respondents on the various aspects of land use within the study area. 303 respondents returned the questionnaires. This translates to questionnaire return rate of 79.32%,which is more than the recommended return rate of 70% by Mugenda and Mugenda (1999). Demographic data on gender, respondents age and area of residence were collected.

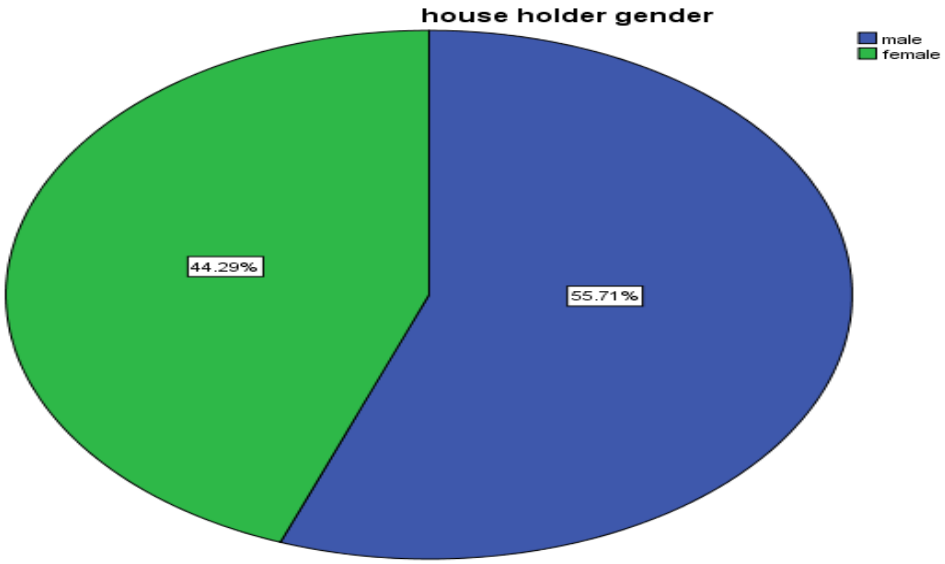

Figure 34: Respondents gender

The pie-chart shows the male respondents were the majority accounting for 55.71% and rest female.

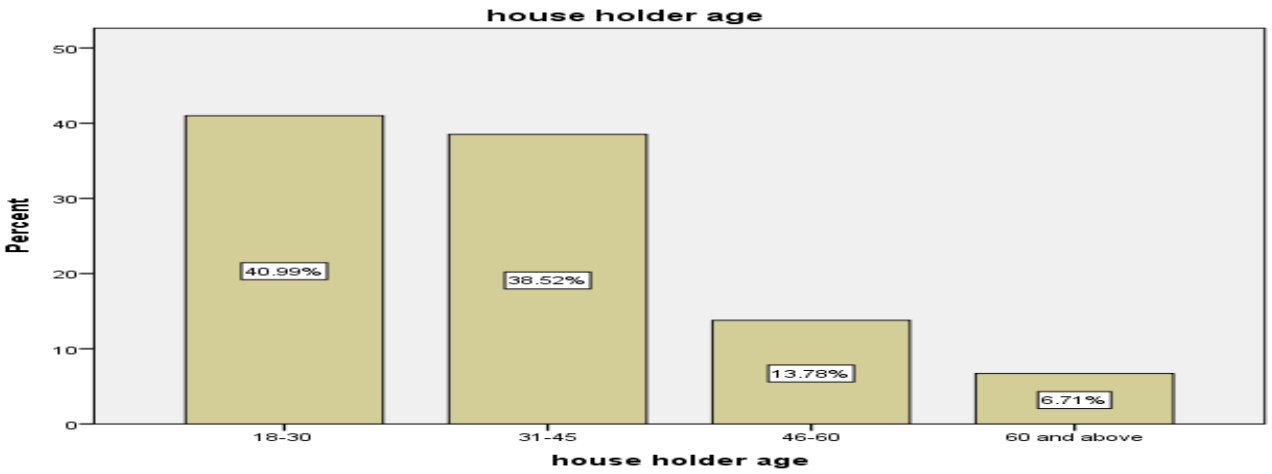

Figure 35: Bar graph of respondent's age

Figure 34 shows that most of the respondents noted that their households had the majority in the age group of 18-30. The second largest category of the house hold age is between 31 and 45 years while minority are above 60 years.

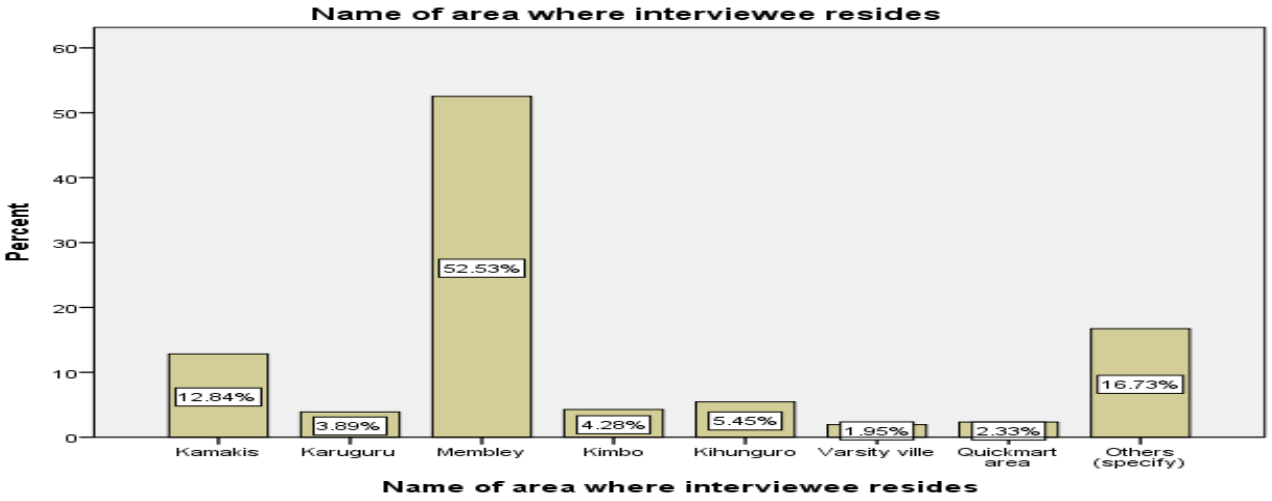

Figure 36: Bar graphs of the respondent's area of residence.

Figure 35 indicates that most of the respondents reside in Membley, while the minority in Varsity Ville. 16.73% did not specify where they reside, which points to a possibility they reside outside the study area. This portion might be those who only come to work in the area. The total number of respondents who answered the question on the area of residence was 257. The response had a standard

deviation of 2.202, which is greater than 1 showing the sparse distribution of respondents' area of residence.

4.3.1 Effects of land fragmentation

On land fragmentation, large tracks of land that were meant for agricultural use have been subdivided into smaller plots to allow for sale of land. This is evident in the land cover analysis for 2009 and 2021 where the initial large parcels have been fragmented into smaller plots. In order to access these properties, more road networks are constructed and everybody wants to buy land next to the road. Household findings on the type of houses that respondents live in indicated that majority, 50.82% noted that they lived in flats/apartments as shown in Figure 36. This is an indication of land fragmentation as these plots have been subdivided to cater for dense residential settlements.

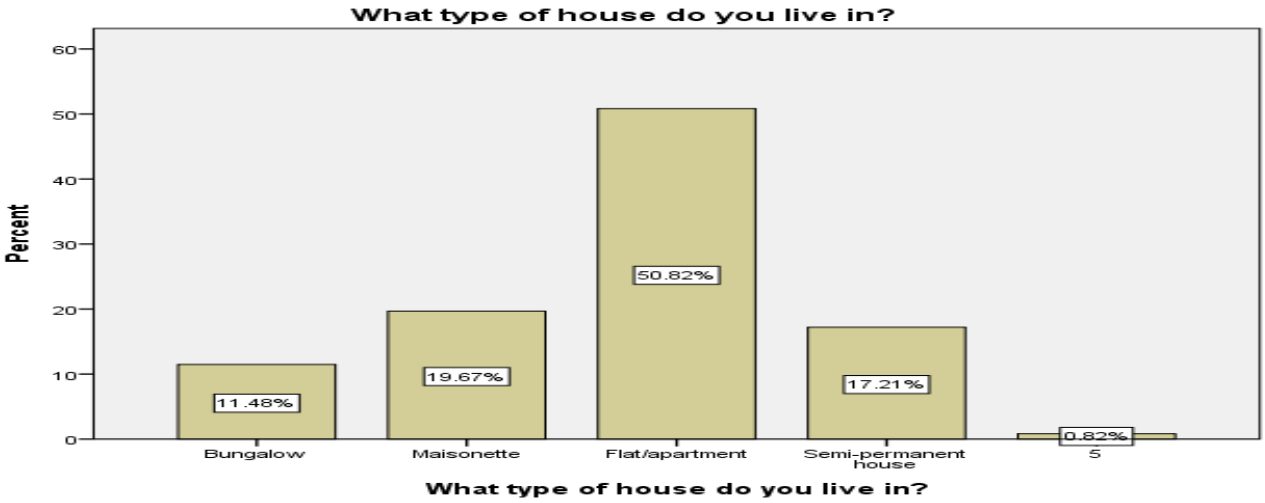

Figure 37: Type of house

The number of respondents who answered the question on the type of house they live in was 244. The response had a standard deviation of 0.899, which is less than 1 showing the less sparse distribution of respondents' type of house they live. This indicates the majority of the response is uniform.

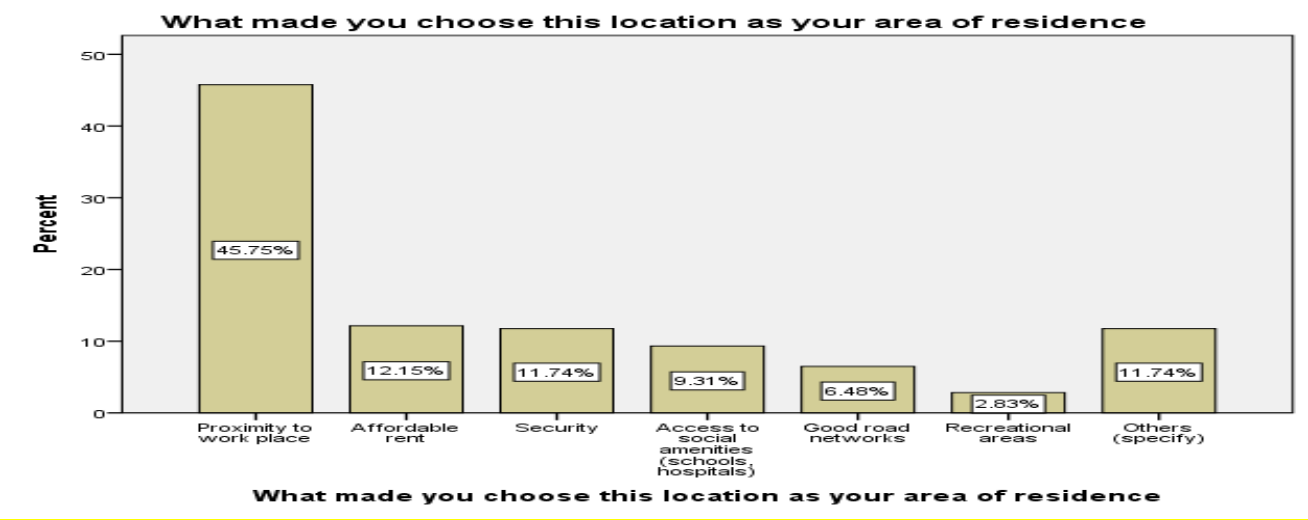

Figure 38: Location of area of residence.

When the respondents were asked why they chose the location of their residence, Figure 37, shows the majority, 45.75%, noted they chose it due to proximity to their workplace. The minority choose it because of the recreational areas. 11.74% choose it because of other reasons that are not specified. The total number of respondents who answered the question on what made the respondent chose the location as area of residence was 257. The response had a standard deviation of 2.095, which is greater than 1 showing the sparse distribution of respondents' chose of area of residence.

Land fragmentation also comes with increased population. This ultimately leads to pressure on the available amenities, which in real case are to cater for a certain number of users. With this increase in population, pressure is exerted on amenities such as power supply, solid waste management, water supply and sewer facilities, therefore, the researcher sought to analyze the level of satisfaction of the services and to establish whether Eastern bypass has affected these services.

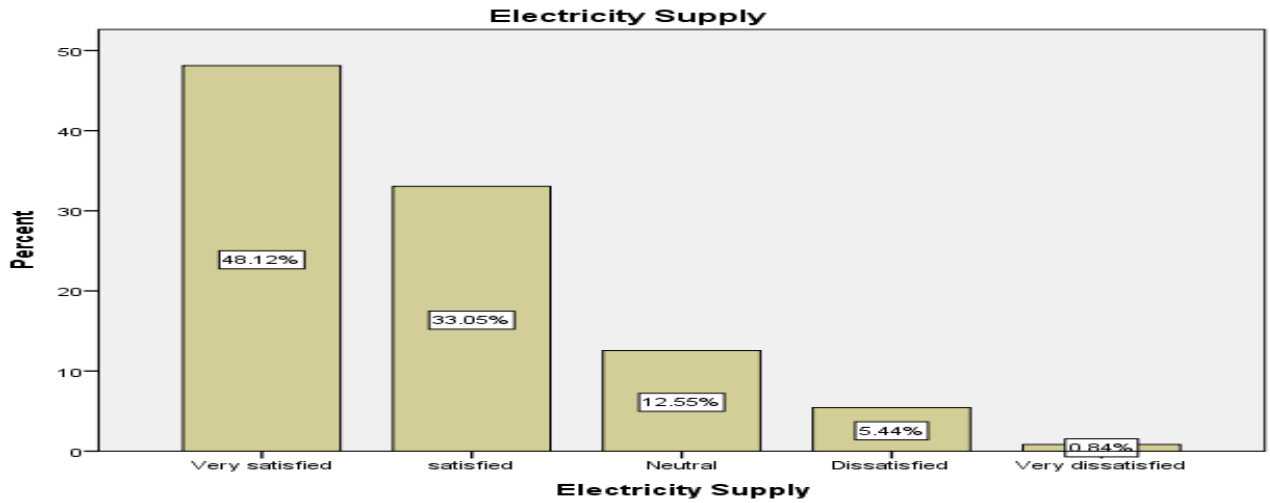

Figure 39: Electricity supply

When the respondents were asked on electricity supply, Figure 38 shows the majority, 48.12 were very satisfied, while 33.05 were satisfied. Those who were very dissatisfied were 0.84%. The figure shows that the number of respondents on this particular question were 239. The response had a standard deviation of 0.924, which is less than 1 showing the less sparse distribution of respondents' response on their satisfaction on electricity supply. This indicates the majority of the response were uniform.

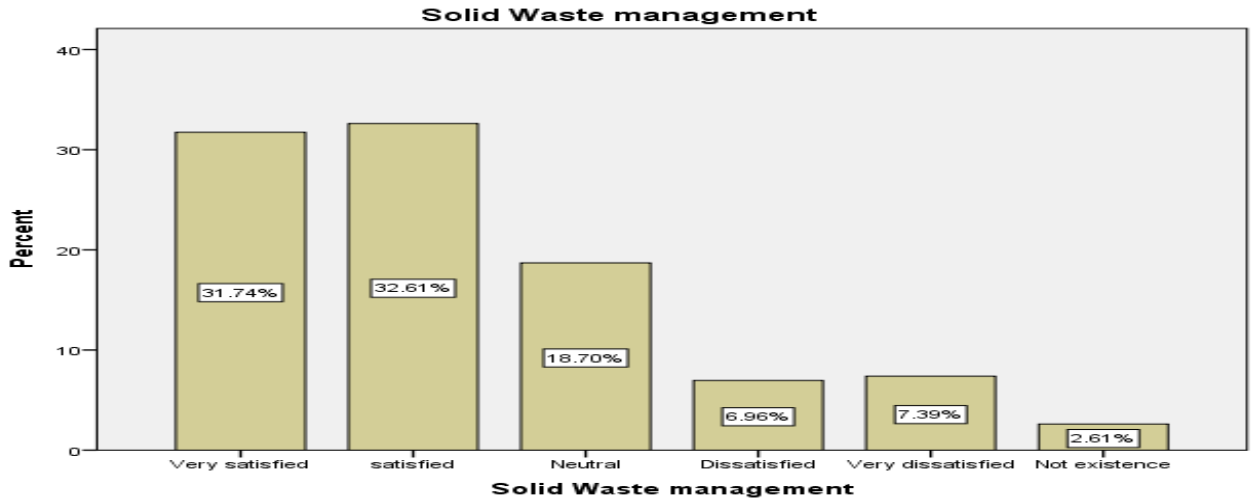

Figure 40: Solid Waste Management

When the respondents were asked on solid waste management, Figure 48 shows the majority, 32.61 were satisfied, while 31.74% were very satisfied. Those who believed it's a nonexistence were 2.61%.

Figure 39 shows that the number of respondents on this particular question were 230. The response had a standard deviation of 1.327, which is more than 1 showing the sparse distribution of respondents' response on their satisfaction on solid waste management. This indicates the majority of the response were not uniform.

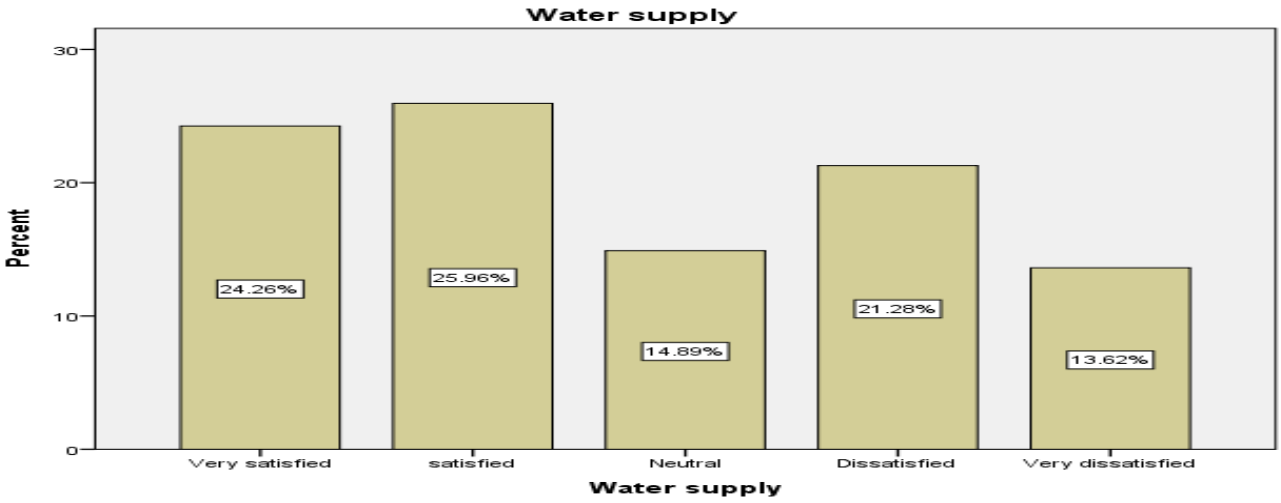

Figure 41: Water supply

When the respondents were asked about their level of satisfaction with water, Figure 40 shows the majority, 25.96 were satisfied, while 24.26% were very satisfied. The minority, 13.62% were very dissatisfied. The figure shows that the number of respondents on this particular question were 235. The response had a standard deviation of 1.389, which is more than 1 showing the sparse distribution of respondents' response on their satisfaction on water supply. This indicates the majority of the response were not uniform.

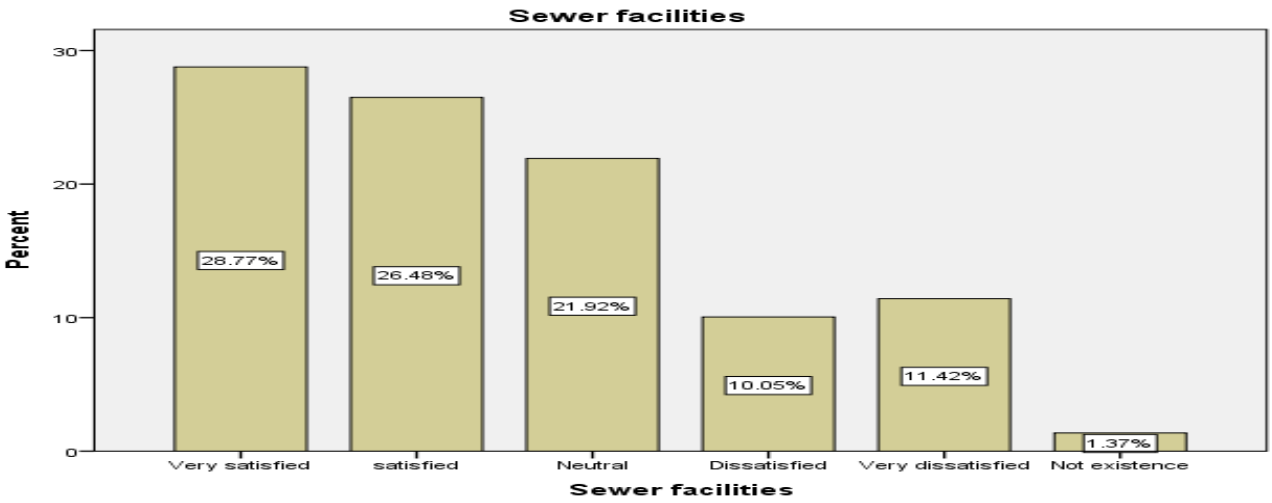

Figure 42: Sewer facilities

When the respondents were asked about their level of satisfaction with sewer facilities, Figure 41 shows the majority, 28.77% were very satisfied, while 26.48% were satisfied. The minority, 1.37% believed the sewer system were none existence. The figure shows that the number of respondents on this particular question were 219. The response had a standard deviation of 1.372, which is more than 1 showing the sparse distribution of respondents' response on their satisfaction on sewer facilities. This indicates the majority of the response were not uniform.

4.3.2 Effects of disorganized/ mixed land uses

The study area depicts a mix of land uses over the period of study and the transformation of the original bare and agricultural land to commercial and residential use. This is evident from the household finding on the location of employment of the residents who work along the Eastern Bypass. This is an indication of the dominance of commercial activities along the Eastern Bypass.

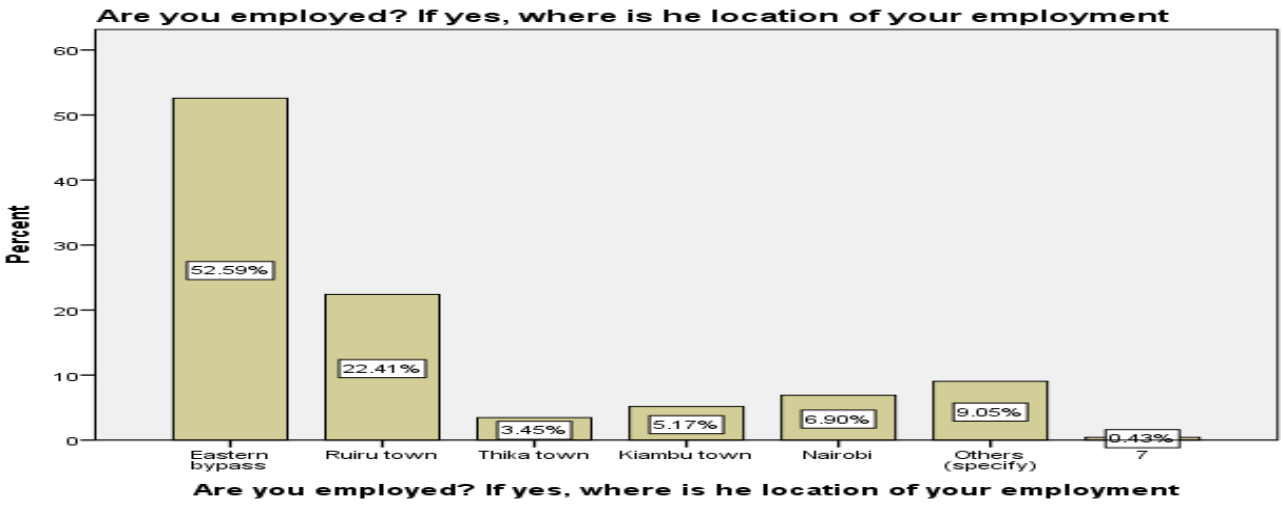

Figure 43: Are you employed? If yes, where is the location of your employment

When the respondents were asked whether they are employed and where is the location of their place of work, Figure 42 indicated the majority, 52.59%, noted they work along Eastern Bypass due to proximity to their houses. The total number of respondents who answered the question on the location of their employment were 232. The response had a standard deviation of 1.707, which is greater than 1 showing the sparse distribution of respondents' location of employment.

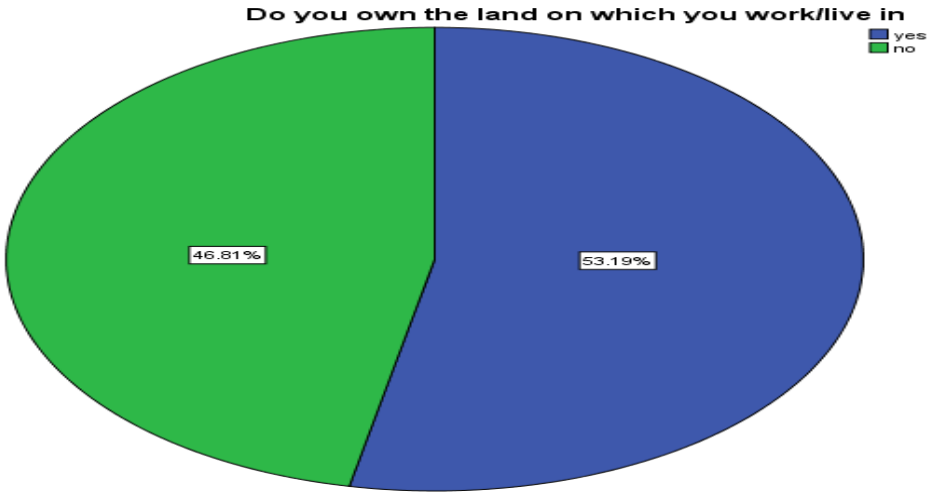

Figure 44: Respondents who own land.

When the respondents were asked if they own the land they live or work in, Figure 43 indicates that 53.19% said they own it, while the rest did not. This implies that the majority of the respondent in that category owned land next to the Eastern bypass. The respondent under this category were 94

while the standard deviation was 0.502. The standard deviation value shows the responses were uniform.

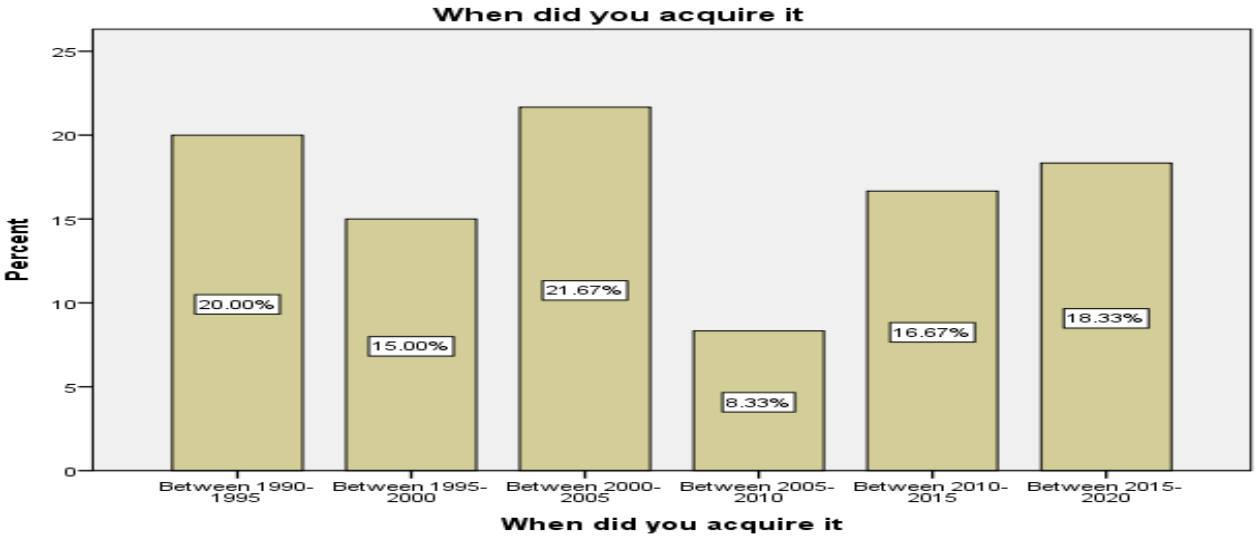

Figure 45: Year of land acquisition.

The respondents who owned land were further asked which year they acquired their land. This was to help establish the correlation between the time of land purchase and the period when the Eastern bypass was constructed. Figure 44 indicates the year range when the respondent acquired the land. 21.67% of the respondents bought land between 2000 and 2005. 20% bought land between 1990 and 1995. 18.33% bought the land between 2015 and 2020. 16.67% bought land between 2010 and 2015. Minority, 8.33% of the respondents bought land between 2005 and 2010. The respondent under this category were 60 while the standard deviation was 1.797. The implication here is that only 60 of the respondents bought the land. This means, that out of the 52 respondents who own the land, only 8 inherited the land. Most of the respondents acquired the land before the Eastern bypass was constructed, though a significant number also acquired their land between 2010 and 2020.

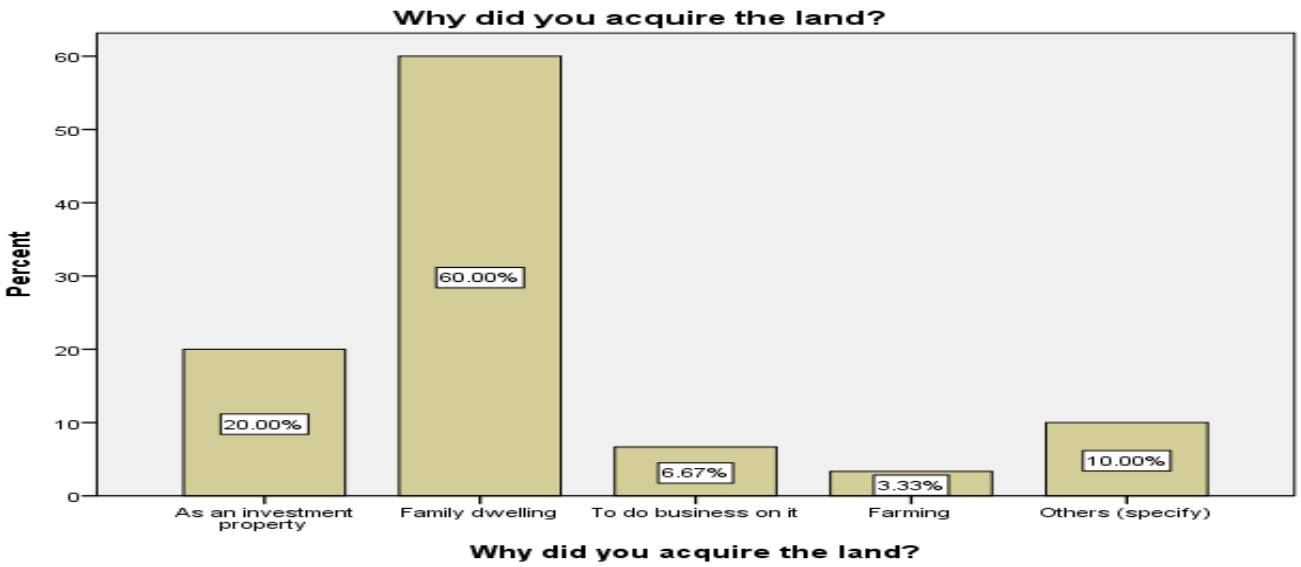

Figure 46: Reasons for land acquisition.

Data collected on the reasons for land acquisition indicated that most respondents acquired land for the purpose of establishing family dwellings as shown in Figure 46. 60% and 20% of the respondents noted they acquired land for family dwelling and as an investment property, respectively. The minority, 3.33% said they acquired land for farming. The respondents who answered the question were 60. The standard deviation was 1.125, which was above unit. This implies that the response was not uniform.

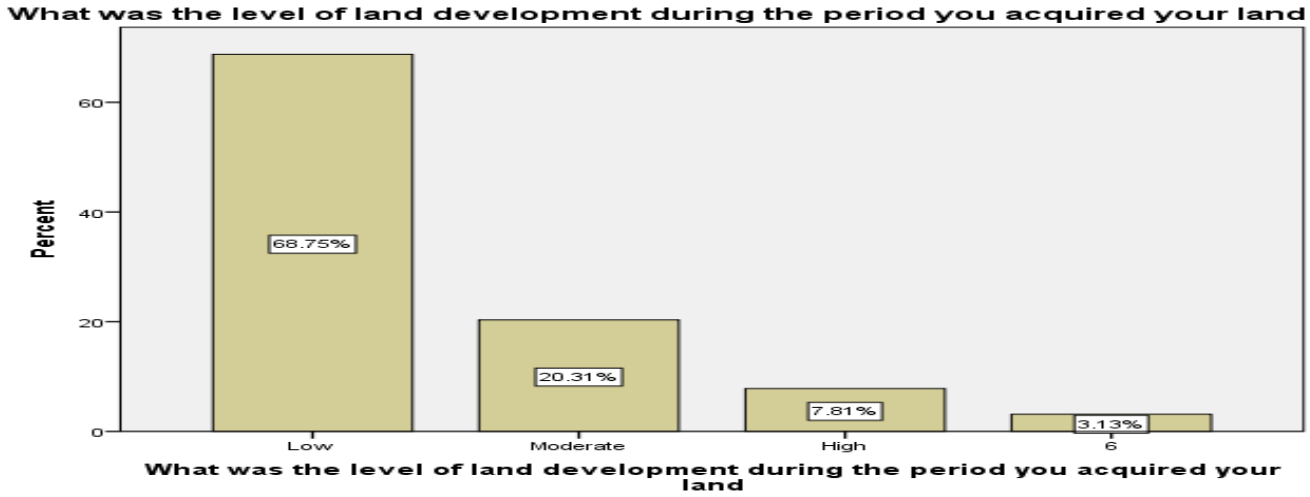

Figure 47: The level of land development during the period of land acquisition.

There was a low level of built-up areas between 2000 to 2005. Majority, which is 68.75% of the respondents noted that when they bought land, the development level of the built-up areas was low. 20.31% noted the development was moderate while minority, 7.81% of noted high development. The respondents who answered the question were 64. The standard deviation was 1.023, which was slightly above unit. This implies that the response was almost uniform, thus we can make uniform conclusion from the observation based on the mean that the level of land development when the respondent acquired land was moderately developed.

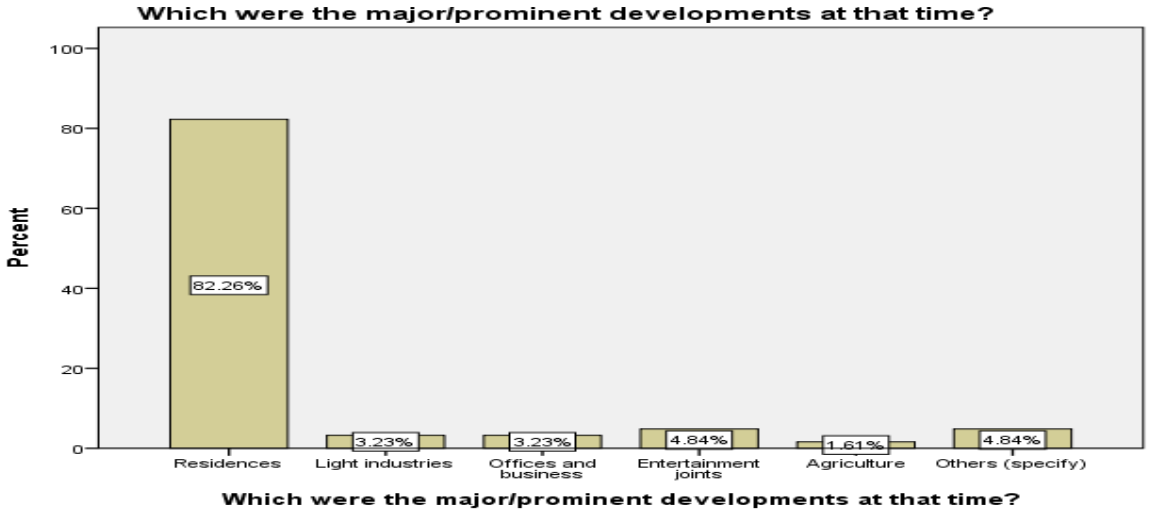

Figure 48: The major/prominent developments at that time when land was acquired.

Data collected on the major developments during the time of land acquisition by the respondents indicated that residential use was more prominent as shown in Figure 47. Majority, which is 82.26% of the respondents noted when they bought land, residences were the major development. 4.84% noted that entertainment joints were also prominent. The respondents who answered the question were 62. The standard deviation was 1.339, which was above unit.

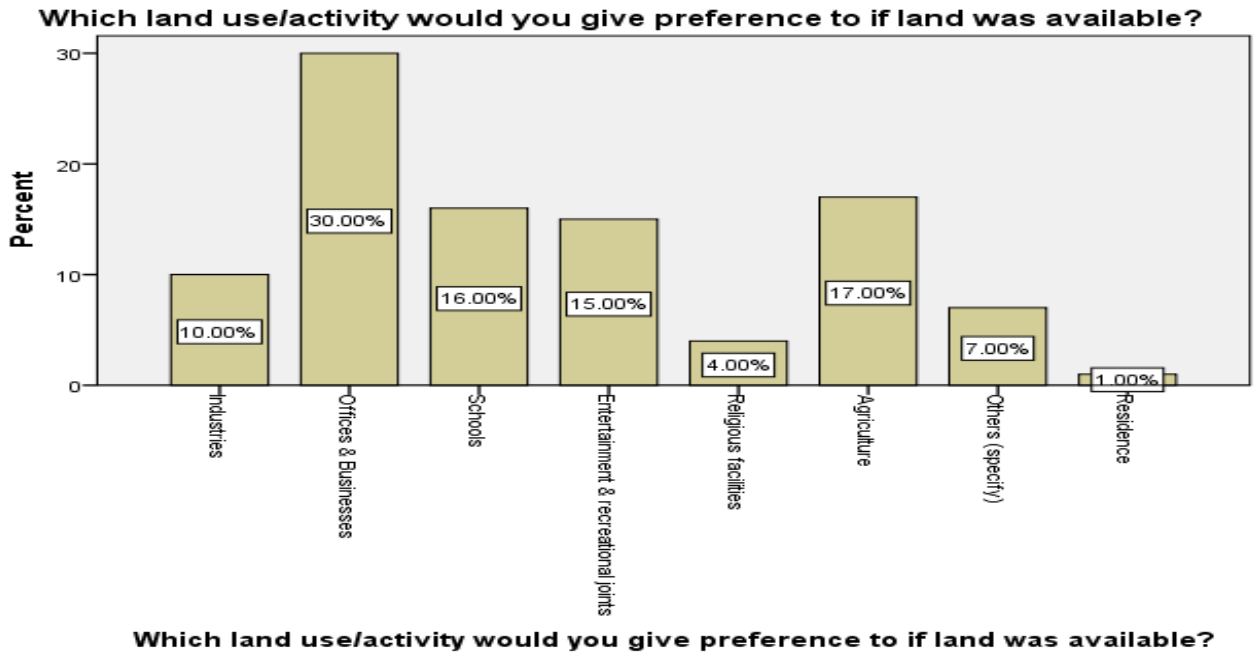

Figure 49: Land use/activity respondents prefers if land was available.

On preferred land use activity, most respondents preferred to have businesses and offices if land was available as shown in Figure 48. 30% of the respondents would prefer offices and business, 17%, agriculture, 16% schools, 15% entertainment & recreational joint, 10% industries. Only 100 respondents responded to the question on the land use preferences. The standard deviation was 1.903, which is more than 1, showing diversity in terms of response. This shows that respondents would prefer land for business or commercial activities as the area along the Eastern bypass is a prime location for business as it acts as a transit route. The high residential population will also bring in more revenue to their businesses. This is an indicator of how people have embraced mixed land uses though it comes with conflict of activities.

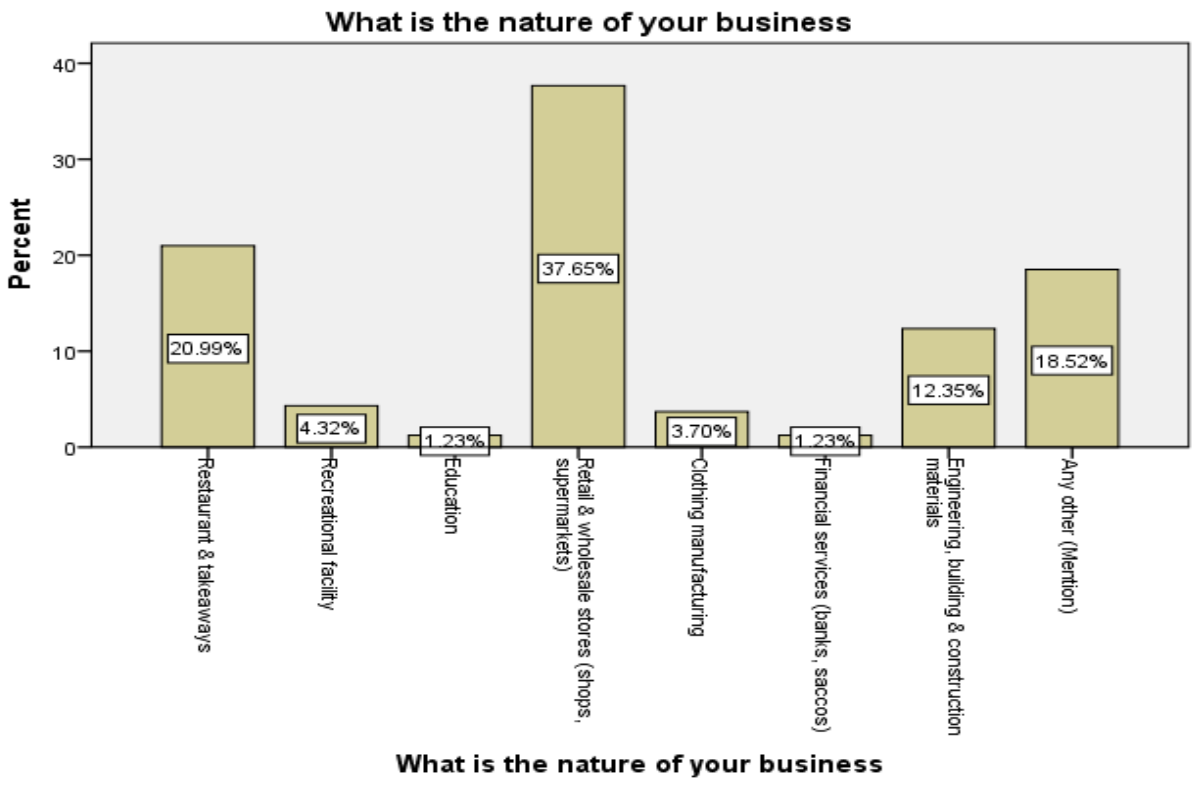

Figure 50: Nature of business along the Eastern bypass.

When asked about the nature of their businesses, Figure 49 indicate that 37.65% of the respondents indulge in retail and wholesale stores such as shops and supermarkets, 20% restaurants and takeaways, 12.35% engineering, buildings and construction materials. Those who do financial services and schools have equal share of the percentage. These findings shows that the number of activities along the Eastern bypass is highly varied and respondents have many options. 162 respondents participated in answering the question on the nature of business along Eastern bypass. The standard deviation is 2.465, which shows higher variability in answering the questions. This is varied from the year 2009 and 2015 as indicated on Figure 21 and Figure 23 where most of the available land were residential with very minimal commercial activities.

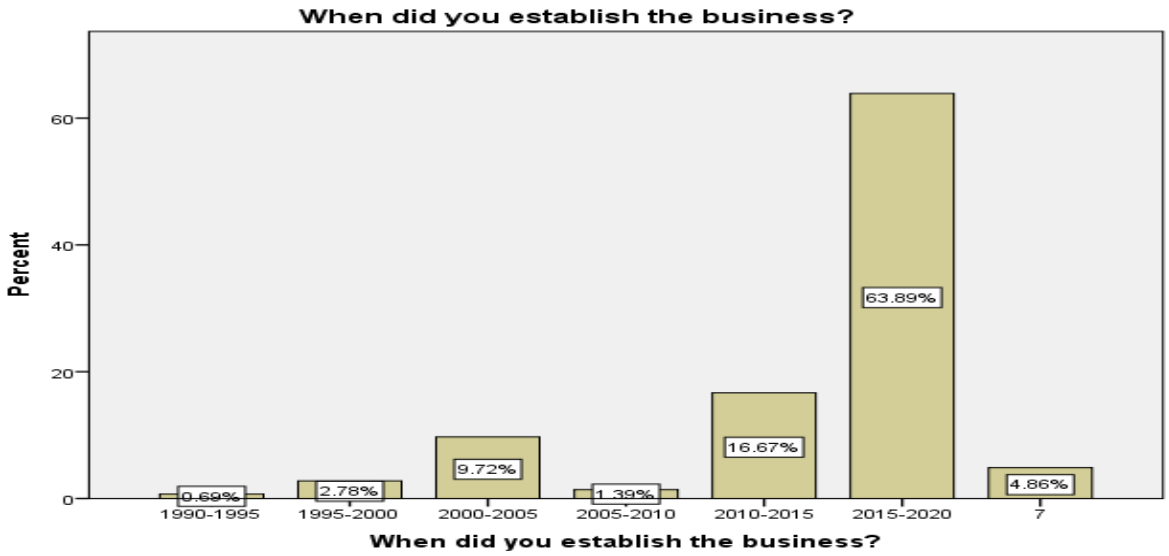

Figure 51: When was the business established

On the business establishment period, Figure 50 indicate that the majority of the business, 63.89% were established between 2015 and 2020. These high number could be due to the completion of the Eastern bypass. 16.67% were also established between 2010 and 2015, which could be lured during the construction of the Eastern bypass. The number of respondents that answered when the business was established were 144.

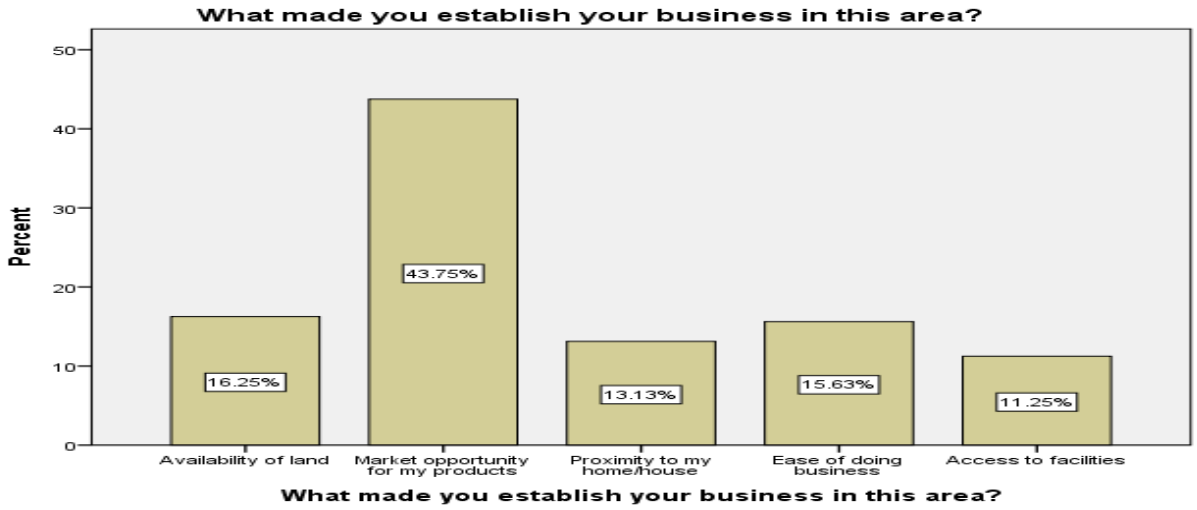

Figure 52: Reasons for establishing business

Figure 51 indicate reasons that made the respondents establish business along the Eastern bypass. 43.75% noted the existence of market opportunity, 16.25% noted the availability of land, while minority 1.25% access of facilities. 160 respondents responded to what made them establish the business along the Eastern bypass. This shows that of the 303 respondents that returned their questionnaires, 160 were business owners. This translates to 52.81% of the respondents. Therefore, majority of the respondents were business owners.

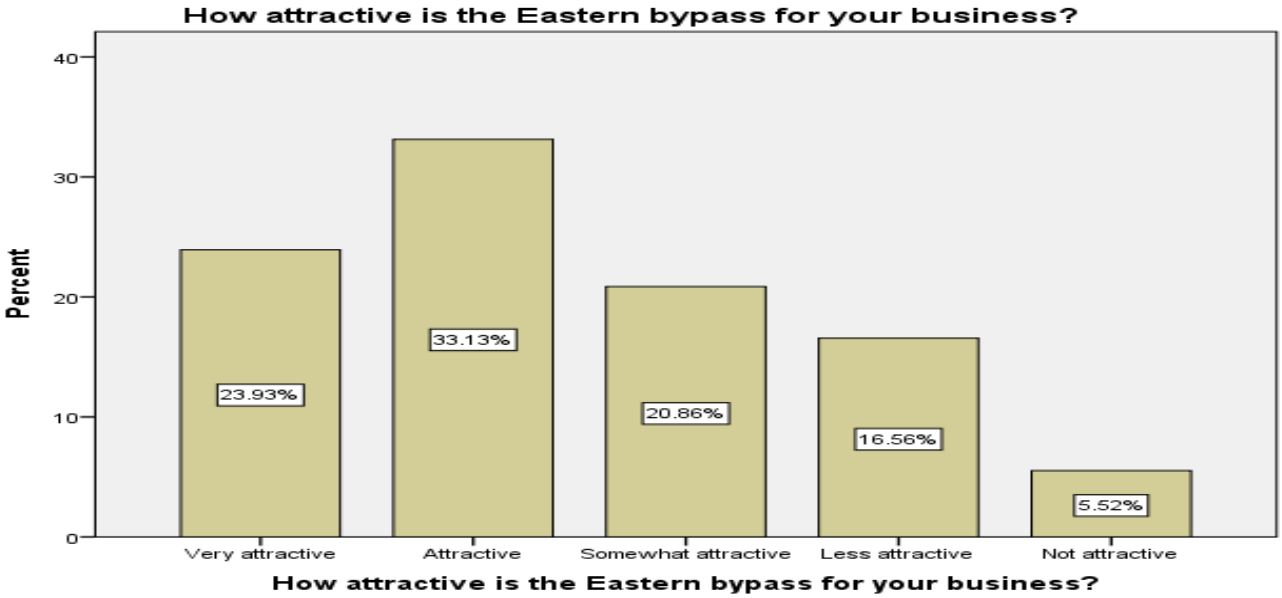

Figure 53: Attractiveness of the Eastern bypass for your business

Figure 52 shows the respondents' response on the attractiveness of the Eastern bypass for the businesses. 33.13% and 23.93% shows Eastern bypass is attractive and very attractive for businesses. Those who do not regard Eastern bypass as attractive their business 16.56% and 5.52%. The respondents who noted the Eastern bypass is attractive were 163. The standard deviation is 1.183, which is more than 1, showing variability of the response. This attractiveness of the Eastern bypass could be the reason for the mixed land use that is happening along the study area.

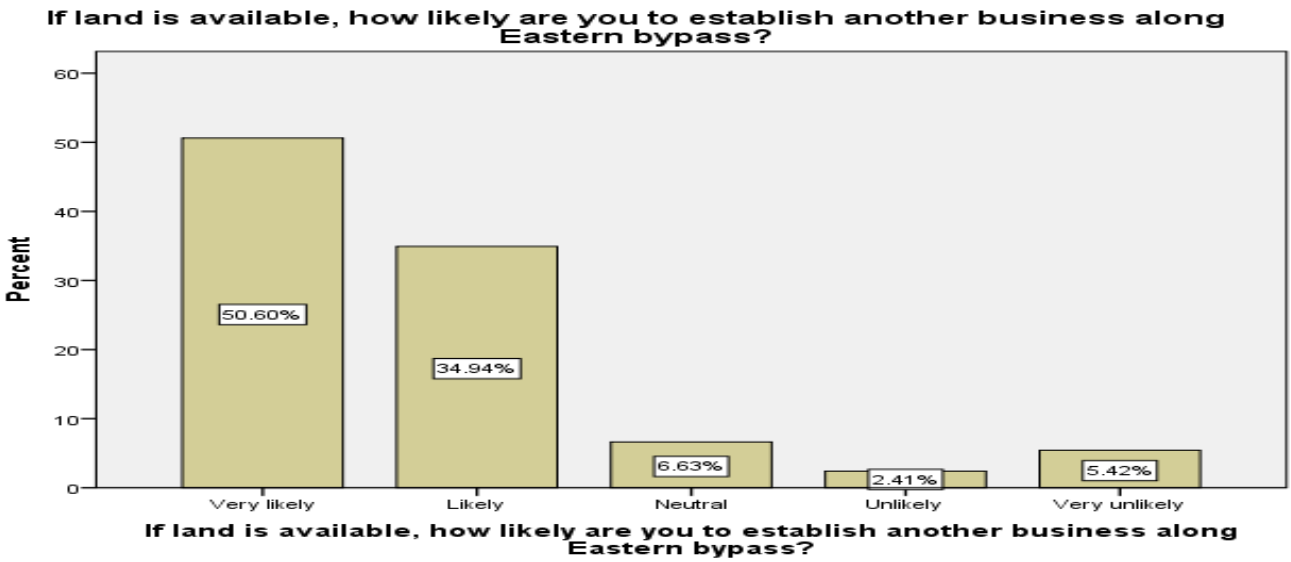

Figure 54: The likelihood of establishing another business along Eastern bypass

Figure 53 shows the likelihood of existing business owners establishing another business along the Eastern bypass. 50.6% and 34.94 indicated very likely and likely, respectively. 5.42% and 2.41% indicate they are very unlikely and unlikely, respectively. 168 respondents show the likelihood of establishing another business along Eastern bypass. The standard deviation is 1.054, which is close to 1, showing presence of almost uniform variation in responses. Thus, we can easily conclude that in the presence of land, respondents are likely to establish another business.

Figure 55: Which of the following services are you able to access?

When the respondents were asked the services, they are able to access, Figure 54 shows the majority, 87.44% could access electricity supply. The minority, 0.93% could access solid waste services. The number of respondents on this particular question were 215. The response had a standard deviation of 1.172, which is greater than 1 showing the sparse distribution of respondents' answers. This indicates the majority of the response were not uniform.

Figure 56: Which recreational facilities can you be able to access?

When the respondents were asked the recreational facilities, they can be able to access, Figure 55 shows the majority, 39.22% could access swimming pool, followed by none 32.35%. The minority, 3.43% could access gold course. The number of respondents on this particular question were 204. The response had a standard deviation of 1.558, which is greater than 1 showing the sparse distribution of respondents' response. This indicates the majority of the response were not uniform.

4.3.3 Effect of high traffic along the Eastern bypass

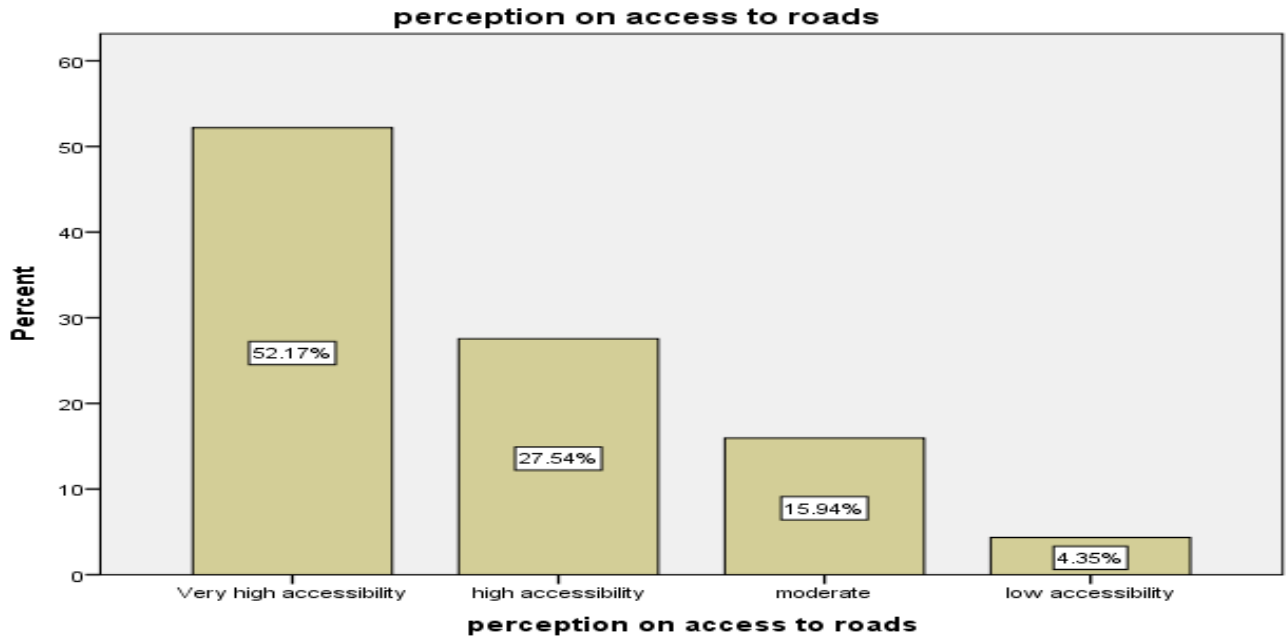

Figure 57: Perception on access to roads

When the respondents were asked about their perception about accessibility to roads, Figure 56 shows the majority, 52.17% noted very high accessibility, while 27.54% perception was highly accessible. The minority, 4.35% perception is that roads are low accessible. The number of respondents on this particular question were 69. The response had a standard deviation of 0.889, which is less than 1 showing the less sparse distribution of respondents' response on their perception on access to roads. This indicates the majority of the response were uniform.

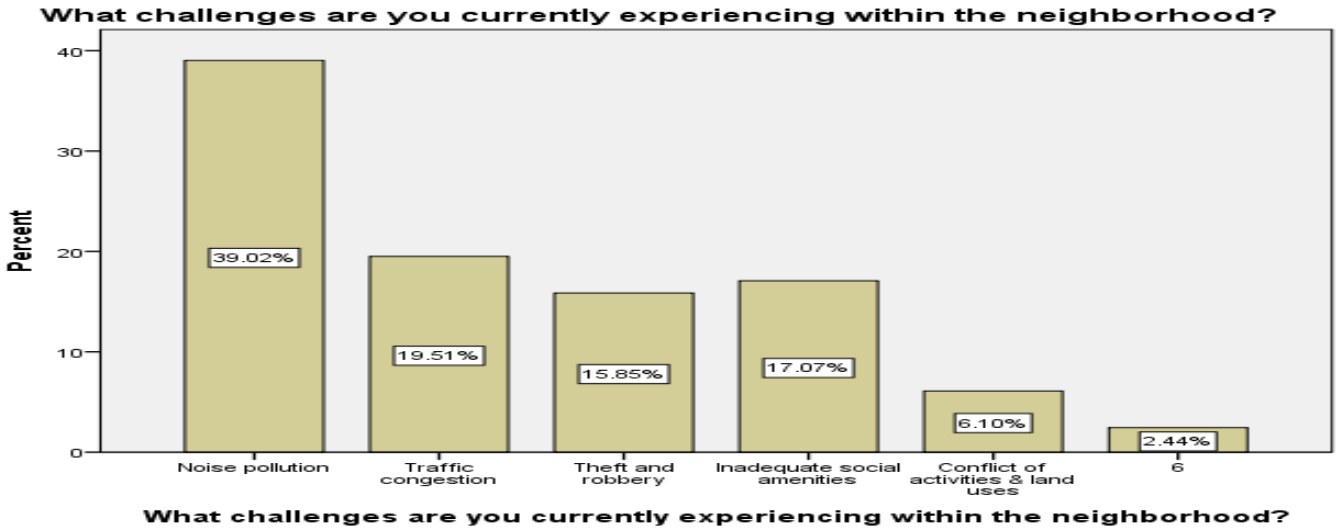

Figure 58: Challenges experienced in the neighborhood.

When asked about the challenges they face along the Eastern bypass, 39.02% of the respondent noted noise pollution is the main challenge followed by traffic congestion (19.51%), then insecurity (15.85%), inadequate social amenities (17.07%) and finally conflict of activities & land uses (6.1%). The number of respondents on this particular question were 82. The response had a standard deviation of 1.429, which is more than 1 showing the sparser distribution of respondents' response on the challenges experience within the neighborhood of Eastern bypass. This indicates the majority of the response were not uniform and the challenges are varied. Even though there were various challenges indicated by the respondents, the major challenge on the road infrastructure was noise pollution and traffic congestion as a result of high population and high number of users of the road.

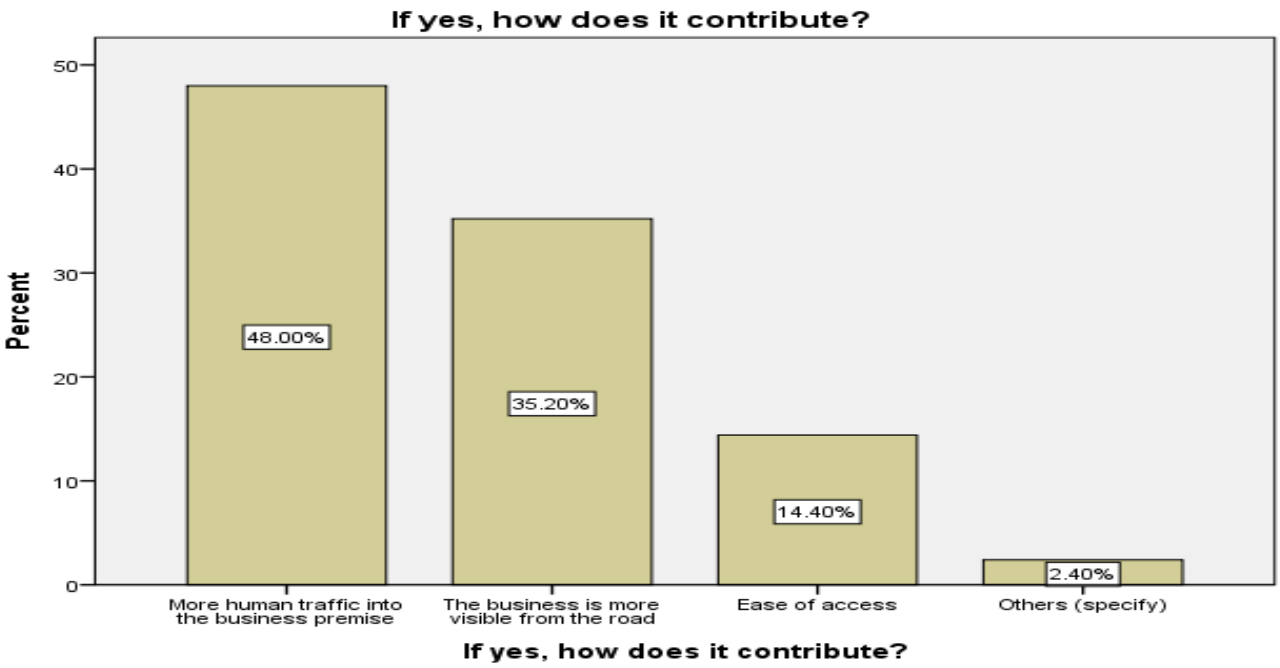

Figure 59: How does Eastern bypass contribute to business

Figure 58 indicate the that 48% of the respondents acknowledge that the presence of more human traffic into the business premises along the Eastern bypass help business, 35.2% visibility of business on the road, 14.4% ease of access and 2.4% did not specify the reason. This implicate that presence of Eastern bypass is beneficial to the business owners. 125 respondents noted that Eastern bypass contribute to their businesses. The standard deviation value is 0.801, showing less variability of the response, hence we can easily draw conclusions from the research that the Eastern bypass has a significant contribution to the businesses.

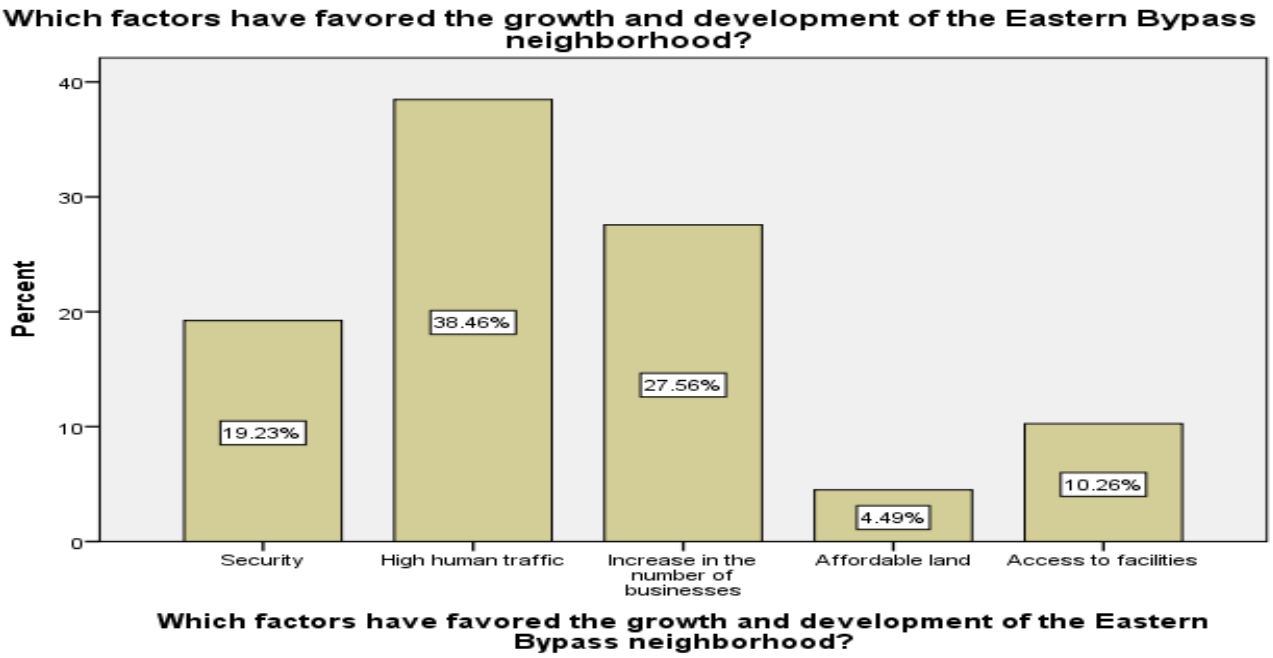

Figure 60: Factors favoring the growth and development of Eastern Bypass neighborhood

Figure 59 indicate that human traffic, increase in the number of businesses and security contribute to 38.46%, 27.55% and 19.23% of factors favoring the growth and development of the Eastern bypass, respectively. Minority, 4.49% of the respondents acknowledge the affordable land. 156 respondents identified factors favoring the growth and development of the Eastern bypass. The standard deviation is 1.161, which is more than 1 by, showing variability of the responses.

4.4 To recommend medium-term urban management framework that will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects.

The researcher sought to understand the respondent's opinion on urban management framework that guides land use by establishing whether they were familiar with development control laws. Data collected from the key informant interview at the Planning department, Kiambu County Government indicated that the challenges faced in enforcing the development controls includes the following: were inadequate policy enforcers, lack of knowledge by the general public on development controls which eventually leads to non-conformity by developers to comply with policy guidelines. In order to ensure compliance of the development control, the respondent indicated the need to increase the enforcing agencies, equip them with adequate resources, availing services closer to the people and creation of public awareness through constant education. Household survey was carried out to establish whether the respondents were familiar with the development controls as indicated in Figure 61.

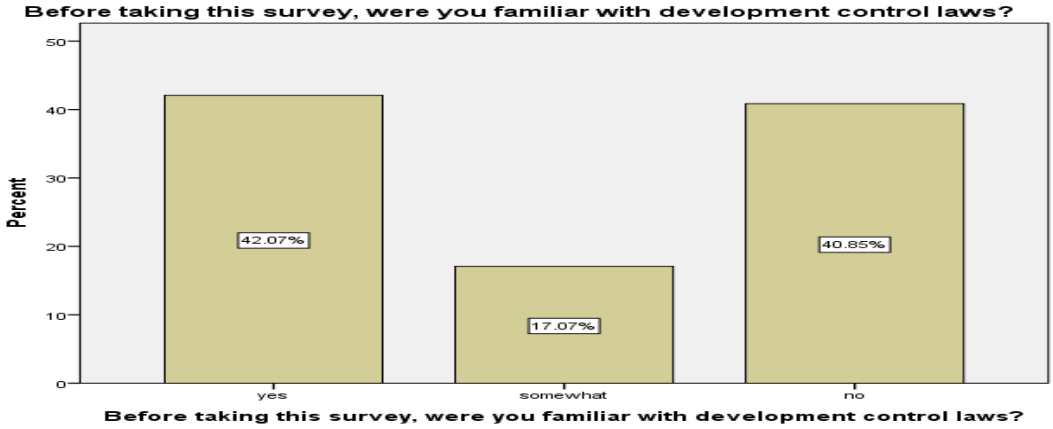

Figure 61: Awareness of development control laws.

When the respondents were asked if they were aware of the development control laws, 42.07% noted they are familiar, while those who were undecided were 17.07% and those who have no idea were 40.85%. This implies that the existing control laws are not commonly used along the Eastern bypass. This could be due to improper planning of the land uses along the study area. 164 respondents responded to the awareness of development control laws. The standard deviation values are 0.913,

which is less than 1, indicating less variability of the response. This implies that the respondents were fairly uniform in their response.

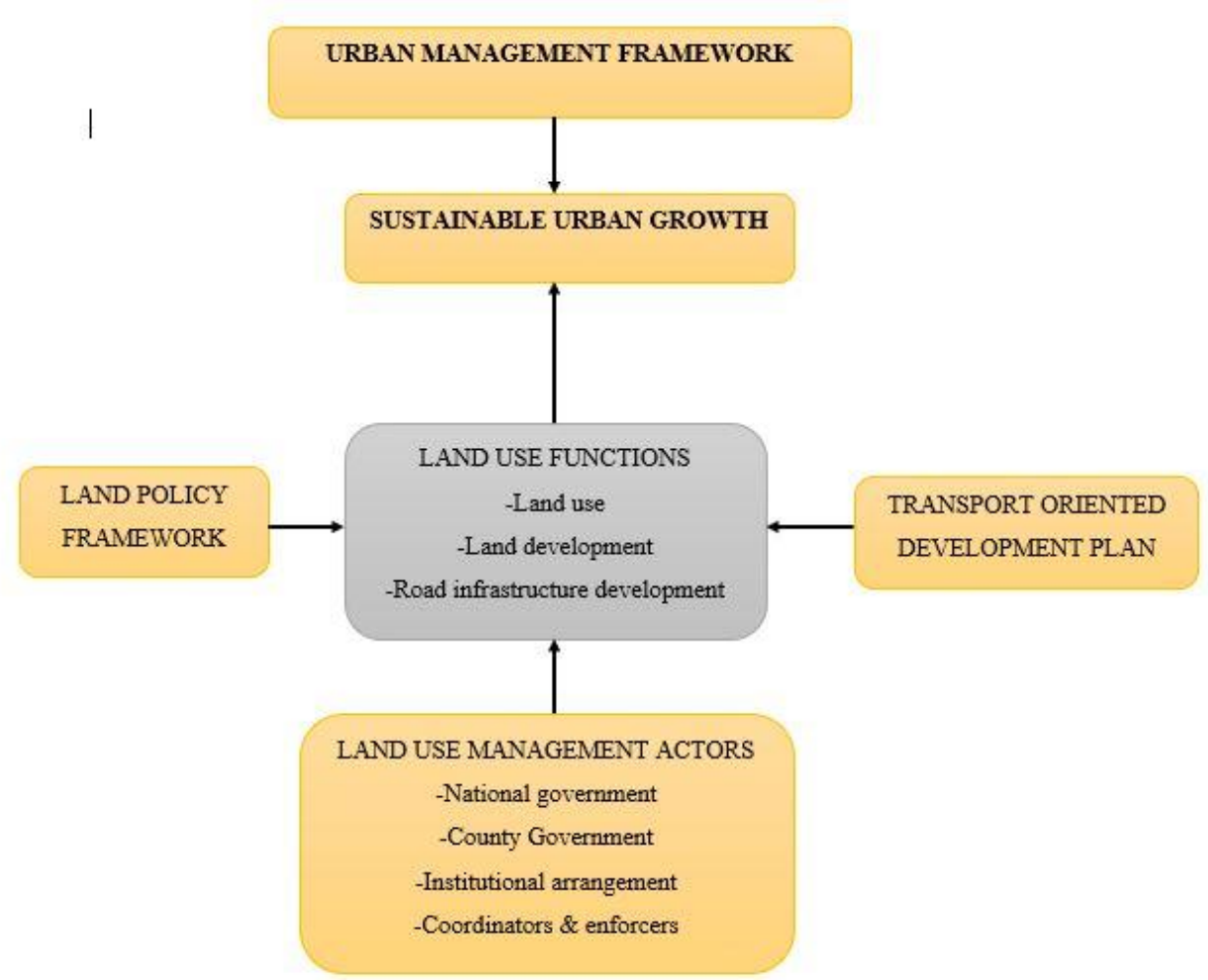

Figure 62: Urban management framework.

Formulation of an urban management framework that incorporates transport-oriented development plan and land policy framework will ensure a sustainable urban growth through the inclusion of land use functions such as land and road infrastructure development and the inclusion of land use management actors such as the national government, county government, coordinators and enforcers in various institutions.

4.5 Summary on results & findings

The road infrastructure development in Kenya has increased the urban land-use changes. Road infrastructure development projects' spatial dynamics affect land-use practices and characteristics. Efficient road infrastructure and an improved road network generate a competitive advantage for a location in trade, boosting urbanization and vice versa.

Ruiru is a classic instance of a town that has grown at a fast rate to accommodate different land uses. Construction of roads in the town, such as the Eastern bypass, has improved development activities in the area leading to the growth of the region. Consequently, the need to: (1) investigate the extent to which road infrastructure development affects land use/land cover along the Eastern bypass.; (2) establish land use conflict driving forces that emerge from road infrastructure development along Eastern bypass; (3) recommend medium-term urban management framework that will guide land management actors in prevention and management of land use conflicts caused by road infrastructure development projects, were studied.

Descriptive and historical designs were used as the main study design with a target population of residents along the Eastern bypass in the Ruiru sub-county. Stratified sampling was used to get a sample size of 382 respondents for collection of primary data that was obtained using structured questionnaires.

The findings on the extent to which road infrastructure affects land use/land cover indicated that vegetation and buildings continuously increased from 2009 to 2021. Consequently, the bare lands reduced throughout the study period. The implication is that as the road network increases and becomes more effective, the need for beautification of the landscape increases, increasing the vegetation. Land use change is also experienced during the study period whereby there is an increase in residential use, as commercial businesses also sprout along the road network and the area coverage for light industries also increases.

The road overlay indicated that the size of the road networks had increased an in 2021 compared to 2015 and 2009. This is an indication of land fragmentation since there is need to provide access roads to plots that have been subdivided, hence an increase in road lengths. This subdivision of the original large tracks of land is an indication of land use change due to lack of zoning and land use planning,

hence developments come up without control, and thereby accessibility is a problem to the land uses that are on the rear side.

Household findings revealed that most of the respondents were male. The respondents' household had a majority in the age group of 18-30. The second-largest category of the household age is between 31 and 45 years, while a minority are above 60 years. Most of the respondents reside in Membley, and they stay along the Eastern bypass due to proximity to their workplaces as majority of them work along the Eastern bypass. Most respondents also live in flats or apartments. The respondents noted that the most common access service is electricity supply.

On land ownership, more respondents indicated that they owned the land on which they lived in. Most of the respondents who owned the land indicated that they acquired it between 2000 and 2005 with a number also indicating that they acquired land between 2010 and 2020, the period in which the Eastern bypass was newly constructed. Majority acquired the land to develop family dwellings.

Majority of the respondents confirmed that there were low rise developments between 2000 and 2005. This changed between the period of 2009 and 2015 when both residential and commercial uses of land increased. This is evident in the data collected from the respondents on when they established their businesses and a majority indicated between 2015 and 2020.

On the preferred land use, majority of the respondents indicated that if land was available, they would prefer to have more offices and businesses followed by land for agricultural use. The reason being that the Eastern bypass is attractive to businesses and there is both high human and vehicular traffic which will promote business.

The most common recreation facility in the area is the swimming pool. More respondents were satisfied with the electricity supply than those who were not. The same applies to solid waste management, water supply and sewerage facilities. The respondents noted that the most common challenge they face in the neighborhood of Eastern bypass is largely noise pollution, traffic congestion and insecurity. Inadequate social amenities and finally conflict of activities and land uses are also challenges they face within the neighborhoods. Majority of the residents and business owners are not aware regarding development control in the area. This implies that the structures in the area might have been developed without consideration of development control and planning laws.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Road infrastructure development in Kenya has risen steadily over the past decade as the need for urban land-use changes becomes a development agenda for economic prosperity. Construction of the Eastern bypass has improved development activities, leading to the region's growth. The impact of urbanization because of an expanded road infrastructure in the area of study has placed more pressure on the existing land uses, thereby resulting to a typical tendency of urban sprawl.

Research findings reveals that change in land use conflicts, which has been caused by land fragmentation, irregularity of land use and traffic snarl-ups as a result of population increase has resulted in rapid urban land use changes with pressure being exerted on the available social amenities which are not able to cater for the population. Road networks have also increased due to the increased land subdivision and thereby resulting to narrow roads that are inadequate hence causing traffic jams. The increase in road networks is not commensurate with the services and amenity provision, hence the increased pressure on the available infrastructure does not support the high demand of the population.

There is also lack of knowledge on the development controls by the respondents and this has created luxury by law enforcers to enforce these development controls. It is therefore important to develop a land use management framework that will incorporate an overarching land use plan that merges with transport-oriented development plan. There is also need to involve land use management actors through interagency coordination of both transport planners and urban planners. This management strategy will ensure sustainable urban growth hence promote social well-being, environmental and economic growth.

5.2 Recommendations

For sustainable urban growth to be achieved, there should be evaluation of land use changes to help in anticipating the effects that come with the change in road infrastructure development projects. Monitoring land-use change at different spatial scales and timelines is important to identify regions that have the potential to change due to road infrastructure improvement. For a better and working

land use and urban management, useful planning indicators such as participatory land use planning and overarching land use planning need to be documented. Such data is necessary for planning by the National and County Governments so as to prevent uncontrolled expansions. This can be done by analyzing and documenting periodic changes and transformation of land uses in different regions so as to update and them continuously to see the direction of land use changes.

There is a need to develop and implement the urban land use management framework to help understand the varying needs of specific areas and therefore assist in developing informed actions related to the indicators. A successful design and execution of a transport-oriented development plan and overarching land use plan will help in development of a comprehensive urban management framework that encompasses both road infrastructure and land use without compromising the existing land uses.

There is need for integrated and enhanced interagency coordination and collaboration in managing and enforcing development controls on use of land and subdivision with strict adherence to the guidelines on plot sizes and provision of required access roads to every property. Better harmony between land use planning and resolution on urban growth as well as political will to execute development control policies should be strictly adhered to.

Although this may be resisted by the residents who mostly have land on free hold, government can impose mandatory and time-bound development obligations for all state granted or sold lands, adoption of mandatory land assets management strategies and policies for both private and public agencies with large tracts of land and penalty or fees imposed on vacant lands. This will help streamline land use development into one direction and also have a centralized planning framework to facilitate coordination.

In areas for further studies, there is need to consider collecting data detailing number and nature of business before and after putting up major road infrastructure projects so as to predict the future land use changes, which can therefore guide policy formulation.

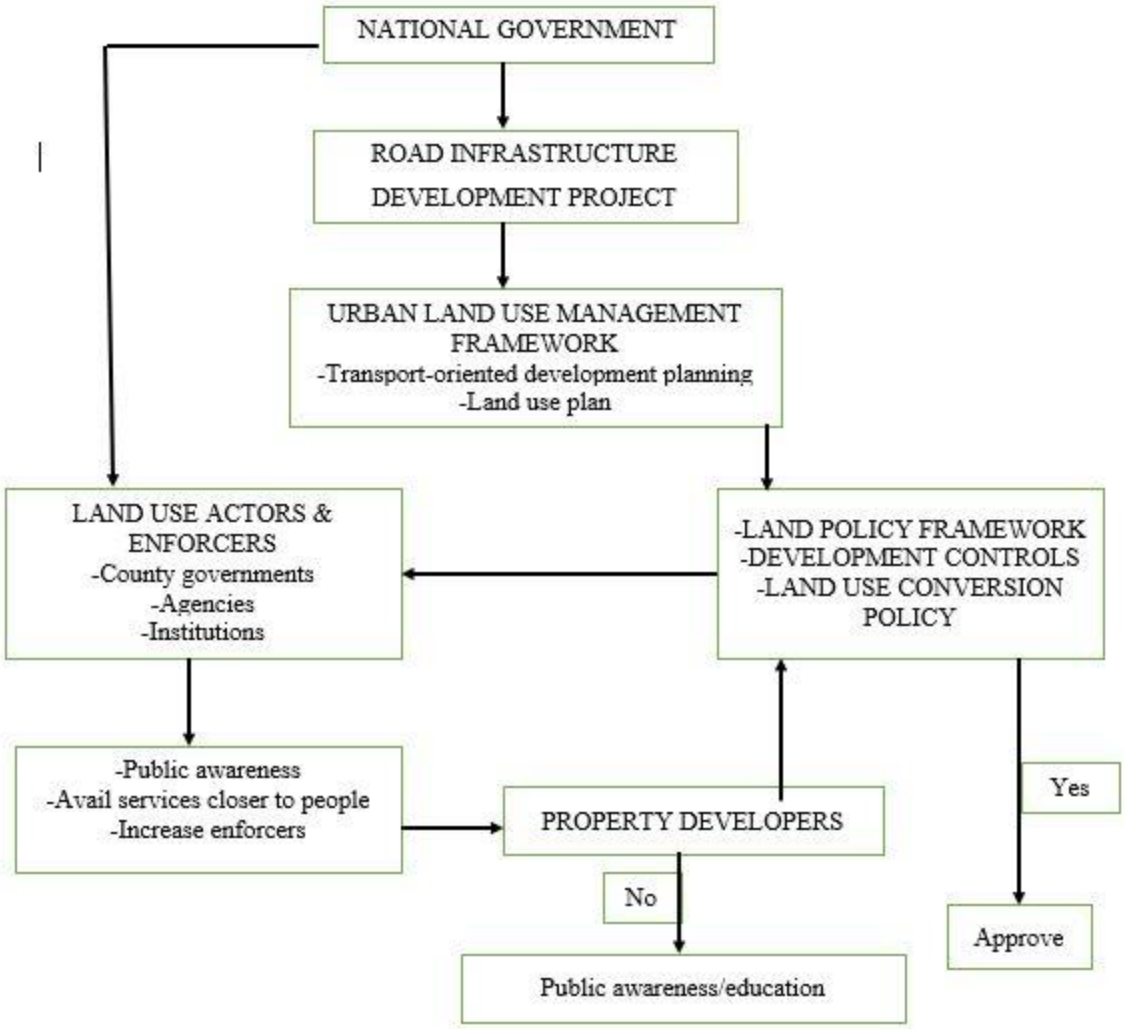

Figure 63: Ideal scenario for an urban land management framework

APPENDICES

Appendix I: Letter of Introduction

UNIVERSITY OF NAIROBI

Faculty of Built Environment and Design

DEPARTMENT OF ARCHITECTURE
E- mail: architecture@uonbi.ac.ke

P.O. BOX 30197,
Nairobi, Kenya
Telephone: 020-4913519
Telegrams: Varsity.

Our Ref: UON/CAE/ABS/87665/16 ***Date:*** 21st February, 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: LOISE ATIENO OUMA NO. W50/87665/2016

This is to confirm that the above named is a bona-fide student pursuing Master of Urban Management in the Department of Architecture, University of Nairobi.

Ms. Ouma wishes to collect data for her project **"The Role of Road Infrastructure Development Projects on Urban Land Use. A Case of Eastern Bypass".**

We are thus requesting you to give her some of your valuable time and respond positively to her enquiries, provision of drawings, maps, etc as may be required. This is for academic purposes only.

Any assistance accorded to her will be highly appreciated.

Yours sincerely,

CHAIRMAN
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF NAIROBI

Arch. Musau Kimeu
CHAIRMAN,
DEPT. OF ARCHITECTURE

REGIONAL CENTRE FOR MAPPING OF RESOURCES FOR DEVELOPMENT
RECEIVED
03 MAR 2022
REGISTRY

Appendix II: Household Survey Questionnaire

Name of researcher: Loice Atieno Ouma

Institution: University of Nairobi

Department: Architecture and Building Science

Program: Master of Urban Management Thesis Project

Topic: Influence of Road Infrastructure Development Projects on Urban Land Uses. A Case of Eastern Bypass.

Questionnaire No:……

Confidential: *The information provided under this survey shall be used for this research study only and not for any other purpose.*

Name of the interviewer……Date……..

Respondent's name …….Gender……Contact……..

Age (yrs): 18-30…….……31-45…….……46-60..…….60 and above……..…...…

A. Housing

1. Name of area where interviewee resides
    a) Kamakis
    b) Karuguru
    c) Membley
    d) Kimbo
    e) Kihunguro
    f) Varsity ville
    g) Quickmart area
    h) Others (specify)
2. What made you choose this location as your area of residence?
    a) Proximity to work place
    b) Affordable rent
    c) Security
    d) Access to social amenities (schools, hospitals)
    e) Good road networks
    f) Recreational areas

g) Others (specify)

3. Are you employed? If yes, where is he location of your employment?
    a) Eastern bypass
    b) Ruiru town
    c) Thika town
    d) Kiambu town
    e) Nairobi
    f) Others (specify)
4. What type of house do you live in?
    a) Bungalow
    b) Maisonette
    c) Flat/apartment
    d) Semi-permanent house
5. How much rent do you pay per month?
    a) Kshs 0-10,000
    b) Kshs 10,001-20,000
    c) Kshs 20,001-30,000
    d) Kshs 30,000-40,000
    e) Kshs 40,001 & above
    f) Others (specify)
6. Average monthly income of the household head
    a) Kshs 0-10,000
    b) Kshs 10,001-20,000
    c) Kshs 20,001-30,000
    d) Kshs 30,000-40,000
    e) Kshs 40,001 & above
    f) Others (specify)
7. Which of the following services are you able to access?
    a) Electricity supply
    b) Solid waste management
    c) Sewer facilities
    d) Water supply
    e) Storm water management
    f) Any other (specify)
8. Which recreational facilities can you be able to access?
    a) Sports fields
    b) Golf course
    c) Swimming pool
    d) Parks & picnic areas
    e) None
9. Tick where appropriate the level of satisfaction of the services provided.

Service	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied
Electricity Supply					
Solid Waste Management					
Water supply					
Sewer facilities					
Sanitation facilities					
Storm Water Drainage					
Access roads					

10. Resident's perception on access to public amenities before and after Eastern bypass construction.

Amenity	Very high accessibility	High accessibility	Moderate	Low accessibility	Very low accessibility
Schools					
Hospitals					
Recreational facilities					
Religious centers					
Social halls					
Access roads					

B. Land ownership

1. i) Do you own the land on which you work/live in? i) Yes ii) No

ii) If yes, approximately how much did you purchase it?

a) Kshs 100,000-250,000
b) Kshs 250,001-500,000
c) Kshs 500,001-1,000,000
d) Kshs 1,000,001-2,000,000
e) Kshs 2,000,001-5,000,000
f) Kshs 5,000,001 and above

iii) When did you acquire it?

a) Between 1990-1995
b) Between 1995-2000
c) Between 2000-2005
d) Between 2005-2010
e) Between 2010-2015
f) Between 2015-2020

iv) What was the level of land development during the period you acquired your land?

a) Low
b) Moderate
c) High

v) Which were the major/prominent developments at that time?

a) Residences
b) Light industries
c) Offices and business
d) Entertainment joints
e) Agriculture
f) Others (specify)

2. Why did you acquire the land?
   a) As an investment property
   b) Family dwelling
   c) To do business on it
   d) Farming
   e) Others (specify)
3. What acreage of land does it cover?
   a) $1/8^{th}$ acre
   b) ¼ acre
   c) ½ acre
   d) 1 acre
   e) Above 1 acre

4. i) Do you have a title deed for the parcel of land? i) Yes ii) No
   ii) If no, what challenges are you experiencing in getting one?
    a) Bureaucracy
    b) Tedious process
    c) Lack of interest
    d) Property is still under mother title deed.
    e) Others (specify)

5. What challenges are you currently experiencing within the neighborhood?
    a) Noise pollution
    b) Traffic congestion
    c) Theft and robbery
    d) Inadequate social amenities
    e) Conflict of activities & land uses
6. Which land use/activity would you give preference to if land was available?
    a) Industries
    b) Offices & Businesses
    c) Schools
    d) Entertainment & recreational joints
    e) Religious facilities
    f) Agriculture
    g) Others (specify)

C. Business owner

1. What is the nature of your business?
    a) Restaurant & takeaways
    b) Recreational facility
    c) Education
    d) Retail & wholesale stores (shops, supermarkets)
    e) Clothing manufacturing
    f) Financial services (banks, saccos)
    g) Engineering, building & construction materials
    h) Any other (Mention)
2. When did you establish the business?
    a) 1990-1995
    b) 1995-2000
    c) 2000-2005
    d) 2005-2010
    e) 2010-2015
    f) 2015-2020
3. What time do you open & close your business?

a) 8am to 1pm
b) 8am to 5pm
c) 1pm to 6pm
d) 6pm to 6am
e) 24 hours

4. Average monthly income from the business
    a) Kshs 0-50,000
    b) Kshs 50,001-100,000
    c) Kshs 100,001-200,000
    d) Kshs 200,001-500,000
    e) Kshs 500,001 and above
5. Which other businesses were more prominent in this area during that time?
    a) Entertainment joints
    b) Light industries
    c) Retail & whole sale stores
    d) Offices
    e) Financial institutions
6. What made you establish your business in this area?
    a) Availability of land
    b) Market opportunity for my products
    c) Proximity to my home/house
    d) Ease of doing business
    e) Access to facilities
7. Does the Eastern bypass contribute to your business income? i)Yes ii) No
    a) More human traffic into the business premise
    b) The business is more visible from the road.
    c) Ease of access
    d) Others (specify)
8. Which factors have favored the growth and development of the Eastern Bypass neighborhood?
    a) Security
    b) High human traffic
    c) Increase in the number of businesses
    d) Affordable land
    e) Access to facilities
9. How attractive is the Eastern bypass for your business?
    a) Very attractive
    b) Attractive
    c) Somewhat attractive
    d) Less attractive
    e) Not attractive
10. If land is available, how likely are you to establish another business along Eastern bypass?
    a) Very likely

b) Likely
c) Neutral
d) Unlikely
e) Very unlikely

11. Development controls are the processes of ensuring that development applications comply with policy guidelines, physical planning standards, approved physical development plans, local authority by laws and other relevant statutes. Before taking this survey, were you familiar with development control laws?
    a) Yes
    b) Somewhat
    c) No

THANK YOU FOR YOUR RESPONSE

Appendix III: Key Informant Interview

Name of Researcher: Loice Atieno Ouma

Institution: University of Nairobi

Department: Architecture and Building Science

Program: Master of Urban Management Thesis Project

Topic: Influence of Road Infrastructure Development Projects on Urban Land Uses. A Case of Eastern Bypass.

Confidential: *The information provided under this survey shall be used for this research study only and not for any other purpose.*

Name of the interviewer……Date……..……..

Respondent's name…….…….……Position……

Contact……..……Gender.....……

1. What is your current place of work or institution?.....
2. Are you a representative of?
    a) The Ministry of Lands & Physical Planning
    b) County government of Kiambu
    c) Residence association
    d) A regulatory body
    e) Others (specify)…….
3. Which land use types are found within the larger Ruiru subcounty?
    a) Residential
    b) Commercial
    c) Industrial
    d) Agricultural
    e) Public amenities
    f) Open/vacant land
    g) Others (specify)……..
4. Which activities have increased along the Eastern bypass in the last 10 years?
    a) Residential use
    b) Entertainment joints
    c) Light industries

d) Go downs
e) Small and medium retail and wholesale shops
f) Recreational facilities
g) Agricultural land
h) Others (specify)…….

5. In your opinion, what attracts people to live and invest in Ruiru?
    a) Availability of land
    b) Affordable land
    c) Affordable house rents
    d) Access to social amenities
    e) Business opportunities
    f) Access to public utilities such as water, electricity.
    g) Good road networks
    h) They have no other choice
    i) Others (specify)……
6. What acreage of land are more prominent along the Eastern bypass?
    a) $1/8^{th}$ acre
    b) ¼ acre
    c) ½ acres
    d) 1 acre
    e) 1 acre and above
7. What challenges do you face when enforcing development control and land use zoning laws?
    a) None conformity by developers to comply with policy guidelines
    b) Lack of knowledge by the general public.
    c) Inadequate manpower
    d) Others (specify)
8. i) In your opinion, are the residents of Ruiru familiar with the development control regulation?
    a) Yes
    b) No
    c) I don't know

    ii) Why? Explain your answer……

    ……..……..

9. In your opinion, what measures should be taken to ensure compliance with the development control guidelines?
    a) Equipping enforcement agencies with adequate resources.
    b) More law enforcers to be deployed
    c) Public awareness and education
    d) Stringent punishment to deter non compliance

e) Availing services closer to the people.
f) Other (specify)……...

10. i) Do you think the available infrastructure is sufficient in quality and quantity?
    a) Yes
    b) No
    c) I don't know.

    ii) Please explain your answer……..…

    …….

11. In your opinion, which land uses are undergoing change of use within Ruiru town? And from which land use to which one?
    a) Residential to commercial
    b) Residential to industrial
    c) Residential to agricultural
    d) Residential to recreational
    e) Commercial to residential
    f) Commercial to industrial
    g) Commercial to agricultural
    h) Agricultural to residential
    i) Agricultural to commercial
    j) Agricultural to industrial
    k) Others (specify)……

REFERENCES

Abuya, D. O. (2020). *Management Of the Effects of Land Use Changes On Urban Infrastructure Capacity: A Case Study Of Ruaka Town, Kiambu County, Kenya* (Doctoral dissertation, University of Nairobi).

Aderamo, A. J. (2003, December). A Graph Theoretic Analysis of Intra-Urban Road Network in Ilorin, Nigeria. *Research for Development, 1 & 2*, 221-240.

Alemu, B., Garedew, E., Eshetu, Z., & Kassa, H. (2015). Land use and land cover changes and associated driving forces in north western lowlands of Ethiopia. *International research journal of agricultural science and soil science*, *5*(1), 28-44.

Alonso, W. (1960, January). A theory of the urban land market. Bobbs-Merrill Company, College Division.

Alonso, W. A. (1964). Location and Land Use: Toward a General Theory of Land Rent. *Harvard University Press, Cambridge*.

Al Khaldi, H. (2005). *Assessing the Efficiency of Transportation Network in Al Mahmoudayah District.* Iraq: Bangladesh University.

Al Tarzy, A. (2003). *Paved Road Network in the Hashemite Kingdom of Jordan and its Effect on Cities Growth.* Jordan: Al Yarmouk University.

Ali, Z. A. (2001). *Urban Transportation Planning Principles.* Baghdad: Dar Al Safa for Publishing.

Andrew, D. P., MacEvoy, C. D., & Pedersen, P. M. (2011). *Research Methods and Design in Sport Management.* Human Kinetics.

Asadi, A., & et al. (2016). Study of Relationship Between Roads Network Development and Agriculture Land Conversion in Iran Northwest. *International Journal of Environmental Research, 1*(1), 51-58.

Arabiyat, M. (2012). *Using Geomatics Technology in Planning Cities; An Applicable Study on Services and Healthcare Facilities in Al Salt City.* Jordan: Al Balqa Applied University.

Balbo, M., & Navez, F. (1995). Urban Fragmentation as a Reseearch Hypothesis: Rabat-Sale Case Study. *Semantic Scholar*.

Batunova, E., & Gunko, M. (2018). Urban shrinkage: an unspoken challenge of spatial planning in Russian small and medium-sized cities. *European Planning Studies*, *26*(8), 1580-1597.

Berliant, M. (2005). Central Place Theory. *ResearchGate*.

Briassoulis, H. (2012). Analysis of Land Use Change: Theoretic and Modeling Approaches. *Regional Research Institute*, Thunder Bay.

Burchfield, M., Overman, H. G., Puga, D., & Turner, M. A. (2006). Causes of sprawl: A portrait from space. *The Quarterly Journal of Economics*, *121*(2), 587-633.

Cervero, R., & et al. (2004). *Transit-Oriented DEvelopment in the United States: Experience, Challenges and Prospects.* Washington: Transportation Research Board.

Chandran, E. (2004). *Research Methods: A Quantitative Approach with Illustrations from Christian Ministries.* Nairobi, Kenya: Daystar University.

Clark, & et al. (2012). Land Change for All Municipalities in Latin America and the Carribean. *ResearchGate*, 84-103.

County Government of Kiambu. (2015). *Ruiru Sewerage Network Improvement Project.* Nairobi.

County Governmnet of Kiambu. (September 2020). *Ruiru Sub-County Integrated Strategic Urban Development Plan.* Nairobi.

Creswell, J. W. (2009). *Research Methods: Qualitative, Quantitative and Mixed Methods Approaches* (4th ed. ed.). London: SAGE Publications.

Dalenberg , D., & Partridge, M. (2006). The Effects of Taxes, Expenditure and Public Infrastructure on Metropolitan Area Employment. *Journal of Regional Science*, 617-640.

Delden, H., Hagen, A., & Luja, P. (2008). *Assessment and Scenarios of Land Use Change in Europe.* Netherlands: Research Institute of Knowledge Systems.

Duranton, G., & Guerra, E. (2017). *Developing a Common Narrative on Urban Accessibility: An Urban Planning Perspective.* Pennsylvania: Brookings.

Erkul, M., & et al. (2016). Stakeholder Engagement in Mega Transport Infrastructure Projects . *Science Direct*, 704-710.

Ewing , R., & Cervero, R. (2001). Travel and the Built Envoronment: A Synthesis. *Transportation Research Board*.

Garmendia, C., Moroz, H., & Rozenberg, J. (2015). *Road Networks, Accessibility and Resilience: The Cases of Colombia, Ecuador and Peru.* Latin America: The World Bank.

Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of transport geography*, *24*, 471-482.

Geurs, K., & Wee, B. (2004). Accessibility Evaluation of Land Use and Transport Strategies: Review and Research Directions. *Journal of Transport Geography*, 127-140.

Ghnaim, O. (1999). *The Role of Topographical Element in Shaping and Directing Urban Development Patterns in Al Salt City.* Jordan.

Giuliano, G. (2004). Land use impacts of transportation investments. *The geography of urban transportation*, *3*, 237-273.

Gulhan, G., & Ceylan, H. (September 2016). *Relationship Between Land Use and Transportation Planning in the Scope of Smart Growth Strategies: Case Study of Denizli, Turkey.* Turkey: Sustainable Urbanization.

Halim, N. D. A., Latif, M. T., Mohamed, A. F., Maulud, K. N. A., Idrus, S., Azhari, A., ... & Sofwan, N. M. (2020). Spatial assessment of land use impact on air quality in mega urban regions, Malaysia. *Sustainable Cities and Society*, *63*, 102436.

Iacono, M., & Levinson, D. (2009). Predicting Land Use Change: How Much Does Transportation Matter? *Journal of the Transportation Research Board*, 130-136.

Kaczorowska, A., Kain, J. H., Kronenberg, J., & Haase, D. (2016). Ecosystem services in urban land use planning: Integration challenges in complex urban settings—Case of Stockholm. *Ecosystem Services*, *22*, 204-212.

Kalkhajeh, R. G., & Jamali, A. A. (2019). Analysis and Predicting the Trend of Land Use/Cover Changes Using Neural Network and Systematic Point Statistical Analysis (SPSA). *Journal of the Indian Society of Remote Sensing*, 1471-1485.

Kasraian, D., & Maat, K. (2016). Long-term Impacts of Transport Infrastructure Networks on Land-use Change: An International Review of Empirical Studies. *Taylor & Francis Online*, 772-792.

KCIDP. (2018-2022). *County Government of Kiambu Integrated Development Plan 2018-2022.* Nairobi.

Kenya Law Reports. (1996). *The Physical Planning Act, 1996.* Nairobi: National Council for Law Reporting.

Kenya Law Reports. (2011). *Urban Areas and Cities Act No 13 of 2011.* Nairobi: National Council for Law Reporting.

Kenya Law Reports. (2012). *County Government Act No 17 of 2012.* Nairobi: National Council for Law Reporting.

KNBS. (November 2019). *Kenya Population & Housing Census.* Nairobi: KNBS.

Koenig, J. (1980). Indicator of Urban Accessibility: Theory and Application. *Journal of Geographic Information System*, 145-172.

Koomen , E., & Dekkers, J. (2005). Valuation of Metropolitan Open Space . *ResearchGate*.

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques* (2nd edition ed.). New Delhi: New Age International Publishers.

Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 607-610.

Lean, W., & Goodall, B. (1977). Aspects of Land Economics. *The Estates Gazette*, 135-141.

Leinbach, T. R. (1975, June). Transportation and the Development of Malaysia. *John Wiley & Sons, 65*(2), 57-63.

Leeson, P. T., Harris, C., & Myers, A. (2021). Kornai goes to Kenya. *Public Choice, 187*(1), 99-110.

Mackett, R., & Edwards, M. (1998). The Impact of New Urban Public Transport Systems: Will the Expectations be Met? *Elsevier*, 231-245.

Mandal, R. B. (1992). *Land Utilization: Theory and Practice.* New Delhi: Concept Publishing Company.

Manderscheid, K., & Bergman, M. (2008). Spatial Patterns and Social Inequality in Switzerland - Modern or Post-modern? *ResearchGate*.

Mansour, S. (2004). Spatial Modeling of Residential Crowding in Alexandria Governorate Egypt, A Geographically Weighted Regression Technique. *Journal of Geographic Information System*, 29-39.

Marwa, A. (2018). *Impact of Land Use and Transportation Modes on Road Networks, Case Study: Alexandria City Center*. (Vol. 176). Boston: WIT Press.

Meijer, J., Huijbregts, M. A., Schotten, K., & Schipper, A. (2018). Global Patterns of Current and Future Road Infrastructure. *ResearchGate*.

Meyer, W. B. (2000). The Other Burgess Model. Urban Geography, 21(3), 261-270.

Moraci, F., Errigo, M. F., Fazia, C., Campisi, T., & Castelli, F. (2020). Cities under pressure: Strategies and tools to face climate change and pandemic. *Sustainability*, *12*(18), 7743.

Mouratidis, A., & Kehagia, F. (2014). On the Track of Road Evolution. *Journal of Infrastructure Development*, 1-15.

Mugenda, O. M., & Mugenda, A. G. (2003). *Research Methods: Quantitative and Qualitative Approaches.* Nairobi: African Centre for Technology Studies (ACTS).

Narvaez, L., Griffiths, S., & Penn, A. (2013). Spatial configuration and Bid Rent Theory: How Urban Space Shapes the Urban Economy. *ResearchGate*, 89.

National Land Commission. (2016). *Urban Land Use Planning, Monitoring and Oversight Guidelines.* Nairobi: National Land Commission.

Nautiyal, A., & Sharma, S. (2021). Scientific approach using AHP to prioritize low volume rural roads for pavement maintenance. *Journal of Quality in Maintenance Engineering*.

Ng, C. P., Law, T. H., Jakarni, F. M., & Kulanthayan, S. (2019, April). Road infrastructure development and economic growth. In *IOP Conference Series: Materials Science and Engineering* (Vol. 512, No. 1, p. 012045). IOP Publishing.

Ngetich, J. K., Opata, G. P., & Mulongo, L. S. (2014). Urban Environmental Planning and Development Control of Medium Sized Towns in Kenya. A Case of Eldoret Municipality. *Journal of Emerging Trends in Economic and Management Sciences*, 351-363.

Njoh, A. J. (2000). Transportation Infrastructure and Economic Development in Sub-Saharan Africa. *Public Works Management and Policy*, *4*(4), 286-296.

Njoh, A. J. (2009, 09 24). The Development Theory of Transportation Infrastructure Examined in the Context of Central and West Africa. *Springer Science*, 227-229.

Oduwaye , A. O., Adeleye, O. A., & Olayiwola, L. M. (2005). Correlates of Land Value Determinants in Lagos Metropolis, Nigeria. *Journal for Human Ecology*, 183-189.

Oduwaye. (2004, October). Land Value Determinants in Medium Density Residential Neighbourhoods of Metropolitan Lagos. *Journal of the NITP, XVII* (1), 97-111.

OECD. (2017). *The Governance of Land Use.* Regional Development Policy Division.

Ogonda, R. T. (1986). *The Development of Road Transport System In Kenya.* Nairobi: University of Nairobi.

Oni, A. O., & Ajayi, C. A. (2011). Land Value Determinants and Rental Values of Office Spaces in Ikeja, Nigeria. *Mediterranean Journal of Social Sciences, 2*(2), 3-4.

Oni, A. O. (2007). A Study of the Accessibility and Connectivity of Ikeja Arterial Roads. *Journal of Land Use and Development Studies*, 108-122.

Oni, A. O. (2010). *Arterial Road Network and Commercial Property Values: Case Study of Ikeja, Nigeria.* Ikeja, Nigeria: Covenant University.

Oruonye, E. D. (2014). An Assessment of the Impact of Road Construction on Land Use Pattern in Urban Centers in Nigeria, a Case Study of Jalingo LGA, Taraba State Nigeria. *Mediterranean Journal of Social Sciences, 5*(10), 82-88. doi:10.5901/mjss. 2014.v5n10p82.

Oyesiku, O. O. (2002). From Womb to Tomb. *24th Inaugural Lecture at Olabisi Onabanjo University.* Ago-Iwoye: Olabisi Onabanjo University Press.

Pradhan, R. P., Arvin, M. B., & Nair, M. (2021). Urbanization, transportation infrastructure, ICT, and economic growth: A temporal causal analysis. *Cities, 115*, 103213.

Puttick, S. (2020). Taking Burgess Out of the Bin. Teaching Geography, 45(1). 6-8.

Qtiashat, D., & Makhmreh, Z. (2018). *Urban Land Use Pattern and Road Network Characteristics Using GIS in Al Salt City, Jordan.* Canada: Canadian Center of Science and Education.

Queiroz, C., & Kerali, H. (2010). *A review of Institutional Arrangements for Road Asset Management:* Washington DC: World Bank Group.

Ravetz, J., Fertner, C., & Nielsen, S. (2013). The Dynamics of Peri-Urbanization. *Springer*, 13-15.

Riad, R. B. (2019). Lanad Management Instruments.

Rui, Y. (2013). *Urban Growth Modeling Based on Land-use Changes and Road Network Expansion.* Stockholm: US AB.

Sandhya, S. (1999). Weber's Theory of Industrial Location Economics. *Economics Discussion*.

SID. (2012). *The State of East Africa.* Nairobi: Society for International Development.

Singh, S. (2013). Sector Theory by Homer Hoyt. *Education*, 7-9.

Shehab, A., & Alladin, M. (1990). *Spatial Requirements of Planning the City.* Baghdad: Ministry of Scientific Research and Higher Education.

Shi, G., & Shan, J. (June 2019). Urban Road Network Expansion and Its Driving Variable: A Case Study of Nanjing City. *International Journal of Environmental Research and Public Health*, 2-6.

Sreelekha, M. G., Krishnamurthy, K., & Anjaneyulu, M. V. (2016). Interaction Between Road Network Connectivity and Spatial Pattern. *Elsevier, Volume 24*, 131-139.

Soma, A. M., & Pandit, R. K. (2013, January). Urban Transformation and Role of Architecture Towards Social Sustainability. *International Journal of Engineering Research and Development, 5*(7), 16-20.

Thuo, A. (2013, November). An Analysis of the Roles of Actors in Land Use Change in the Nairobi Rural-Urban Fringe, Kenya. *International Journal of Research in Social Sciences, 3*(4), 319-328.

UN Habitat. (2017). *Ruiru Sustainable Urban Mobility Plan (SUMP).* Nairobi: UN Habitat.

UN-Habitat. (2010). *United Nations Human Settlement Programme.* Nairobi: UNON.

United Nations. (2004). *Integrated approach to the Planning and Management of Land Resources.* UN Department of Economics and Social Affairs.

UNPD. (2009). *World Population Prospects, The 2008 Revision.* New York: United Nations.

Wegener, M. (2004). Overview of Land-use Transport Models: Transport Geography and Spatial Systems. *Elsevier Science,* 127-146.

Yin, R. K. (2009). Case Study Research: Design and Methods (4th ed.). *Canadian Journal of Action Research*.

Zhang, Q., & Lund University. (2004). Modeling Structure and Pattern in Road Network Generalization. *ICA Workshop on Generalization and Multiple Representation.* Leicester, Sweden: 2004.