UNIVERSITY OF NAIROBI

ASSESSMENT OF THE RELATIONSHIP BETWEEN LAND USE AND TRAFFIC ALONG THE THIKA SUPERHIGHWAY, NAIROBI, KENYA

BY

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DECLARATION

I declare that this thesis is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has been properly acknowledged and referenced in accordance with the University of Nairobi's requirements.

Signature …… Date ……

Dennis Songole Bugunye Lugalia

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This thesis has been submitted for examination with my approval as research supervisor.

	Signature	Date
Dr. S.V. Obiero	……...	……..

DEDICATION

I dedicate this work to the MA class of 2013 with whom we started this journey together and MA class of 2014 who adopted me and made me one of their own. I am eternally in your debt.

I also wish to thank the Department of Urban and Regional Planning teaching faculty who have been with me throughout my studies and who have widened my scope of thinking. I could not have chosen better tutors.

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Abstract

The Thika Superhighway is perhaps the most massive infrastructural project in the East African region, save for perhaps the standard gauge railway (SGR) project. It was anticipated by the business community, leading to the change of use of land along it, manifested in the development of malls and housing estates. This land use change is continuing despite the road having been completed in February of the year 2012. The road was built with the aim of easing the traffic congestion problem, but traffic congestion persists. This phenomenon has not been documented in this part of the world and the study aims at doing so.

A study area was isolated along the Thika Superhighway which had a variety of land uses. An examination was done on the nature of the superhighway itself, the predominant land use in this area, the nature of the land use changes and the effect of this on traffic along the highway. This was done with a view to establishing a link between adjacent land use changes and traffic along the superhighway.

Results from the study indicate that there is a relationship between adjacent land use change and traffic on the highway. This was evidenced from changes in the design of the highway at some friction points where land use change had occurred and had had an impact on the traffic flow. As well, the desire for most of the respondents to own private vehicles would tend to have the effect of increasing traffic along the highway from a planning point of view.

The conclusions drawn from the study therefore point to a need to have a reliable transport system to bring down the numbers of private vehicles on the roads thus congestion. As well, it is incumbent upon transport and planning authorities to come up with means of performing conclusive studies on the impact of certain developments to roadways and thus mitigate these impacts early on in development.

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List of Abbreviations

BRT – Bus Rapid Transit

CBD – Central Business District

CCN – City County of Nairobi

DOT – Department of Transportation

EIA – Environmental Impact Assessment

EMCA – Environmental Management and Co-ordination Act

GDP – Gross Domestic Product

JICA – Japanese International Cooperation Agency

KeNHA – Kenya National Highways Authority

KeRRA – Kenya Rural Roads Authority

KNBS – Kenya National Bureau of Statistics

KRB – Kenya Roads Board

KURA – Kenya Urban Roads Authority

NMT – Non-Motorized Transport

PPA – Physical Planning Act

PPA – Physical Planning Act

PSV – Public Service Vehicle

SACCO – Savings and Credit Co-operative Society as applied to PSVs

SGR – Standard Gauge Railway

SoK – Survey of Kenya

SPSS – Statistical Package for Social Sciences

UTM – Universal Transverse Mercator Projection

CHAPTER1: INTRODUCTION

1.1 Introduction

Expenditure on transportation infrastructure uses up a significant portion of a country's funds the world over. In America, the funds allocated to infrastructure development in the financial year 2018/2019 is estimated to be in the region ofUSD76.6 billion or nearly 7.6 trillion Kenya Shillings(USGov, 2018). The UK on the other hand spentabout USD 119 billion on infrastructure in the year 2014, with total expenditure on infrastructure projected to reach about USD 182 billion by the year 2025 (PwC, 2015).It is however useful to note that these regions have a very advanced transportation infrastructure network which includes very efficient rail and water transportation networks; and expenditure on infrastructure also includes spending on utility networks and other related works. However, roads still form an integral part of the overall transportation networks.

Kenya's transportation infrastructure comprises of a road network, rail services, air transport corridors, waterways and an oil pipeline. A 2009 Transport Sector Indicator Framework Study for the Northern Corridor Improvement Project, indicates that the road network consisted of approximately 63,292 km of classified roads and an estimated further 80,000 – 130,000 km of unclassified roads (KRB, 2009). In the same report, it was estimated that 80% of the total passenger traffic and 76% of the total freight volumes are on roads. The rail network comprises 3,360 kms of single track, one metre gauge railway with 163 stations and 3 inland depots at Embakasi, Kisumu and Eldoret. A further 472.3 kms of the standard gauge rail has been added to the total running from Mombasa to Nairobi and it is further being expanded to extend all the way to Malaba (Mwende, 2017). Kenya also has a major seaport at Mombasa which handles 13 million tonnes of cargo as at 2009 and inland port facilities at Kisumu on Lake Victoria (KRB, 2009). The air transport network is vast compared to both rail and water in terms of reach with an estimated 570 aerodromes, 156 of which are public. Of the public, 9 are operated by Kenya Airports Authority (KAA) of which the major ones include the Jomo Kenyatta International Airport in Nairobi, Moi International Airport in Mombasa, Eldoret International Airport in Eldoret and Kisumu Airport in Kisumu. The oil pipeline, operated by the Kenya Pipeline

Company (KPC), had a total length of 896 kms as at the year 2009. However, this has increased by a further 450 kms following the commissioning of a 20-inch pipeline in the year 2018 (KPC, 2018). Plans are underway to increase the pipeline to reach Turkana and Lamu.

Kenya's budget estimates for the financial year 2018/2019 envisaged expenditure of 2,556.6 billion of which a total of 194.7 billion will go toward the construction of transport infrastructure(GoK, 2018). Of this amount, the lion's share of 115.9 billion has been allocated to roads, 74.7 billion to the SGR, 1.4 billion towards the expansion of Malindi, Isiolo and Lokichogio Airports and Kabunde, Kakamega, Kitale and Migori Airstrips and finally a sum of 2.7 billion towards the Mombasa Port Development plan.

Accordingly, in terms of transportation infrastructure, expenditure still leans heavily on the road sub sector followed closely by the SGR. To further put this in perspective, the Thika Superhighway, was constructed at a cost of US Dollars 360 million (about 36.2 billion by current exchange rate of Kes 100.55 to 1 US dollar), with the AfDB contributing US $ 180 million through a loan via the African Development fund, the Government of Kenya contributing US $ 80 million and the Exim Bank of China contributing US $ 100 million, the latter being used for upgrades between Kenyatta University and Thika (AFDB, 2012).

However, even when modern infrastructure is built, as is the case with Thika Road and other recently reconstructed roads, congestion still occurs on it particularly during the peak periods. On the surface it appears that the infrastructure built seems to not fulfil its purpose, which is to meet the perceived needs of the users. Other recently constructed roads in the country have had similar problems such as the recently constructed Outering road, which cost the tax payer approximately 9.9 billion shillings (KURA, 2018).

The cost of traffic congestion is high as well. Nairobi's roads are the fourth most congested in the world according to International Business Machines Corporation's 'Commuter Pain Survey' of 2011. The Government estimates the cost of congestion to be about US 578,000 per day by Government(McGregor & Doya, 2018). In as far as land use and transportation are concerned; the two seem to be inextricably linked.

As early as 1995, the United States recognized the need for planning for both. Transport planning was recognized as needing constant interaction between land use and transportation in a consistent fashion, and thus creating the need for land use transportation models (Southwork, 2018)

This then points out to a much larger problem than the currency or the quality of the road network. Mombasa road is a relatively new road which has had its capacity increased by increasing the number of lanes on it but still suffers congestion. That a new road can be completely overwhelmed points out to the fact that there must be underlying issues that cause congestion on roads that may not be infrastructure related.

Poignant questions then arise from the discussion so far; does the Government have policies that govern land use and that also incorporate transport, does the government have mechanisms for measuring feedback on existing transport infrastructure and finally,given the massive spending on infrastructure that the current government is incurring, are there lessons to be learnt and do they inform the current wave of infrastructural spending?

1.2 Problem Statement

Outdated infrastructure has some major impacts, including their contribution to impeded traffic flow in major urban areas. Some studies done concerning the state of the infrastructure in the city of Nairobi suggest that the infrastructure dating to more than half a century old is to blame for the perennial traffic jams (Kushner, 2014)

(Kushner, 2014). However, new roads built to cover up for inefficiencies brought about by dilapidated ones suffer from congestion in the long and sometimes the short term. (Litman, 2001) suggests that new roads suffer from induced and generated travel meaning that the purpose for which they were built sometimes is not met. This then implies that an infrastructure led solution of decongesting city roads may not be 100% successful in relieving the city of its problem.

Slow moving traffic affects the wellbeing of road users and non-road users in different ways. Indeed, in the U.S. it has been found out that transportation plays a significant role in carbon dioxide emissions, approximately a third of its inventory (Barth & Boriboonsomin, 2008). Aside from contributing to carbon dioxide emission,

there are other potentially harmful gases that are released into the atmosphere in larger quantities whenever there is stop and go traffic conditions.

Growth and development that is experienced particularly in the real estate industry tends to bring about a change in the density of traffic. (Fernando, 2001). Fernando argues that developments tend to generate traffic. Uncontrolled development will lead to the filling up of a roadway which would be disastrous in the long term.Shubho & Neema (2014) argue rightly that traffic is a function of land use hence the way land is used affects its development and the character of traffic on the streets and highway network. A haphazard nature of development in this case then tends to exacerbate the traffic flow problem. For instance, the siting of a commercial activity near a roadway section can be directly attributed to peak traffic. As well, a ribbon kind of development has been known to affect traffic pattern, as the road frontage of some of the enterprises tends to be converted into parking slots effectively turning a two-way street into one way. This is especially so when the roadside developments lack parking slots.

Traffic volumes on a busy roadway is normally associated with the type and density of activity built along the highway, according to our intuition (Kuzmyak, 2012). However, does this also account for bumper to bumper traffic in a stretch that is devoid of obvious commercial activity or higher density residential development? Generally, travel may be equated to a tabular format pitting origin demand against destination supply which is then superimposed on the transportation network. Highways are used for longer trip travels while local arterials are used for local trip travels. However, in some instances, there is a mix whereby the longer trip traffic uses the local arterials and vice versa. This then implies that traffic volumes and thus flow may then not be entirely explained away using adjacent development as causes but may have multiple contributing causes.

At its completion, the Thika Superhighway, at an approximate cost of 36 billion,was perhaps the most massive infrastructural project in the East African region. This has since been surpassed by the recent construction of the standard gauge railway (SGR) at a cost of 327 billion. Its construction was anticipated by the business community, leading to the change of use of land along it, manifested in the development of malls, housing estates and other commercial ventures. This land use change is continuing

despite the road having been completed about six years ago, in February of 2012. The road was built with the aim of having a more efficient traffic flow, but traffic volumes are still very high especially around peak times. This phenomenon has not been documented on in this part of the world and the study aims at doing so.

1.3Research Questions

The pertinent questions raised by the study include:

1. What are the characteristics of the Thika Superhighway?
2. What is the land use along the Thika Superhighway?
3. What are the characteristics of traffic flow and volumes along the Thika Superhighway?
4. What is the effect of land use change on traffic along the Thika Superhighway?

1.4 Research Objectives

The general objective of the study is to investigate the impact that the land use changes along the Thika Superhighway have had on the road itself. The specific objectives of the study include:

1. To establish the characteristics of the Thika Superhighway
2. To assess the land uses along the Superhighway
3. To examine the characteristics of traffic flow and volumes along the Superhighway
4. To investigate the effects of land use changes on the traffic situation along the Thika Superhighway

1.5 Assumptions

The study assumes that the rate of land and economic development along the Thika Superhighway will continue for the foreseeable future. It also assumes that road transport will continue to be the dominant mode of transportation that the inhabitants along the superhighway will continue to use owing to its affordability and availability.

1.6Justification and Significance of the Study

The relationship between land use and transportation, though documented in various parts of the world has not been documented for the recently constructed Thika Superhighway and its adjacent land uses. This study aims at documenting the same and drawing some meaningful conclusions at the end of it.

It is the hope of the researcher that the results of the study will provide some basis of policy decisions especially on mass transit and traffic impact assessment tests especially in the case of high traffic land use development.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

That there exists a link between land use and transportation is not in doubt. Urban planning paradigms of the past and the present need to be realigned with current and future concerns which among others are the necessity to combat sprawl and additionally to recognize the need to incorporate transport planning into land use planning. This chapter looks at existing urban growth models, economic growth models and their implications on transport.

2.2 Ribbon Development as a Model of Urban Growth

Ribbon development may be loosely defined as development along a major communication route, in many instances a road, which is characterized by the proliferation of buildings on both sides of the road, along the face of it but not extending much farther inwards. When examining ribbon development, Garrison (1969) contends that there are four types of business patterns that are associated with this phenomenon:

the *nucleation* which ranges from isolated neighbourhoodgrocery stores to highly developed urban centres, the *urban arterials*, which are also defined as nucleations, but when nucleated they locate on urban arterials. They too can differ in size according to differences in traffic flow along the highway, the*automobile row* includes businesses such as auto dealers, used cars, food lockers, and motels and are associated with the specialized automobile district of larger nucleations and finally the *highway-oriented* uses which includes those business types which are successful only when highway-oriented for instance gas, restaurant, motel, and fruit and vegetable produce. Their size is also determined by the volume of traffic moving along the highway(Garisson, 1969).

Ribbon developments occur due to some factors which would relate to profit, more so in the case of businesses. In her thesis titled '*A ribbon development study in Ontario, Oregon*', Clark (1978) contends that pirating was responsible for the rapid ribbon development along highway 201 in Ontario, USA. According to the study, development was rapid past the year 1970 with the planned construction of West Park Plaza, which started in 1971, which attracted over 70% of the establishments that were studied in her work in the year 1978(Clark, 1978).

To further try to understand the phenomenon is to adopt the findings of her work, in trying to understand the seven important criteria that commercial users often consider when choosing a location:

1. The decision maker who is most times motivated by net profit.
2. Land availability and costs which prohibit the siting of businesses in some sites.
3. Hierarchical order of the centre in terms of supply and demand.
4. Transferability of customers which seeks to take advantage of higher numbers of prospective consumers by locating next to highways. The premise is that a consumer will tend to change to a place which offers least effort and maximum satisfaction.
5. Scale, whereby consumers will tend to prefer to frequent stores where they can attend to their every need due to the agglomeration of different businesses within one location.
6. Location of other activities whereby consumers will be drawn to frequent places where there is a variety.
7. Constraints and incentives.

Some of these factors may also be extended to other users. For instance, transferability as applied to a residential user may be modified to refer to the ability of a resident to get to their place of residence with least effort about easily available transportation networks. Another example that would go further to emphasize commercial siting is to look at how constraints and incentives sometimes drive businesses to specific locations. In Kenya for instance, the provision of an export processing zone (EPZ) in Athi River has provided incentive for export-oriented businesses to locate in the region owing to incentives offered to them by the government.

2.3Land Use Determinants

Land use is determined by a variety of factors some anthropogenic and some nature oriented. In this regard then, four factors may be identified (K'Akumu, 2014):

1. Nature
2. Technology
3. Market forces

4. Administrative instruments

2.3.1 Nature

With regards to land use, nature refers to what is predominant on the land. This is the soil, vegetation, air and so on. This then determines what the leading use should be. For instance, soil that is clayish in nature may only support cotton farming, red soils are good for farming for instance in Kiambu county.

However, nature alone may not entirely determine what predominant land use may occur at a site. Simply put, in the absence of other factors, nature takes precedence when it comes to the determination of land use.

2.3.2 Technology

Where nature has made habitation impossible, technology intervenes and changes the nature of land use. One such popular intervention is irrigation. Nature may have relegated some site to desolation but through the intervention of man this site may be rehabilitated and made useful.

In some instances, technology has been utilised to reclaim part of the sea in order that the use may change to dwelling land. This is so particularly in the Netherlands with the Dutch having reclaimed part of the sea using dykes. The Palm Islands of the UAE are another example. The Emir realizing that the oil revenues will not last forever chose to create a tourist attraction and he based this on the palm tree. Land was reclaimed from the sea and an island in the form of a palm tree was designed and implemented. It now boasts of high end luxury mansions for the affluent all over the world(Malkin, 2011).

Figure 2.1 Palm Island
Source: Malkin (2011)

2.3.3 Market Mechanism

A particularly useful method of evaluating how the market determines the land use is by looking at the bid rent function, an economic tool of analysis. The concept of bid rent function is defined in the book *Introduction to Land Economics* by King'oria (2013). The bidding aspect refers to the act of passive landowners (speculators) who own land for sale or rent in a specific location. Their behaviour is that they tend to hold on to the land despite numerous persons desiring to buy or rent the parcels until the highest bidder comes along so that they may maximize returns(Kingoria, 2013). The *bid rent* term thereby emphasizes the bidding aspect in an open market and is essentially a price competition. The assumption made is that of a monocentriccity on a unitropic plain and that every user tends to want to locate near the centre on order to minimize their travel costs.

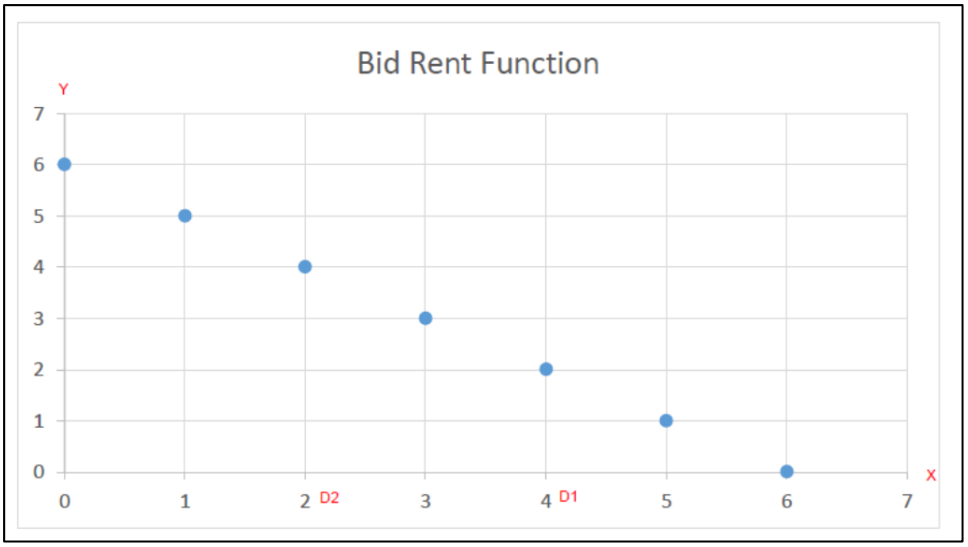


Figure 2.2Bid Rent Function for One User

Source: K'Akumu (2014)

Now assuming the x axis is the distance from the core (0, 0) while the y axis is the rent to pay. A user at the core has 6 units to pay for rent and can thus comfortably use this for that purpose. A user at D2 had four units due to losing some for transportation. The production frontier is D1 where the user all the units for transportation.

This can be used to model the bid rent function for two competing users. This is especially important to see how competing land uses may behave toward acquiring the space.

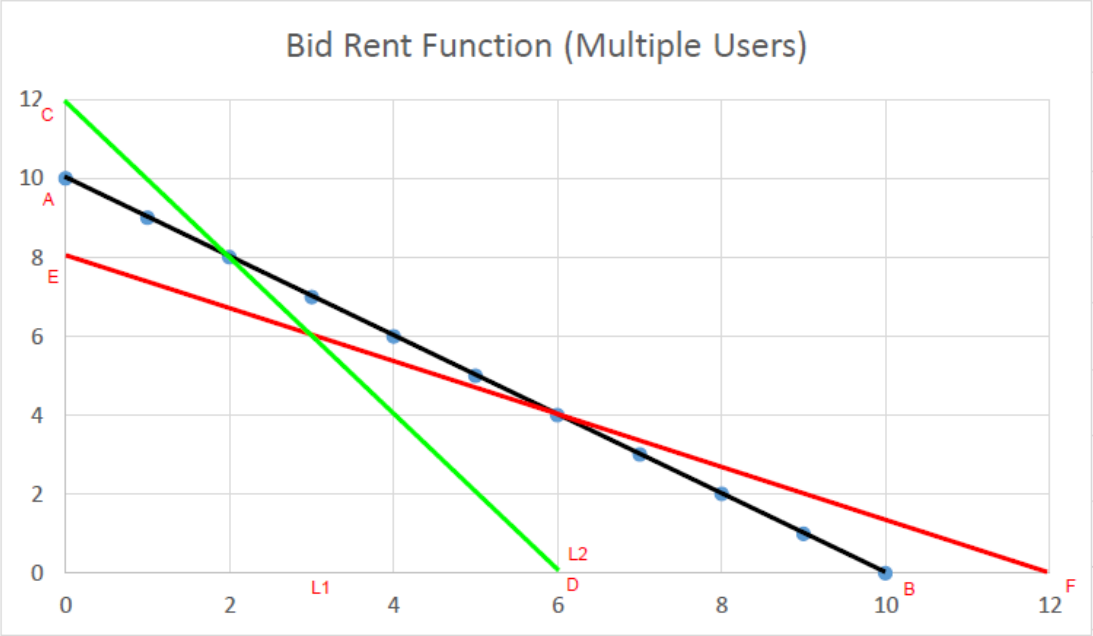
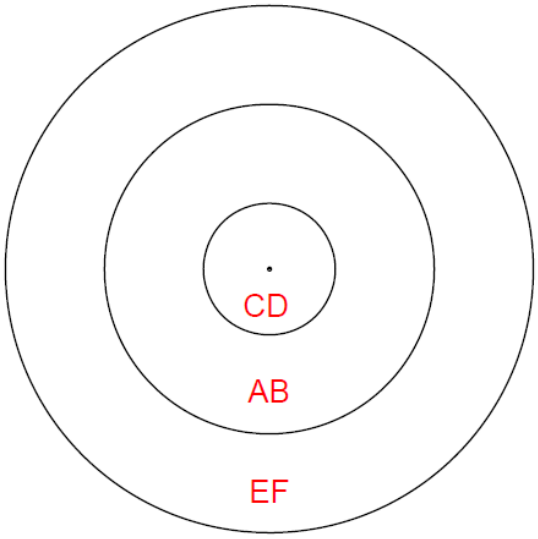


Figure 2.3Bid Rent Function for Multiple Users
Source: K'Akumu (2014)

Up to the point L1, the user CD has a higher function than anybody else, so the user will outbid both users AB and EF to occupy space O – L1. However, past L1, the user AB has the higher function and will easily outbid the users CD and EF for the space between L1 and L2. Past point L2 the user EF outbids the rest. However, point F is the production frontier and no user would wish to occupy the land beyond that.
A result of a monocentric city may be graphically shown as below:



Zone 1: CD = Commercial
Zone 2: AB = Residential
Zone 3: EF = Industrial

Figure 2.4Urban Land Use Zones
Source: K'Akumu (2014)

The urbanisation process and growth of towns forces a change in the urban land uses through the bidding process. This is prevalent in some of the older neighbourhoods of Nairobi such as Ngara, Hurlingham and Upper hill,whichare slowly turning into commercial, with the residential user slowly being pushed away. The commercial user tends to outbid the residential user since they can afford the higher rents and would like to take advantage of proximity to the city.

The result of such a system causes market failures which if not solved will result in chaos. However, the remedy is administrative action which is highlighted in the next section.

2.3.4 Administrative Instruments

The instruments that may be uses to correct market failures are:

1. Expropriation
2. Cadastral systems
3. Police power
4. Planning

Expropriation is also known as compulsory acquisition in Kenya. The state gets to appropriate the proprietor's land without their permission through eminent domain. However, the appropriation should be for public purpose, planning purposes or in the event of war. This has its basis in law through the Land Act of 2012 S9 and the procedure is laid out in Part VIII of the same Act (GoK, 2012a).

Cadastral systems are based on a cadastre which is a record of land details. Each record will have a use which may be changed through application to the relevant authority. The state may use its power to grant or refuse changes to the user according to zoning plans or may grant renewal of leases giving certain conditions that may have an impact on the use of the land. This is outlined in the Physical Planning Act in S32(GOK, 1996) and as well in the Land Act S36 (GoK, 2012a) as well as other Acts of parliament.

Police power refers to the power of any government agency to ensure legal use of private land if the wrong use is made of the land or the land is neglected thus posing a risk to the environment. It is exercised through many Acts such as the Physical Planning Act in S33 and the Environment Management and Co-ordination Act (EMCA) S108 (GoK, 1999).

Planning is exercised by institutions that are government related. There are a multitude of legislation provisions that govern the use of land and as well land use plans. Nairobi has the Nairobi Zoning Ordinance which stipulates the kind of development that may be allowed in different parts of the city(CCN). By allocating land to different users, planning aims to provide land use planning.

2.4 Von Thunen's Land Use Model and its Application

Johann Heinrich von Thünen, a 19th Century economist from Germany came up with a model in 1826 to try and explain the pattern of agricultural activities surrounding

cities in pre-industrial cities (Fujita & Thisse, 2002). The idea was that in its most basic form, that a farmer will face a choice between land rents and transport costs.

The theory focuses on transportation cost differential across locations. The setting is a plain with homogeneity in all aspects but a marketplace in which all transactions regarding final goods must occur. Thus, the price of land at any location reflects its proximity to the market so that the closer the land is to the market place, the higher the land rent.

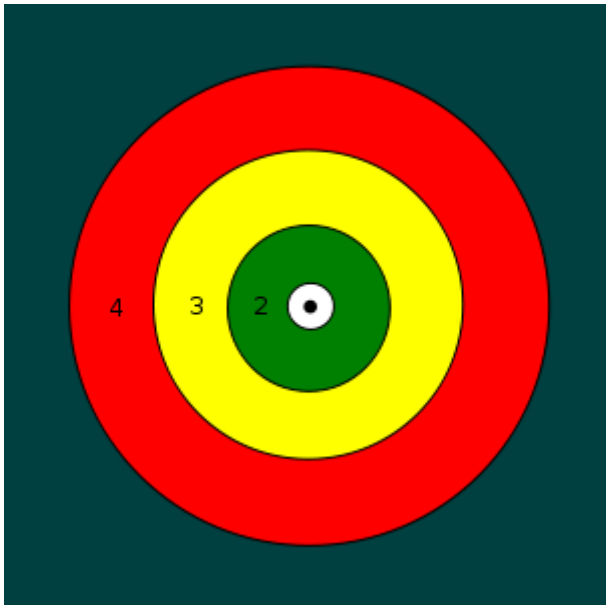


Figure 2.5Von Thunen's Land Use Model
Source: King'oria (2013)

The dot in the middle represents the city/marketplace and represents the highest rents. The red ring represents the outlying areas and where the rents are cheapest. It however represents the places with the highest transport costs. This is also illustrated in the diagram below representing the same. At the marketplace, the prices (P) are the highest and they tend to reduce the further away from the marketplace and are lowest in the outskirts.

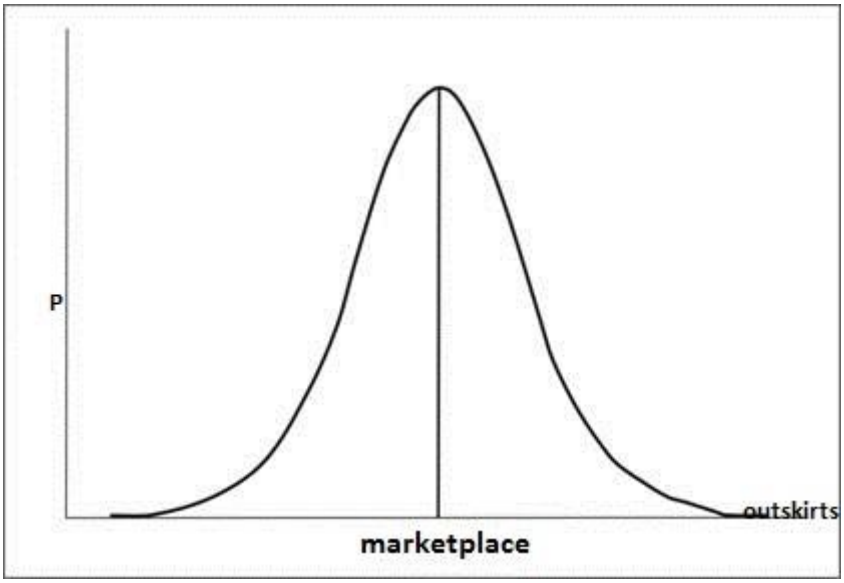


Figure 2.6Von Thunen's Land Use Model

Source: King'oria (2013)

The principle underlying the model is the distance to some specific areas endowed with desirable characteristics is the reason there is a *differential land rent.* In many places the world over, the supply of land vastly outstrips its demand. If we remove the need for accessibility, *land should almost certainly be a free good* (Fujita, M. & Thisse, J., 2002).

The same can be applied to a transportation network. Figure 2.7 illustrates the same concept.

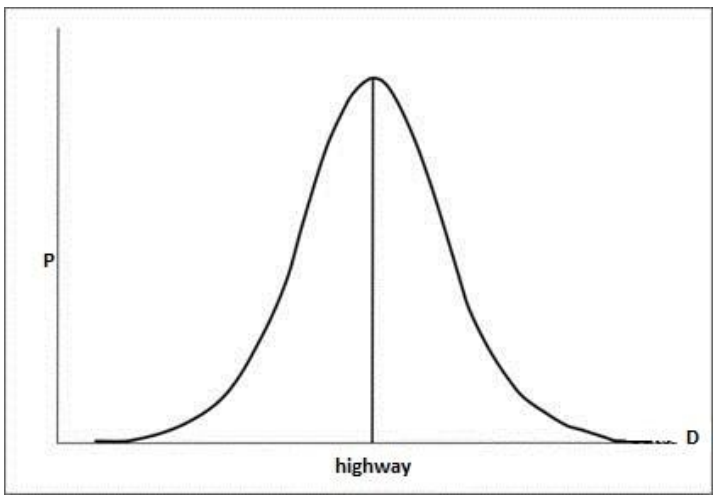


Figure 2.7Von Thunen's Land Use Model Applied to a Transportation Network

Source: K'Akumu (2014)

If the price of land is P and the distance from the highway is D, it is noticeable that the further the distance from the highway, the lower the price of land. This is evident

in the pricing of land next to roads and particularly major highways. In a study of land values in Shanghai between the years of 1993 and 1994, a study done revealed that the Nanjing road in Shanghai is the most important location factor affecting spatial distribution of land values(Du & Xu, 1998). In the same study, it was deduced that the closer the land to Nanjing road, the higher the land values.

2.5 Implications of Land Use Change on Roads

There are various implications that a change in land use has on the prevailing roads. The level of service derived from infrastructure depends as much on prevailing land use and demographic characteristics as it does on the attributes of the infrastructure itself (Heikkila, et al., 1989). These impacts could be two-fold:

- Change in service levels brought about by imposing changes on a fixed transport infrastructure. These changes are for the worse.
- Mitigation costs which are additional public investments required to offset what would be an otherwise unacceptable decline in transportation level of service. This robs the other sectors of the economy of much needed investment.

A high population density and a mixture of land uses maintains low distances between origins and destinations and therefore encourages mass transit and less automobile trips. This has huge implications for the transport infrastructure which is illustrated in Figure 2.8.(Arias, et al., 2007)

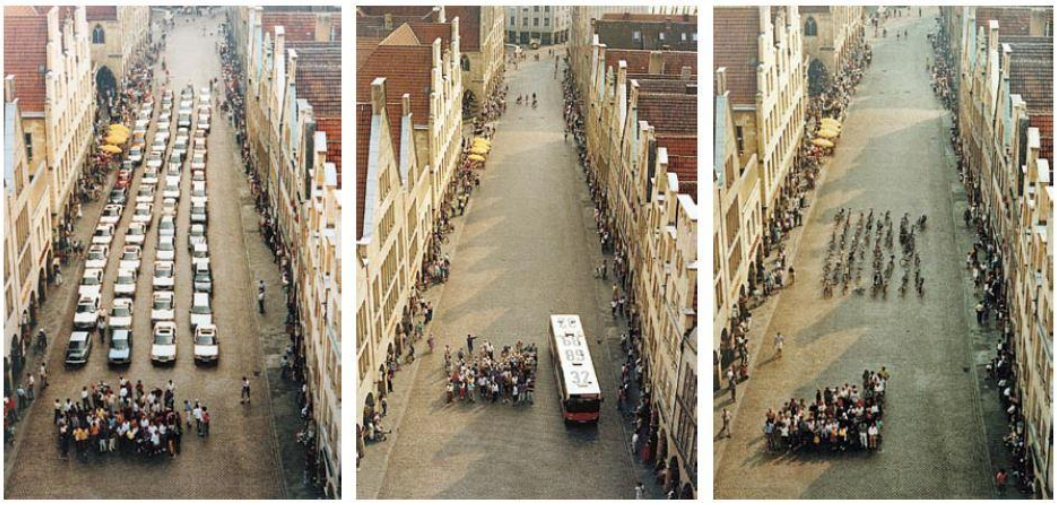


Figure 2.8Space Requirements for 80 Persons in a Car, a Bus, Walking or Cycling
Source: Bus Rapid Transit Planning Guide (2007)

Policies that mitigate against emissions may encourage mass transit hence sustainability. Other policies such as compaction policies may reduce total trip length, a modal shift from private cars to public or NMT. This though must be coupled with mixed land uses to combat traffic congestion and rising maintenance costs of high-rise buildings. Increased investment in urban public transportation revitalizes the core and advocates the development of a compact city.

2.6 Uncontrolled Land Use Change and Generation of Traffic

Roads are a major public investment. According to Fernando (2001), developments generate traffic and therefore the link between roads and development should not be downplayed. As a rule, new roads tend to attract new developments and the problems will tend to recur later as capacity is filled in that road system. Uncontrolled developments will tend to lead to disastrous consequences for the existing roadway.

Deakins (1990) had intimated that the failure of planning in the professional domain is to blame for the congestion problems that faced California at that time. In studying suburban California, she contends that as developments seek to go further away from the centre, there is a lack of policy shift to consider expansion of existing facilities to cope with that trend(Deakins, 1990). In principal, there is a lack of anticipatory planning to be able to provide the suburbanites with a level of service provision that the centre enjoys, principally provision of roads. As far back as 1990 at the writing of her paper, she contends that there is a lack of control in the way land uses are allocated. Thus,there should be emphasis on sizing development to reflect transport capacity among doing other things. If there can be increase in densities, she argues, transit and other share ride transportation modes can attract adequate ridership.

Shubho & Neema (2014) argue rightly that traffic is a function of land use hence the way land is used affects its development and the character of traffic on the streets and highway network. A haphazard nature of development in this case then tends to exacerbate the traffic congestion problem. For instance, the siting of a commercial activity near a roadway section can be directly attributed to peak traffic. An agreement is made with Fernando's (2001) findings that developments attract traffic and produces traffic in a great amount. He proposes the adoption of a denser model of settlement to increase modal choice of travel amongst the dwellers, for instance

cycling, walking, public transport as opposed to the model that is synonymous to our sprawled settlements where the modal options are severely limited.

Ostler (1989) in the thesis '*Government Policies to alleviate suburban traffic congestion: An institutional and Economic Analysis of the Transport – Land Use System*' supposes that developers are not fully paying the price for the effect of land use changes that their developments have on the traffic. These tend to generate traffic both upstream and downstream. The study also alludes to the failure of planning at various levels(Ostler, 1989). The case given is that of the local and the national governments. It is true that the local government is given authority to plan for the local unit and it does so in line with requirements at the local level including construction of roads. However, there is sometimes a disconnect between roads agencies which operate at the national level and the local unit of planning which makes the two plans incompatible. In addition, traffic at the local level may not be wholly intra but inter meaning that the traffic being generated is a function of some other land uses and the local system is only being used as a conduit to transfer this traffic.

A link between land use policy and traffic is proposed in the text Public Transportation and Land Use Policy (Pushkarev & Zupan, 1977). They propose that policy affects transportation choice and thus may contribute to the congestion problem. They intimate that for public buses to operate efficiently, they need a population density of about 4200 persons per square miles, equivalent to approximately 1500 persons per square kilometre. Rail systems require much higher densities. However, areas of sprawl typically have lower densities due to the nature of residence. These areas would then not be able to sustain public transportation systems and instead would likely be characterized by high vehicle ownership rates.

2.7Traffic Characteristics

Information on traffic is important in selecting the appropriate geometric features of a roadway. These characteristics include traffic volume, traffic speed and the percentage of trucks or other large vehicles.

2.7.1Traffic Volume

This is an important factor to consider in determining the improvements, if there are any, to be made on a roadway(Texas DOT, 2018). It may be expressed in terms of average daily traffic or design hourly volumes. These volumes may be used to calculate the service rate which is useful when evaluating geometric design alternatives. The two parameters used are:

- *Average daily traffic (ADT)* which represents the total annual traffic divided by the number of days in the year. It is highly volatile and hence is rarely used in the design of high volume traffic. It is in most cases applied to low and moderate traffic volume facilities with two lanes or less.
- *Design hourly volume (DHV)* which refers to the 30^{th} highest hourly volume for the design year, commonly 20 years from the time construction was completed.

2.7.2Traffic Speed

This is influenced by several factors including volume, capacity, design, weather, traffic control devices, posted speed limits and individual driver preference. However, for design purposes*low speed* is 70 km/h and below and *high speed* is 80 km/h and above.

The design speed is a selected speed which is used to determine the various geometric features of a roadway. Design elements such as sight distance, vertical and horizontal alignment, lane and shoulder widths, roadside clearances, super elevations and so on are influenced by design speed.

Selection of design speed for a section of a road is influenced by terrain, economic considerations, extent of roadside developments and highway type. The choice should be influenced by the expectation of drivers, which are closely related to traffic volume conditions, potential traffic conflicts and topographic features.

In addition, roads may have indicated on them what are *posted road speeds*, which refers to the maximum speed limit posted on a section of a road. Speed zoning guidelines permit consideration of other factors such as roadside development, road and shoulder surface characteristics, public input and NMT activity.

2.8Effects of a Highway on the User Population

A highway may have many effects on its user population, a few of which are detailed hereunder (Wikipedia, 2018):

2.8.1 Social Effects

The reduction in travel time caused by efficient highways increases opportunities for people to travel for business, trade or pleasure and provides trade routes for goods. This implies that highways as an important part of physical infrastructure increases a country's GDP.

However, there is an increase in latent traffic demand. This is caused when at the planning stage; prediction is poorly done whilst not factoring in the propensity of the user population to increase vehicle ownership due to the efficiency of the system. Congestion will be caused where vehicle ownership increases, and the users tend to use vehicles even where other modes would be just as efficient. Thus, a new road may be seen to bring only short-term traffic congestion mitigation.

2.8.2 Economic Effects

A summary of this is that a new road may bring about positive and negative externalities of the network. The positive may include the ability to offer emergency medical services, increases of land value and agglomeration benefits. The latter include localized pollution, safety hazards, community severance and congestion.

2.7.3 EnvironmentalEffects

This manifests itself mainly as pollution. Roadway noise is bound to increase with the building of a new highway and this effect will be felt near the highway. Highways also suffer increased air pollution because of increased traffic volumes especially whenever traffic congestion occurs.

New highways may also encourage urban sprawl and cause habitat fragmentation.

2.9 Management of Roads in the Study Area

The task of management of roads has been clearly defined in part II of the Kenya Roads Act with the various classes of roads designated and placed under three authorities responsible for their maintenance(GoK, 2007a). The fourth category of roads is classified as unclassified and should be the responsibility of the county governments. S3,6 and 9 of the Roads Act establish the Kenya National Highways Authority (KeNHA), the Kenya Urban Roads Authority (KURA) and the Kenya Rural

Roads Authority (KeRRA). The classification of roads as per the first schedule of the Act is as in Table 2.1.

Table 2.1 Classification of Kenya Roads as per Kenya Roads Act
Source: Kenya Roads Act (2007)

NATIONAL ROADS	
Class	**Description**
CLASS A	International trunk roads linking centers of international importance and crossing or terminating at international ports
CLASS B	National trunk roads linking nationally important centers
CLASS C	Primary roads linking provincially important centers to each other or to higher class roads
RURAL ROADS	
Class	**Description**
CLASS D	Secondary roads linking locally important centers to each other, to more important centers or to higher class roads
CLASS E	Any link to a minor center
CLASS F	Forest roads
CLASS G	Roads serving government institutions
CLASS K	Roads accessing coffee (kahawa) growing areas
CLASS L	Roads accessing settlement scheme areas
CLASS R	Roads accessing rural areas
CLASS S	Roads accessing sugar growing areas
CLASS T	Roads accessing tea growing areas
CLASS U	Unclassified rural roads including minor roads
CLASS W	Roads accessing wheat growing areas
URBAN ROADS	
Class	**Description**
CLASS UA	Urban arterials
CLASS UC	Urban collectors including primary distributors, district distributors

CLASS UL	Urban local roads including minor distributors, local streets, residential stand accesses, commercial and industrial stand accesses, shopping streets

The KNBS gives a breakdown on all roads in the country as per Table 2.2. It is useful to note that the KNBS uses a road classification done in 1970 under the roads department where:

A – International Trunk Roads are classified as those that link centers of international importance and crossing international boundaries or terminating at international ports

B –National trunk Roads indicate those roads that link nationally important centers

C – Primary Roads indicate those roads that link locally important centers to each other and to higher class roads

D – Secondary Roads which are those that link important centers to each other and to higher class roads

E – Minor Roads which are those that are a link to a minor center

F Special Purpose Roads – which are those that include park, township, agriculture, fish and strategic roads

Table 2.2 Classification of Kenya Roads by KNBS

Source: KNBS (2017)

Category	**2012**		**2013**		**2014**		**2015**		**2016**	
	BIT	**ERD**	**BIT**	**ERD**	**BIT**	**ERD**	**BIT**	**ERD**	**BIT**	**ERD**
A	2967	621	2890	700	3007	816	3238	380	3314	304
B	1534	1111	1580	1110	1580	1156	1607	1038	1578	1067
C	3182	4675	3460	4570	3460	4568	3360	4497	3560	4298
D	1233	9485	2090	8620	2091	9435	2067	8651	2200	10602
E	587	26133	1050	26460	1053	26128	1000	25724	1034	25700
F	109	10406	160	10950	172	10376	106	10399	110	9310
Total	9612	52431	11230	52410	11363	52479	11378	50689	11796	51281

A – International trunk roads

B – National trunk roads

C – Primary roads

D – Secondary roads

E – Minor roads

F – Special purpose roads

BIT – bitumen roads

ERD – earth/gravel roads

S 4(1) of the Roads Act gives the mandate of management, development, rehabilitation and maintenance of national roads to the KeNHA, while S7(1) gives the mandate of management, development, rehabilitation and maintenance of rural roads to the KeRRA. KURA has the mandate of managing, developing, rehabilitating and maintaining all public roads in the cities and municipalities in Kenya except where there are national roads under S10(1) of the same Act.

Management of the three authorities is by the respective boards which comprises various individuals who are specified under the second schedule of the same Act. For KeNHA, the various representatives outlined do not include a physical planner. For KeRRA, there is a representative from physical planning although the specifications are that the person may be from academia or nominated through local authorities, which have since become counties. The schedule also specifies an urban planner as one of the representatives to the board of KURA.

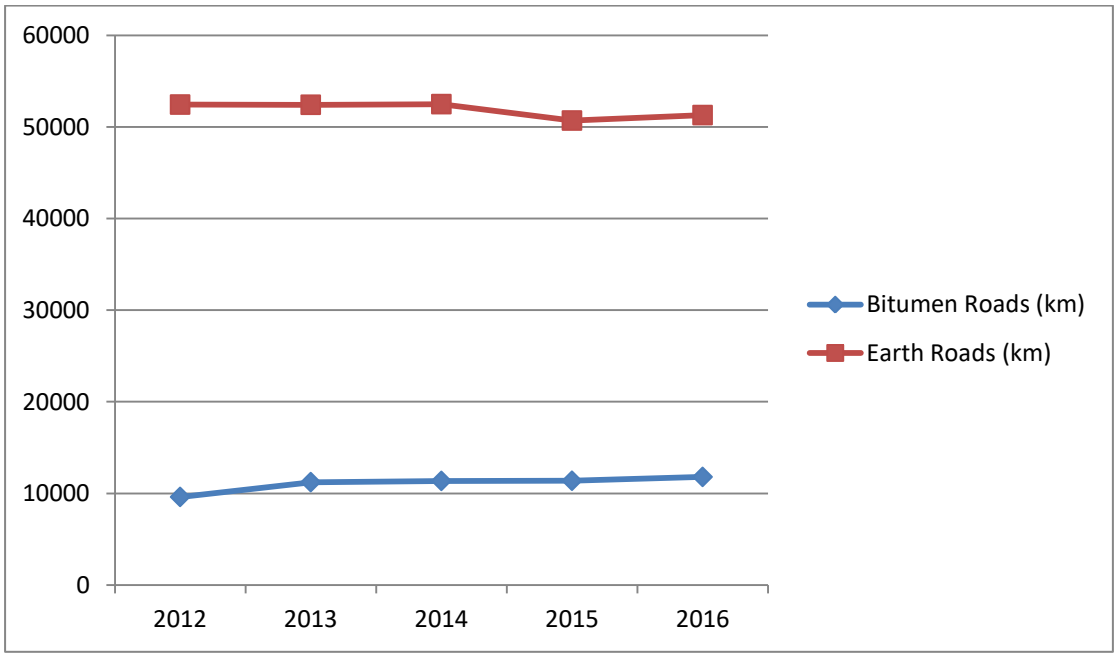


Figure 2.9Kenya Road Length from Years 2012 to 2016

Source: KNBS (2017)

From Table 2.2, it is evident that the road network has kept on increasing every year with the length of bitumen roads having increased from 9612 kilometres in the year 2012 to 11796 kilometres in the year 2016, a 22.7% increase. It is also evident that the length of earth roads in the entire country keeps fluctuating year by year. The data indicates a decrease in the length of these roads in the years 2014 to 2015. This decrease cannot be accounted for, so it may be a typographical error. However, similar decreases in road coverage correspond to similar increases in the other type of road, if the rate of development is commensurate.

2.10 Legal and Policy Framework Governing Land Use in the Study Area

Land use is a form of development that is governed by various statutes and as well various policy decisions that aim to ensure that there exists planning in development. These statutes and policy decisions also link land use change and transport/access. Some of the more important ones are the Physical Planning Act, the Environment Management and Co-ordination Act, the Nairobi Zoning Ordinance and the Physical Planning Handbook.

2.10.1 The Physical Planning Act

Part IV of the Physical Planning Act Chapter 286 makes provisions for various types of plans including regional physical development plans, local physical development plans and special plans(GOK, 1996). There is also a distinction between long term plans and short-term plans and their respective contents.

For short term plans, there are renewal and redevelopment plans which have different aims chief among them being providing a road traffic pattern and traffic network designed to improve vehicular access and parking space and facilitate the segregation of vehicles and pedestrians. Road improvements in the study area could have emanated from this type of plan considering that there was some impediment to the traffic flow at the various intersections where there have since been interventions including Allsops, Garden City and Roysambu intersections respectively.

The Act also provides for the regulation of change of user via the form PPA1 in the fourth schedule of the Act. Among the key requirements related to roads is the statement of whether the development requires a new or alternative means of access.

This then implies that the change of user considers matters of access and thus pre-empts the notion that land use may affect roads of access.

2.10.2 The Environment Management and Co-ordination Act (EMCA)

EMCA enacted in 1999 is an Act of parliament that provided for the establishment of an appropriate legal and institutional framework for the management of the environment and for matters connected and therewith and incidental thereto. It introduces the concept of the environmental impact assessment which is defined in the S(1) as a systematic examination conducted to determine whether a program, activity or project will have any adverse impacts on the environment(GoK, 1999).

It provides for the establishment of the National Environment Management Authority which with one key function S7 (2d) as the examination of land patterns to determine their impact on the quality and quantity of natural resources. As well, it provides for a National Environmental Action Plan which in S38 identifies and appraises trends in the development of urban and rural settlements, their impacts on the environment and strategies for the amelioration of their negative impacts. Among projects that are set to undergo environmental impact assessment (EIA) as specified in the second schedule include transportation including all major roads, which in the case of the area of study would be the Thika Superhighway.

2.10.4 The Physical Planning Handbook

This document was prepared with a view to providing clear and user-friendly guidelines and minimum standards on the process and practice of physical planning, as per the forward given by the then acting Director of Physical Planning. Accordingly, it gives various guidelines that touch on land use and transportation networks(GoK, 2007b).

Apart from emphasizing on the classification of roads in the country, it also gives the road widths as per table 2.3.

Table 2.3Road Reserve Widths in Metres
Source: Physical Planning Handbook (2007)

Class		**Road reserve (m)**
International trunk roads	A	60

National trunk roads	B	40 -60
Primary roads	C	25 - 30
Secondary roads	D	20
Minor roads and Special roads	E	18

Regarding land use and roads, it gives recommendations to carry out appropriate land use planning for land that is adjacent to highways. It also calls for the integration of transportation with recreation by providing bicycle paths and outdoor resting places.

In respect to these recommendations, Thika Superhighway has been constructed with NMT in mind with the design such that there is provision for motorcycles and bicycles. However, there does not appear to be resting places along the entire stretch right from its intersection with Murang'a road all the way to Thika itself. As well, land use along the stretch within the study area is of mixed type. There is commercial, industrial, public purpose and more typologies along the same stretch. Whereas the interior land uses may benefit from this shielding, there may be some incompatibility in the land use mix. An instance is the stretch between Allsops and Garden City where industrial use shields residential use.

2.11Conceptual Framework

The problem under study involves two key dynamics, land use and traffic volumes. These two are linked and a diagrammatic representation of how they are linked is given by the Strafford Regional Planning Commission.

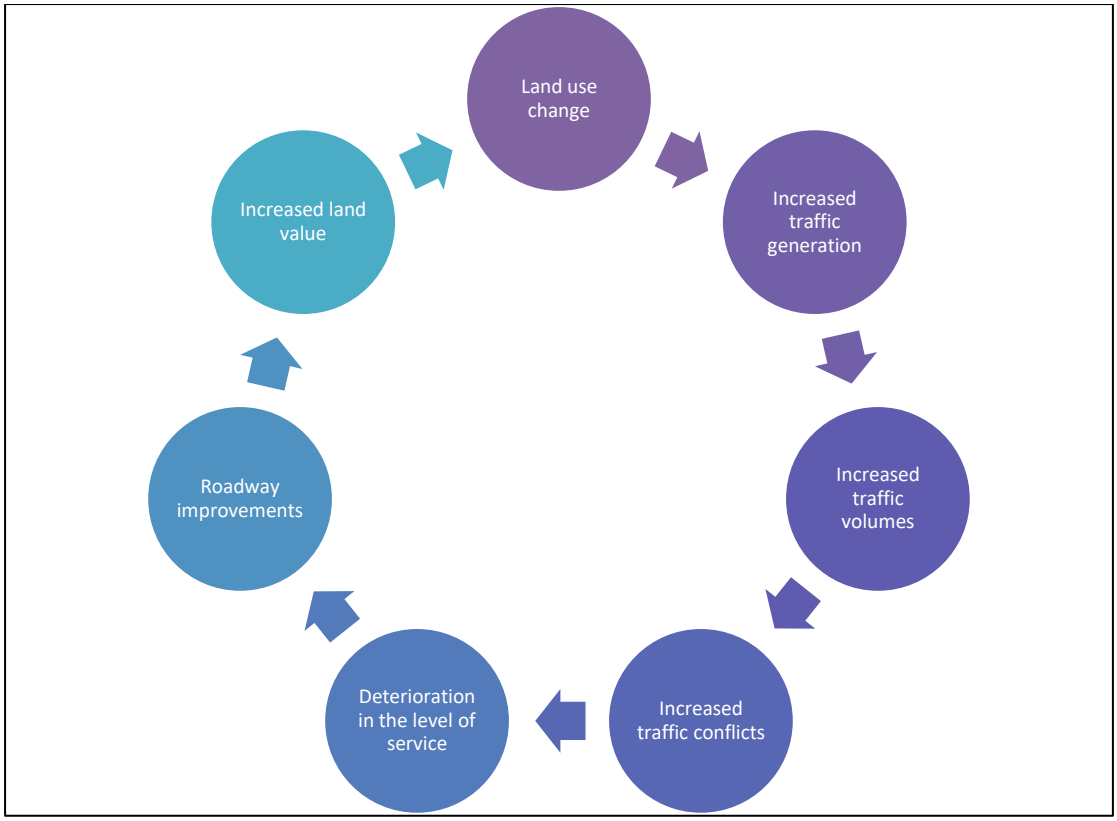


Figure 2.10Conceptual Framework Adopted and Modified from Strafford Planning Commission

Source: Strafford Planning Commission (2017)

Basically, the premise put is that how we use our land directly affects our transportation facilities, modes of travel, services and vice versa. The cycle describes what happens when a road is built or improved. Land along the road becomes more accessible making it attractive to developers. As that land is being developed, it generates traffic and the number of driveways increases. This results in more congestion and deterioration of the road's capacity to efficiently service the users. This necessitates improvements which may necessitate further development and the cycle continues.

CHAPTER 3: DEFINITION OF THE STUDY AREA

3.1 Introduction

The study area is in the City county of Nairobi. Nairobi is Maasai for “enkare nairobi” meaning a place of cool waters. Its origins stem from the pre-colonial era, when it was headquarters of the Kenya – Uganda railway and was established in 1899 when the railway reached Nairobi. It grew and became the capital of Kenya following its attractiveness as both a business and commercial hub (Mitulla, 2003)

3.2 Characteristics of Nairobi

3.2.1 Population of Nairobi

TheCity County of Nairobi, one of the 47 counties in the Republic of Kenya, has an area of 694.4 km^2 and a population of 3,138,369 persons (KNBS, 2010a). It is third smallest in size, with only Mombasa (212.5 km^2) and Vihiga (531.3 km^2) being smaller than it. The population distribution across the different age cohorts is as illustrated in Figure 3.1.

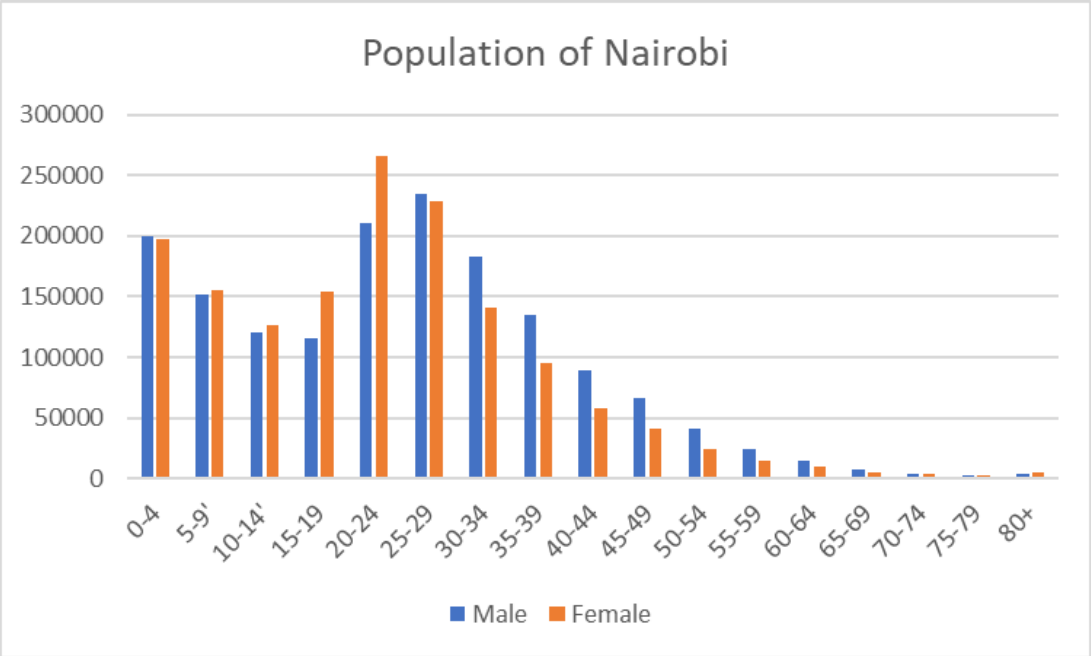


Figure 3.1Population of Nairobi

Source: KNBS (2010)

The county was divided into four districts for purposes of the 2009 population and housing census. These were Nairobi West, Nairobi East, Nairobi North and Westlands (KNBS, 2010b). A tabulation of the characteristics of Nairobi's population with regards to gender, number of households and density is as in table 3.1.

Table 3.1Demographic Characteristics of Nairobi
Source: KNBS (2010)

	Male	**Female**	**Total**	**Households**	**Area in km^2**	**Density**
KENYA	19,192,378	19,417,719	38,610,097	8,767,954	581,309.29	66.42
NAIROBI	1,605,219	1,533,150	3,138,369	985,016	695.10	4,514.96
NAIROBI WEST	352,226	332,539	684,765	212,295	261.78	2,615.81
NAIROBI EAST	582,550	561,866	1,144,416	369,866	226.69	5,048.46
NAIROBI NORTH	545,695	516,391	1,062,086	327,428	109.26	9,720.77
WESTLANDS	124,748	122,354	247,102	75,427	97.38	2,537.52

As can be seen from the table 3.1, the most populous of Nairobi's districts from the census is Nairobi North with an average density of 9721 persons per km^2. This area comprises estates such as Kasarani, Githurai, Kahawa and others that are home to high-rise buildings that contribute to this density. Another factor is also that the land under coverage within this district is less implying a greater density. It should also be noted that there are high end estates such as Garden estate, Kahawa sukari and Muthaiga north among others within this district that have also taken up some of the land to contribute to the high population density.

3.2.2 Physical Characteristics of Nairobi

Nairobi lies between 1600 to 1850 m above mean sea level (CBS, 2001). The western part of the city is highest while the eastern part of the city is lower and generally flatter. The latter is normally seen to be more conducive for settlement and has high end estates such as Karen, Lavington, Kilimani, Westlands while the latter is known to be a less affluent neighbourhood. The city is traversed by three main rivers, these being the Mathare, Ngong and Nairobi rivers. Part of northern Nairobi has the Karura forest(Mitulla, 2003).

Nairobi is bordered by three counties namely Kiambu, Machakos and Kajiado to the North, East and West respectively. A map showing Nairobi county in its regional context is as shown in figure 12.

3.2.3 Administration of Nairobi

Nairobi is the capital city of the Republic of Kenya and thus is the heartland of the National Government. Nairobi , as with other counties, has a political structure led by the Governor and an administrative structure led by the County commissioner(Standard Media Group, 2014). The administration structure is illustrated in Fig 11.

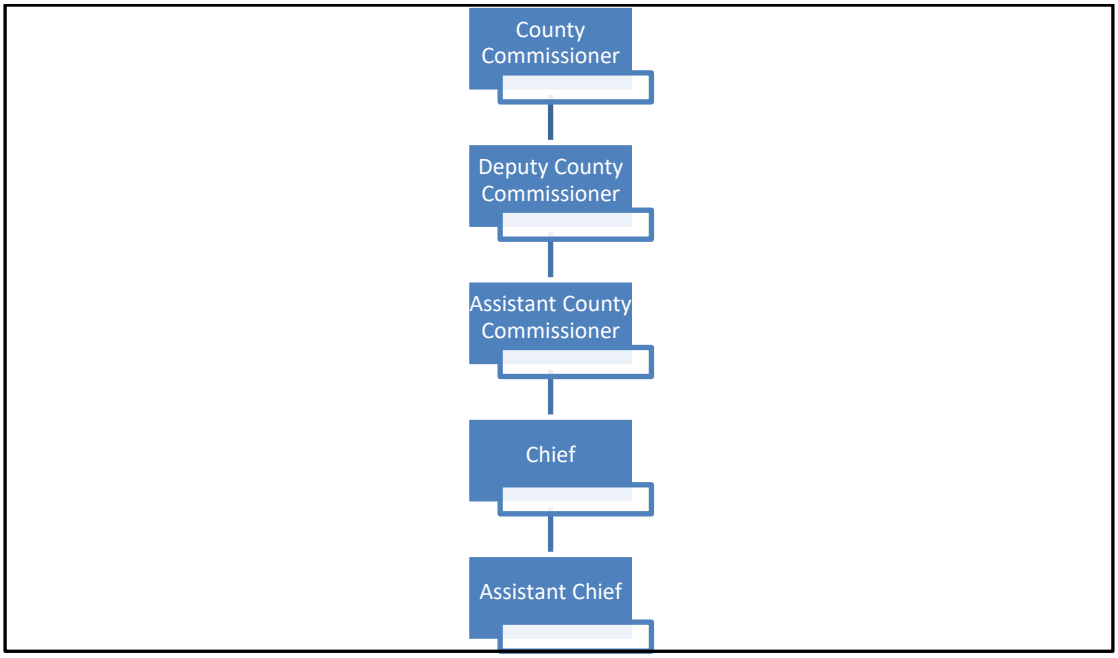


Figure 3.2Kenya County Political Administrative Structure

Source: Standard Media Group (2014)

The administration system so highlighted is a carryover from the old constitution that was replaced in the year 2010. The introduced constitution created the counties whose structure is as in the figure3.3. The county government structure is shown in figure 3.4(Lubale, 2012)

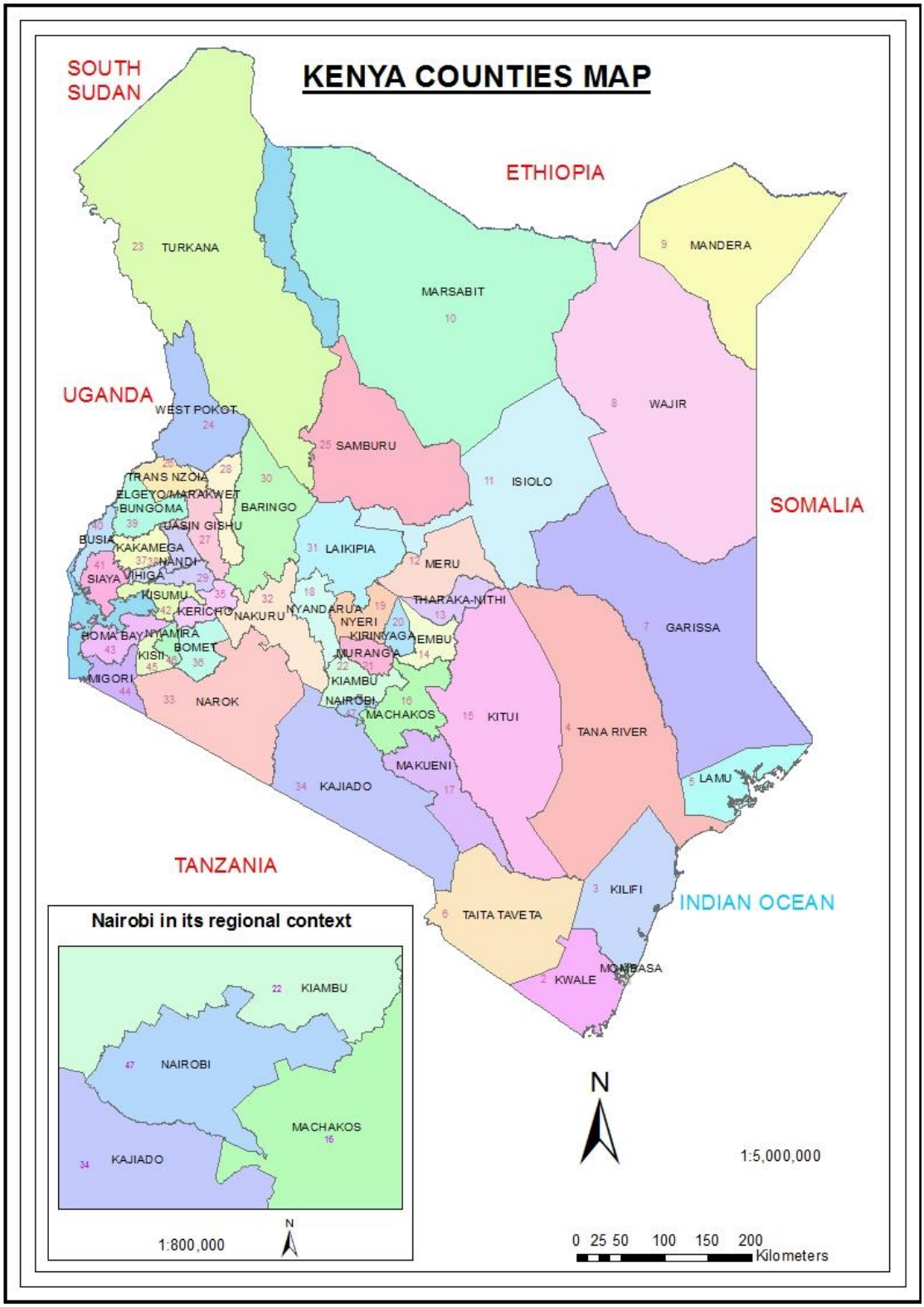


Figure 3.3A Regional Perspective of Nairobi

Source: SoK (2018)

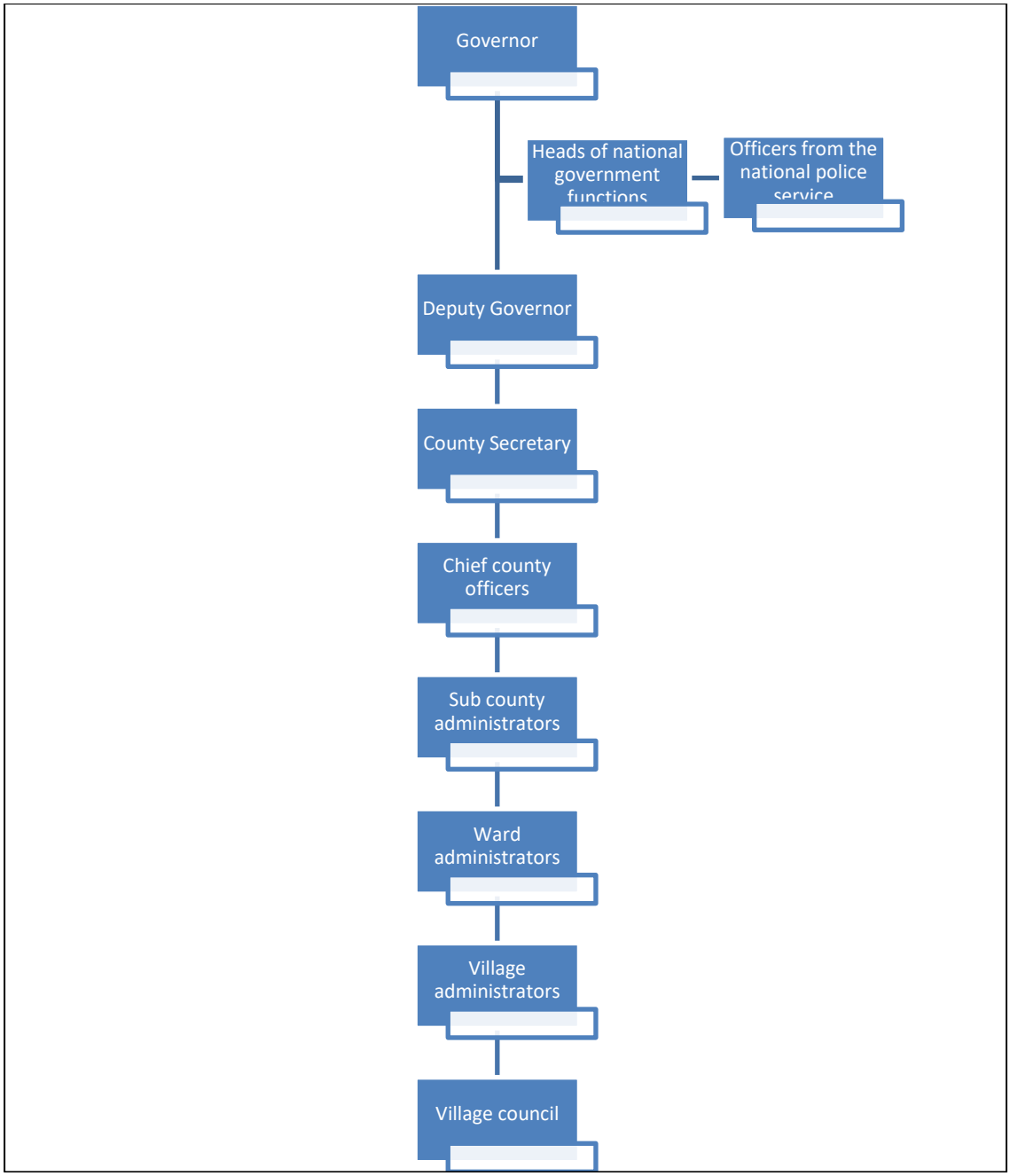


Figure 3.4Kenya County Government Structure

Source: Lubale (2012)

3.2.4Land Uses in Nairobi

Nairobi has several land uses summarized in ranging from high income residential to agricultural (Lamba, 1994). These are in table 3.2.

Table 3.2Land Use in Nairobi

Source: Lamba (1994)

Land	**Area (Hectares)**	**Proportion (%)**
High income residential	11,000	16.1
Medium income residential	4,070	5.9
Low income residential	4,500	6.6
Unplanned slums and squatter settlements	2,190	3.2
Commercial	270	0.4
Industrial	2,410	3.5
Institutional	7,480	11.0
Recreational	15,330	22.4
Agricultural	21,150	30.9
Total	68,400	100

Significant changes have since occurred that may have an impact on the numbers in table 3.2. For instance, Upper hill area once classified as a residential district has a lot of commercial developments. As well, several upper-class/high income neighbourhoods such as Kileleshwa, Kilimani have seen an influx of high rise residential and commercial buildings spring up over time.

3.2.5 Economic Activities in Nairobi

Nairobi's economy is diverse and has players in many industries. The economy is mainly split into three groups, the formal, straddle and informal sectors (Audi, 2011). Formal activities in Nairobi include dealing in retail goods, financial activities, micro loans, transport services, public services, professional services and so on. These services are provided both by the public and the private sector.

Informal activities include hawking, small scale trading, repairs of various types, services offered by quacks, provision of labour services and so on. These are largely provided by the private sector and are in many cases not regulated. There is an ongoing effort by the authorities to formalize these activities to widen the tax base.

Straddle activities are those classified as being facilitators. These include the transportation, communication, financial services and so on.

3.3 Development Control in Nairobi

Development control is practiced in the City County of Nairobi by the provisions of the Physical Planning Act. The main document used as a reference in planning is the Nairobi Zoning Ordnance.

3.3.1 The Nairobi Zoning Ordnance

The City County of Nairobi Government developed the Nairobi Zoning Ordnance to give quick guidelines to developers based on planning and that would hasten awareness on development control, ease the procedures for making development applications and thus limit illegal developments.

The study area is split into several zones as per table 3.3. It is useful to note that there is agitation for a rezoning of the city by the City County Government to accommodate more development specifically high density, high rise development which could change the face of the study area in the future. It also has implications on the traffic generated within the study area and thus contributing to the Thika Superhighway.

3.3.2 Development Control in the Study Area

A key informant interview with the Nairobi County's Department of Lands, Housing and Physical Planning revealed that every development that happens within the city must be subjected to evaluation beforehand. The proponents are required to apply for development permission, through a registered physical planner who does a comprehensive analysis of the proposed development and their likely impacts. If the County Government is convinced that the development is viable, permission is granted. In addition, the architects and engineers are required to submit architectural and structural drawings respectively for approval before the commencement of a development.

In cases of road construction projects, a traffic impact study is usually undertaken and the submitted to the County Technical Committee and thereafter to the County Executive Committee, both of which advise the developers on the appropriate ways to mitigate against possible negative impacts.

In the case of Thika road, the Department of Lands and Physical Planning reportedly undertook all these procedures and subsequent developments have had to be approved

before implementation. Most of the developments in the study area were said to be commercial and residential in nature.

Table 3.3Planning Zones in the Study Area

Source: CCN

Zone	Area	GC	PR	Type of development allowed	Minimum area (ha)	Comments
13	Garden Estate	25	25	Low density residential (one family dwelling house)	0.2	
	Safari park/Balozi housing	25	25			
14	Roysambu	25	25	Low family residential	0.2	Intensive development in Marurui and Roysambu
	Thome	25	25			
	Marurui	25	25			
16	Baba Dogo			Industrial zone Residential (mixed residential development)	0.05 (lower if comprehensive)	High density residential
	• Industrial	80(s) 50(u)	300(s) 100(u)			
	• Residential	35(s) 25(u)	75(s) 25(u)			
	Ngumba/Ruaraka	50(s)	200(s)			
20g	Moi Sports Complex, Kasarani			Public open spaces, reserves and recreational facilities		

3.3.2.1 Predominant Land Use in the Study Area in the Year 2009

The study area had a mix of land uses. In the year 2009, the predominant land use and the respective acreages is as shown in table 3.4.

Table 3.4Land Use in Nairobi in the Year 2009

Source: Google Maps (2009)

Land Use	**2009 Size in Ha**	**%**
High density residential	218.6	13.21
Medium density residential	552.89	33.41
Industrial	190.78	11.53
Educational	51.76	3.13
Recreational	103.02	6.22
Public purpose	152.98	9.24
Commercial	30.98	1.87
Public utilities	1.41	0.1
Agriculture	32.59	1.97
Unutilized	181.38	10.96

3.4 Road Network in Nairobi

Nairobi is served by several roads of different classes. Being that it is an urban centre, some of the roads in it are under Kenya Urban Roads Authority (KURA), some under the Kenya National Highways Authority (KeNHA) and some under the City County of Nairobi. The major arteries getting into and out of Nairobi are the A104 highway that emanates from the Coastal region and end in the Western region of the country respectively; and the A109 highway that emanates from the city and ends up in the Northern region of the country.

In terms of hierarchy then, we have as in Figure 3.5:

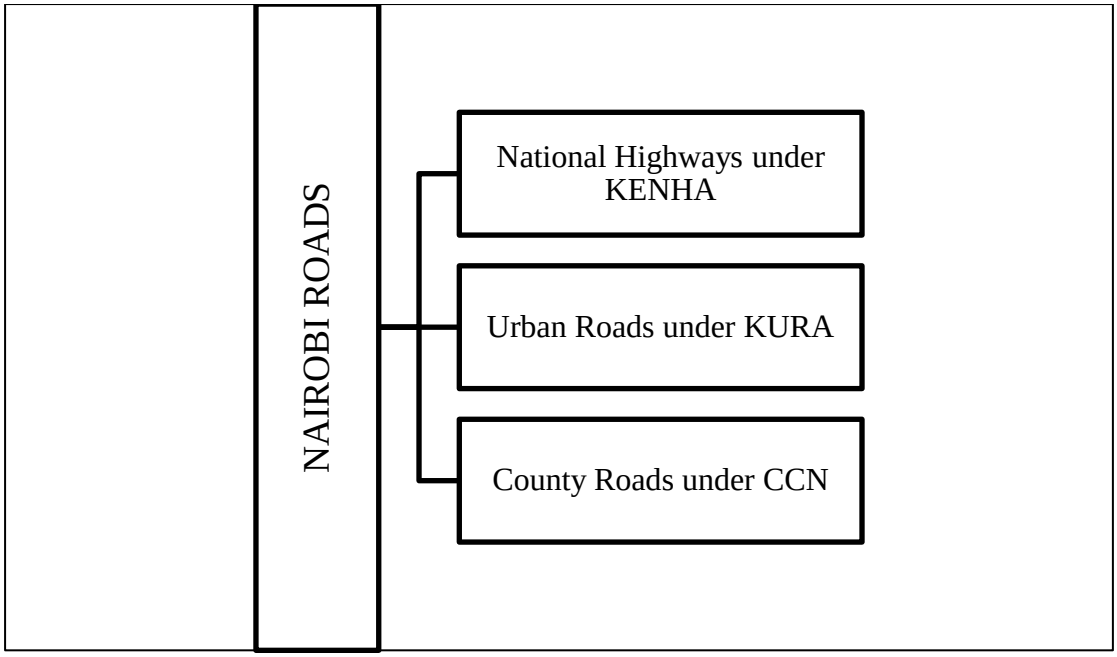


Figure 3.5Nairobi Roads Hierarchy

Source: Researcher (2018)

It is useful to note that within the city, the road hierarchy has somewhat been destabilized by the addition of bypasses and ring roads designed to alleviate the congestion problem that has bedevilled the city for some time. The Eastern, Southern, Northern bypasses as well as Outering road are some of those designed and implemented in the last few years save for the Outering road which has recently undergone a major rehabilitation. A map showing some of the Nairobi roads is as shown in figure 3.6.

3.5 Definition of the Study Area

The area of study is along Thika Superhighway between Roysambu and Allsops. It is confined to the area highlighted in red and shown on the Google map in figure 3.7. It comprises the following wards:

1. Baba Dogo ward – population 30741
2. Kasarani ward – population 30658
3. Roysambu ward – population 40331

The total population in the study area is 101,730 persons as per the 2009 census (KNBS, 2010a).

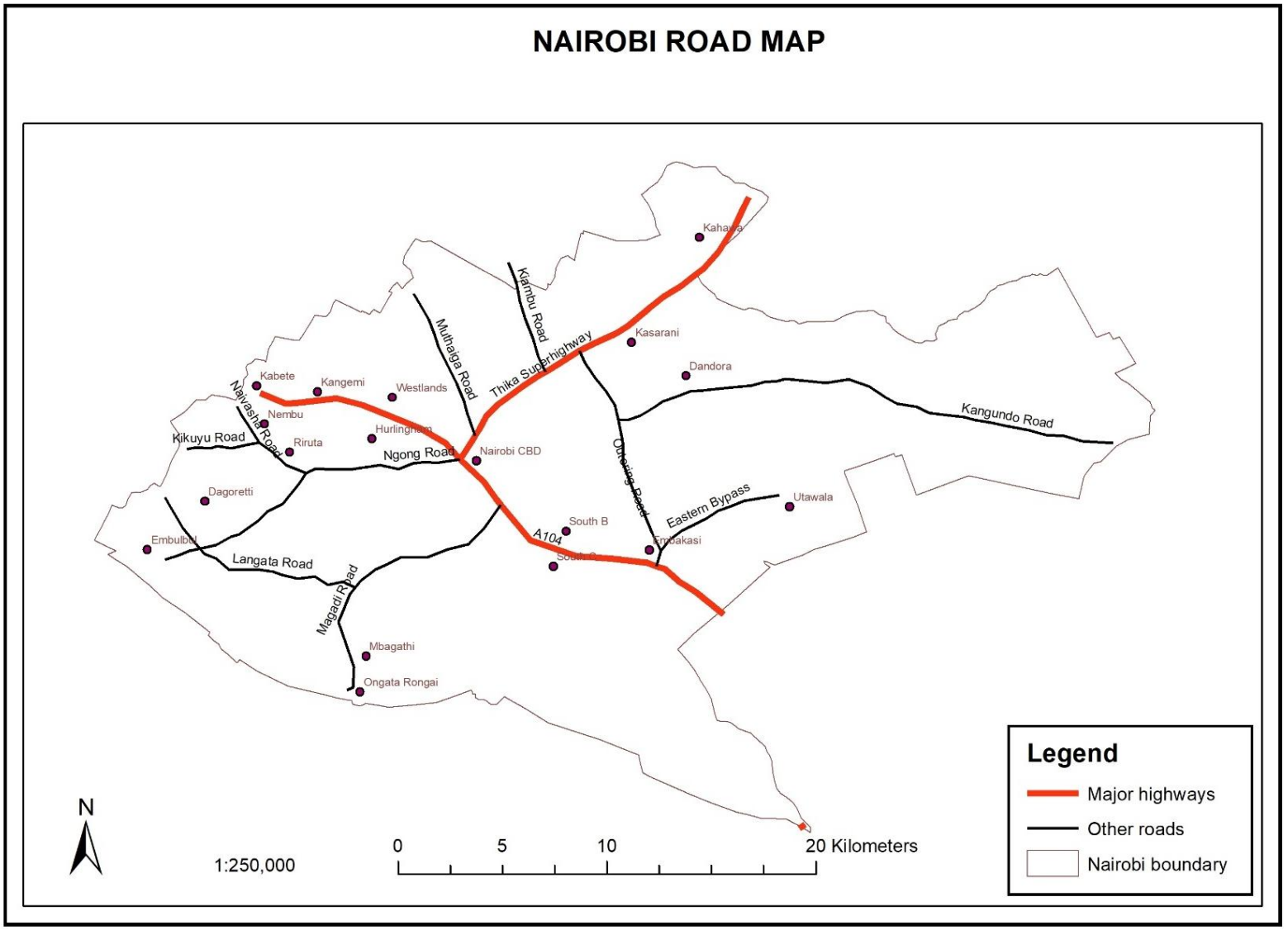


Figure 3.6Nairobi Old Roads

Source: SoK (2009)

Figure 3.7Study Area

Source: Google Maps (2017)

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Overview

This chapter summarises the research design adopted to achieve the objectives of the study and as well the methodology identified to achieve the same, including the materials used.

4.2 Research Design

The research design used for the study is as outlined.

4.2.1 Introduction

The research problem was formulated through extensive research of secondary data available and enhanced by extensive knowledge of the area by the researcher. Most of the preliminary data that informed the study was collected using secondary sources.

4.2.2Formulation of the Research Design

The research design adopted was of a mixed design in that both quantitative and qualitative methods were used to achieve the objects of the study.

A correlational study was done to test the relationship between the land use, land use change and the effect it had on the road. In this case, sampling was carried out to gauge respondents' views of the same as well as empirical data from mapping the study area.

The study itself, being a case study of an area specific in description is a qualitative design. From the study of the area, useful information was derived that enabled the researcher to have a better understanding of it.

4.2.3 Flow of research

A schematic showing the various stages in the research process is as shown in figure 4.1. It shows a systematic approach to solving of the research problem starting with the choice of research problem to penning of the report.

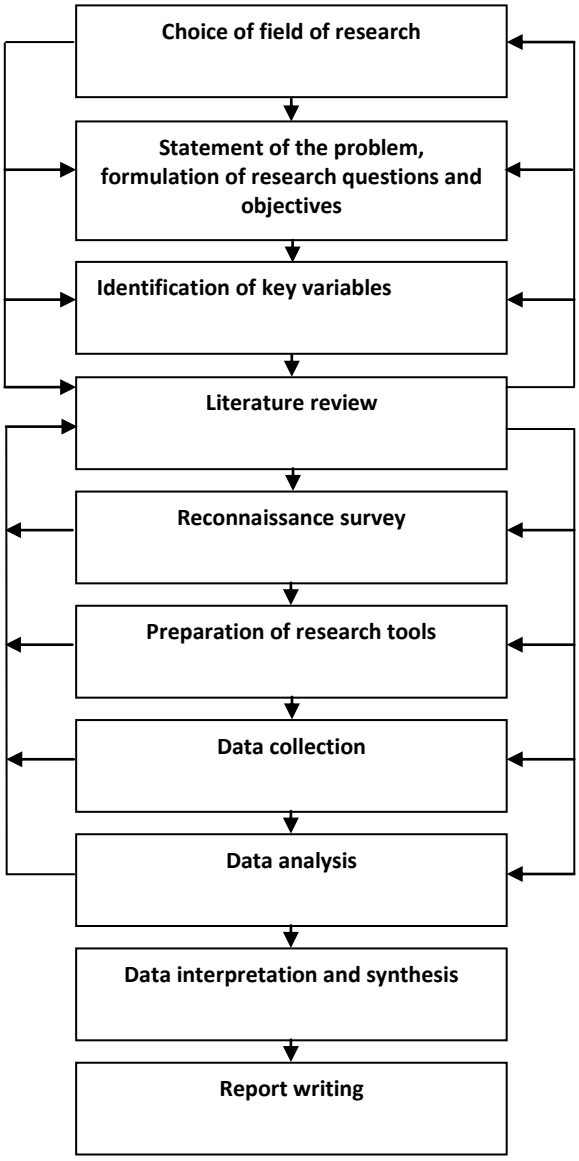


Figure 4.1Research Design

Source: Researcher (2017)

4.3 Methodology

4.3.1 Introduction

Considering the study to be undertaken, several stakeholders and several key data items were identified early on. These included:

i. Inhabitants within the area under study
ii. PSV operators plying routes within the area under study
iii. Business operators within the area of study

iv. A key informant working at the Nairobi County Government's Ministry of Lands, Housing and Physical Planning
v. Satellite and aerial imagery of the area under study

A data matrix formulated at the proposal stage enabled the researcher to further refine the needs of the study to meet the objectives therein. The methodology adopted for the study broadly consisted of four key steps:

1. Data identification
2. Data collection
3. Data preparation and analysis
4. Data presentation

4.3.2 Data Identification

The data that was identified as key to the study was extracted from a data matrix formulated at the proposal stage. It is attached in appendix E.

A systematic approach was used to identify this data by breaking down each study objective into its component parts and further specifying the deliverables attached to it. In this way, it was possible to establish the data needed and its characteristic, whether quantitative or qualitative. The following data was ascertained as necessary for the study:

1. Cross sectional data for Thika Road together with the signage
2. Aerial and satellite imagery of the study area
3. Literature on various statutes and other legal provisions binding development within the study area
4. Traffic data
5. A social study

4.3.3 Data Collection

Provisions were made for collection of the data that was identified as useful to the study. Accordingly, then various methods were devised for collection of the different data sets.

Cross sectional data

For the cross-sectional data, the method chosen was that of extraction of any relevant data from secondary sources. A transect walk and drive was also incorporated in the data collection exercise. Photographs of the roadway were also taken.

Spatial data

This was made possible through a detailed definition of the study area. The study area was defined by a polygon which has the Thika Superhighway intersecting it. The polygon lay within three wards; Baba Dogo, Kasarani and Roysambu. From this definition then, the spatial imagery could be captured.

Data from to epochs was chosen being the years 2009, prior to the construction of the highway and the year 2017, 5 years after the construction of the superhighway.

Literature review

Various pieces of literature review were necessary firstly to build up the theory behind the work and to give a wider scope of the subject under study. Theories on urban growth models were studied and their implications on the subject under study put forth. These included the Ribbon Development theory and Von Thunen's theory on urban development.

Other literature reviewed included literature on land use determinants, implications of land use change, traffic characteristics, effect that a highway has on a user population and on management of roads in the country and zeroing in on the area of study.

Of importance was the legal and policy framework that informed the study. As a result, the key pieces of literature reviewed were the Physical Planning Act (PPA), the Environment Management and Coordination Act (EMCA), the Nairobi Zoning Ordinance and the Physical Planning Handbook.

Traffic Data

Traffic data collected mainly focused on the numbers of vehicles on the roads and the numbers of vehicle in the country in time. This was collected from secondary sources as getting raw data proved to be economically not feasible.

Social Research/Study

As part of the study, it was required to collect raw data from stakeholders who would form the *research population*. These were identified to be:

- Inhabitants residing in the area under study
- Business operators in the area under study
- PSV operators operating within the area under study
- A key informant from the City County Government of Nairobi

A *sampling plan* devised outlined the various measurements to be taken at what times, in which manner and by whom.

The *sampling unit* was determined as the inhabitant on the Thika Superhighway corridor within the area of study and preferably those who were identified as utilising the same corridor for their commute.

The population of the three wards comprising the area of study was found to be 101,730 persons (KNBS, 2010a). Household questionnaires were administered through personal interviews to 100 respondents at a precision of 0.1. The technique in choosing the respondents that formed the sample was random stratified using the junction of Mirema road and USIU road to split the study area into two zones. Thome, Garden Estate and the neighbourhood was designated zone A. It is currently classified as low density residential under *A Guide of Nairobi City Development Ordinances and Zones*by the Nairobi City County. Zone B comprised Roysambu, Ngumba, Ruaraka and Baba Dogo and is designated industrial zone residential (mixed residential development) in the same document. Zone A comprised 11 households and zone B comprised 89 households.

The social study targeting the matatus SACCOs identified nine PSV operators plying the routes within the area of study. Nine SACCOs were identified as providing transportation services within the study area (NTSA, 2015) These are:

1. Nakathi Travellers Sacco
2. Nazigi Sacco
3. Kiu Investment Sacco
4. Mwiki PSV Sacco
5. Mwirona Sacco
6. Nawaku Sacco
7. Unified International Limited
8. Forty-Four Sacco
9. Githurai 45 Sacco

PSV operator questionnaires were administered to the relevant contact persons of all these SACCOs. The questionnaire was designed to derive data on the relationship between traffic pattern and intervening variables which was given by the respondents.

4.3.4 Data Preparation and Analysis

Cross sectional data

The various dimensions obtained during the cross-sectional analysis of Thika Superhighway were charted in AutoCAD to give an impression of it.

Spatial data

The polygon defining the area under study was projected in UTM but using two main datums, Arc 1960 which is one of the Nationally approved system for use in surveys within the Republic and WGS84 which is useful for Google Earth applications.

Using these two polygons, it was possible to define the extent on an aerial image and Google earth respectively to vectorise some of the important data. The aerial imagery obtained was in Arc 1960 datum and UTM projection while imagery obtained using Google Earth is normally in WGS84 datum and UTM projection.

Vectorization was done for the land uses and the road and appropriate symbology used to distinguish the various land uses. Observations of land use change over time were made to determine the nature of land use to determine the predominant land use using two epochs, the years 2009 and 2017.

Visualization was done to indicate the various infrastructural changes that had since occurred for impact assessment.

Traffic Data

Vehicle numbers data was tabulated in Ms Excel and graphs drawn. Traffic data derived from the JICA study done in preparation of for the development of the Integrated Urban Development Master plan for the City of Nairobi formed part of the literature review were adopted as findings of the study.

Social Research/Study

For the interview, the voice transcript was downloaded, played back and useful information derived from it.

For the larger social study involving residents of the area and the smaller one involving the business owners, the filled in instruments were systematically arranged. SPSS was used to key in responses using an already defined data frame. Frequencies were then computed showing the various responses.

4.3.5 Data Presentation

The various data collected and analysed was presented in various formats. These are respectively:

Tables and charts detailing the results of the social study;

Maps and aerial imagery depicting the land uses and road network coverage and changes over the two epochs. As well, imagery was used to show changes in infrastructure over the course of the two epochs and modifications to the same.

4.5 Materials Used for the Study

The following materials were used during the research process:

1. Microsoft Word software for typing the report
2. ArcMap v10.0 software for spatial analysis
3. Google Earth Pro software for downloading satellite imagery
4. Microsoft Excel software for computing land use coverage
5. SPSS software for processing field data
6. Adobe Acrobat software
7. Google Chrome software for utilizing internet sources
8. HP ProBook laptop model 4330s

CHAPTER5: DATA ANALYSIS

5.1 Overview

The findings of the study are presented in this chapter. They are geared towards filling in the knowledge gap that prompted this research. The sources of information presented include households, the business community, the service providers in the public transport sectors and key informants at Nairobi City County's Department of Lands, Housing and Physical Planning.

The organization of this chapter is aligned to the objectives of the study which include:

1. To establish the characteristics of the Thika Superhighway
2. To assess the land uses along the Superhighway
3. To examine the characteristics of traffic flow and volumes along the Superhighway
4. To investigate the impact of land use changes on the traffic situation along the Thika Superhighway

5.2 Nature of the Population Served by Thika Superhighway

The characteristics of the households served by a transport corridor is key in the understanding of the traffic generation patterns since various members of a household make different types of trips and in varying frequencies. In this study therefore, the following parameters were assessed:

- Age of household members
- Number of dependants
- Employment status of household members
- Number of years of residence along Thika road corridor
- Household car ownership

5.2.1 Age of Household Members

The majority of those that reside along Thika road Corridor are aged between 18 and 40 years. They altogether form about 84% of the total population as depicted in table 5.1. This is evidence that the population is predominantly made up of youth and people with young families.

Table 5.1Age of Respondents

Source: Field Survey (2017)

Age bracket	Percent
18 – 30 yrs.	50.0%
31 - 40 yrs.	34.0%
41 – 50 yrs.	10.0%
51 – 60 yrs.	6.0%
Total	100.0%

5.2.2 Number of Dependants in Households

The fact that the study area is dominated by young families is further depicted by the number of household dependants as revealed in this study. About 37% of the of the residents have no dependants at all and this means that it is highly likely that the people in this group are unmarried or those who are married have no children (see figure 5.1).

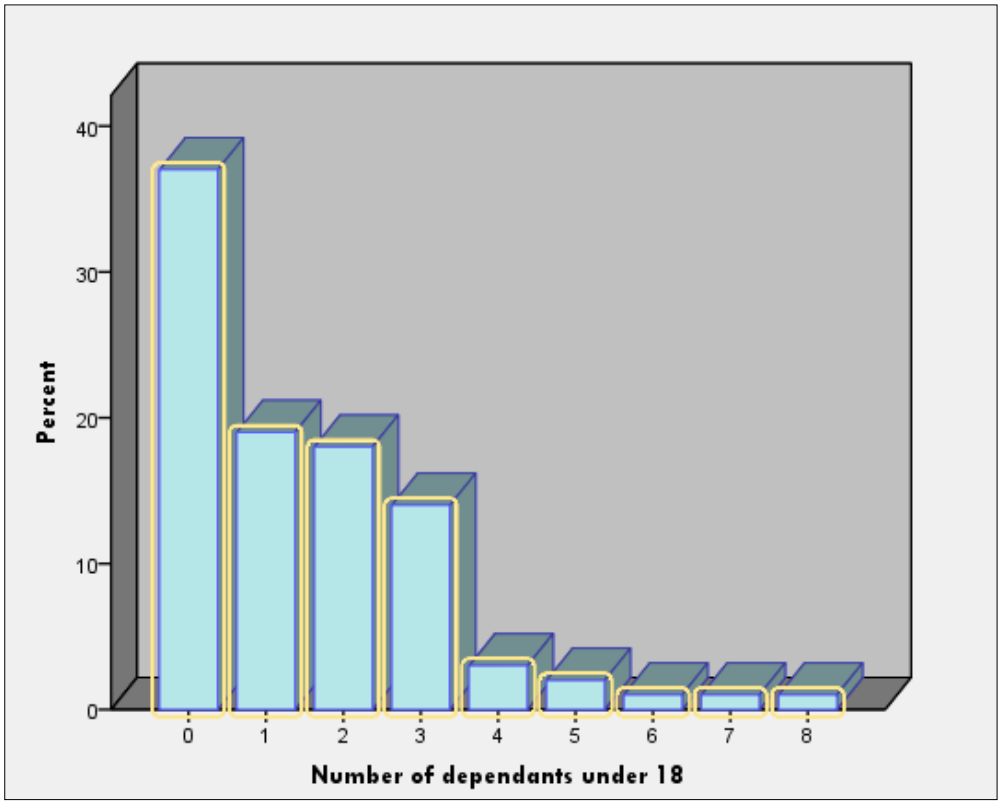


Figure 5.1Number of Dependants

Source: Field Survey (2017)

5.2.3 Household Employment

Most of the people involved in this survey (60%) reported that they are employed while 33% were self-employed, especially in the business sector. This is shown in the chart herein under.

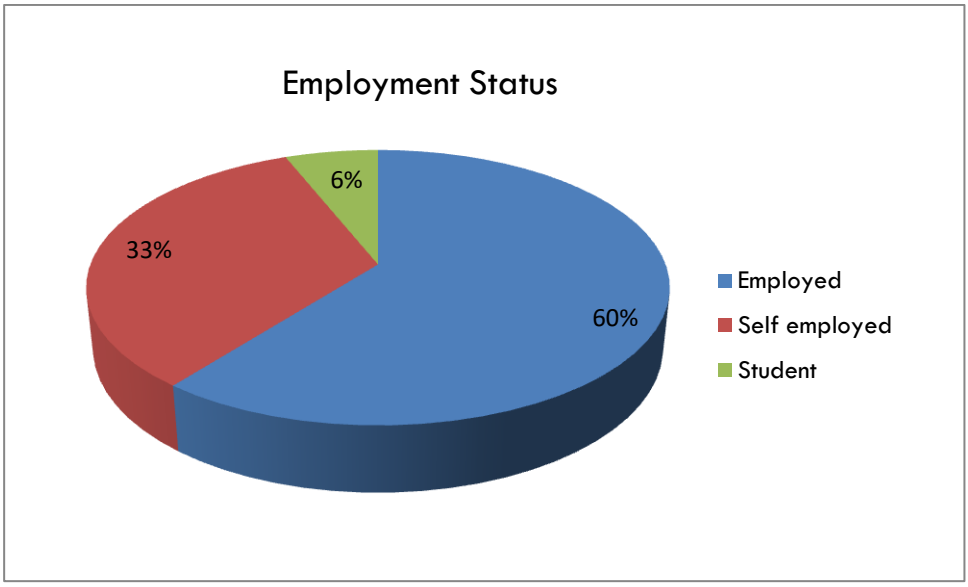


Figure 5.2Employment Status of Respondents

Source: Field Survey (2017)

5.2.4 Number of Years of Residence along Thika Road Corridor

More than half of the households have lived in the study area for only 5 years while only 18% have been there for over 10 years. This is depicted in table 5.2.

Table 5.2Years of Residence along Thika Road

Source: Field Survey (2017)

No. of years	**Percentage**
0-2 yrs.	29.0%
3-5 yrs.	29.0%
6-10 yrs.	24.0%
Over 10 yrs.	18.0%
Total	100.0%

Since Thika super highway was completed in the year 2012 (about 5 years ago), there is an indication that most of the residents moved to the corridor after the highway was completed.

Looking at the factors that influenced the households' decisions to move to the estates along the highway, it is noted that affordability of rent, proximity to work place and good transportation networks were the key drivers of those decisions. This is depicted in the table 5.3.

Table 5.3Reasons for Residing along Thika Road Corridor

Source: Field Survey (2017)

Reasons for residing along Thika road	Percent
Affordable rent	40.0%
Proximity to place of work	35.0%
Good transportation network	14.0%
Security	3.0%
This is my home	5.0%
Proximity to school	1.0%
Access to various services	1.0%
No response	1.0%
Total	100.0%

5.2.5 Household Car Ownership

Those that reported to be in possession of personal cars vis a vis those that did not were 47% and 53% respectively. For those that did not have cars, about 91% of them indicated plans to buy one in the future. About 9.5 % of them said they planned to buy a car for going to work; 47.6% would buy a car for business; 38.1% needed a car for convenient travels and 4.8% wanted a car for luxury.

Those that had no cars, yet they did not plan to buy any were very few (only 9%). They gave various reasons for their stand against buying personal cars. Some mentioned that there were other life priorities to be fulfilled (30%) while others pointed out that there was a lot of traffic congestion already (10%). Others also said that they had no financial capacity to buy cars (40%); car expenses were high and difficult to meet (10%); and that personal cars were inconveniencing (10%).

These statistics generally show that the current traffic volumes along Thika road are significantly made up of private cars and that in the future, the number of cars may only increase rather than reduce since a majority of those who don't have cars plan to buy them.

5.2.6 Household Travel Patterns

The household travel patterns were assessed based on the places to which different members of households made trips frequently and the routes they used. Some the places were of work areas, shopping points and schools.

Regarding the places of work, 30% of the people operated in Nairobi CBD, 13% were within residential neighbourhoods and 17% worked in institutions located along Thika road. This implies that the bulk of the traffic from the study area ended up in the city's CBD.

The routes used to various destinations were as shown in table 5.4.

Table 5.4Routes Commonly Used

Source: Field Survey (2017)

Route	**Percent**
Thika Superhighway	76.0%
Other main roads leading to various places (e.g. Babadogo, Outering, Roysambu and Kiambu roads)	14.0%
Estate access roads	6.0%
Bypass	2.0%
No response	2.0%
Total	100.0%

The Superhighway was the most plied route since most of the people worked in the CBD and the located institutions along the highway. A few people used the Bypass as an alternative route to the highway. Those that used the estate access roads were those that worked, schooled and shopped within their estates of residence.

Furthermore, the various routes were used for different reasons as depicted in table 5.5.

Table 5.5Reasons for Using Different Routes

Source: Field Survey (2017)

Route used	Reason for using the route								Total
	Less traffic	Route is direct	Easy to use	Best route	It's the only route	Convenient	Faster route	No response	
Superhighway	34%	9%	1%	4%	13%	5%	7%	3%	76%
Bypass	0%	0%	0%	0%	0%	1%	1%	0%	2%
Ngumba lane	0%	0%	0%	0%	1%	1%	0%	0%	2%
Estate access road	0%	0%	0%	1%	0%	2%	0%	1%	4%
Babadogo road	0%	1%	0%	0%	2%	1%	0%	0%	4%
Outering Road	5%	1%	0%	0%	0%	1%	1%	0%	8%
Roysambu road	0%	0%	0%	0%	0%	1%	0%	0%	1%
Kiambu road	0%	0%	0%	0%	1%	0%	0%	0%	1%
No response	0%	0%	0%	0%	0%	0%	0%	2%	2%
Total	39%	11%	1%	5%	17%	12%	9%	6%	100%

From table 5.5, it is evident Thika Superhighway is preferred for various reasons, even though about 13% of the people use it because it is the only route. Those that use the bypass argue that it is more convenient and a faster route than the highway. The rest of the routes are used either because they are the only routes or are the most convenient.

Thika road, (which is the most plied route) was used for reasons as in table 5.5.

Table 5.5Manner of Use of Thika Superhighway

Source: Field Survey (2017)

Use of the route	**Percent**
Going to work	63.0%
Shopping	5.0%
Going to school	6.0%
To accomplish errands in town and other places	19.0%
Travelling out of Nairobi	3.0%
Going to recreational places	1.0%
No response	3.0%
Total	100.0

It is evident that most of the people used Thika road to go to work and accomplish other errands in the CBD and other places.

5.2.7 Household Modes of Travel

The findings of this study show that more people use PSV modes (52%) than those that use private cars and NMT modes (36% and 9% respectively). See the chart below.

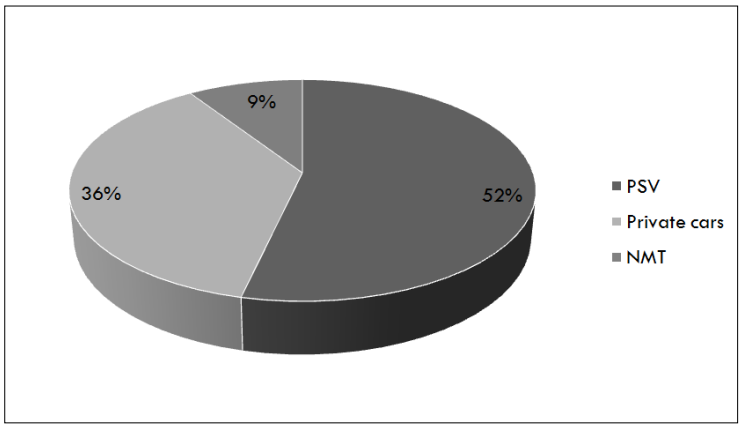


Figure 5.3Modes of Transport Used

Source: Field Survey (2017)

There is evidently a high level of reliance on the Public Transport System in the study area. As such it is important that the system operates efficiently and effectively.

The people were further asked to indicate their level of satisfaction with the modes the used and a majority 76% pointed out that they were satisfied. This can be attributed to the fact that the main route (Thika superhighway) is well developed and has the capacity for very many vehicles.

5.3 Nature of the Thika Superhighway

Thika superhighway consists of a six-lane passage way with four extra service lanes, two on either side of the highway making up a total of ten lanes. Along the entire stretch of the highway, provision has been made for NMT with a three-meter passage for the bicycles and motorcycles having been provided. Next to the three-meter passage there exists an elevated two-meter lane for pedestrians to walk on to separate them from the motorised transport. There are also bollards to separate bigger vehicles from using the passage lane meant for motorcycles and bicycles.Across section of the highway is given in the figure 5.4.An illustration of the separation is illustrated in plate5.1.

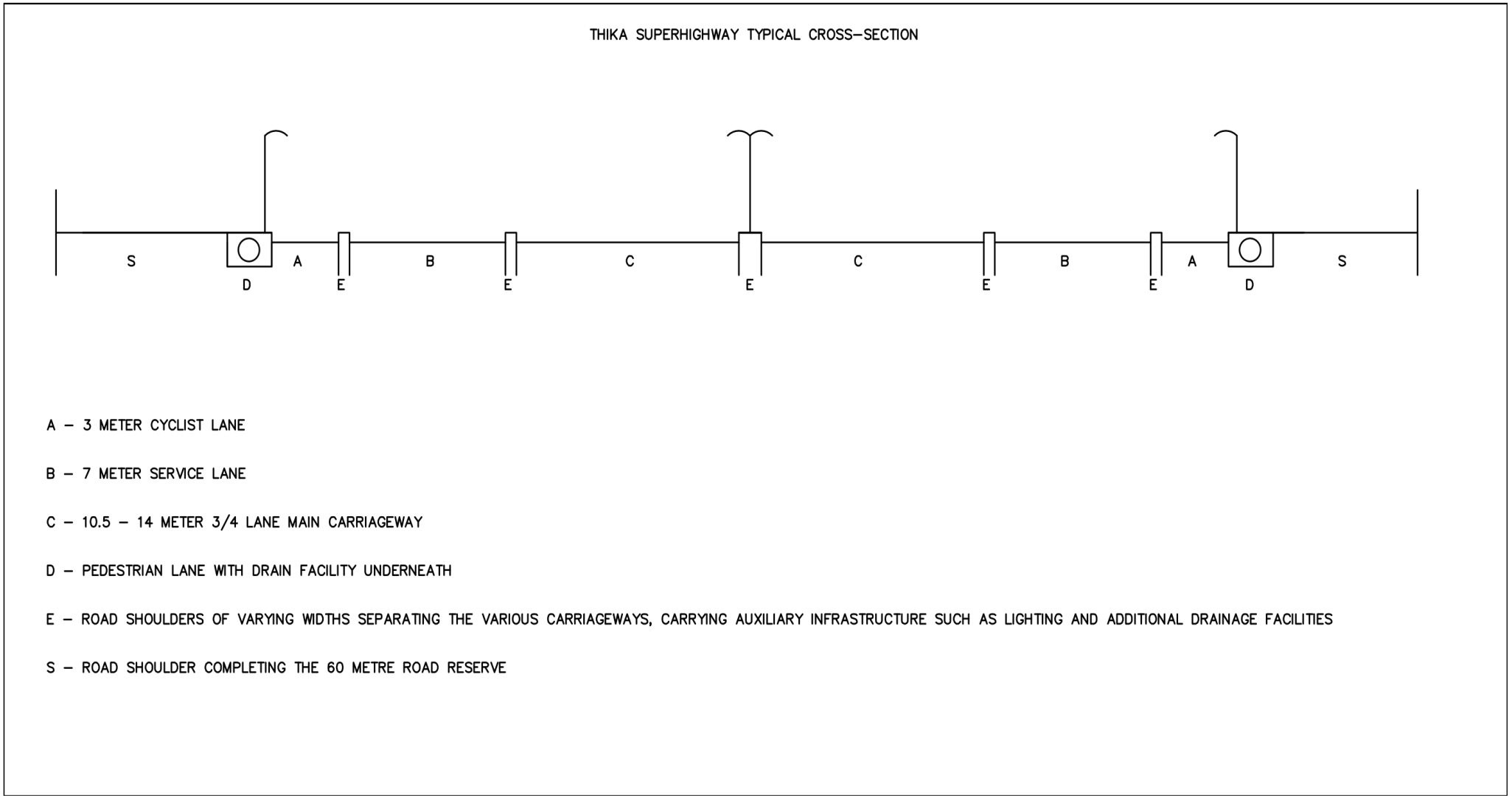


Figure 5.4Cross-section of Thika Superhighway

Source: Field Survey (2017)

Plate 5.1NMT and Motorcycle Lane
Field Survey (2017)

Along the highway between Roysambu and Homeland/Garden City, the highway has eight lanes, four heading to Roysambu and four heading to Homeland, with four service lanes, two on either side of the highway. Between Garden City and Allsops, the highway reverts to six lanes, with three heading to Garden City and three heading to Allsops, and four service lanes, two on either side of the road. An illustration of the Highway from different points of view is given in plates 5.2 and 5.3.

Plate 5.2Six Lane Highway Between Allsops and Garden City Intersection
Field Survey (2017)

Plate 5.3Eight Lane Highway Between Garden City and Roysambu Intersections
Field Survey (2017)

There are three intersections within the study area, one at Roysambu, one at Garden City and one at Allsops stage. These intersections are at separate grade, making passage along the highway smooth. The intersection at Roysambu intersects with

Kasarani road. Traffic along the highway passesatop the intersection while traffic headed to Kasarani and Kahawa West passes beneath the highway. This is illustrated in plate 5.4.

Plate 5.4Roysambu Intersection
Field Survey (2017)

At Garden City, the highway passes beneath the intersection. Trafficfrom Ngumba estate, East African Breweries Limited (EABL) and Garden estate passes atop the highway. There have been improvements made at this intersection following the opening of Garden City mall to cater for increased traffic and as well segregate the traffic. This is illustrated in plate 5.5.

At Allsops, the highway passes beneath the intersection as well, with the major artery into Thika Superhighway being Outering road. Recent improvements on Outering road have necessitated a redesign of the intersection with the latest redesign happening in January of the year 2017 to address the perennial traffic conflict at the intersection.

Plate 5.5Garden City Intersection
Field Survey (2017)

The ceiling of the two intersections at Allsops and Roysambu are 5.5 metres from the surface of the highway thereby restricting traffic that exceeds that height.

The section between Roysambu and Allsops also has one footbridgeat USIU thereby ensuring no conflict between NMT traffic and motorised traffic that flow along the highway. There are bumps and a pedestrian crossing (what is commonly referred to as zebra) crossing at Garden City to enable the movement of pedestrians across the highway. This crossing causes tailback at peak times owing to increased vehicular traffic along the highway depending on the direction of traffic. There are plans underway to construct a footbridge at Garden City to improve the flow of traffic that is normally disrupted by the pedestrian crossing currently present. There exists another pedestrian crossing at Roysambu. The footbridge and the pedestrian crossings are illustrated in plates 5.6 to 5.9.

Plate 5.6USIU Footbridge

Field Survey (2017)

Plate 5.7Pedestrian Crossing at Garden City

Field Survey (2017)

Plate 5.8Pedestrian Crossing at Garden City from the Opposite End

Field Survey (2017)

Plate 5.9Pedestrian Crossing at Roysambu

Field Survey (2017)

Plate 5.10USIU Bus Stages

Field Survey (2017)

Plate 5.11Bollards near the Bus Stage in Black and White

Field Survey (2017)

One element of the highway that makes manoeuvrability a bit easier is the presence of clear signage along it. A sample is given in plate 5.12.

Plate 5.12Signage along the Highway

Field Survey (2017)

Plate 5.13Developments along the Highway

Field Survey (2017)

Improvements at the intersections are shown in Plates 5.14 to 5.15.

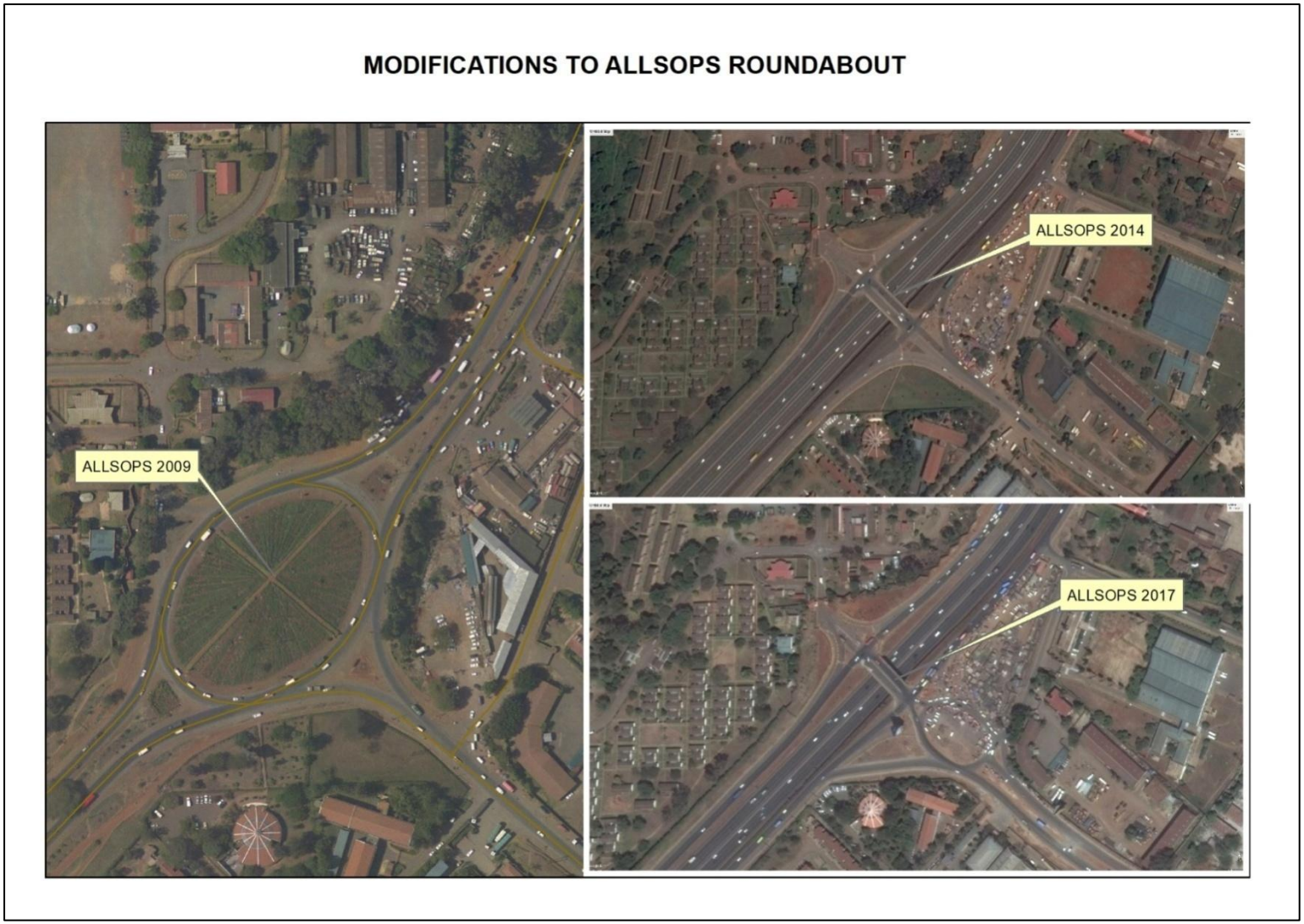


Plate 5.13Allsops Roundabout Modifications
Google Maps (2018)

Modifications have been done to allow for the smooth flow of traffic since the completion of the Superhighway

Plate 5.14Garden City Intersection Modifications
Google Maps (2018)

A portion of land was converted to public purpose from commercial user to allow for the smoother flow of traffic on the lower part of the images. Notice the inclusion of a round-about evident in the year 2017. The presence of various malls at the intersection was partly necessitated the changes.

Plate 5.15Roysambu Intersection Modifications Google Maps (2018)

The blue roofed building in the 2014 and 2017 photos is the Thika Road Mall. Changes to its entry were done and are evident in the 2017 image. This was to allow for smooth traffic flow into and out of the mall and its surroundings.

5.3.1 Characteristics of Nairobi Traffic

According to the JICA study done in preparation for the development of the Integrated Urban Development Master plan for the City of Nairobi, traffic between the years of 2004 and 2013 increased 1.69 times. The methodology approached for getting the total count was a cordon line survey conducted at 14 points, 12 of these coinciding with the points used in the year 2004, which showed an increase from a count of 121,096 in the year 2004 to a count of 204,675 in the year 2013.

In terms of traffic composition, six types of motorized carriers were identified; the motorcycle, the private car, the light truck, the heavy truck, matatus and large buses. Private cars occupied the largest proportion, increasing by 44% to a count of 84,000 vehicles. However, about increasing ratio by vehicle type, it was observed that motorcycles increased by the largest amount, increasing 9.9 times from the 2004 figure. A comparison made between large buses and matatus did not yield a substantial increase in the latter owing to government policy to shift to larger carriers and affordable fares. A chart showing the trend in growth of vehicles between the years 2008 and 2012 as per KNBS statistical abstracts is as shown in figure 5.4.

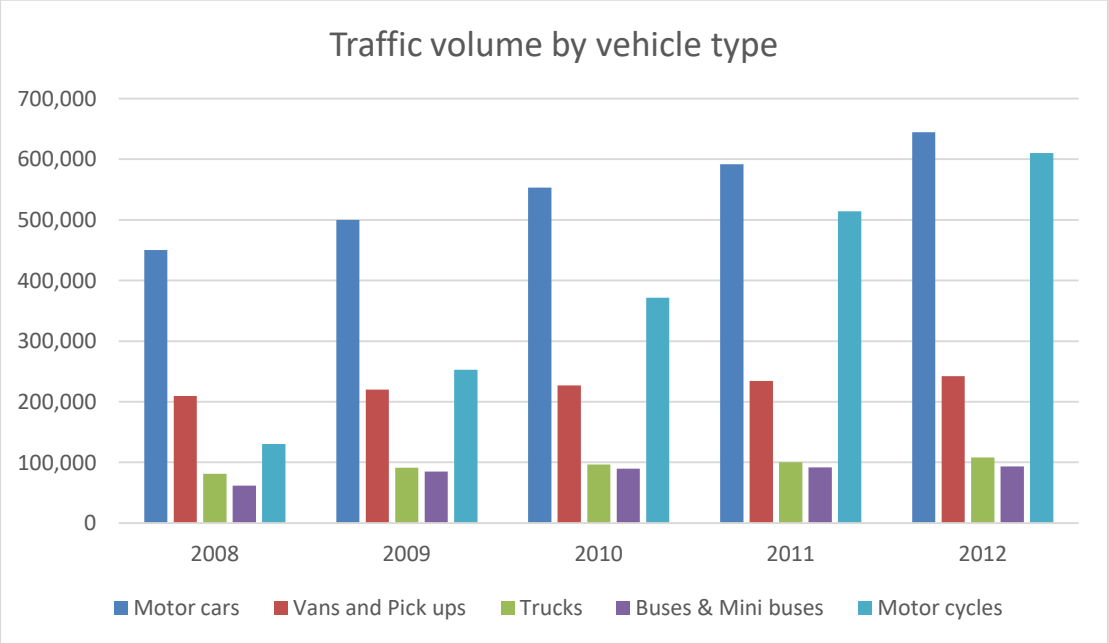


Figure 5.4Vehicle Ownership Between the Years 2008 to 2012

Source: KNBS (2013)

Between the years of 2012 to 2016, there was a steady rise in vehicle ownership in the country as evidenced by the figure 5.5.

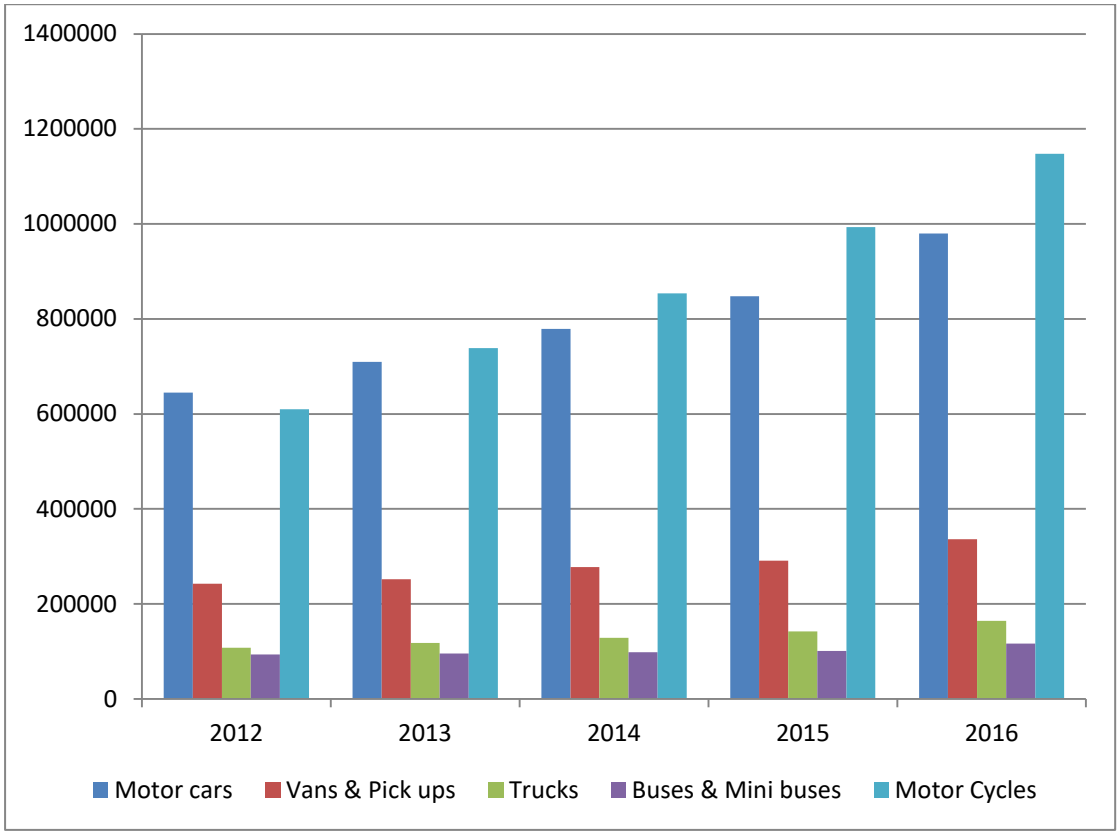


Figure 5.5Vehicle Ownership Between the Years 2012 to 2016

Source: KNBS (2017)

This rise in vehicle numbers is most greatly felt in the City County of Nairobi. Comparing the total number of vehicles as given by the cordon line census of 2013 against the total number of vehicles overall, about 21% of the total number of vehicles in the country have a presence in the City County of Nairobi. Given the steady rise in vehicle ownership numbers, it is then possible to roughly estimate that in the year 2016, there were approximately 335,000 vehicles in the same geographical space. This is despite that fact that the road carrying capacities remain nearly the same and ae expected to carry this 33% increase in volume.

Within the study area, the traffic patterns indicate a predominant use of the Superhighway to access the CBD, from wherever the respondents were domiciled. From tab 10, 76% of those interviewed indicated that they used the Thika Superhighway to access the CBD. Additionally, of these 76% the 63% of these

respondents access the CBD to access their work places. The respondents indicated that they use PSVs predominantly (at about 52%). These statistics imply that unless some decentralization is done to have some work places shift from the CBD, then this component of the travellers will continue to contribute to the traffic volumes.

Additionally, about 91% of the respondents indicated willingness to purchase vehicles in the future, with 9.5% indicating that they planned to purchase them for going to work, 47.6% for business, 38.1% for convenient travel while 4.8% for luxury. In these numbers, it can be deduced that there is a general feeling that the public transportation system is not enough for the forms of travel favoured by the respondents.

5.4 Land Use Transformations and their Impacts

Previous observations have pointed out to the fact that there have been notable changes in land use along Thika road corridor since the superhighway was completed in the year 2012. This study sought to assess the existence of such changes and the nature thereof.

5.4.1 Predominant Land Uses in the Study Area

Several land uses were identified andtabulated in table 5.6.

Table 5.6Land Use in the Study Area

Source: Field Survey (2017)

Land use in hectares	**2017**	**%**
High density residential	202.11	12.21
Medium density residential	617.14	37.29
Industrial	202.22	12.22
Educational	52.85	3.19
Recreational	103.02	6.22
Public purpose	153.59	9.28
Commercial	56.88	3.44
Public utilities	3.31	0.2
Agriculture	0	0
Unutilized	123.16	7.44

The study area occupies a total of 1655 hectares. Thika road dissects it into two parts, with the upper (northern) part generally more affluent than the lower (southern) part

of it. The lower part of it is also of more mixed usage than the upper part characterized by industrial, recreation, residential usage among other usage.

A comparison of the land use acreages in the study area is derived from tables3.2 and 5.6. In the year 2009, 13.21% of this land was under high density residential usage. This includes estates such as Baba Dogo, Ngumba, Roysambu and Lucky Summer. Babadogo is unique in the group in that the usage is high density although the users are spread horizontally thereby using up a lot of land in a non-intensive manner. The other three estates mentioned have high rise apartment buildings that makes their usage high density though in the vertical sense. In the year 2017 however, the land used under this category reduced somewhat. This was occasioned by the conversion of a part of Baba Dogo settlement into industrial use.

Medium density usage accounted for 33.41% in the year 2009 and rose to 37.29% in the year 2017. These users are mostly located in Garden estate, Thome estate and what is commonly called Muthaiga north estate on the upper side of the Thika Superhighway. The rise in the acreage under this user is mostly accounted for by the conversion of idle/unutilized land into residential land usage in the years in between.

Industrial users accounted for 11.52% and 12.22% in the years 2009 and 2017 respectively. This user is in Babadogo area and mostly comprises factories. Prominent factories in the area include Chandaria Industries, Vista windows among others. The slight increase in acreage under this user is due the conversion of a portion previously under high density residential into industrial user in the Babadogo area.

Land under educational purposes covered 3.13% of the total land in the study area in the year 2009 while in the year 2017, the same covered 3.19%, a slight increase. This was occasioned by the conversion of an idle piece of land adjacent to the river to educational purposes in Lucky summer area. The prominent educational facility in the area was noted to be the United States International University (USIU).

Land under recreational land use remained the same at 6.22% in the period under study. The main establishments in the study area including Safari park hotel and Moi International Sports Centre Kasarani among other establishments remained under the same acreage.

Public purpose occupied 9.24% of the land in the study area in the year 2009 and increased to 9.28% in the year 2017. This slight increase was occasioned by a change in user from unutilized to public purpose in Thome area within the study area.

Land under commercial usage increased from 1.87% to 3.31% in the study area, a significant increase. Part of this was conversion of large swathes of land into malls. Thika Road Mall (TRM) and Garden City Mall were built in between this period. The former was built on unutilized land at Roysambu while the latter was built on land formerly occupied by the EABL. Notably then, land under industrial usage shrunk due to this conversion but the amount of shrinkage was compensated for by the change in user from high density residential to industrial in Babadogo area, and which was earlier alluded to. In addition, a strip of land fronting Thika Superhighway near Garden City Mall and the river at Allsops was largely converted to Commercial usage, with the most prominent feature being the Natives Sports Bar, right next to Garden City Mall. This strip also has car yards and complementary businesses such as car accessory shops. It is useful to note that car yards have existed on the opposite side of the highway since before the improvements of the highway at homeland area. The notable ones include CarMax and Volex motors.

Land under public utilities more than doubled in coverage from 1.41% to 3.31%. Part of the land in the study area was under agricultural us in the year 2009 and accounted for 1.97% of the total area. However, in the year 2017, the same parcel has largely remained unutilized. The parcel is surrounded by prime parcels which have so far been converted to residential usage.

The unutilized land dropped from 10.96% to 7.44% in the period under review. Most of the conversion was geared towards apportioning it to residential usage while some was converted to other users.

Two maps produced show the predominant land uses and further show the change in land use during the period under review. These maps are shown in figures 5.4 and 5.7.

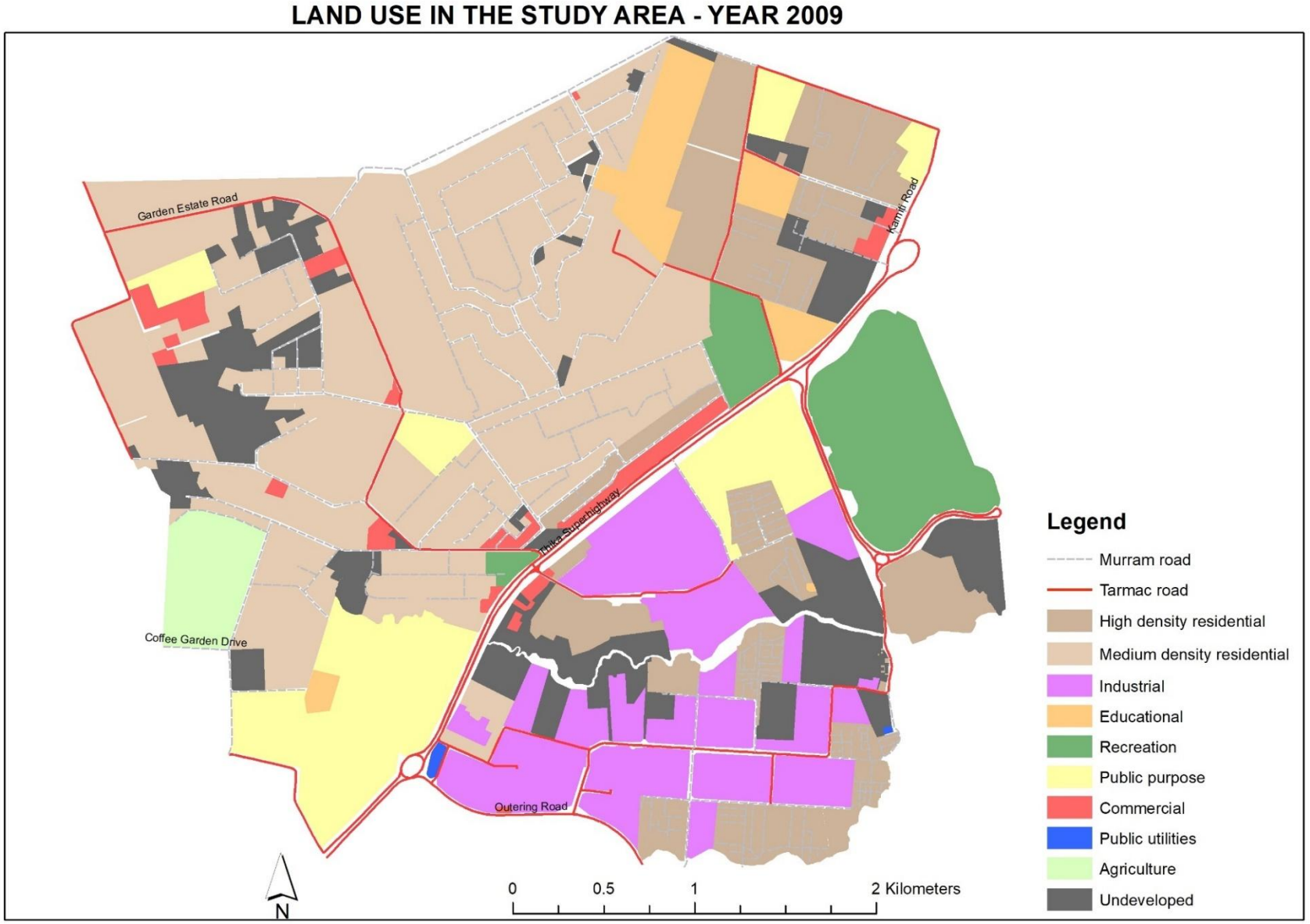


Figure 5.6Land Use in the Study Area in the Year 2009

Source: Google Maps (2018)

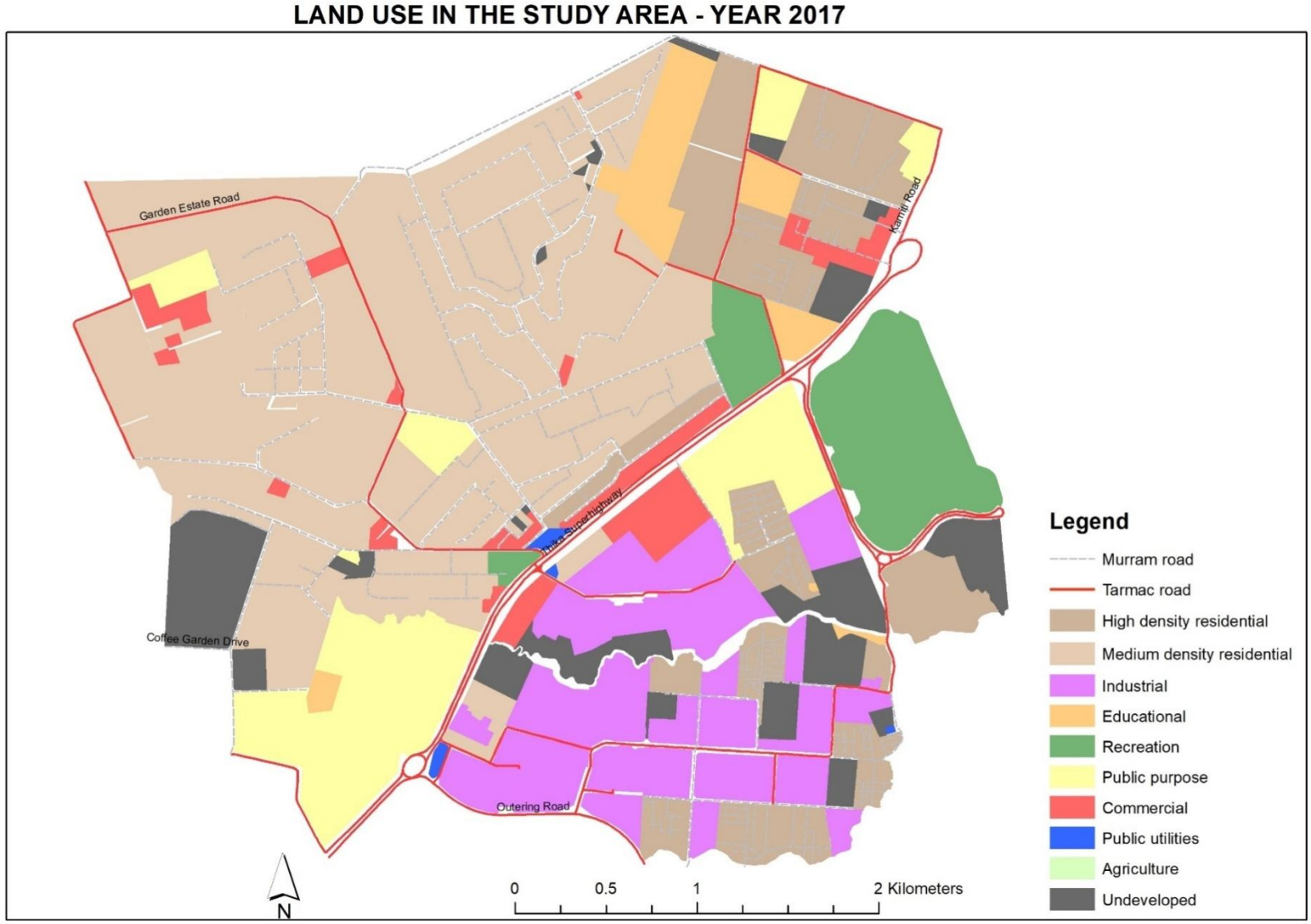


Figure 5.6Land Use in the Study Area in the Year 2017

Source: Google Maps (2018)

5.4.2 Respondent Views on Nature of Land Use Transformations

The findings of this study confirm the existence of land use changes along Thika road corridor since the time of completion of the highway. Upto 93% of the people reported that they had noted various land use changes. They further specified the changes as follows:

Table 5.7Respondents Views on Nature of Land Use Changes

Source: Field Survey (2017)

Land use changes	**Percent**
Residential developments increasing	14.3%
Recreational areas increasing	1.1%
Malls/ commercial buildings coming up	34.1%
New mixed-use developments taking place	38.5%
High rise developments increasing (Densification)	3.3%
Development of roads and buildings increasing	4.4%
Hotel developments upcoming	1.1%
Industrial developments upcoming	1.1%
Emergence of commercial nodes	1.1%
Change of residential land to commercial	1.1%
Total	**100.0%**

Furthermore, the respondents indicated the predominant types of land uses that were coming up in the neighbourhoods. These were residential, commercial and industrial, the latter of which was mostly reported in Ruaraka area as in figure 5.7.

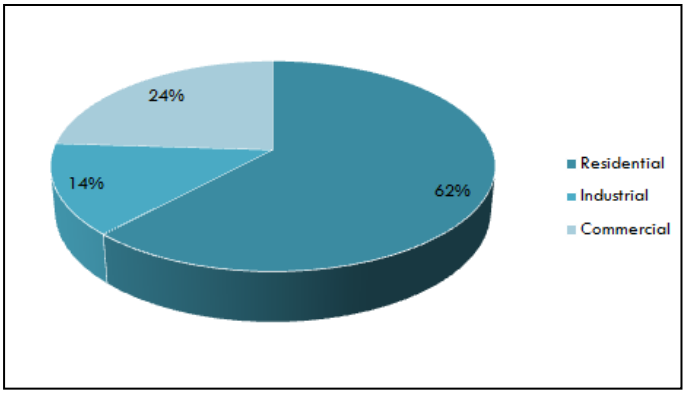


Figure 5.7Respondents Views on Upcoming Land Uses

Source: Field Survey (2017)

Notably, significant residential and commercial developments have taken place in the study area in the last five years, which majority of the residents attribute to the development of the superhighway. It is also evident that the densities of developments in the area have increased over the same period.

Tying the above observation with the one made earlier on the number of years that most of the residents have been in the study area; it is arguable that the upgrade of Thika road attracted not only new developments but also several immigrants from other parts of the city. As a result, the traffic volumes along the corridor increased considerably.

Further to this, it was noted that also infrastructural developments had taken place, especially in the road sector. About 56% of the respondents in this study indicated that roads within their estates had been improved since the construction of Thika superhighway.

It was also noted that the newly constructed roads led to changes in land values therein. About 98% of the respondents who indicated land value changes mentioned that the values increased significantly.

5.4.3Effects of Land Use changes

The above land use changes have impacted of various aspects of life, including traffic volumes, travel situations, business operations and the public transport system. Each of these is discussed elaborately herein below.

5.4.3.1 Effects on Traffic Volumes

As noted earlier, this study shows that most people in the study area moved there in the last five years and a lot of new developments have also come up since then. The household car ownership also stands at 47%. All these show that both human and vehicular traffic has increased significantly between the time when the superhighway was constructed and now.

Furthermore, upto 89% of the respondents indicated that they noted changes in traffic volumes along Thika road due to the land use changes. Out of these people, 97.7% said that the volumes had increased while only 2.3% reported a decrease in the traffic volumes.

In addition, the respondents were asked to state whether the superhighway had affected traffic within their estates and if so, they needed to state the manner which the situation had been affected. The two tables 5.8 and 5.9 show the responses.

Table 5.8Respondents Views on effect of Thika Superhighway on Intra-estate Traffic

Source: Field Survey (2017)

Statement	**Percent**
Superhighway has affected traffic in estate	84.0
Superhighway has ***not*** affected traffic in estate	16.0
Total	100.0

Table 5.9Nature of Impact on Traffic within the Estate

Source: Field Survey(2017)

Nature of impact	**Percent**
Increased traffic congestion	94.0
Reduced traffic congestion	6.0
Total	100.0

The above statistics show that there has been increase in traffic; to a level that most of the people feel that there is congestion.

5.4.3.2 Effects on Travel Situations

It has been observed in this research that many people in the study area have witnessed changes in the travel situation along the corridor. About 73% of the people confirmed that the travel situation had changed while 23% reported no change.

Regarding the specifications on the nature of travel changes, 95% of those who reported travel changes pointed out that travel times had increased over the years while 5% said that the travels became slower as in figure 5.8.

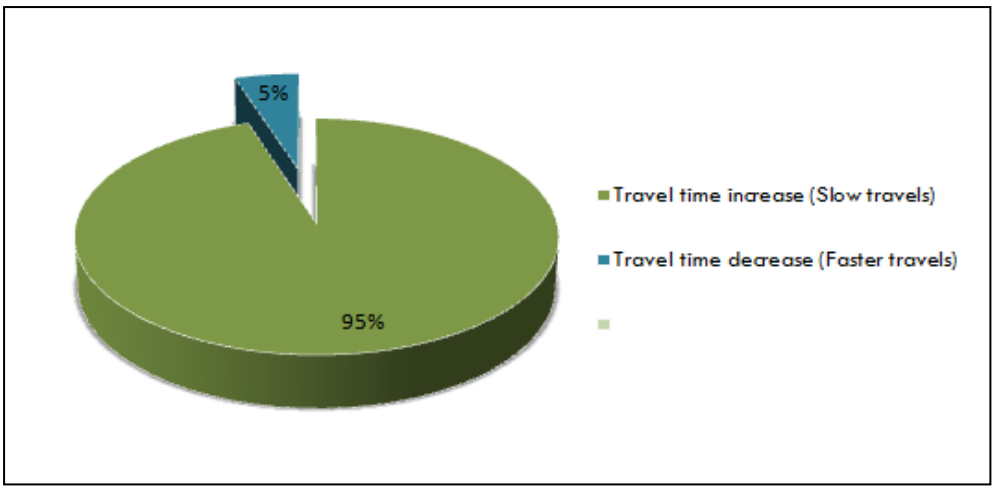


Figure 5.8Nature of Impact on Travels

Source: Field Survey (2017)

5.4.3.3 Effects on Business Operations

The business sector is a very important sector which tends to be influenced by the state of infrastructural developments in an area. As such, it was found necessary that this study interrogates the way the highway and the resultant land use changes had worked either for or against businesses in the study area.

Like many households, quite several businesses were found to have been established after Thika road was upgraded into a superhighway. This is shown by the statistics in the graph 41 below.

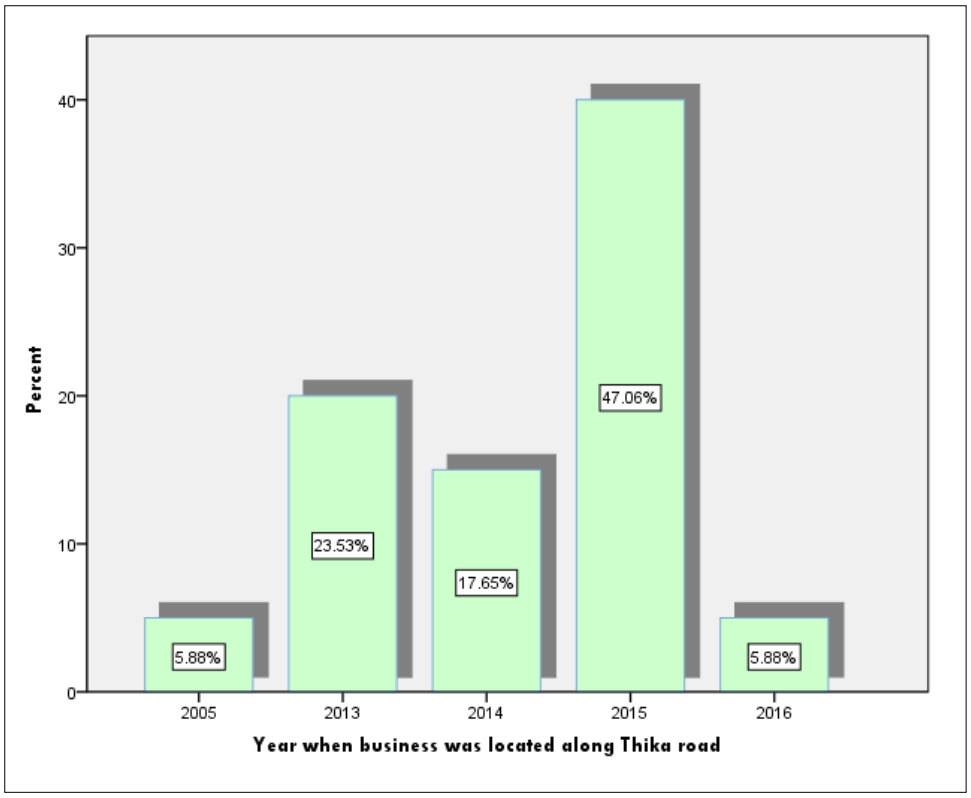


Figure 5.8Year of Business Establishment

Source: Field Survey (2017)

Evidently only 5.9% of the businesses were established before 2012, which is the year when the superhighway was completed. This shows that the highway attracted very many businesses.

The business operators further expressed their opinions on the impacts that the superhighway had had on their businesses. Only 10% of them said that there had been no impact at all while 75% and 15% pointed out positive and negative impacts respectively . This is illustrated in table 5.10.

Table 5.10Impact of the Superhighway on Business

Source: Field Survey(2017)

Nature of Impact	**Specific Impacts**	**Percent**
None	-	10.0%
Positive impacts	Improved business visibility	15.0%
	Increased sales	5.0%

	Better delivery of goods	10.0%
	More customers	40.0%
Negative impacts	Congestion along the road reduces access to business place	10.0%
	Accidents on the road discouraging people from going to the businesses in the study area	5.0%
	Delay in business opening and closing hours	5.0%
Total	-	**100.0%**

Generally, it can be said that business improvement has been registered in the study area as shown in the statistics above. However, the shortcomings noted can also not be ignored. It is important that they are mitigated if business is to improve further.

5.5 Impacts of Business Developments on Thika Road Traffic

When the business operators were asked to give their evaluation on whether their businesses had affected the traffic on Thika road, half of them said that the businesses had impacted on the traffic while the other half said there had been no effect.Those that pointed out that there were effects further specified the impacts.

Table 5.11Nature of Impacts of Business Developments on Thika Superhighway Traffic

Source: Field Survey(2017)

Impacts	**Percent**
Customers from businesses add on to traffic along the road	60.0%
Vehicles transporting goods to and from businesses increase traffic along the road	10.0%
Congestion	30.0%
Total	100.0%

In cases where the traffic impacts were reportedly negative, the business people were asked to state some of the mitigation measures they had taken. They are tabulated in table 5.12.

Table 5.12Mitigation Measures against Negative Business Impacts on Traffic

Source: Field Survey(2017)

Mitigation measure	Percent
Provision of numerous exits from the mall	20.0%
None	50.0%
Delivery of goods in bulk to reduce number of trips along Thika road	10.0%
Provision of a lane to serve the mall	10.0%
Development of roundabouts by government	10.0%
Total	**100.0%**

5.6 Assessment of Transportation Changes by Public Transport Service Providers

This research also sought to examine the public transport service providers' assessment of transportation situation along Thika superhighway. As such the public transport SACCOs operating in the zones served by the highway were interviewed. The SACCOs durations of operation along Thika road were reported to be as tabulated below.

Table 5.13Duration of Operation along Thika Superhighway Route

Source: Field Survey(2017)

No. of years	Percent
0-2 yrs.	14.3%
3-5 yrs.	14.3%
6-10 yrs.	42.9%
Over 10 yrs.	28.6%
Total	**100.0%**

Since the majority of the SACCOs had at the time of this research operated in the study are for over years, their experience was considerably reliable.

5.6.1 Assessment of Traffic Volumes

About 85.7% of the public transport service providers pointed out that there had been changes in traffic volumes in the study area while 14.3% were of the contrary opinion. The former group stated the following causes of increase in traffic volumes:

- Increased number of personal cars
- Population influx to the areas along Thika road

The latter cause was cited by 66.7% of the respondents while the former was cited by 33.3%.

On the other hand, the people that said that traffic volumes had not changed explained that the traffic along Thika Superhighway had not matched its increased capacity. In other words, the traffic volumes were much lower that the highway could accommodate.

5.6.2 Assessment of Traffic Flow Patterns

The SACCOs were also asked to give the evaluation on whether the traffic flow patterns had changed. A smaller proportion (42.9%) mentioned that there had been a change. The other 57.8% said there had been no change in traffic flow [pattern.

Those that had noted changes further specified them as follows;

- Ease of manoeuvring along Thika road has increased
- Increased traffic to the roundabouts has influenced controlled traffic flow

Considering the above assessments, it is evident that increase in traffic volumes has been witnessed while traffic flow patterns have only changed in terms of the entry and exit points to the highway and the ease of changing lanes by motorists.

5.6.3 Feeder Road Network Changes in the Study Area

The road network in the study area has been changing as the land use has changed. There has been an increase in the length of feeder roads within the study area and increased investment in the form of tarmacking of the roads in the area. A visual representation of the same is shown on figures5.9 and 5.10.

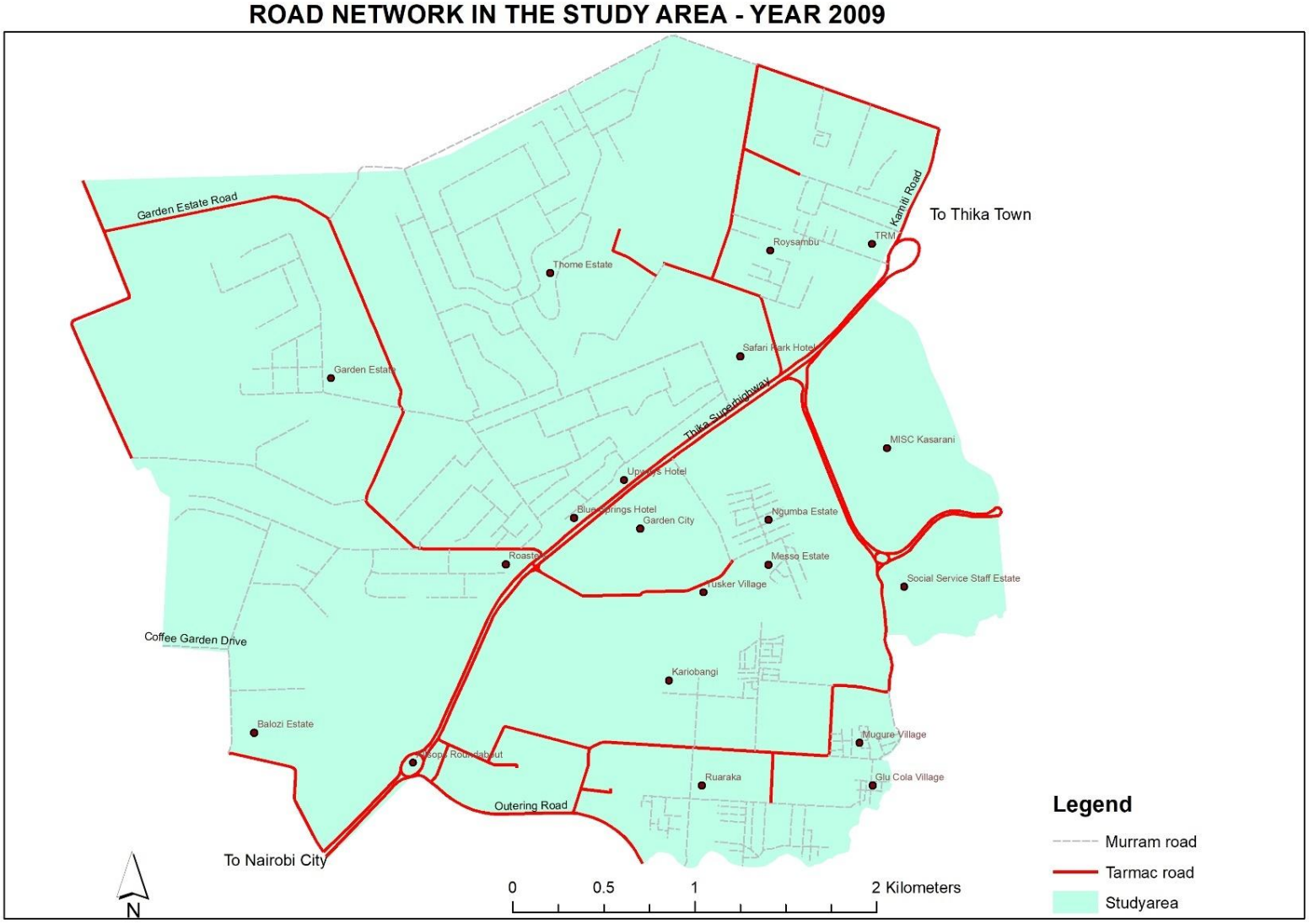


Figure 5.9Road Network in the Year 2009

Source: SoK (2009)

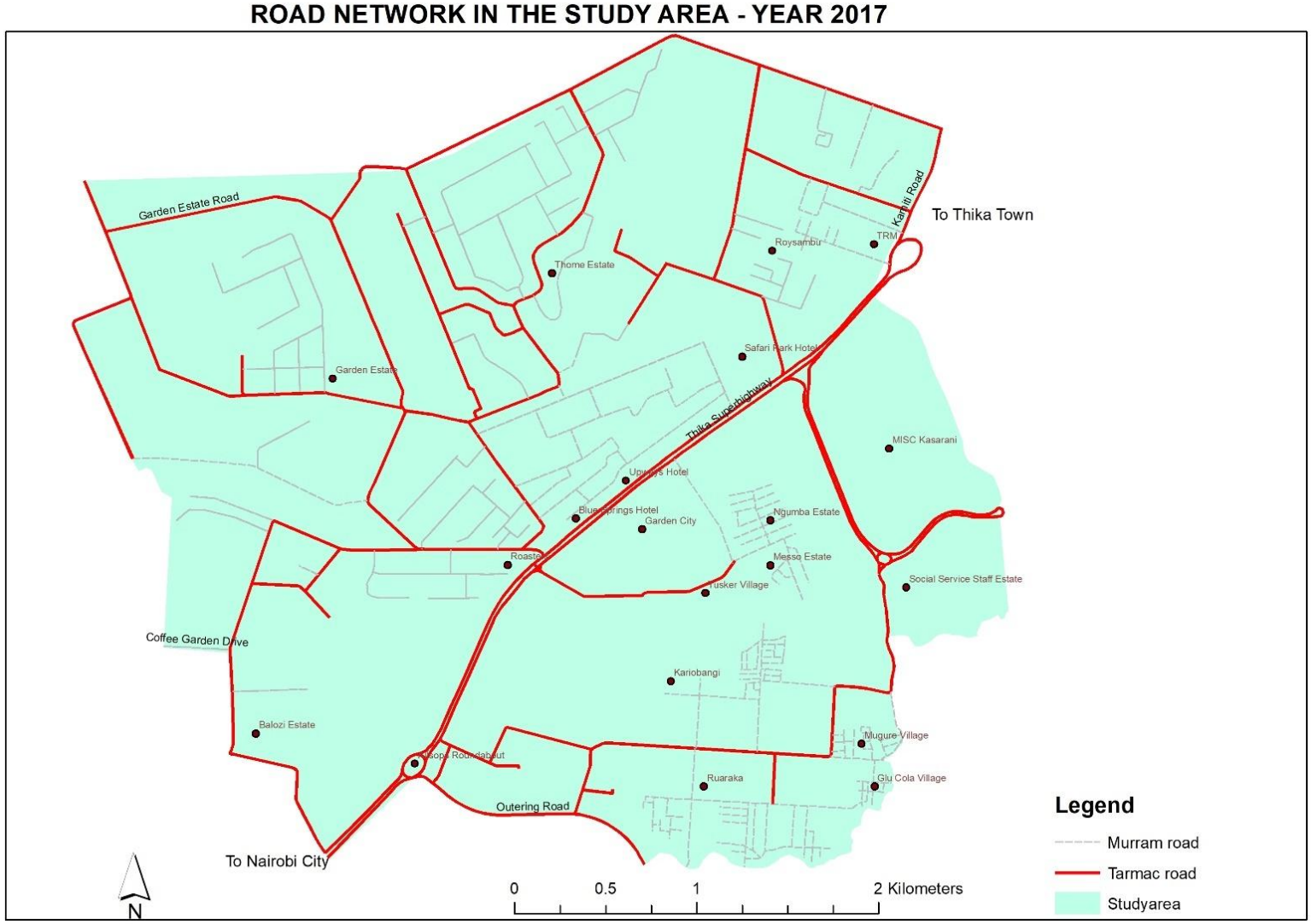


Figure 5.10Road Network in the Year 2017

Source: Field Survey (2017)

The approximate total road length in the study area was 95 kilometres in the year 2009 and 96.3 kilometres in the year 2017. A summary of the road statistics is as given in table 5.14.

Table 5.14Road Statistics

Source: Field Survey (2017)

	2009	**2017**
Total road length (km)	95	96.3
Bitumen road length (km)	33.4	48.8
Murram road length (km)	61.6	47.5

There was an approximate net increase of 1.4% on the total road length in the study area during the period under study. Bitumen roads in the study area increased by 46.2% in the period under study while unpaved/murram roads reduced by 22.9% in the same period. This latter phenomenon can be directly attributed to the increase in bitumen roads in the study area.

5.7 Conclusion

Thika superhighway is one of the major trunk roads serving Nairobi city. Its upgrade has caused major changes in the areas it serves, the most significant of which are the land use changes. The findings of this study have further pointed out to the fact that while Thika road has attracted new developments and major land use changes, these developments have in turn affected the traffic volumes in the study area.

The most important lesson that can be drawn from this study is that it is essential that transport development decisions are made in consideration for the inherent egg and chick relationship between land use and transportation.

CHAPTER 6:CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

The aim of the study was to establish the impact that land use change has had on the Thika Superhighway, particularly since its upgrading in the year 2012. The respondents in the study were the inhabitants along the Thika Superhighway in the selected study area and the business community within the study area. A quantitative study was used with administration of research instruments of type questionnaires and interview schedules mainly used. Desktop review was used to extract additional data to supplement data obtained in the field. Sampling was achieved by using random stratified method.

6.1Summary of Findings

The study set out to achieve four objectives which were to establish the characteristics of the Thika Superhighway, assess the land uses along the Superhighway, examine the characteristics of traffic flow and volumes along the highway and to investigate the impact of land use changes on the traffic situation along the Superhighway.

The highway was seen to comprise six to eight lanes of high moving traffic comprising the highway aspect. It was also established that there are two service lanes on either side of the highway catering to local traffic and public transport vehicles. Provision of NMT facilities was seen to exist, with a special lane for bicycles and an elevated pathway for pedestrians to walk on and thus acting as a segregating factor keeping apart the pedestrians from the other roads users.

The land uses within the area of study were seen to be varied in nature due to the nature of developments within the area of study. However, the predominant land use in the area under study was determined to be residential in nature with a coverage of approximately 49% of the land within the study area under it. The mixing of residential and industrial land uses in Baba Dogo posed an interesting phenomenon given the nature of recent developments which are high end apartments in nature along Baba Dogo area. This is in stark contrast to the low-income housing occupying the areas adjacent to the river banks.

According to the surveys carried out, there was consensus that traffic volumes had increased within the area of study. Whereas the operators overwhelmingly felt that

volume of traffic had increased due to the number of smaller capacity vehicles in the area under study, they were split on whether traffic had increased. However, given the high numbers of those commuters planning to buy personal cars for various uses, given countrywide trends in car ownership that there will most likely be congestion in the future should this come to pass.

The study showed a conversion to land use within the are under study from purely idle land to residential, industrial to commercial, with the most notable changes occurring within Garden Estate and Thome in the case of residential changes. Other notable changes include the conversion of idle land to commercial in the case of Thika Road Mall and industrial to commercial in the case of Garden City Mall. In either of these cases, there was a redesign of the road to cater for increased traffic and this happened after the malls had been set up. This goes to show that some land uses do indeed affect adjacent road characteristics.

6.2 Conclusions

The topic under study was 'the impact of land use change on traffic along the Thika Superhighway, Nairobi, Kenya'.

It was established that the superhighway had been upgraded to include 6 to 8 lanes, with provision for NMT. A service lane with two lanes on either side of the Superhighway was provided as was a dedicated motorcycle lane which is segregated from the main carriageway.

The study was able to establish the main land uses in the study area with the help of transect walks, transect drives and a study of historical imagery.

Respondents views were arrived at using different methods which enabled accomplish the study objective on traffic volumes and their impact on the Superhighway.
Finally, the study was able to link the land use conversions and an increase of traffic volumes along the Thika Superhighway.

In summary, the study objectives were met, and useful observations made in relation to them.

6.3Recommendations

Based on the study, there are several recommendations that have been proposed in order that the full benefit of the investment on the Superhighway is felt by the users of the same.

6.3.1 Land Use Transport Modelling

It is highly recommended that there be a dynamic land use transport model that informs planning decisions particularly in the urban areas, Nairobi at the forefront. This would enable key decision makers to make prudent choices regarding the effects of land use change on the transportation networks. For instance, within the study area, changes on the design of the superhighway where there are malls was necessitated and this cost the taxpayer money that would have otherwise been spent on other needs in the economy.

6.3.2 Public Amenities

It is recommended that the design of the superhighway, though good be rethought of with a view to providing more public amenities. These include resting places, public washroom facilities and such other facilities which will make the NMT experience much better and perhaps induce some more travellers, particularly the short distance travellers to use NMT modes. It would in the long run reduce traffic congestion brought about by induced traffic on the roads and contribute to a fitter nation.

6.3.3 Public Transport

It is recommended that the long-awaited BRT system be finally realized. Most of the traffic statistics point out to the proliferation of smaller vehicles as the main cause of traffic volumes, not incidents. If there is a comfortable and reliable public transportation system that will adequately take care of the number on the roads, then there will be fewer private vehicles and thus less volumes to choke the roads.

6.3.4A Move Towards a 24-hourEconomy

As noted from the study, most of the respondents reported to having some business to do in the CBD ranging from commerce to reporting to work and so on. This happens daily and at round the same time as the reporting time for most workplaces is 8:00 am. The implication of this is that no matter how much traffic management is

practiced, the effort will be negated by this cyclical manner of road usage. The traffic patterns remain the same Monday to Friday, with no variations.

A shift to a 24-hour economy would address some of these shortcomings in our traffic system. This would also imply a shift in the reporting times so that workers report in shifts thus spreading the traffic over several peaks. This would in the opinion of the researcher help reduce the traffic volumes at the current peak periods and make travel a little bit more convenient.

6.3.5 Establishment and Empowerment of Satellite Towns

Within the city, there are several satellite towns that have eased some of the pressure off the CBS. These include Westlands, Hurlingham, Upper Hill and so on. In the view of the researcher, more of these need to be established along the Thika Superhighway to perhaps reduce congestion on the road by directing some of the traffic towards these towns. In the short run, there will be creation of employment in industries and in the long run, there will be a diversion of traffic towards these, hence distributing the traffic within the city and lessening the commuter pain index.

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APPENDICES

Appendix A - Household Questionnaire

*The information collected is for purposes of postgraduate research for the project titled **'The Impact of Land Use Changes on Traffic along Thika Superhighway, Nairobi, Kenya'**. Any information collected shall be used solely for that purpose and shall remain confidential*

1. Name (optional)_____
2. Age bracket
   18 – 30(1) 31 - 40 (2) 41 – 50 (3)51 – 60 (4)Over 60(5) __
3. Number of dependants under 18 _ _
4. How long have you lived here?
   0-2 yrs. (1) 2-5 yrs. (2) 5-10 yrs. (3) Over 10 yrs. (4) __
5. What influenced your decision to live here?
   Affordable rent (1) Proximity to place of work (2) Good transportation network (3) Other reason (4) specify_____
6. Employed (1) Self-employed (2)

a. Where do you work?_____

7. Which mode do you use to go to work? Private Car (1) PSV Matatu (2) Boda-boda (3) NMT (4)

a. Are you satisfied with the mode you use? Yes (1) No (2)

8. Which route do you use to go to work? Superhighway (1) Bypass (2) Other (3) specify _____

a. Why do you use that route? Less traffic (1) Other (2) Specify _____

9. Do you own a vehicle? Yes (1) No (2)
10. Do you plan on getting a vehicle? Yes (1)No (2)
    a. If yes, what are your reasons for planning to buy one? Going to work (1) Business (2) Other (3) specify _____
    b. If no, what are your reasons for not wanting one?
    c. What do you use the Superhighway mostly for? Going to work (1) Other (2) specify
11. Have you noticed any change in the way land is being used along or surrounding the highway? Yes (1) No (2)

a. If yes, detail _____

12. Have these changes impacted your travel in any way? Yes (1) No (2)

a. How? Increase in travel time (1) Decrease in travel time (2)

13. In your opinion, have these changes (in 11) had an impact on traffic along the Superhighway? Yes (1) No (1)

a. If yes, what impact? Increase in traffic (1) Decrease in traffic (2)

14. In your opinion, did the Superhighway affect traffic within the estate? Yes (1) No (2)

a. How? More congested (1) Less congested (2)

15. Have the roads within your estate been improved since the construction of the superhighway? Yes (1) No (2)

a. Has this (15) affected the value of the land? Yes (1) No (2)

b. If yes, how? Increased land values (1) Decreased land values (2)

16. What is the predominant nature of developments taking place in your neighbourhood? Residential (1) Industrial (2) Commercial (3) Other (4) specify _____

Appendix B – Interview Schedule for Business Owners

*The information collected is for purposes of postgraduate research for the project titled **'The Impact of Land Use Changes on Traffic along Thika Superhighway, Nairobi, Kenya'**. Any information collected shall be used solely for that purpose and shall remain confidential*

1. When was the decision made to invest along the highway?
2. Has your business had an impact on traffic along the Superhighway?

a. If yes, what was the impact?

b. Has anything been done to mitigate this impact(s)?

3. What impact has the Superhighway traffic had on the business? Detail

Appendix B – Interview Schedule for Key Informant (CCN)

*The information collected is for purposes of postgraduate research for the project titled **'The Impact of Land Use Changes on Traffic along Thika Superhighway, Nairobi, Kenya'**. Any information collected shall be used solely for that purpose and shall remain confidential*

1. Are land use change applications in the city documented?
2. Have these applications increased, decreased or remained stagnant in the study area since the construction of the Superhighway?
3. What characterizes the predominant changes/ what is the preferred user?
4. For commercial change of user, is a traffic impact study done and presented? Yes/No

a. If yes, what are the criteria for the study?
b. If not, how is the effect of the user quantified to assess their effect on traffic along the Superhighway?

Appendix D – Interview Schedule for PSV Operators

PSV QUESTIONNAIRE

*The information collected is for purposes of postgraduate research for the project titled **'The Impact of Land Use Changes on Traffic along Thika Superhighway, Nairobi, Kenya'**. Any information collected shall be used solely for that purpose and shall remain confidential*

PSV operators

1. How long have you operated on the route?
   0-2 yrs. (1) 2-5 yrs. (2) 5-10 yrs. (3) Over 10 yrs. (4) __
2. Have you seen an increase or a decrease in traffic volumes along the route over the years?

a. What do you attribute this change to? _____
3. Has the traffic pattern changed over the years? Yes No

a. If yes, how? _____

Appendix E – Data Needs Matrix

Research Objective	Factors of Analysis	Analysis Techniques	Expected Results
To establish the characteristics of the Superhighway.	▪ Width of the road ▪ Number of lanes ▪ Design speed of the highway ▪ Number and location of exits and entrances ▪ Junctions of the Superhighway and its feeders	▪ Analysis of cross sectional data ▪ Observation of the various speed signs ▪ Observation of the various junctions along the Superhighway	▪ Information on the volume of vehicles the Superhighway can accommodate comfortably ▪ Identification of zones of conflict
To establish the land uses along the Superhighway corridor	▪ Current land uses ▪ Land use changes along the highway ▪ Predominant land uses	▪ Spatial analysis of satellite and aerial imagery ▪ Descriptive analysis of land use changes as documented by the relevant authorities	▪ A map showing the various land uses ▪ Explanation of observed trends
To examine the characteristics of traffic flow and volumes along the Thika Superhighway	▪ Traffic volumes daily ▪ Peak demand traffic numbers ▪ Origins and destinations of the subjects of the study daily	▪ Analysis of secondary traffic data collected by the relevant roads bodies ▪ Analysis of research instruments administered to the various subjects of interest in the study	▪ Graphs depicting traffic volumes as analysed ▪ Representation of the origin and destinations as detailed by respondents
To establish the effects of land use change along the superhighway.	▪ Respondent views on positive and negative impacts ▪ Changes in the roadway resulting from the land use	▪ Analysis of research instruments administered to the various subjects of interest in the study ▪ Analysis of aerial and satellite imagery of the area of study	▪ A representation of the impacts that the land use has had on the Superhighway ▪ A representation of the changes that have occurred because of the land use changes