TRANSPORT DEVELOPMENT AND IMPLICATIONS ON WILDLIFE CONSERVATION

CASE STUDY OF PROPOSED GREATER SOUTHERN BYPASS (KITENGELA LOOP)

BY

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DECLARATION

I, the undersigned student declare that this research proposal is my original work and has never been submitted in any university or any other research institution toward thesis report for the award of a degree.

Signature……………………………..date ……………………..

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This thesis has been submitted for examination with my approval as the university supervisor

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DEDICATION

I dedicate this work to my Wife, Edith and my children Dion, Lynn and Bridget for the much time I was absent from home as I pursued this course. I owe you this and much more.

ACKNOWLEDGEMENT

ABSTRACT

Wildlife dispersal and migratory corridors play a critical role in the conservation of wildlife not only in Kenya but all over the world. Areas dedicated as National Parks may not be sufficient enough to cater for the varying needs of wildlife. When Nairobi National Park was established in 1946, it was immediately recognized that at approximately 117 square kilometers it was too small to meet the ecological requirements of the existing migratory wildlife species (Kristjanson et al., 2002; Gichohi, 2000) and hence the need for the study of the corridor .

Roads on the other hand play an important role in economic development. The city of Nairobi has experienced heavy traffic in its major roads in the recent past. In order to address traffic congestion, the government designed road bypasses to diffuse traffic from the central business district where major traffic routes normally pass. One of the bypasses, the greater southern pose a conservation challenge since it is planned to cut across Kitengela wildlife migration area. This will undermine the conservation efforts of wildlife in Nairobi National Park (NNP) which is a unique park within the city and a major tourist destination.

This study was carried out to; identify and assess wildlife and other environmental concerns in the study area; examine impact of proposed infrastructure development on the environmental and wildlife elements; and propose suitable spatial planning, wildlife and environmental approaches to mitigate against any negative impacts identified for sustainable transport corridor development. A household survey with a sample size of 63 was carried out to examine and assess wildlife and other environmental concerns. Institutional survey was also done to establish the impacts of the proposed infrastructural development on environment and wildlife elements and find out the suitable spatial planning, wildlife and environmental approaches to mitigate against the identified negative impacts for sustainable transport corridor development. Chi-square statistical test was used to test the hypothesis.

The impacts of the proposed road on the environment would include pollution, soil erosion, increased noise, increased human settlement, affect drainage systems, edge effects, reduced water quality and increased invasive species. The impacts of the road on wildlife elements are road mortality, habitat fragmentation, human habituation, habitat loss, increased human use of the area, alteration of the physical environment, modification of the animal behaviour and mortality from construction.

The study recommends: a) KWS to be more empowered to tackle rampant cases of human – wildlife conflicts, more conservation NGOs be encouraged to supplement KWS in conservation and government to develop a policy framework for management of wildlife corridor/ dispersal areas; b) an environmental impacts assessment needs to be carried out to assess the impacts of the many quarrying activities in order to propose and enforce mitigation measures to curb environmental degradation; c) adoption of a landscape-scale planning process that assesses road route alternatives before route selection; d) Involve environmentalist, conservationist and road engineers at all stages of road planning in order to identify all environmental and wildlife impacts, reduce them or avoid them if possible, if not, provide adequate mitigation; e) Integrate conservation planning into transportation planning; f) Build wildlife crossings where necessary to repair ecological damage and restore habitat connectivity; and g) Comprehensive

understanding of the environmental consequences of transportation networks and developing methods to support ecological impact evaluations at early planning stages.

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LIST OF ACRONYMS

NNP   Nairobi National Park

CBD   Central Business District

BNP   Banff National Park

EMCA   Environmental Management and Coordination Act

GDP   Gross Domestic Product

KWS   Kenya Wildlife Service

EIA   Environmental Impact Assessment

TCH   The TransCanada Highway

ROW   Right Of Way

UNESCO   United Nations Educational, Scientific and Cultural Organization

TSIP   Transport Sector Improvement Program

FoNNaP   Friends of Nairobi National Park

NEMA   National Environmental Management Authority

DOT   Department Of Transportation

MoNMD   Ministry of Nairobi Metropolitan Development

DC   District Commissioner

MVA   Minimum Viable Area

KCA   Kitengela Conservation Area

GIS   Geographical Information System

NGO   Non Governmental Organization

KURA   Kenya Urban Roads Authority

SPSS   Statistical Package for Social Scientists

TWT   The Wildlife Foundation

AWF   African Wildlife Foundation

ACC   African Conservation Centre

ANAW   Africa Network for Animal Welfare

GSB   Greater Southern Bypass

CHAPTER ONE

INTRODUCTION

1.1 Background

The government of Kenya has embarked on an ambitious process to decongest the city of Nairobi and open up transportation network. The development of the improved road infrastructure would relieve the traffic congestion and pressure that Nairobi city faces. The proposed Nairobi Bypasses (map 3) are currently under construction by the Kenyan government and financed by Chinese Government. Their construction seeks to ease congestion in Nairobi's downtown area and the surrounding suburbs. The bypasses will comprise the, Northern bypass - linking Limuru road to Thika road, Eastern bypass - linking Mombasa road to Ruiru-Kiambu road near Kamiti prison and Southern bypass - runs from Kikuyu to Mombasa road via Ngong road & Langata. The other bypasses are the Greater Eastern and the Greater Southern. The Greater Eastern bypass is to connect Mombasa road (A109) at Lukenya hills to Garisa road (A2) at Kilimbogo. The Greater Southern bypass (GSB) is to connect Mombasa road (A109) at Katlini to Narok road (B3) at Suswa (map 3).

The greater southern bypass is currently at planning stage. It is however proposed to pass next to the Nairobi National Park along the wildlife migration corridor (map 3). This is a region which has in the past experienced human wildlife conflicts arising from settlements in the migration corridor. Animals cross the Mbagathi River which comprises the southern National Park border every day as they look for food and water. These animals include a great variety of wildlife among them wildebeest, zebra, giraffe, Coke's hartebeest, eland, Grant gazelles, Thompson's gazelles, and lions (Kahumbu and Kent ,2012). The construction of the bypass is being opposed by the conservation lobby groups allegedly that it will adversely affect the conservation of the wildlife inspite of the positive economic shift attached to it as witnessed with the completion of other bypasses.

This study aims at exploring the impacts of the establishment of the bypass both on the environment and wildlife elements. This will inform the best way forward with regards to the

construction of this road. The Nairobi National Park (NNP) conservation is key for preserving the city unique identity as a city where one can view wild animals in less than 15 minutes drive from Central Business District (CBD). On the other hand the city experiences serious traffic jams which can be minimized with the construction of the proposed bypasses. Data will be collected from the various interest groups and the local residents.

1.2 Problem Statement

This study is informed by various experiences on how highway development and use affects wildlife. At the same time the study also include mitigation measures which can be adopted to contain the negative effects on wildlife on its habitat and during migration. Different parts of the world have been analyzed, with situations which are similar to what is likely to happen in the study area. According to Ban-Bow Valley Study (1996), the current rate of habitat fragmentation and human development along the TransCanada corridor is a threat for the long term survival of wildlife in Banff National Park (BNP). This is as a result of the commercial Trans-Canada Highway bisecting the park.

Currently public roads have both direct and indirect ecological effects on an estimated one-fifth of the area of the U.S. with the 'road- effect zone' extending hundred of metres from the road itself (Forman 2000). The effects include habitat loss, degradation and fragmentation; direct wildlife mortality; and road avoidance behaviours by wildlife (Andrews 1990, Bennet 1991, Forman and Alexander1998). Wildlife-vehicle collisions also affect the safety of motorists.

In Tanzania the commercial road of about 53 kilometres connecting Serengeti- and Loliondo districts was proposed to run through the Serengeti National Parks, dissecting the northern Wilderness area of the park. According to the Frankfurt Zoological Society (undated), as a result of the anticipated increased traffic, the road was to be the highest risk to the wildebeest migration. At the time of undertaking this study the matters of construction of Serengeti Highway was a court case at the East African Court of Justice in Arusha (Word press, February, 13 2014). The African Network for Animal Welfare (ANAW) was seeking to permanently stop the construction of the Highway on the basis that the road will create negative impacts which will adversely affect the eco-system and the environment. Further argument was that the road

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would be a potential threat to wildlife as it would interrupt their movement and migration (Word press, February, 13 2014). This would have culminated in the integrity of the Serengeti as the number one natural wonder of the world upon which Tanzania's tourism depends.

In the area of study while the bypass is expected to ease traffic congestion in Nairobi, it will also cut off the migration routes for the wildlife in Nairobi National park (Kahumbu and Kent, 2012).Thousands of animals move out of the NNP through the southern fence of the park annually. Many of the park's animals spend much of their time outside the protected area which is only fenced on three sides. The proposed road will put traffic in the way of the wildlife route endangering animals as they migrate. This bypass would consequently result in the destruction of NNP. During the wet season the wildlife migrate out of NNP through this corridor and return during the dry season. The road as proposed will interfere with the conservation of wildlife in the dispersal area. Many organizations have long recognized the value of the dispersal area for NNP (Kahumbu, 2011). It will also lead to the degradation of this critical ecosystem. The transport corridor would spur an accelerated human settlement resulting in grave interferences with the ecosystem.

The anticipated ecological effects of the corridor include physical disturbance, habitat loss and fragmentation, extinction of animal populations, mortality of wildlife on roads. Habitat fragmentation would be one of the most serious threats to the ecosystem. The implications are loss of biological diversity of species, populations and genetic levels. Kitengela wildlife dispersal area is therefore vital to maintaining wildlife populations in NNP which is Kenya's oldest wildlife park (Kahumbu, 2011).

This study seeks to establish the effects of the construction of the proposed Greater Southern bypass (map 1) on the wildlife migration corridor. It will find out how transportation planning is carried out in wildlife migration areas and the impacts of the road to the wildlife and environment. It will also establish the suitable planning and environmental approaches to mitigate against any negative impacts. This would help to propose measures necessary to integrate transportation planning and wildlife conservation in order to attain sustainable development.

Numerous authors have indicated that further research is needed about the road-related impacts on plants, animals, habitats and ecosystems (Daigle, 2010). Some authors have also cited the need for more information related to road effects on landscapes and regions (e.g Spellerberg 1998; Whittington et al. 2004), which could help with road planning and access management.

1.3 Scope of the Study

The area of study will spatially cover Athi River North sub location (map 1). The sub location had a population of 1,572 (male 790 and 782 female) people according to the 2009 census and 353 households. Its borders the Nairobi national park to the north and Kajiado County to the west and south. The area includes the wildlife migration corridor and is within the proposed locality of the Bypass transport development corridor. Administratively this area is in Machakos County. According to map 1, it is within the region containing the migration routes especially for the wildebeest. It also contains the hippo crossing point, capture base and the cheetah crossing point.
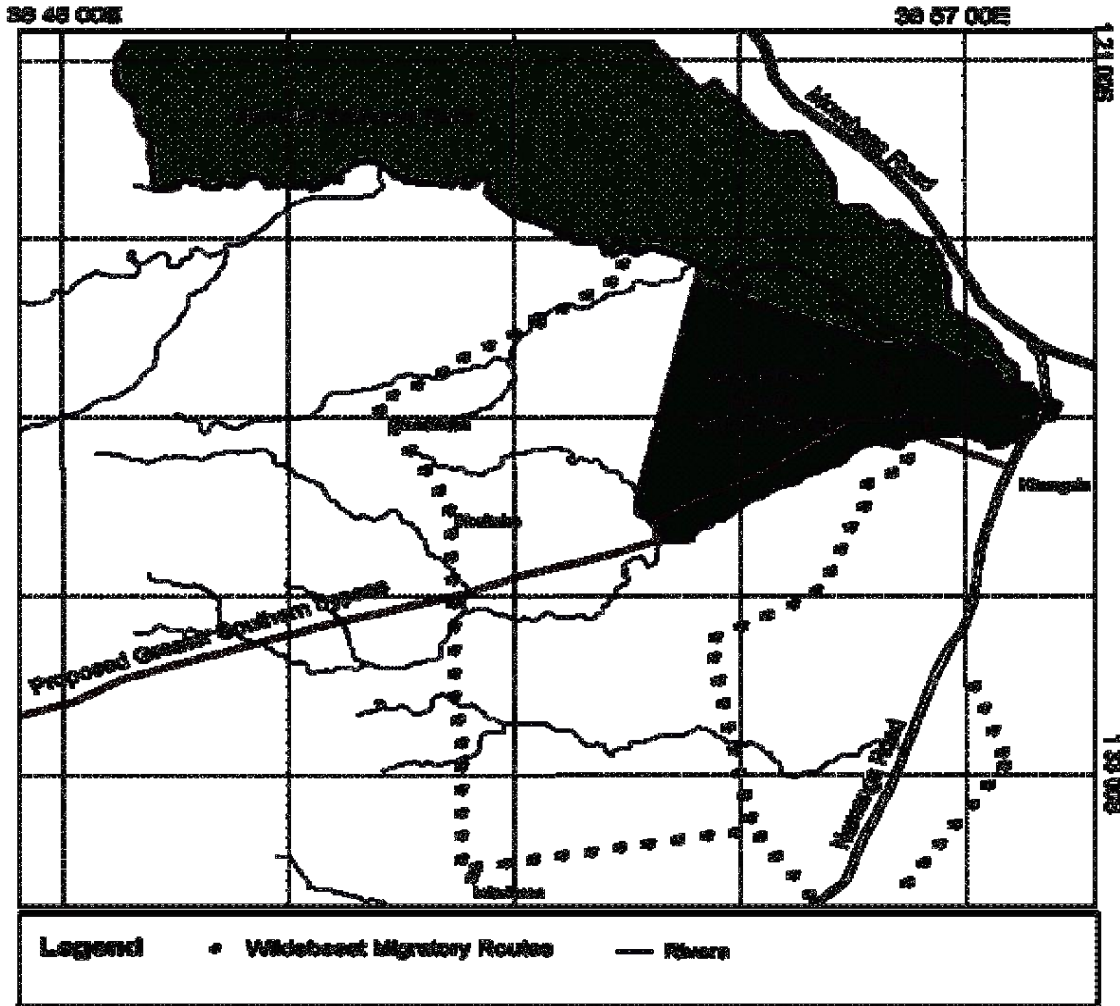
Map 1: Athi River North sub location. Source: Composed by author, 2014: Proposed Greater Southern bypass adopted from ministry of transport and wildebeest migratory routes from KWS GIS Department, 2003.

1.4 Research Objectives

The objectives of this study are**;**

1. Identify and assess wildlife and other environmental concerns in the study area
2. Examine impact of GSB infrastructure development on the environmental and wildlife elements
3. Propose suitable spatial planning, wildlife and environmental approaches to mitigate against any negative impacts identified for sustainable transport corridor development

1.5 Research Questions

The research questions for this study are;

1. What are the wildlife and other environmental concerns in the study area?
2. What are the impacts of GSB infrastructure development on the environmental and wildlife elements?
3. What are the suitable spatial planning, wildlife and environmental approaches to mitigate against any negative impacts identified for sustainable transport corridor development?

1.6 Research Hypothesis

The research hypothesis for this study is;

H1: The road is likely to negatively affect the migration patterns of wild animals.

H0: The road will have no negative effect to the migration patterns of wild animals

1.7 Justification of the Study

The Constitution of Kenya, (2010), part 2 section 69(1e) provides that the state shall protect genetic resources and biological biodiversity. Sub-Section 1(h) provides that the state shall eliminate processes and activities that are likely to endanger the environment. Whereas subsection 2 states that every person has a duty to cooperate with the state organs and other persons to protect and conserve the environment and ensure ecologically sustainable development and use of natural resources. These provisions clearly demonstrate the importance of an ecologically sustainable environment despite the need of other developments. EMCA Act, (1999), provides that land use methods should be compactable with the conservation of biological diversity. The Act promotes the integration of environmental considerations into development policies, plans and programmes and projects with a view to ensuring the proper management and rational utilization of environmental resources on sustainable yield basis.

This study has been motivated by the fact that Friends of Nairobi National Park (FoNNaP) have petitioned the government to reconsider the relocation of the Bypass in order to conserve the wildlife migration corridor and consequently NNP. FoNNaP is a non-government organization group that works to preserve the park. This study therefore seeks to find out the implications of construction of the Bypass in the proposed site to the wildlife migration and to a greater extent the sustainable conservation of NNP.

Tourism is a major income earner in Kenya. The Nairobi National Park contributes a major source of foreign exchange through wildlife tourism. It contributes significantly to the national economic development. The tourism industry accounts for 21% of the country's foreign exchange earnings and 12% of the gross domestic product (GDP), (KWS, 2005, 2007). Nairobi National Park generates an average of Kshs 45 million annually, directly employs 120 permanent staff and an average of 20 temporary staff per week, (Korir, 2006). Tour operation and hospitality industries contribution to indirect employment opportunities is even greater.

The park provides recreational and educational facilities to many scientific researchers and institutions. It has an advantage of being in Nairobi where many schools and academic institutions are located. Ease of accessibility to both locals and foreigners is a great advantage to users of the park. It provides convenient leisure facilities with five picnic sites.

It is an important atmospheric ventilator ecologically for the city constituting part of Athi and Tana watershed. It is home to over 400 species of birds, conserves two major ecosystems, highland dry forest and the savannah and provides dry season refuge for most herbivores (Kwadha, 2009). All these important roles are threatened by the construction of the greater southern bypass as the breeding grounds and the ecosystem may be interfered with by locating this transportation development corridor in this area (Kahumbu and Kent, 2012).

It is anticipated that construction of this transport development corridor will relieve the traffic congestion and pressure that Nairobi now faces. The government wants to decrease traffic through the centre of Nairobi to make it easier to move goods from the coastal port of Mombasa to Nairobi and beyond. This will help Kenya to make more money easily and is part of the government programme to make the country economically stronger. Despite this being a noble

and important development project where the transport corridor is proposed to pass will pose major challenges to the wildlife conservation. This can consequently end up destroying Nairobi national park. It is alleged that it will sever the migration routes of wildebeest, Zebra, Giraffe, Cokes hartebeest, eland, Grants gazelles, Thompson's gazelles and many other wild species. Others include the endangered cheetah and lions-all of which depend on the land south of the park. The park depends on these important seasonal migrations for its survival during the dry season.

This study aims at investigating the implications of this proposed development transport corridor on the wildlife dispersal area. This will be with respect to how it interferes with the dispersal area and the effects on the wildlife human conflicts. It will then suggest mitigation measures which include spatial planning and environmental approaches.

1.8 Assumptions of the Study

An assumption is any fact that a researcher takes to be true without actually verifying it (Mugenda and Mugenda, 2003). The assumption underlying this study is that the proposed infrastructure development would affect the migration patterns of the wild animals. The wildlife dispersal area is also assumed to be affected uniformly by the construction of the proposed transport corridor.

1.9 Operational Definitions

Explanation of terms adopted from Seiler and Folkeson, (2006), and modified where appropriate. Many explanations, especially those pertaining to landscape ecology are to be understood in the context of this study

Migration corridor- a continuous "protected" natural area or pathway used by native wildlife regularly for movement into and out of the national park between their seasonal ranges. They are important in maintaining biodiversity, allowing population to interbreed, and provide access to larger habitats.

Wildlife- usually used to refer to both animals and plants that are not tamed. This study limits this term to animals only.

Habitat- this refers to the general environment in which wildlife lives and where they also get shelter and food.

Conservation- this refers to the rational use of resources to achieve the highest quality and integrates both use of and protection and not preservation.

Fragmentation – this refers to the change in the spatial configuration of habitat. It may disrupt the movement of individual organisms, resulting in genetic and demographic isolation of population, which can consequently result to regional extinction.

Dispersal areas- means areas adjacent to or surrounding protected and wildlife conservancies and sanctuaries into which wild animals move during some periods of the year

Sustainable development- means development that meets the needs of the present generation without compromising the ability of future generations to meet their needs by maintaining the carrying capacity of the supporting ecosystem

Avoidance measures- measures such as project abandonment or infrastructure re-routing employed in order to avoid unacceptable environmental impacts

Barrier effect – the combined effect of traffic mortality, physical hindrances and avoidance, which together reduce the likelihood and success of species crossing infrastructure
Buffer zone – vegetated strips of land that are intended to protect sensitive receptors, e.g. protected sites, from impacts such as pollution or disturbance from infrastructure
By-pass- highway section following a route that passes around a congested or vulnerable area
Corridor- tract of land connecting two or more areas
Edges (effect) - the portion of an ecosystem near its perimeter, where influences of the surroundings prevent the development of interior environmental conditions
Environment Impact Assessment (EIA) – a method and a process, by which information about environmental effects is collected, assessed and used to inform decision- making

Habitat fragmentation – dissection and reduction of the habitat area available to a given species- caused directly by habitat loss (e.g. due to land- take) or indirectly by habitat isolation (e.g. due to barriers increasing distances between neighbouring habitat patches)

Impact – the immediate response of, e.g., an organism, species or property to an external factor. This response may have an effect on the species or condition that may result in wider consequences to the population or species community over a longer time scale.

Migration – the regular, usually seasonal, movement of all or part of an animal population to and from a given area

Mitigation – action to reduce the severity of, or eliminate, an adverse impact

Overpass- structure (including its approaches) which allows one infrastructure element to pass above another (or other type of obstacle)

Road corridor – linear surface used by vehicles plus any associated (usually vegetated) verges, includes the area of land immediately influenced by the road in terms of noise, visual, hydrological and atmospheric impact (normally within 50 to 100 m of the edge of the infrastructure)

Underpass – structure, including its approaches, which allows one route to pass under another route or obstacle

Verge – the strip of land (often vegetated) beyond the infrastructure surface itself, but within the infrastructure corridor

Wetland – land or area containing high levels of soil moisture or completely submerged in water for either part or the whole of the year

Wildlife corridor – linear- shaped area or feature of value to wildlife – particularly for facilitating movement across a landscape

Wildlife overpass – construction built over infrastructure in order to connect the habitats on either side. The surface is, at least partly, covered with soil or other natural material that allows the establishment of vegetation

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Transport is an important component of a spatial development plan. Roads are integral to the financial development and prosperity of the local and national economy and there is a potential conflict between development and conservation (MoNMD, 2011). They impact in a profound way the spatial structure of a city and its region. It determines the direction of growth. Transport affects the economic viability and social mobility of the region and its people. It consumes a large share of the resources (land, capital, time, environment, etc) (MoNMD, 2011). Further research and discussion is required to ensure roads are ecologically sustainable and improve people's livelihoods. Recent work suggests that these two aims (development and conservation) are not always mutually exclusive. Roads are byproducts of the human need to travel and interact with the natural environment; in the process of facilitating human movement they have caused direct wildlife mortality, fragmentation and isolation of habitat. Where transport corridors are located will have a significant impact on the wildlife. According to White, et al (2007), identifying areas where wildlife will be affected and sharing this information with transportation planners, conservationists have the opportunity to inform the transportation process before specific projects are launched. Sharing spatial data with transportation planners early on gives all stakeholders the opportunity to see potential trade-offs between development and natural areas protection and find workable solutions before projects progress too far (White, et al,2007).

Road is the most important transport system in Kenya as it caters more than 85% of travel demand in the country (MoNMD, 2011). There are a radial corridor traversing Nairobi city and extend into the region and beyond. Among them are Nairobi-Thika road (A-2), Nairobi-Eldoret-Uganda (A104) and Nairobi-Mombasa (A109) are important international trunk roads carrying large volume of traffic (MoNMD, 2011). The major concentrations of people and activities are along these road corridors. Nairobi city contains nearly 67% of the motor vehicles in Kenya (MoNMD, 2011). A number of roads development programs are under implementation. Land use is an integral component in any planning process. Its helps in estimating and analyzing the

quantum of land put to various uses and also which can be utilized for future development. This study has analyzed three case studies, one in Canada, United States of America and Tanzania.

2.1.1 Banff National Park in Canada.

The rate of habitat fragmentation and human development along the TransCanada corridor was a threat for the long term survival of wildlife in Banff National Park (BNP) (Banff-Bow Valley Study, 1996). The TransCanada Highway (TCH) had serious effects on wildlife population in the Park, fragmenting habitat, acting as a barrier to natural movements in the Bow Valley and more importantly it was a significant factor in wildlife mortality. Roughly half of the reported deaths in BNP were attributed to Highways (Shurry, 1996). Levels of Highway- related mortality for some populations in Banff was equal or greater than mortality rates in hunted populations (Gibeau and Heuer, 1996). Ironically the park had been intended to serve as a core refuge and source for replenishing peripheral, unprotected populations outside its boundaries. In 1997 the TCH was the most important transportation route in Canada, bringing high-speed and high-volume traffic into the park. For a twenty years period, traffic had increased steadily and the highway was frequently upgraded to meet the demand.

Several measures were taken to mitigate the adverse effects of the highway upgrades on wildlife. Crossing structures (under and overpasses) were constructed to link habitat and provide wildlife with safe routes across the highway. Wildlife exclusion fencing kept animals off the highway Right-Of-Way (ROW) and directed them to the crossing structures. Studies showed that when crossing structures were used in conjunction with fencing, highway-related mortality was reduced (Reeds et al.1975, Woods 1990, Foster and Humphrey, 1995).

2.1.2 Impacts of Roads on Wildlife in United States

Direct effects of roads on wildlife in the United States include road mortality, habitat fragmentation and loss, and reduced connectivity. The severity of these effects depends on the ecological characteristics of individual species. Direct road kill affects most species, with severe documented impacts on wide –ranging predators such as the cougar in southern California, the Florida panther, the ocelot, the wolf, and the Iberian lynx (Forman et al. 2003).In a 4-year study of 15,000 Km of road observation in Organ Pipe Cactus National Monument, Rosen and Lowe

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(1994) found an average of at least 22.5 snakes per Km per year killed due to vehicle collisions. United States is covered with over four million miles of pavement, adding 5,500 new miles every year. For each mile of highway, up to 48 acres of habitat is destroyed (Clinnick, 1985). With only 40% of the historic native vegetation remaining (Bryer et al., 2000), habitat loss, fragmentation, and degradation are the leading causes of species imperilment in the United States (Wilcover et al., 1998). Roads cause habitat fragmentation because they break large habitat areas into small, isolated patches which support few individuals. These small populations lose genetic diversity and are at risk of extinction.

The roads also create noise and vibration that interfere with the ability of reptiles, birds and mammals to communicate, detect prey and avoid predators. They also increase the spread of exotic plants, promote erosion, create barriers to fish, and pollute water sources with roadway chemicals (Forman et al. 2003). Highway lighting also has important impacts on animals (Rich and Longcores, 2006)

In mitigation wildlife crossing structures have been used to facilitate movements through landscapes fragmented by roads. These include wildlife overpasses and green bridges, bridges, culverts and pipes. Although these structures were not constructed with ecological connectivity in mind, many species benefit from them (Clevenger et al. 2001; Forman et al. 2003)

2.1.3 The Serengeti North Road Project (Tanzania).

The Serengeti National Park in Tanzania is a unique wilderness harbouring perhaps the most spectacular terrestrial wildlife migration on earth. Its great significance has been recognized through its designation both as a national park in Tanzania and as a UNESCO World Heritage site (ZLS, Undated). Tanzania has previously had an outstanding record of commitment to biodiversity conservation, and the Serengeti is one of four UNESCO world heritage nature reserves in the country. However this internationally significant and unique wildlife heritage is currently threatened by a proposal to construct a new public road through the park (ZLS, Undated).. This road would bisect the path of the world famous annual wildebeest and zebra migration comprising of nearly two million Wildebeest and Zebra (ZLS, Undated). The road had

been planned to better link Serengeti- and Loliondo-Districts to the National grid of major roads (Frankfurt Zoological Society, Undated). The proposed road had been suggested in the Governments 10 years Transport Sector Improvement Program (TSIP). That need of both regions was undisputed but could be solved without dissecting the Serengeti.

Tanzania's people had a right to improvements in infrastructure, which would provide people and industries with greater access to markets and productive resources, thereby promoting economic growth and development. There was no doubt that infrastructure development between the East African coast and Lake Victoria is much needed. However there were extreme concerns of the location of the proposed road, which was expected to adversely impact the wildlife values for which the Serengeti is globally renowned (ZLS, Undated). Public roads through protected areas would have catastrophic effects on wildlife and seriously degrade the environment. The proposed Serengeti road was to pass through the dry season migration route of nearly two million animals, resulting inevitably in large numbers of wildlife and human casualties (ZLS, Undated). The loss of the Serengeti Migration – the last of its kind in the world - would not only mean the end of Tanzania's priceless natural and national heritage, the end of the Serengeti as iconic World Heritage Site but also a significant decline in tourism in the Serengeti. Any development affecting the Serengeti ecosystem will have impacts on its neighbour, Kenya, which harbours the Mara River which provides the water source that drives the migration (Frankfurt Zoological Society, Undated). A reduction in the migration in the Serengeti would lead to impacts on the Maasai Mara and bordering wildlife areas, with consequent impacts on tourism and the Kenyan economy. Arising from intense pressure from international organizations the Tanzanian government scraped the plans to construct the Serengeti road (Pflanz, 2003).

2.1.4 Study Area Scenario

According to Kahumbu et al., (2012), Kenya has protected 12.3 percent of its land and only 30 percent of the wildlife lies in these protected areas. Tourists normally go to these protected areas to see the wildlife. Landowners interact with the wildlife in the migration corridors and coexist with the animals on a daily basis. Protecting these animals and providing them with essential habitat means working with the landowners as well as government. In order for conservation efforts to be successful in and around the NNP, Kenyans must find solutions to living with

nature. This expands beyond the scope of roads that ease human traffic congestion and interrupt wildlife traffic patterns. The migratory nature of the wildlife in Kenya means that conservation must happen on a countrywide scale for it to be successful. According to the published draft Wildlife Bill (2011), Nairobi National Park as well as the Athi- Kitengela and Kaputei Plains and Machakos ranches are listed as critically endangered areas due to impeded migration routes, land subdivision and urban sprawl.

On the other hand many goods are shipped from the port of Mombasa to others part of Kenya and other eastern African countries by the highway that runs through Nairobi. This has contributed to heavy traffic as these heavy trucks of goods transit Nairobi. In 2011, the Kenyan government proposed building a highway around Nairobi called the Greater Southern bypass (Kahumbu and Kent, 2012). While the Bypass would help ease the traffic congestion in Nairobi, it would cut off migration routes for many of the wild animals in the NNP. Thousands of animals move out of the NNP through the southern edge of the park which is unfenced to facilitate migration. According to Kahumbu (2011), the Bypass as planned poses an even larger threat to NNP than the northern Serengeti Highway would have done to Serengeti National Park, which the Kenya Government successfully petitioned to have rerouted to the south

Traffic is not the only problem wildlife would face with the construction of the Greater Southern Bypass. As Nairobi grows and people needs more room to live, construction of residential and commercial houses as well as factories would conglomerate along the bypass (Kahumbu and Kent, 2012). This growth also known as urban development would happen in the area that animals used to travel to seasonal grounds increasing the wildlife human conflicts seriously undermining the conservation of the wildlife in NNP. This development would affect the income that NNP generates annually through tourism estimated to be over US $ 500, 000 (Kahumbu, 2011). The road construction itself would be loud and would frighten wildlife, disrupting their normal behaviour. It would also likely take a long time, meaning the disruption would continue for years. According to Kahumbu and Kent (2012), without migration routes and breeding grounds, wildlife would decrease, and species that are already at risk would suffer more. Also traffic accidents may rise from the animals crossing the highway

2.2 Evolutionary and Ecological Principles

According to Njuguna (2007), there are evolutionary and ecological principles that govern the interaction of organizations and their environment, which along with the physical laws have direct application to environmental planning and management. The principle of the *Law of diversity and stability,* has been interpreted by ecologist to mean that 'stability leads to diversity'. The principle states that stable environments tend to develop diverse ecological communities over time.

Another relevant principle is the *connection principle* (Njuguna, 2007). This principle states that everything is connected to everything else- the question is how? According to this principle our economic, social and physical lives depends on the socioeconomic structures and interactions for nourishment and sustenance, and we have to strive in ensuring that none of our deliberate actions upset the delicate balance of nature.

2.3 Conservation Legislations in Kenya

Conservation in Kenya is supported by several legislations such as the Constitution of Kenya (2010), Wildlife Act (Cap 376), Environmental Management and Coordination Act (EMCA), 1999 and the Lands Act. The Constitution of Kenya, (2010), provides for the encouragement of public participation in the management and protection of the environment, protection of genetic resources and biological diversity, establishment of systems of environmental impact assessment, environmental audit and monitoring of the environment. It also provides for the elimination of processes and activities that are likely to endanger the environment and utilization of the environment and natural resources for the benefit of the people of Kenya. It confers to every person a duty to cooperate with state organs and other persons to protect and conserve the environment and ensure ecologically sustainable development and use of natural resources.

The Wildlife Act gives powers to the Director of Kenya Wildlife Service to enter into agreement with a competent authority which he may consider necessary for the purpose of ensuring that animal migration patterns essential to the continued viability of a National Park or National

Reserve are maintained. The NEMA Act establishes the National Environmental Management Authority which is mandated to identify potential threats to biological diversity and devise measures to remove or arrest their effects. It is also mandated to undertake measures intended to integrate the conservation and sustainable utilization ethic in relation to biological diversity in existing government activities and activities by private persons. The authority is also mandated in consultation with the relevant lead agencies to prescribe measures adequate to ensure the conservation of biological resources in-situ by issuing guidelines for land use methods that are compactable with conservation of biological diversity. The guidelines shall also include the selection and management of protected areas so as to promote the conservation of the various terrestrial and aquatic ecosystems under the jurisdiction of Kenya and selection and management of buffer zones near protected areas.

Lands Act (2012), provides that the National Land Commission shall make rules and regulations for the sustainable conservation of land based natural resources and the rules and regulations may contain measures to protect critical ecosystems and habitats.

2.4 Spatial Actions and Transportation Planning

Transportation planning is an inherently spatial exercise (White et al., 2003). It is a process that entails identification of future transportation needs and presents a strategy to address them through a combination of expanding existing corridors, adding additional corridors, or expanding alternative transportation options. Sometimes where these corridors are located will have a significant impact on wildlife. Some areas can impact wildlife migration and conservation negatively. By indentifying these areas and sharing this information with transportation planners, conservationists have the opportunity to inform the transportation planning process before specific projects are launched (White et al., 2003). If conservation efforts are taken into account at the earliest stages of transportation planning both protecting natural areas and building transportation infrastructure can be realized, in less time and at less cost (White and Ernst, 2003).

Sharing spatial data with transportation planners early on gives the relevant stakeholders the opportunity to see potential trade-offs between development and natural areas protection (White et al., 2003). This will in turn provide workable solutions before projects progress too far. In

transportation planning maps clearly indicating priority conservation areas need to be availed. The plans are expected to identify and map those habitats that are essential to the long-term conservation (White and Ernst, 2003). They should also include priority habitats and places. According to White et al., (2003) maps are an effective means of communication between conservationists and transportation planners. They provide clear guidance to transportation planners as they move forward with their plans.

Transportation planners can alter or prohibit road construction to avoid impacts to high priority conservation areas. Effectively plans can suggest closing of old and underused roads, fixing old roads rather than building new ones and how best to mitigate for road impacts (White et al., 2003). In order to implement these actions, wildlife agencies must have and share with transportation planners, a landscape level conservation plan that identifies priority conservation areas, or sensitive areas, to avoid or protect through mitigation. Planners can overlay conservation maps with anticipated transportation projects to discover potential conflicts before considerable resources are invested (White and Ernst, 2003). Taking a landscape –level view of a region's conservation needs allows both transportation and conservation planners to understand the trade-offs inherent in various development scenarios. Without this landscape perspective, habitat connectivity and integrity will continue to degrade incrementally, with every new road (White et al., 2003).

2.5 Linking Conservation and Transportation Planning

It is very clear that roads have a significant influence on wildlife populations and ecosystems functions (White et al., 2007). Transportation planning can provide a key leverage point for influencing development at multiple levels. The transportation planning agencies determine the overall, best way to solve a particular mobility problem affecting the planning area. Information on land-use planning, environmental goals, zoning objectives, and resource protection and management priorities need to be incorporated (NCHRP Synthesis 305, 2002). In addition to the impacts from roads themselves, transportation corridors often serve as catalyst for future residential and commercial development. As particular areas become more accessible, development in those areas is more desirable. The inherent regional and interconnected nature of

our roads systems provides an opportunity to improve regional and national coordination, which is critical for protecting wildlife and natural systems. Therefore it is clearly evident that although working with land use planners is critical, conservationists and wildlife biologists can put their expertise to good use by working with transportation planners (White et al., 2003). Coordination should begin at early stage of transportation planning for projects that have the potential to impact on wildlife because this is when plans can still be changed (NCHRP Synthesis 305, 2002). Getting resources agencies involved early in the planning process allows them to express their concerns in hope of preventing issues from becoming large and significant(White, 2006).

There are two mechanisms for reducing the impacts of roads on wildlife (White et al., 2007):

1. Alter the design of existing roads to facilitate safe wildlife crossings and reducing surrounding environmental impacts, and
2. Proactively incorporate wildlife into transportation planning so that new roads avoid sensitive areas and habitats to begin with.

Arising from advancement in technology, relevant institutions should be well equipped with the science and technology to achieve these goals. What is required is a new level of cooperation between wildlife agencies, conservation advocates and transportation planners. Transportation planning provides a key opportunity for conservationists to influence where roads are built, how they are designed and how effectively transportation agencies mitigate for unavoidable impacts. Successfully designing a transportation system to have minimal impacts on wildlife requires that conservationists get involved in the early stages of planning (White et al., 2007).

The environmental information needed for reviewing the transportation system and projects is often contained in environmental resource agency maps (NCHRP Synthesis 305, 2002). Environmental concerns are mainly addressed as the environmental review process near the end of a project's approval. This is carried out locally by the National Environment Management Authority (NEMA).At this point, the transportation agency and associated land use planners have invested significant resources in the project and it is difficult and costly to change course in any meaningful way (White et al., 2007). If wildlife biologists can participate in the early stages of

transportation planning, they have a better chance of influencing transportation policy successfully.

2.5.1 Transportation Planning Process

An understanding of the relationship of the transportation system to wildlife populations in a given area is critical to early planning (NCHRP Synthesis 305, 2002) It is during the transportation planning process that opportunities are available to enhance wildlife conservation activities. The first and best option for protecting wildlife is to avoid placing roads in ecologically significant areas (White et al., 2007). A more complete approach to habitat and wildlife considerations in relation to highways can be derived from viewing total landscapes that include numerous ecosystems and associated wildlife (NCHRP Synthesis 305, 2002). The transportation planning process itself goes through many phases where spatially explicit conservation information can help inform transportation decisions. Generally there should be integration of wildlife and ecological principles into the transportation planning and planning of road locations to avoid sensitive habitats and important natural resources (White et al., 2007). Mechanism should be established on how this integration can take place in order to come up with a process of linking wildlife and transport planning. Natural resource agencies should be involved early in order to identify potential conflicts and helps planners to develop projects with minimal environmental impact (White and Ernst, 2003). Facilitating this process is a key role for state wildlife agencies. According to White et al., (2007) in this interaction wildlife biologists can provide transportation planners with technical assistance that includes informing planners of where "sensitive" habitats and species are located.

2.6 National Roads Project Planning Process.

New highways are constructed when the existing highway network no longer meets the requirement of traffic or land use and these requirements cannot be satisfactorily met or eliminated through road improvements or other transport system developments, or the negative impacts caused by traffic cannot be reduced enough (Finnish Transport Agency, 2010). The planning and design process for a national road scheme entails a number of phases before a route

is finally selected and the scheme approved for construction. According to US Department of Transportation (DOT) (2012), a typical national roads project would consist of the following basic stages, planning, project development (preliminary design), final design, right-of-way and construction (Figure 1). The planning of road projects is a process becoming more detailed stage by stage. At each stage, the level of planning accuracy and decision- making is adapted in accordance with land use planning (Finnish Transport Agency, 2010). The names of these stages may vary but they generally represent the basic phases. Though these phases are distinct activities, there are considerable overlaps in terms of coordination among the various disciplines that work together, including designers, throughout the process. If designers and communities work together during the first three phases of planning, project development and design, the project can have the greatest impact on the final design features. In fact, the flexibility available for the road design during the detailed design phase is limited to a great deal by the decisions made at the earlier stages of planning and project development (DOT, 2012). A key objective is to ensure the effect delivery of national roads in a manner which minimizes adverse human and environmental effects, while maximizing the benefits of the new road infrastructure and respecting all applicable legislation (National Roads Authority, Undated). The following are the planning processes;
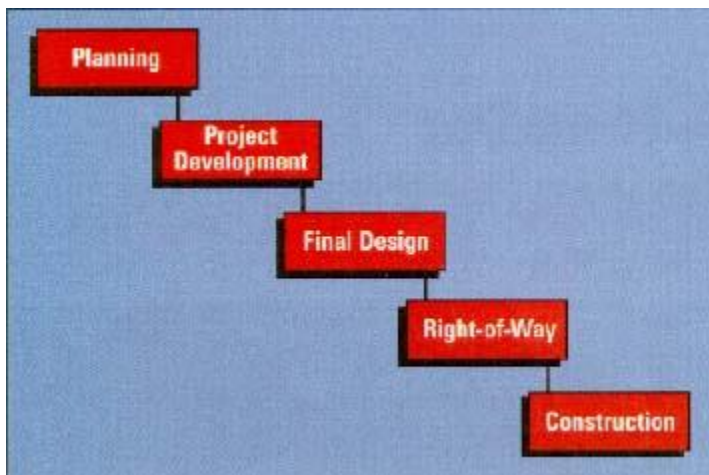
Figure 1: The various phases of national road planning and development. There is considerable overlap of all the phases. Source; US Department of Transportation, 2012. http://www.fhwa.dot.gov/environment/publications/flexibility

2.6.1 Planning

Planning for national road project takes place in the context of the Government's objectives for investment in road infrastructure (National Roads Authority, Undated). The initial definition of need for any road project takes place during the planning phase (DOT, 2012). The problem definition can occur at the State, regional, or local level, depending on the scale of the proposed road development. During this stage the public is involved and provide input into the decision making process. The road is usually projected to address the need of existing or projected future transportation demands which necessitates the need to increase mobility. It is in this phase that problems are identified with the agreement of all involved parties and consensus arrived at how to address them.

Factors to Consider During Planning

It is important to look ahead during the planning stage and consider the potential impact that a road project may have while the project is in the conceptual phase. Key decisions are made during planning that will affect and limit the design options in subsequent phases. Some of the questions to be asked in the planning phase include (DOT, 2012):

- How the proposed road will affect the general physical character of the surrounding area
- Whether the area to be affected have unique historic or scenic characteristics
- The safety, capacity , and cost concerns of the community

The answers to the above concerns can be found in planning level analysis, as well as in public involvement during the planning. This informs the manner in which the eventual route will be selected and the considerations that will inform the choice i.e. environmental, engineering, financial and traffic patterns (National Roads Authority, Undated).

2.6.2 Project Development

After a project has been planned and programmed for implementation, it moves into the project development phase (DOT, 2012). At this phase the environmental review is done. This review varies widely depending on the scale and impact of the project. The project development generally includes a description of the location and major design features of the recommended

project that is to be designed and constructed, while continually trying to avoid, minimize, and mitigate environmental impact. In this stage planning is performed at a level of detail which ensures that the plan is technically, financially and environmentally feasible (Finnish Transport Agency, 2010).

According to DOT (2012), the basic steps in this stage include the following:

- Refinement of the purpose and need
- Development of a range of alternatives
- Evaluation of the alternatives and their impact on the natural and built environments
- Development of appropriate mitigation

Decisions made at the project development phase help to define the major features of the resulting project through the remainder of the design and construction process.

As is the case in the planning phase, there are many decisions made during the scoping phase of project development. In this regards, it is important that the various stakeholders in the project be identified and provided with the opportunity to get involved. The designer should be sensitive to the project's surrounding environment by considering its context and physical location carefully during this phase of project planning. During development planning an important issue to consider is whether there are historic or especially sensitive environmental features (such as wetlands or endangered species habitats) along the roadway.

According to National Roads Authority (2005), a preferred route is identified based on the respective advantages and disadvantages of the various options. Several issues are taken into account in arriving at the preferred route. These issues include:

- People, plants and animals
- Soil, water, air, climate and the landscape
- The interaction between any of the matters referred in the above issues
- Material assets
- The cultural heritage including archeology

The basis for choosing the preferred route is mainly informed by information on the relative attractiveness of each option based on the potential impacts on the various aspects set out above.

2.6.3 Final Design

Once a preferred alternative has been selected and the project description agreed upon as stated in the environmental document, a project can move into the final design stage. Final design determines the precise location of the road, areas required for the road and detailed solutions such as measures necessary to the prevention of negative traffic impacts (Finnish Transport Agency, 2010). The product of this phase is a complete set of plans, specifications, and estimates of required quantities of materials ready for the solicitation of construction bids and subsequent construction.

As part of the statutory procedures governing the development of a road scheme, an environment impact assessment report (a description of the likely effects on the environment of the proposed road development) will be required (DOT, 2012). The necessary changes/ ameliorative measures of the environmental impacts identified can be incorporated in the scheme design

2.6.4 Right of Way

The needed right of way is then purchased after the final designs have been prepared. The approval decision is made on the final engineering plan allowing the road authority to take possession of the required area for the road (Finnish Transport Agency, 2010). During the right of way acquisition, minor adjustments in the design may be necessary. There should therefore be continuous involvement of the design team throughout these phases (DOT, 2012).

2.6.5 Construction

Construction bid packages are made available after right of way is purchased. Within the limits of the final engineering plan, interaction between road constructors and landowners and other concerned parties continues throughout the entire planning and construction phase (Finnish Transport Agency, 2010). A contractor is selected and construction is initiated. During the construction phase minor adjustments in the design may also be necessary (DOT, 2012). Compensation is paid for any damage caused to external property final design or construction planning and construction (Finnish Transport Agency, 2010).

2.7 Wildlife Corridor

A wildlife movement corridor is a linear habitat whose primary wildlife function is to connect two or more significant habitat areas (Harris and Gallagher 1989:26-27). According to McEuen (1993), wildlife corridor is a linear landscape element which serves as a linkage between historically connected habitat/natural areas, and is meant to facilitate movement between these natural areas. When development projects threaten to disrupt natural patterns of wildlife movement, proper mitigation measures should be sought to address the resulting impacts. Measures should be put in place to either preserve a natural corridor (impact avoidance) or to create a wildlife movement corridor out of a formerly unobstructed (mitigation).

Rigidly defined boundaries in national parks and game reserves mean that there will be no changes in future for the area occupied by the wildlife community. Wildlife corridors play a special role in an ecosystem. They enable the wildlife community to migrate freely in search of pastures, water and even breeding. Animals are able to respond to changes or variations in their environment through migration. According to Kwadha (2009), a wildlife corridor is a continuous natural "protected" pathway along which native wildlife species can move in relative security between high natural habitats. The corridor can also be considered as a habitat patch connecting two or more areas of undeveloped habitat that are isolated from one another. Connectivity is the degree to which the landscape facilitates or impedes the movement of organisms among patches (Metro, 2010). The land used for this purposes can either be privately owned or through public roads. Wildlife corridor plays an important role in reducing habitat fragmentation and increasing the size of habitat. It provides an establishment to maintain a nearly contiguous greenbelt of native vegetation. A sparsely developed area provides an ideal environment for a wildlife corridor (Kwadha, 2009).

The corridors play a perfect role in maintaining biodiversity, allowing populations to interbreed and provision of access to adjacent habitats. According to Wildlife Management Institute (2005), wildlife corridors connecting core reserves are crucial since they increase the effective amount of habitat that is available for species and effectively reverse habitat fragmentation. The corridors are especially critical to migratory animals with large home ranges. In order to support greater biodiversity, larger animal populations and a wider range of food sources and shelter large

habitats are inevitable. They allow populations to interbreed and improve long term genetic-viability. The wildlife corridors can only supplement but not substitute large areas of protected habitat like those in core reserve systems or in this case the national park (Kwadha, 2009).

Basically, there two major types of wildlife corridors. There are corridors which are present on the landscape level which are generally thought to serve a connective function. They benefit species requiring large expanses of undeveloped habitats since they have large home ranges, disperse over great distances, or need to travel great distances to find mates. A good example of this type is wildlife corridors to Nairobi national park (map 2). The second type of wildlife corridors are those which exist on a smaller scale usually at a local level. They generally connect two isolated habitats that are not necessarily separated by large distances. These corridors are mainly found in agricultural areas and they are often referred to as fencerows or hedgerows. These are normally strip habitats providing food and cover for wildlife. A second example of this local scale wildlife corridor is the buffer strip of vegetation along a river or a stream (Kwadha, 2009).

The determination of what would be the right size of a wildlife corridor is a major challenge facing land use planners. It would be difficult to locate migration corridors and crucial wildlife habitats neatly within human created boundaries. There is usually a mix of land-ownership patterns and management decisions across these patterns or even international borders. This in turn has an impact on the wildlife populations. The appropriate size of a wildlife corridor is yet to be determined (Wildlife Management Institute, 2005). The size of the wildlife corridors varies according to the species of the animals involved. Studies carried out in Alaska shows that wolves need corridors ranging from 12 to 22 kilometres in width while bobcats require at least 2.5 kilometres wide (Kwadha, 2009). Largest mammals like Wildebeests, Elephants, Buffaloes, and Zebra among others require large enough wildlife corridors to allow easy movements. The corridor requirements for such mammals could be several kilometres in width.

The general scientific consensus is that connections between habitat fragments are crucial to persistence of many species and populations, and that well designed corridors can play a key role in maintaining ecosystem functions (Metro, 2010). Connectivity for Smaller species like amphibians and birds require relatively smaller scales of wildlife corridors. These are

particularly crucial along riparian reserves where connectivity is provided both for aquatic and terrestrial migration. Similarly migration corridors in urban areas provide significant recreational opportunities. They provide important linkages in highly fragmented landscapes. Whenever possible functional wildlife corridors should be provided to link both urban and rural parks. Wildlife corridors are typically vulnerable and must therefore be managed with extreme caution in order not to interfere with the delicate ecosystem (Kwadha, 2009).

If we consider reserves and parks which are areas of high biodiversity as nodes, then they will not be constant throughout the time and will be expected to migrate (Kwadha, 2009). The migrating species from the node will establish populations in the corridors. One particular node can be smaller than the Minimum Viable Area (MVA) for the population of a given species so long as the sum area among the nodes connected by the corridors encompasses the MVA. MVA defines an area with a set of resources, such as nest sites, food and water required to sustain a population large enough to retain at least 90 percent of the genetic diversity of the species for 200 years (Bush, 2000). Connectivity of nodes via the corridors provides a single continuous habitat rather than a landscape of isolates. Corridors are more than just highways between nodes since they also provide temporary homes for the wildlife populations. According to Bush (2000), they must therefore be suitable for long term survival of species. Urban and rural parks and open spaces should whenever possible be linked to form functional wildlife corridors which can then be joined to outlying core reserves. The relationship between nodes and corridors is synonymous to the connectivity between interdependent towns or cities through transport corridors that is beneficial for the continuation of such relationships. The good maintenance of such transport corridors is thus as essential as that of the wildlife corridors (Kwadha, 2009).

The critical features of a wildlife corridor are not physical traits such as its length or width or vegetation but rather how well a particular piece of land fulfils several functions. In particular, corridors provide avenues along which:
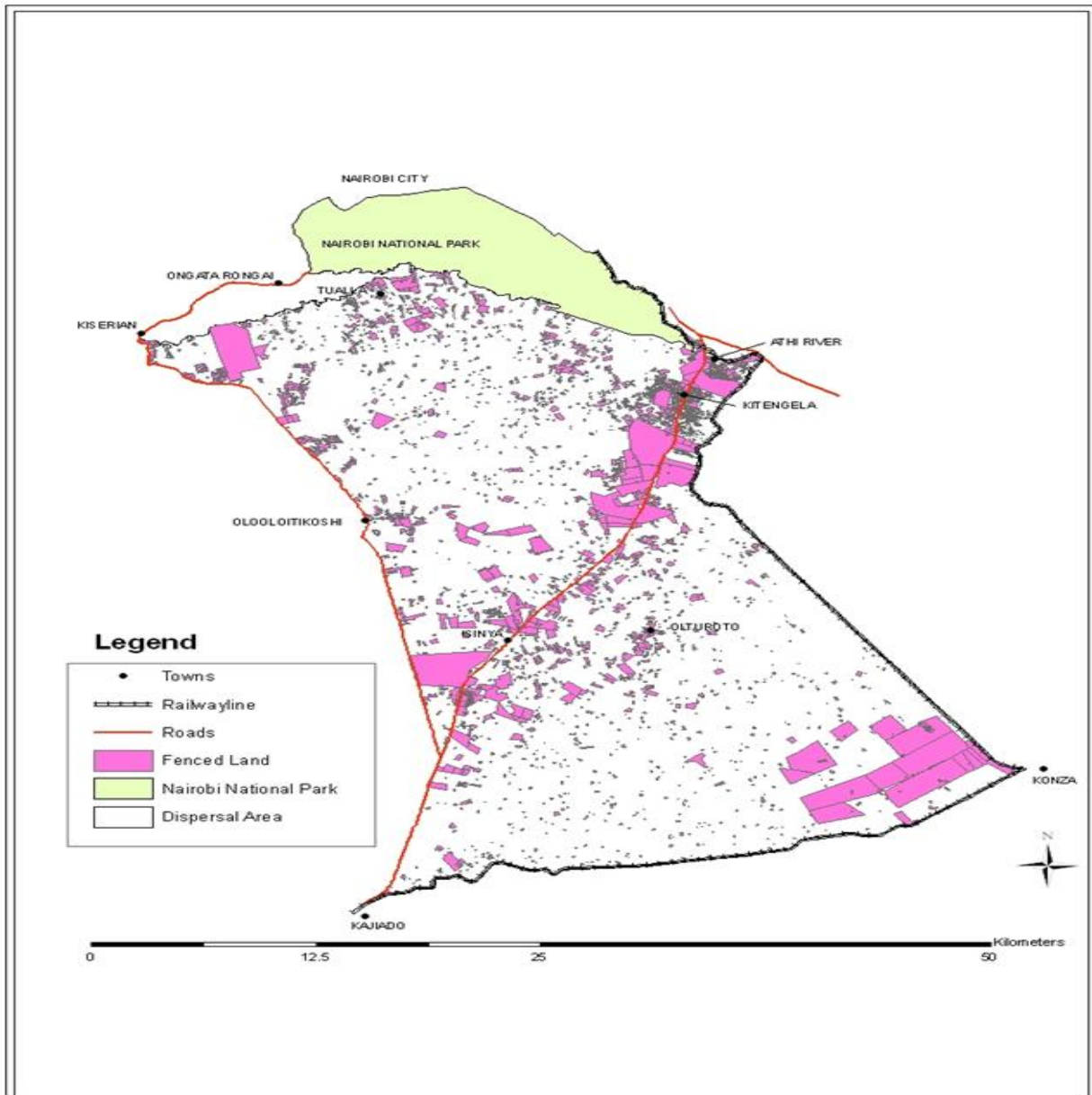
Map 2: Kitengela wildlife dispersal area. Source: Yatich et al., 2008

1. Wide- ranging animals can travel, migrate and meet mates. Although corridors may also provide avenues for parasites, disease, and fire (Simberloff and Cox 1987), ecological catastrophes caused by the presence of corridors have not been documented. Corridors are generally used to maintain connectivity among formerly contiguous wildlands, not to connect naturally isolated units (Noss 1987), and the advantages of providing corridors outweigh the potential drawbacks (Noss 1987).

2. Plants can propagate (Harlan, 1963)

3. Genetic interchange can occur (Ralls et al. 1988)

4. Populations can move in response to environmental changes and natural disaster (Noss, 1983)

5. Individuals can recolonize habitats from which populations have been locally extirpated (Henein and Merriam, 1990)

2.9 Ecological Effects of Roads

Establishment of the transport corridor along conservation areas has ecological effects. These effects could impact negatively to the conservation of wildlife in the ecosystem. The ecological effects include;

2.9.1 Alteration of the Physical Environment

Roads construction affects the immediate environment due to the need to clear, level, fill, and cut. Roads destroy and fragment the habitat wherever they are built and transform the environment well beyond the pavement's edge. Construction work changes soil density, landscape relief, surface and ground water flows. It affects ecosystems, vegetation and fauna in the wider landscape. At ground level, soil water content and density change leading to altered surface-water flow, run off patterns and sedimentation. Road cuttings through the slopes may drain acquifers, increase the risk of soil erosion and modify disturbance regimes in riparian networks (Forman et al., 1997; Jones et al., 2000). By opening the canopy and removing vegetation, the amount of light and heat increases. Additional light invites different plant species, often replacing native communities. Effects on vegetation and fauna due to edge effects have been observed up to several tens of meters away from the road (Ellenberg et al., 1981). Mader 1987, observed changes in plant and animal diversity occurring up to 30 m from the road edge into the adjacent forest. Road surfaces store heat, creating heat islands that attract species like birds and snakes.

Traffic stirs up dust and other contaminants that settle on plants, blocking necessary processes like photosynthesis and transpiration. Traffic mobilizes dust from the road surface that deposits along verges and in the nearby vegetation. In addition, traffic noise can make roadside areas inhospitable to certain nesting songbirds (Forman and Deblinger 2000). Road maintenance and traffic aggravate edge effects on the surrounding environment by noise and pollution.

2.9.2 Mortality from Road Collisions

Road mortality is probably the most acknowledged effect of traffic on wildlife, as carcasses of dead animals are a common view along trafficked roads (White et al., (2007). Roadkill is one of the most visible results of roadways through wildlife habitat (NCHRP Synthesis 305, 2002). Traffic causes the death of many animals that utilize verge habitats or try to cross the road. Mortality from traffic has been growing constantly over the years. It is considered as a severe threat only to few species. Vehicle collisions claim individual animals regardless of age, sex or condition of the individual animal, and can have substantial effects on a population's demography (White et al., 2007). Collisions between vehicles and wildlife are also an important safety issue of concern to the responsible authorities.

Animals killed on the roads have been a major concern to the biologists over many decades. The number of casualties appears to be constantly growing with increasing traffic and expansion of infrastructure. According to Forman and Alexander (1998), sometime during the last three decades, road collisions with vehicles probably overtook hunting as the leading direct human cause of vertebrate mortality on land. For example in Belgium, comprehensive field inventories revealed a loss of about 4 million larger invertebrates per year due to road traffic (Rodts et al. 1998). Hansen (1982), estimated a yearly road kill of 1.5 million mammals. Many birds are also killed annually due to roads. The collisions between vehicles and wildlife is a growing concern not only to conservation and game management but also for traffic safety, private and public economy (putman, 1997). Traffic safety in most countries is the driving force behind mitigation efforts against fauna casualties. Although human fatalities are relatively rare in wild-life vehicle collisions, the number of injured people is high and the total economic damages to vehicles can

be substantial. Police records in Europe (excluding Russia) suggest more than half a million ungulate- vehicle collisions per year, causing a minimum of 300 human fatalities, 30,000 injuries, and a material damage of more than us$ 1 billion (GrootBruinderink and Hazebroek, 1996). Also from a humane point of view a lot of pain is inflicted to the animals as some are injured as a result and may not die immediately, but later from the injuries or shock. Carcasses of larger mammals that litter road verges or road surfaces are of growing annoyance to the public.

It therefore follows that irrespective of whether road mortality is significant to the survival of species or not, there are economical and ethical concern that demands for the construction of mitigation measures. To determine whether, when and where road casualties do require mitigation, the problem has to be studied both from an ecological perspective and human point of view.

2.9.3 Wildlife Behavioural Changes

Roads can alter animal behaviour by causing animals to shift their home range, changing migration patterns, altering reproductive success, affecting escape responses and influencing an animal's physiological state (Trombulak and Frissell 2000). The mere presence of a road in wildlife habitat can be enough of a disturbance to alter animal behaviour. Roads bisecting habitat can cause wildlife to shift entire home ranges, modify movement patterns and escape responses and change physiological state. Research shows that impacts, such as traffic noise that disrupts avian nesting behaviour, can be measured over 100 meters from the road's edge (Forman et al. 1997). In a study stoats inhabiting beech forests, Murphy and Downing (1994), found that a road through the study area affected the behaviour of stoats. Female avoided the road but males preferred it.

According to White et al., (2007), the most cited cause for modification of animal behaviour is the barrier effects roads impose when built within the natural dispersal paths. Roads are recognized as barriers both to seasonal and life time migrations, plant and animals species and terrestrial and aquatic species. They can make dispersal nearly impossible for species of low mobility such as amphibians, reptiles and some small mammals.

2.9.4 Habitat Degradation

Roads lead to habitat degradation by increasing pollution run off, reducing water quality and facilitating the spread of invasive species (Trombulak and Frissell, 2000). According to Seiler and Erikson (1997), habitat degradation can also be referred to as landscape degradation and refers to changes in functional relationships among biotopes caused by altered disturbance regimes or land use patterns. Based on these far reaching effects, researchers estimate that transportation system negatively affects one fifth of the land area in the United States (Forman et al. 2003). Roads also lead to soil erosion which contributes to habitat degradation.

2.9.5 Habitat Loss

The construction of a new road inevitably transforms natural habitats into a sealed and highly disturbed environment (Seiler, 2001). The very presence of a road can represent an impassable barrier to many animal species either psychologically or physically (White and Ernst, 2003). Construction of roads always implies a net loss of wildlife habitat. The physical encroachment on the land gives rise to disturbance and barrier effects that contribute to the overall habitat fragmentation due to infrastructure (Seiler, 2001). Narrow roads occupy less area per kilometer compared to wider ones. Since narrow roads are more frequent in an area their combined effect on landscape can be considerably larger. Habitat loss is the most significant threat to endangered species, 85 percent of which are imperiled in this way (White and Ernst, 2003). When one includes all associated features, such as roadsides, embankments and slope cutting, parking places, pedestrian walkways, the total area designated for transport is several times larger than the paved surface of the road (Seiler, 2001).

The allocation of space for new infrastructure is a superior problem for land use planning, as it necessarily conflicts with many other interests in the landscape (Seiler, 2001). The total loss of habitat due to infrastructure can impossibly be evaluated from what is physically occupied. Barrier effects isolate the otherwise suitable habitats and make them inaccessible for wildlife. Animal populations that are isolated are also more vulnerable to natural catastrophes such as flooding or drought because they are unable to move to other areas (White and Ernst, 2003).

Also edge effects on hydrology and microclimate and the pollution by toxins, nutrients and noise reduce the suitability of the remaining habitats. Disturbance effects spread into the surrounding landscape contribute far more to the overall loss and degradation of natural habitat than the road body itself (Seiler, 2001). Many attempts have been made to assess the overall width of the affected zone around infrastructure. Depending on what impacts that has been measured, the estimation range from some tens of metres (Mader, 1987) to several hundred metres (Reichelt, 1979; Reijin et al, 1995; Forman and Deblinger, 2000) and even Kilometres (Reck and Kaule, 1993; Forman et al., 1997). Therefore, despite its limited physical extent, transport infrastructure is indeed one of the more important actors in the landscape and its total influence on land use and habitat has probably been underestimated a lot (Seiler, 2001).

There is no straightforward answer to area of habitat actually affected by a new road or how much reduced is the ecological quality of the areas adjacent to roads. The spread of disturbances is influenced by road and traffic characteristics, landscape topography and hydrology, wind and slope and vegetation (Seiler, 2001).

2.9.6 Spread of Exotic Species

The construction and presence of roads create perfect conditions for non-native, invasive species to move in and ultimately displace native vegetation (White et al., 2007). Exotics species are able to take advantage of the disturbed, altered conditions created when a road is originally built and native species are stressed or removed altogether. Native plants are preferred for native wildlife because they tend to control non-native wildlife, support more insect prey, require little maintenance when established and provide habitat diversity (Metro, 2010). Some roadside exotics are no accident. Transportation agencies have historically planted rapidly growing exotic species on bare ground and slopes after construction to control erosion (White et al., 2007). According to White and Ernst (2003), roads can encourage the entry of invasive species in three other ways; techniques used to maintain road roadways may encourage the growth of exotic plant species; roads may facilitate the spread of invasive plant and animal species and degradation of habitat caused by roadways may usher in exotic and invasive plants and animals.

2.9.7 Increased Human Use of an Area

Roads are built for many uses, from mere access into remote areas to full blown development, but they are all built for human activities (White et al., 2007). Roads increase access to formerly remote areas, thus increasing the frequency and intensity of human activity – both legal and illegal. They facilitate human access to adjacent areas. The presence of a road can encourage residential and commercial development or increase access for people interested in recreation and poaching. Not only do roads themselves pose a threat to wildlife, they also significantly influence future development patterns, which in turn severely impact wildlife populations (White and Ernst, 2003). Improved human access has lead to increased hunting pressure and poaching in many areas (Manville 1983; Fuller 1989; Cammara and Parde 1990; Ferreras et al.1992)

2.9.8 Mortality from Construction

In the course of clearing the work site in preparation for road construction, any slow moving organisms are killed. Species that nest underground, like gopher tortoise are often buried alive when their dens are bulldozed and eventually paved over. Compared to mortality from road collisions, few studies have been done on the direct mortality caused during road construction (Spellerberg and Morrision, 1998). Road construction affects the immediate environment due to the need to clear, level, fill and cut. Construction work changes soil density, landscape relief, surface and ground water flows (White et al., 2007). This, in turn, can affect ecosystems, vegetation and fauna in the wider landscape.

2.9.9 Barrier Effect

The barrier effect of all primary effects of infrastructure contributes most to the overall fragmentation of habitat (Reck and Kaule, 1993; Forman and Alexander, 1998). Infrastructure barriers disrupt natural processes, such as ground water flow, fire spread, affect plant dispersal and inhibit animal movements (Forman et al., 1997). The barrier effect on wildlife arises from a combination of disturbance and avoidance effects, physical hindrances, and traffic mortality that all reduce the number of movements across the barrier. Disturbances due to traffic noise, vehicle

movement, pollution, and human activity may repel many species from approaching infrastructure corridors. The clearance of the road corridor and the open verge creates habitat conditions that are unsuitable or hostile to many smaller species. The road surface, the gutter, ditches, fences, and the embankments, may all imply physical barriers that animals cannot pass. Traffic mortality further reduces the number of individuals that successfully manage to cross the road barrier. Most infrastructure barriers do not completely block animal movements, but reduce the number of crossings quantitatively (e.g. Merriam et al. 1989). The central question is thus how many successful crossings are needed to maintain habitat connectivity.

2.9.10 Habitat Fragmentation

Habitat fragmentation also sometimes referred to as landscape fragmentation has become a major focus of research in conservation biology (Spellerberg and Morrison, 1998). Fragmentation means a splitting of contiguous areas into smaller and increasingly dispersed fragments (Seiller, 2001). Landscape fragmentation due to road construction refers to physical changes in the connectivity of the landscape and is mainly a consequence of the barrier effects of roads (Seiler and Erickson, 1997). Roads are always part of a wider network, where synergetic effects with other infrastructure links occur, which cause additional habitat loss and isolation (Seiler and Folkeson, 2006). Roads cause a loss and degradation of habitat due to disturbance effects and isolation. With increased road density, areas of undisturbed habitat are reduced in size and become inaccessible. Remnant fragments of suitable habitat may eventually become too small and too isolated to prevent local populations from going extinct. The critical threshold in road density is species specific, but will also depend on landscape and infrastructure characteristics. The process of habitat fragmentation has been studied extensively in forestry and agriculture (Harris, 1984). With increasing degree of fragmentation, the individual fragments may become too small and too isolated from each other to support the species that depended on the entire habitat before fragmentation.

Fragmentation reduces the amount of habitat available to wildlife in the landscape and thereby diminishes population sizes and the number of species that can live in the landscape (Seiler, 2001). Empirical studies on habitat fragmentation due to for example forestry practises suggest

that a habitat loss of more than 80% in the landscape may entail sudden extinctions (Andrén, 1994). Increased degrees of fragmentation may reach to a stage where species finally becomes extinct. In contrast to other causes of fragmentation, it is not primarily the direct loss of habitat that characterises the fragmentation impact caused by roads, but the increased isolation due to barrier effects. The question is how transport infrastructure can be integrated into the ecological infrastructure in the landscape to ensure minimal adverse effects on the animal species. There are many ways of quantifying habitat fragmentation (Spellerberg and Morrison, 1998).

2.9.11 Pollution

Roads and the development they facilitate cause light, sand, dust, air, noise pollution and other particulates such as metals (Spellerberg and Morrison, 1998).Motor vehicles also emit a variety of heavy metals: motor oil and tires contain zinc and cadmium; gasoline contains nickel; and diesel fuel contains lead (White and Ernst, 2003). These heavy metals are have been found in greater concentrations closer to roads and in areas with high traffic volumes. The effects of emissions and disturbances can extend some hundreds of metres from a road (Spellerberg and Morrison, 1998). Roads also form impervious surfaces, causing runoff to flow more quickly into open bodies of water rather than allowing it to seep naturally into the ground to recharge aquifers. This runoff flowing into streams, rivers, or creeks leads to erosion and sedimentation, thereby degrading aquatic habitat. Runoff also carries with it numerous pollutants, including sediments, nutrients, trace metals, pesticides and petroleum hydrocarbons (White and Ernst, 2003).

Noise pollution from roads, initially during constructions and later from heavy traffic, can degrade wildlife habitat and impair biodiversity. Most frequently, noise leads wildlife to not only avoid roads, but has also been shown to change reproductive behaviour and other patterns of activity (White and Ernst, 2003). Different species of plants and animals tend to respond to different pollutants in different ways, and even different stages in the life history may have very different responses (Spellerberg, 1998).

2.10 Addressing the Detrimental Ecological Effects

There are many ways of addressing the environmental effects of roads and road traffic and these depends on the particular effect. Appropriate choice of route may help to lessen the ecological effects (Spellerberg and Morrison, 1998). According to Iuell et al., (2005), mitigation is one of the planning alternatives transportation agencies have to reduce or eliminate impacts of road construction and expansion projects. This can be done by having road alignments that avoid critical wildlife habitat, mitigating affected wildlife populations and habitats and compensating for the loss of wildlife habitat (figure 2).

The first step in avoiding impacts from road construction on wildlife populations and their habitats before initiating project planning for wildlife habitat connectivity is to make alignment adjustments to prevent conflicts. Road construction or expansion projects may be unable to avoid habitats completely. In such situations roads alignments can be planned to minimize impacts to wildlife. Roadways traversing suboptimal habitats for wildlife can help reduce adverse effects
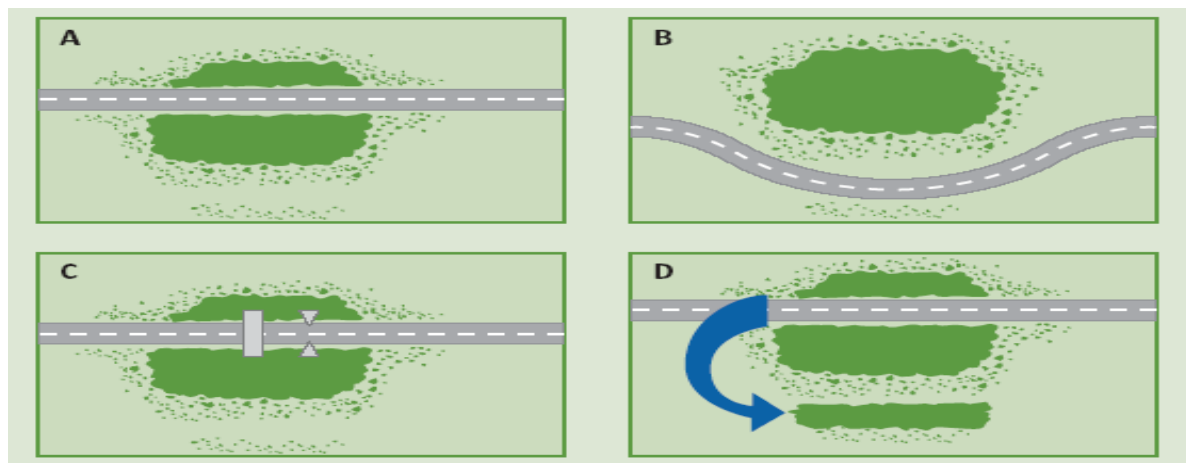
Figure 2:   Schematic. Representation of road construction and habitat (A) fragmentation (B) avoidance (C) mitigation by use of under/overpasses, and (D) compensation by creation of replacement habitat (from Iuell et al. 2005).

compared to those crossing optimal habitats (Iuell et al., 2007). Mitigation is an alternative if impacts cannot be avoided.

For the projects that are unable to avoid or mitigate their impacts then another option consists of compensation measures. The compensation principle holds that for road construction or expansion there no net loss of habitat, natural processes or diversity. This principle is commonly applied in transportation projects throughout North America (Iuell et al., 2007).

Reflecting lights at the side of the road may deter mammals from attempting to cross a road. Measures can be undertaken to reduce the effects of pollution. This can be done by avoiding contamination of wet lands and containing surface run-off from roads. To reduce road mortality tunnels, underpasses (Plate 1) and overpasses can be constructed. The barrier effects of roads can be reduced with tunnels and nature overpasses.

Mitigation banking can also be used (Spellerberg and Morrison, 1998). Mitigation banking is not new but is becoming increasingly popular (Spellerberg, 1998). It involves compensating for loss or damage to habitats in one place by providing for establishment or enhancement of habitats for wildlife elsewhere.

Plate 1: Elephants underpass in Mt. Kenya.
Source: http://www.ewt.org.za/programmes/WTP/newsletter/July 2012.pdf

Landscaping and planting roadside verges have been used for erosion control and to provide habitats for wildlife (Spellerberg and Morrison, 1998). Buffer zones (undisturbed areas or strips)

and filter strips (undisturbed except to provide access; Clinnick, 1985), have been popular in conservation. Buffer zones on field margins have long been developed in Britain with aim of encouraging habitats for wildlife. Buffer zones can also be used to absorb pollutants. Some kinds of dense vegetation may act as sinks for some pollutants. However the common question is how wide the buffer zone should be. Of all ways of addressing ecological impacts, that of not building the road is the most important, particularly for avoiding habitat fragmentation and subsequent incremental damage to nature (Spellerberg and Morrison, 1998).

2.11 Conceptual Framework

Causes/Factors

Clearing, drainage, ditching
construction work
Pavement, emission, traffic noise
Road side management
Human activity

Local scale

PRIMARY EFFECTS

Habitat loss, habitat transformation
disturbance effects, corridor effects,
barrier effects, road mortality

Landscape scale

SECONDARY EFFECTS
Habitat fragmentation   **Habitat degradation**

Barrier effects   Intoxication effects
Road mortality   Traffic disturbance effects
Habitat loss   Habitat transformation

Regional scale

CONSEQUENCES
Ecological stress
Loss of biodiversity
Change in land use

Figure 3a: Cause, effects and consequences of road construction. Source: Author, 2014.
Modified from Seiler and Eriksson, 1997.

A conceptual framework for causes, effects and consequences of road construction on the environment can be simplified as shown in figure 3a. Roads and traffic lead to loss of natural areas and a reduction in quality of the remaining ones. Vehicle traffic leads to pollution from toxins and noise, which can cause mortality in wildlife species. Roads impose dispersal barriers to many animals, divide habitats, and lead to fragmentation of the landscape in a literal sense (Reichelt 1979, Mader 1984, Cuperus et al. 1993). Roads construction results in roadsides which may provide a new and valuable habitat for some plants and animal species, and also function as transition or dispersal corridors. Distinction can be made between six classes of primary ecological effects of roads and traffic: habitat transformation, habitats loss, barrier effects, corridor effects, disturbances, and road mortality (Van der Zande et al.1980). Immediate effects of the road construction results in primary effects and they are often confined to a single road and its nearest surrounding. Primary effects from the interaction of different roads consequently cause secondary effects such as habitat fragmentation and habitat degradation. Secondary effects therefore denote higher organizational levels and broader scales, i.e. populations and landscape. The choice of mitigation and compensation measures must be based on the considered causes, effects, or consequences considered (Seiler and Erikson, 1997).

However the conceptual model can be simplified further resulting in two models during and after construction (figures 3b and 3c.). In order to make an informed decision on the road construction negative and positive impacts have to be evaluated with a view to coming up with appropriate policies and strategies. These would in turn deliver sustainable conservation and transport corridor.
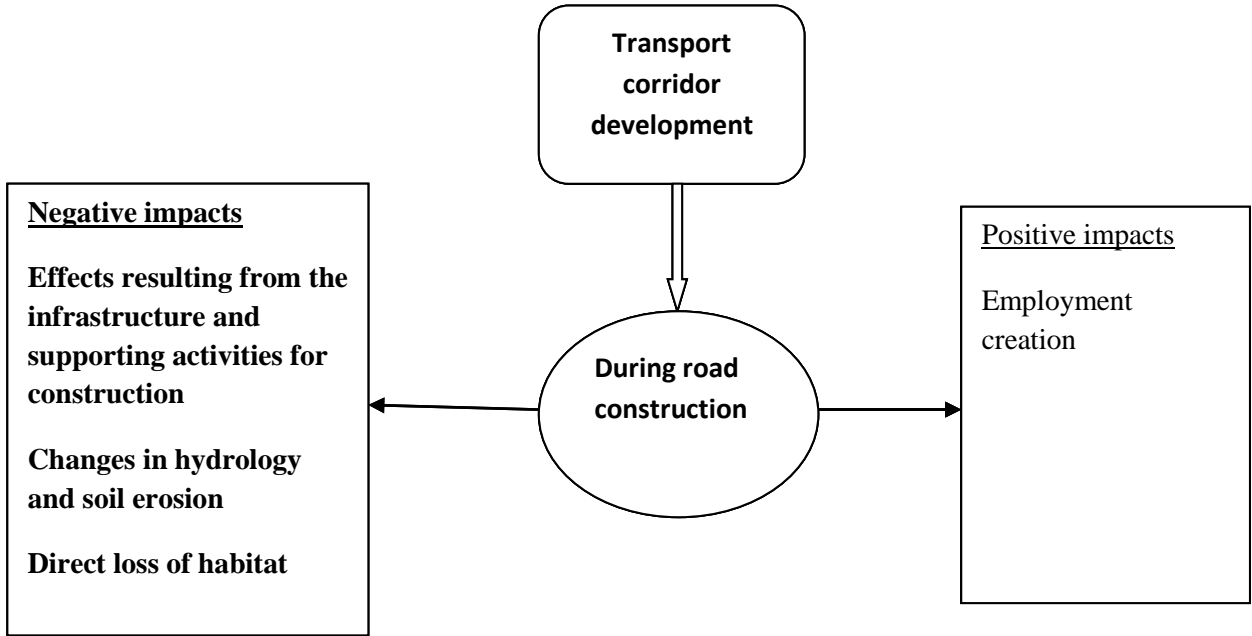
Figure 3b: The impacts during the construction of the road. Source: Author, 2014
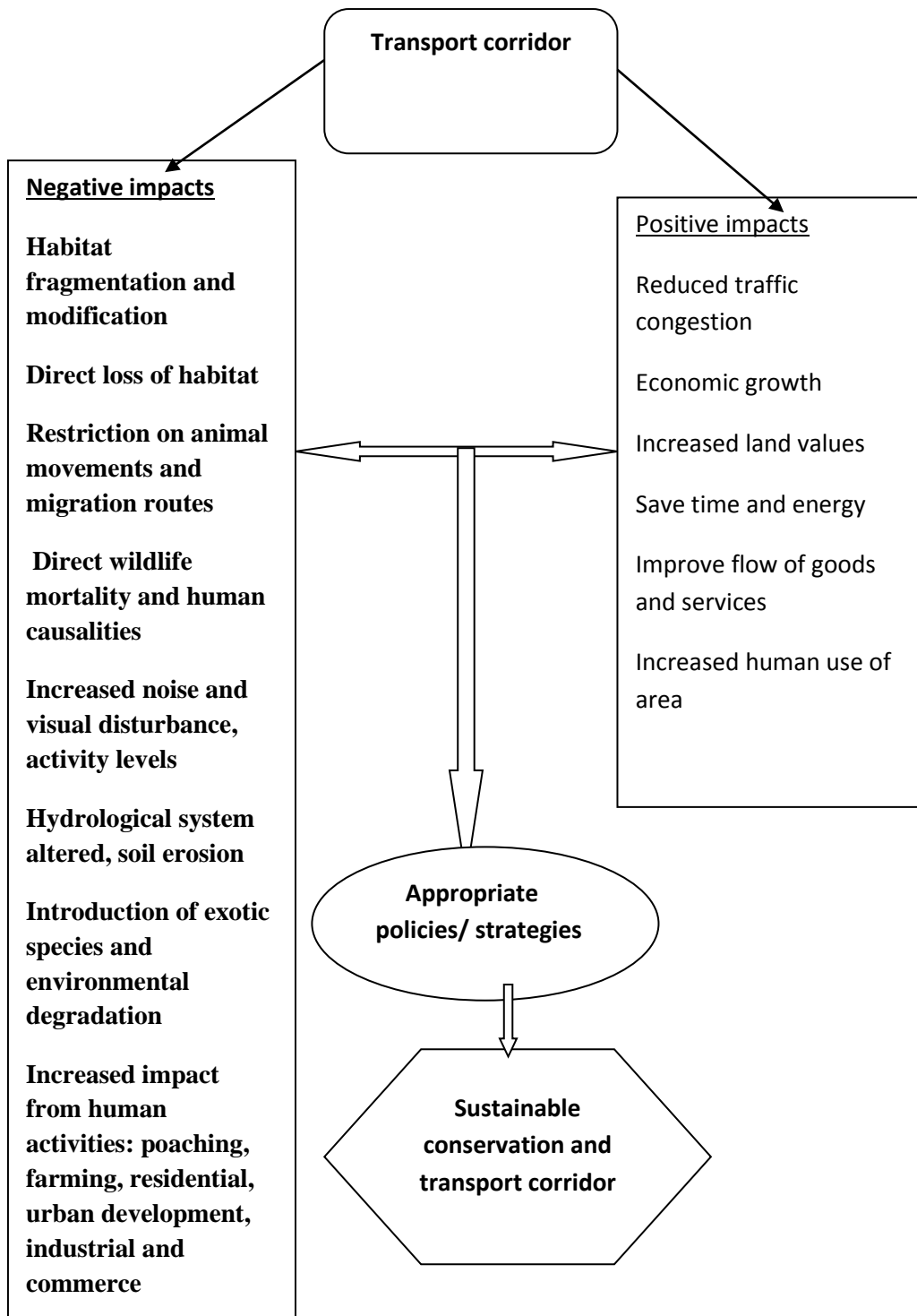
Figure 3c: The impacts of the constructed transport corridor. Source: Author, 2014

CHAPTER THREE

STUDY AREA

3.1 Bypasses in Nairobi

The through traffic passes through the Central Business District (CBD) and is one of the most serious causes of traffic congestion in the area. The bypasses are planned to direct and re-route the traffic to the outside fringe of densely developed areas by providing appropriate routes (map 3).
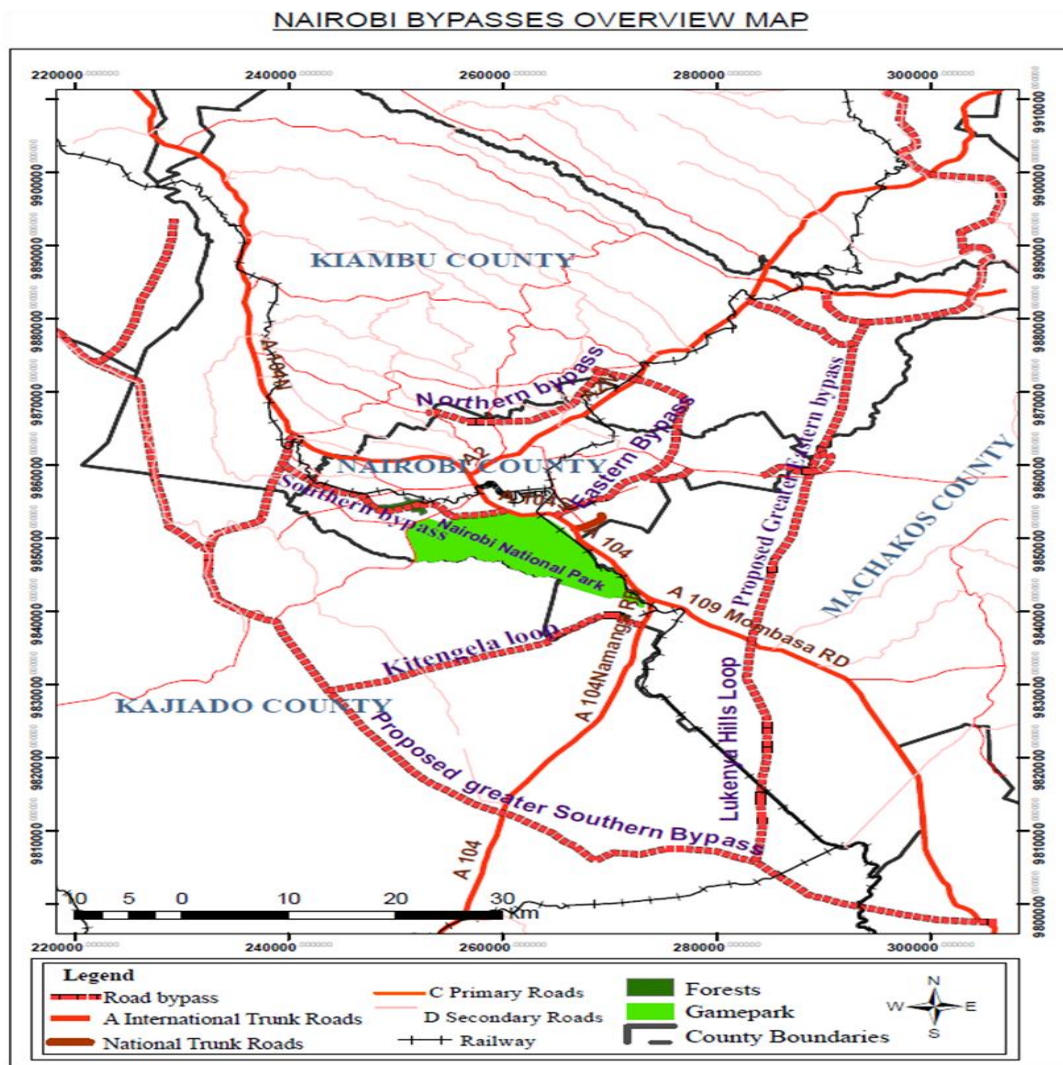
Map 3: Overview of Nairobi bypasses. Source: Author, 2014: Modified from Ministry of Transport bypass map of 2013

The study area was Athi River North sub location in Machakos County (map 4). It lies between 1° 24′ S, 1° 30′S and 36° 51′ E, 37° 00′ E (map 4). Purposive sampling was used to select this area since it accommodates the wildlife migration corridor and the proposed Kitengela loop of the Greater Southern bypass (map 4). It was also easily accessible compared to the other areas affected by the wildlife migration. According to Kenya National Bureau of Statistics (2009), the area measures 38.3 square kilometres approximately. This area borders the Southern boundary of Nairobi National Park (NNP). In order to enable the animals to migrate freely unlike all other borders the southern one is not fenced.
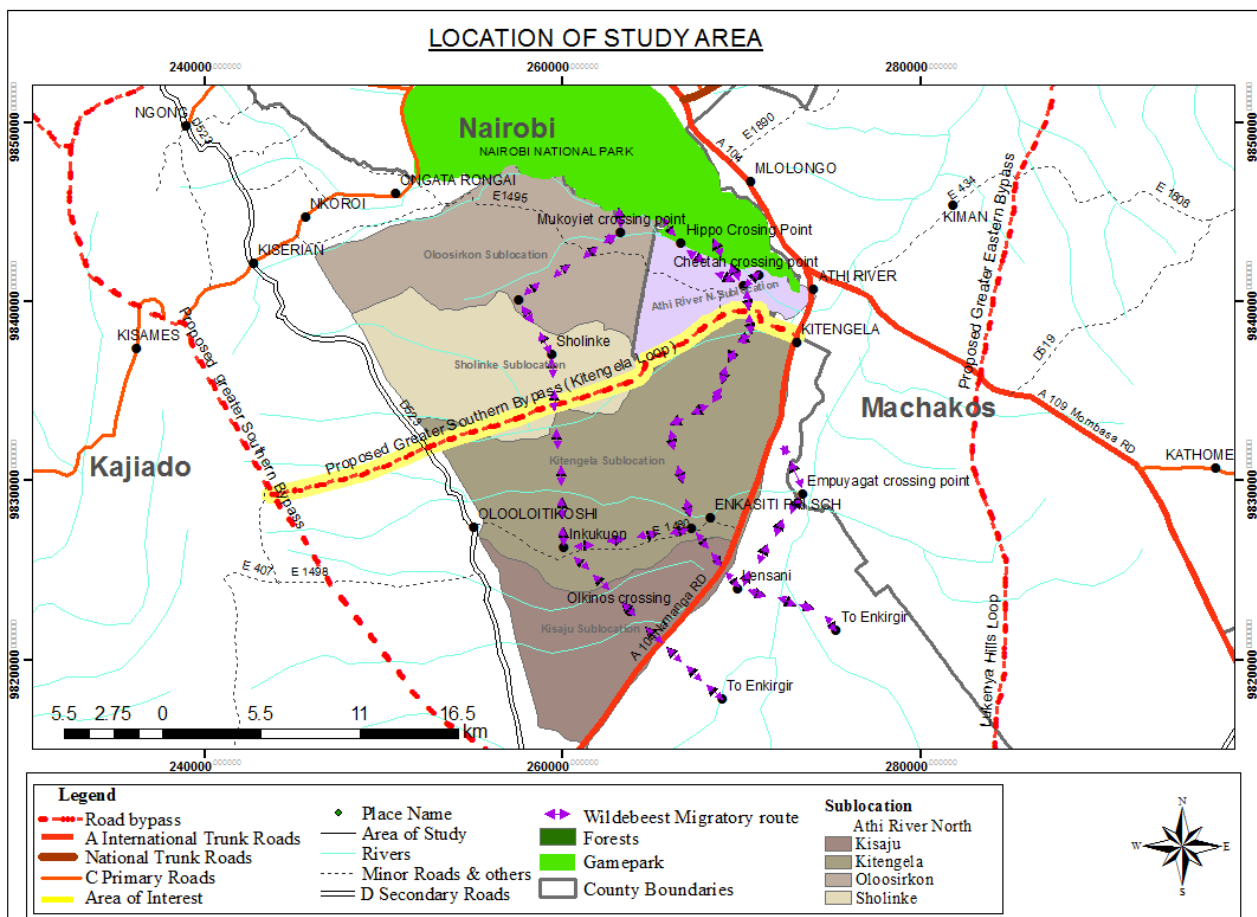
Map 4: The Proposed Greater Southern Bypass, wildebeest migratory routes, and study area. Source: composed by Author, 2014; Proposed greater southern bypass adopted from Ministry of Transport bypass maps and wildebeest migratory route from KWS GIS Department, 2003

3.1.1 The Greater Southern Bypass.

The design proposal of the bypass is to start at Mukaa DC's office Makueni County, pass through Ilpolosat across the wildlife conservancy, Ewaso Kedong to Suswa and Mai mahiu (map 3). The other section called Kitengela loop is to begin from Namanga road in Kitengela town then cut across the wildlife migration corridor to join the longer section. This is the section where the study is based (map 4).

3.2 Nairobi National Park.

The National park was the first to be created not only in Kenya but also in East Africa in 1945 (Oimbo, 2007). It was the first park to be gazetted in Kenya in 1946 and covers an area of 117 square kilometres (Nairobi National Park, Undated). It is a unique ecosystem by being the only protected area in the world close to a capital city. The park is located only 7 Km from Nairobi city centre (Kahumbu and Kent, 2012). The geographical location is about 2°18' South and 36°50' East. It has over two dozen big game species. To the south of the park are the Athi-Kapiti Plains and Kitengela migration corridor which are important wildlife dispersal areas during the rainy season.

The park has a diversity of environment with characteristic flora and fauna. Scattered acacia bush in open grass plains predominate the ecosystem. The park has a highland dry forest in the western site and a permanent river with a riverine forest (Nairobi National Park, Undated). It has also stretches of broken bush, deep rocky valleys and gorges with scrub and long grass. In order to be water sufficient there are man-made dams that add a further habitat to certain species of birds and other aquatic biota. These dams attract dependent herbivores during the dry season. The park harbours a variety of animal life as a result of the various different habitats each harbouring its own typical fauna (Parks and Reserves, Undated). It has a permanent Mbagathi river with fringe thickets, lugass, long and short grass, flat land and foothills. It also comprises of open plains, broken bush and some real forest. The savannah ecosystem comprise of different vegetation types. Open grass plains with scattered acacia bush are predominant.

Due to its close proximity to the city, the park is a principal attraction for visitors to Nairobi and the local inhabitants as well as those residing in its environs. The main attractions are the large mammals and most popular species. However the park has no elephants with the herbivore population consisting of black rhino, buffalo, eland, maasai giraffe, plains zebra, wildebeest, coke's hartebeest, grant's and Thompson's gazelles. Other includes impala, waterbuck, bushbuck and warthog. The available carnivore population consists of the lion, leopard, cheetah, hyena, jackal civet and genet. A variety of bird species resides in the park with about 400 species recorded (Nairobi National Park, Undated). It is important to note that all those species are not always present and their availability depends on particular seasons.

The park is also providing one of the most successful rhino sanctuaries which is already generating a stock for reintroduction in the species former range. About 50 rhinos have recently been moved into the park from the remote parts of the country where poaching is rife (Oimbo, 2007). This provides an opportunity where a visitor can be able to view a black rhino in its natural habitat. This has promoted tourism industry consequently providing added economic benefits to the country (Oimbo, 2007).

Captain Archie Rithie, who was the first Game Warden in Kenya, stressed the importance of the park. He said that "NNP is indeed unique and must be nurtured at all costs, not just for its obvious tourist appeal, and the revenues it brings into the country, but for important therapeutic reasons. The human soul needs access to nature to heal its psyche, for humans are an integral part of nature and need the tranquility wilderness offers to offset the negative impacts of stress. More importantly still, the park serves the vital role of being the lungs of Nairobi city. Its natural vegetation and remnant forests renewing the oxygen levels and cleansing the air of pollution spewed forth from a sprawling city now harbouring close to 3 million people". Others have emphasized the parks importance in different words. Hellen Gichohi, a wildlife biologist referred to NNP as the most remarkable park of its size anywhere in the world (FoNNaP Newsletter, 2001). David Western, a former Director of KWS said the following about the park "… truly unique and the envy of the world's capitals" (FoNNaP, Newsletter, 2001). The question is does every sector with a role to play within the environs of the park consider its conservation

with the same seriousness. The government has a duty to play in ensuring that the various concerned sectors and agencies work in harmony so as not to jeopardize the conservation efforts of the park.

3.3 Kitengela Wildlife Corridor

The role of wildlife dispersal areas outside the protected areas is critical to wildlife conservation in Kenya. The Maasai pastoral area adjacent to Nairobi National Park (NNP) acts as a dispersal area for the parks migratory wildlife (map 2). When NNP was established in 1946 (as the first park in both Kenya and Africa), it was immediately recognized that at 117 square kilometers it was too small to meet the ecological requirements of the existing migratory wildlife species (Kristjanson *et al.*, 2002; Gichohi, 2000). Kitengela rangeland is about 450 square kilometres stretching south from Nairobi National park. The area is a wet- season wildlife dispersal corridor for wildlife from the park. The corridor is the grazing and calving ground during the wet season. Much of the park's wildlife is dependent on the willingness of private landowners in the dispersal area to tolerate wildlife on their properties. The adjacent Kitengela plains were therefore declared a conservation area, and were referred to as the Kitengela Conservation Area (KCA) in order to provide protection for migratory wildlife. The status of this area was however never legalized and the land is privately owned (Kristjanson *et al.*, 2002; Gichohi, 2000). The area has no land-use constraints (Gichohi 2000).

The wildlife on the land is owned by the government and KWS is the official custodian. There are serious human-Wildlife conflicts in the area mainly due to competition for forage and water and the frequent wildlife predation (FoNNaP, 2001).The park is fenced on its northern, eastern and western boundaries, but only the Mbagathi River marks its southern boundary. This allows free movement of wildlife into KCA and then further south into the Athi-Kapiti plains. For animals to migrate to the southern part of the ecosystem (especially Lenchani and Enkirigirri where the threatened Wildebeest breed) they have to pass through the privately owned parcels of land and then cross the Namanga road to and from the park. The KCA, together with the Athi-Kapiti plains, forms a dispersal area covering about 2,500km² (Gichohi, 2000) (map 5).
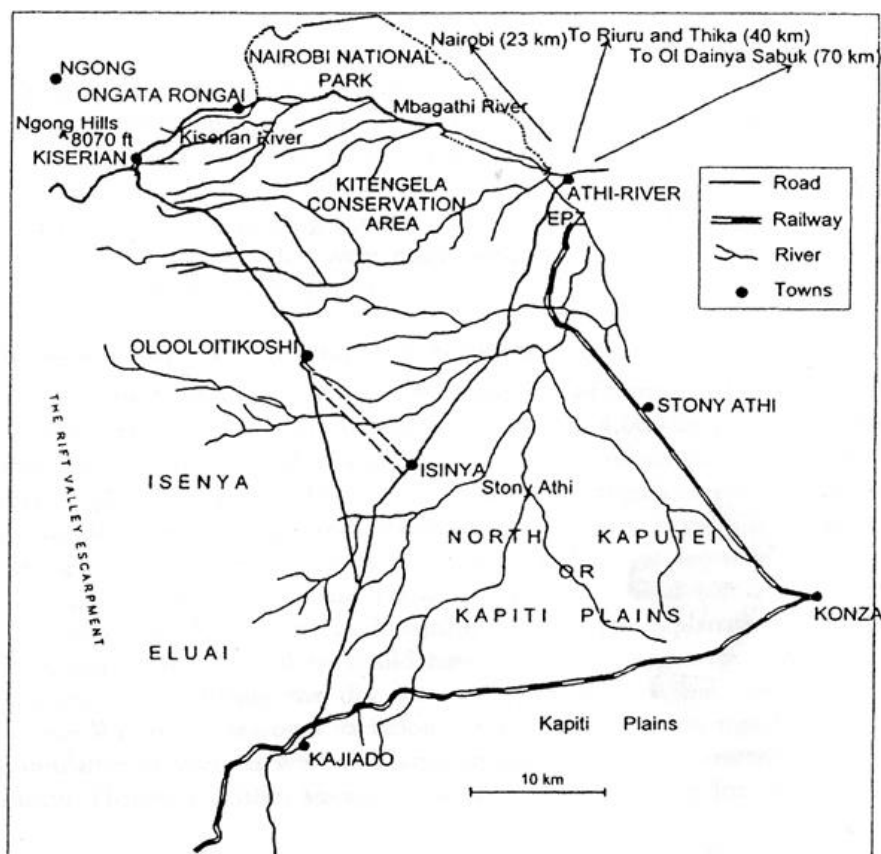
Map 5: Showing Athi-Kapiti ecosystem. Source: Gichohi, 2000

This area also acts as a migratory corridor for the migratory species, with a seasonal movement in and out NNP. The Maasai who live in these areas are semi-pastoralist with their livestock herds comprising of predominately cattle, sheep and goats, with donkeys in some areas. Over three quarters of the Athi-Kapiti ecosystem falls on land that is privately owned (Gichohi, 2000), and changes in land tenure over the last 40 years have had a huge effect on the development of the area. Due mainly to demographic and changing land use patterns the area has been shrinking with time. The kitengela Game conservation area and the entire Athi-Kapiti ecosystem is such an important dispersal area of NNP and -needs to be managed. Given the high observed rate of land sales and fragmentation within rangelands, viable wildlife corridors need to be established before it is too late.

Currently as a consequence of increasing population pressure and the proximity to Nairobi, the Kitengela Plains are in a fast process of subdivision, fencing, development of permanent

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settlements, and conversion of grasslands to croplands and creation of industries for export revenue. These changes in land use affect the integrity of the dispersal area: declining primary productivity, diminishing animal biodiversity and reducing wildlife migratory corridors (Nkedianye, 2004). Establishment of a transport corridor would consequently accelerate the development even further. This would further result in a much more aggravated problem to the wildlife migration. Landowners currently have no incentives to tolerate wildlife on their land and most households report significant increase in human–wildlife conflicts caused mainly by the reduction of farm size, lack of economic benefits from wildlife, increasing human population, livestock and wildlife competition for water and grass and frequent episodes of predation on farm animals (Gichohi, 2000).

Conservationists are all in consensus that the future and wellbeing of the park depends on the continued availability of this rangeland. It serves as a wetland dispersal area for many of the park's large herbivores. The bi-annual rainfall variation within the ecosystem is the major reason for the movement of wildlife as it creates a seasonal difference in the availability of forage and water. The wild animals use the NNP during the dry season for water and move outside to the Athi-Kapiti plains during the wet season. This ecosystem has the second largest migration of Wildebeests and Zebras in the country after Mara- Serengeti migration (NNP Files, 2002) (map 6). Conservationists have also noted that ring-fencing of the park would isolate this adjoining dispersal area and 50% of the large mammal species currently found in the park would die out. This justifies the need to preserve the KCA for the benefit of NNP and the Kenya economy at large. Proper mechanisms need to be put in place either by Government or non-governmental agencies such as FoNNaP to ensure that any interference or enclosure of this habitat is prohibited or highly discouraged. In cases of unavoidable circumstances proper mitigation measures should be make to ensure that migration of wildlife is not curtailed.

Through the ambitious process of decongesting the roads in Nairobi the government has planned the Greater southern Bypass to cut through the KCA. This will have serious implications to the wildlife as it will disconnect the KCA, reduce the dispersal area, and increase human use of area

among many other effects as elaborated in the conceptual model (Figure 4a, 4b and 4c). These will seriously curtail the wildlife population in the NNP.
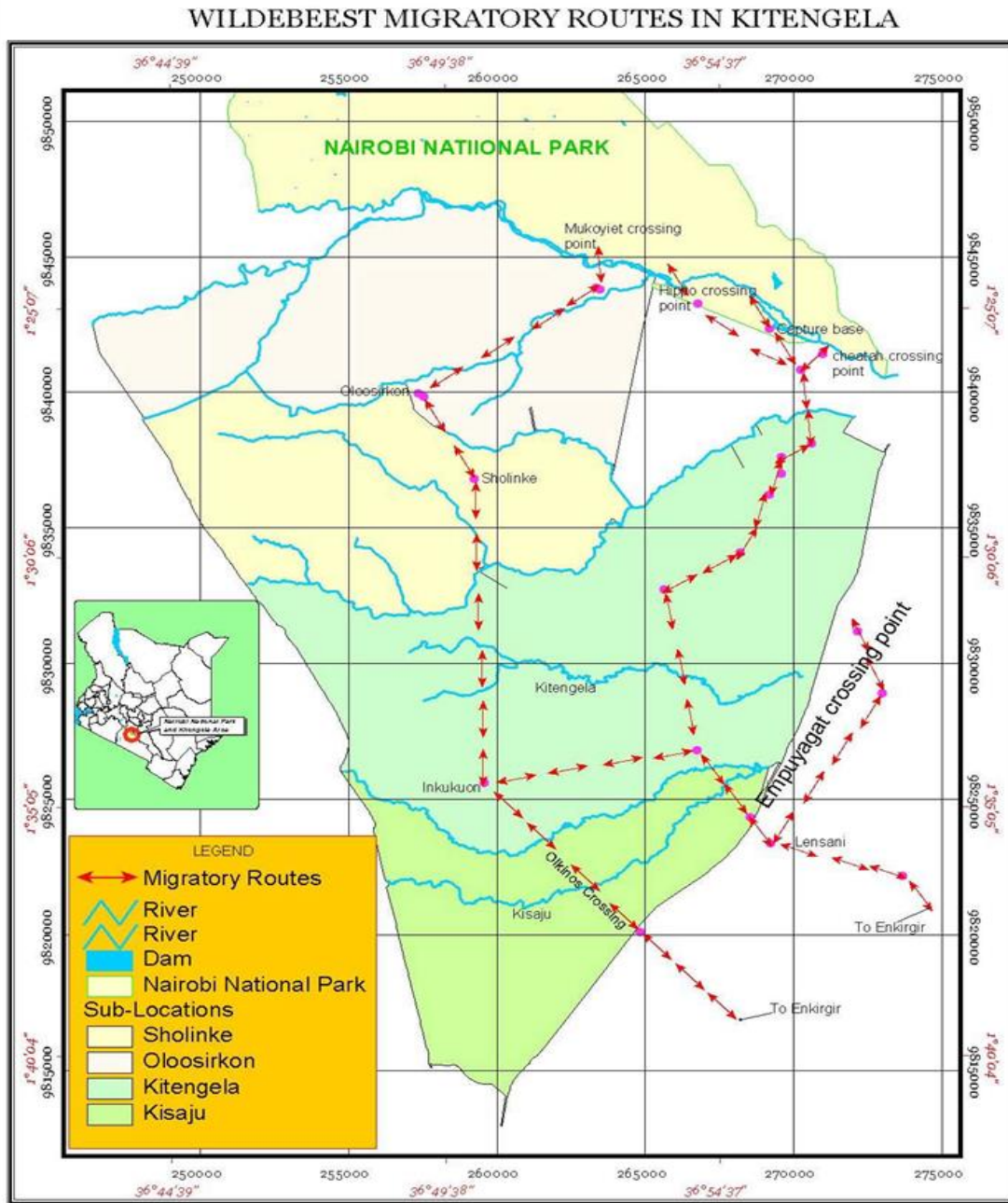
Map 6: Map showing Wildebeest migratory routes in Kitengela. Source: KWS GIS department. Results from a wildebeest tracking survey in October 2002

3.4 Land-Leasing Project

New land management schemes had to be considered in which local pastoralists receive direct payment to compensate for the extra costs derived from the use of their properties as a wildlife dispersion area could provide incentives for more appropriate use of land, promoting the sustainability of the conservation areas and reducing negative impacts of conservation policy on people's livelihoods (Rodriguez et al., 2012). According to Mwangi and Warinda (1999), a survey was carried out by African Conservation Centre (ACC) in 1999 to examine the impacts of the wildlife corridor on the welfare of the local community and assess the acceptability of an easement programme to the land owners in the area based on their willingness to accept financial compensation in exchange for allowing free movement of wildlife. The survey focused on the socio-economic factors associated with sustainable livestock production systems and wildlife conservation in the area. It was found that landowners in this area suffer frequently from wildlife-related problems. These problems included, increased cases of human-wildlife conflicts caused by increased livestock numbers, lack of economic benefits from wildlife, increasing human population, increased risks of human attack, severe competition for water and grass and frequent predation . Majority of the local community were willing to leave part of their land (between 0.5-250 acres) unfenced, if in return they were paid a modest sum of money for accommodating wildlife (Mwangi and Warinda, 1999).

In this regards, Friends of Nairobi National Park (FoNNAP, a non-governmental organization) initiated a pilot land-leasing project in 2000 (ILRI, 2002). Landowners were paid Ksh 300/acre (approximately US$ 3.80/acre) per year in return for agreeing to leave their land open to wildlife and not engage in quarrying, fencing, land subdivision and sale or poaching activities (ILRI, 2002). This lease programme started in 2000 with 214 acres initially signed and increased to 2708 acres in 2001 (ILRI, 2002). Plans were underway to establish a permanent fund to ensure sustainability of the programme.

CHAPTER FOUR

METHODOLOGY

4.1 Introduction

Methodology focuses on the procedure used in carrying out this study. Research methodology is normally a series of systematic research procedures and techniques to assist the researcher avoid self-deception, and minimize the probability of being inaccurate (Prewitt, 1974). A good research methodology is key in attainment of the stipulated goals of the study.

Data was collected on the following four main areas;

4.2 Background Information

This entailed the background information of the household questionnaires respondents. The information sought for involved the name, age, sex, period of time one has lived in the area, occupation and place of work. This was important to enable one gauge the respondents understanding of the wildlife, environmental and roads network issues of concern. The information has also a direct linkage to the other research areas.

4.3 Wildlife and Other Environmental Concerns

The residents of the area through the household survey gave varying experiences with respect to the wildlife and environmental issues. The wildlife areas of concern which the respondents were asked involved human-wildlife conflicts, causes, and activities of Non Governmental Organization (NGOs) including KWS which are actively involved in conservation. Additionally the survey requested for information on benefits of wildlife conservation and the efforts being made to secure the wildlife dispersal area. Other information included the state of the roads in the area and on awareness of the proposed road bypass and it anticipated impact.

On environment which has a direct linkage to the wildlife habitat the respondents were asked on the major environmental concerns. The area is known greatly as a feeder of quarrying materials to the many cement factories located in Athi-River and its environs. Other information sought

from the respondents included soil erosion, deforestation, pollution, increased human settlement, water quality and sand harvesting

4.4 Impacts of Proposed GSB Development on Environment and Wildlife Elements

The survey asked respondents from the various institutions directly involved in wildlife and environmental conservation, planning of roads and land use, the impacts of the proposed infrastructure development on environment and wildlife. The institutions included NEMA, KWS, KURA, Physical planning department in the ministry of lands, housing and urban development, FoNNaP, African wildlife foundation and planners in private practice. This information was collected through interview schedules. Respondents were asked on the road – related mortality of wild animals and the effect of the road on their natural migration. The survey also sought to find out the effect of the road on the population of animals in Nairobi National Park (NNP) and the resultant ecological effects.

4.5 Suitable Spatial Planning, and Environmental Mitigation Approaches

The respondents were asked on the suitable spatial planning and environmental mitigation approaches in order to enable sustainable infrastructural development without compromising the conservation of both the wildlife and the environment. The survey also interrogated the road planning process and the experts' involvement in order to ensure that all relevant fields are integrated in road planning. This minimizes critical issues which would arise before, during and after construction. This becomes critical especially when planning roads in critical conservation areas like the migration corridor.

4.6 Research Design

The research design used in this study was descriptive survey. Description of the state of affairs as they exist is the major purpose of descriptive research. Descriptive studies are not only restricted to fact findings, but may often result in the formulation of important principles of knowledge and solution to significant problems (Kerlinger, 1969). Household survey was employed in this study. Interview schedules were used to get information from the various

relevant experts in their respective institutions. The researcher used both primary and secondary data. Primary data was obtained through questionnaires and interview schedules while secondary data was gotten through the internet, journals and books. A diagrammatic representation of the research design is as shown in figure 4.
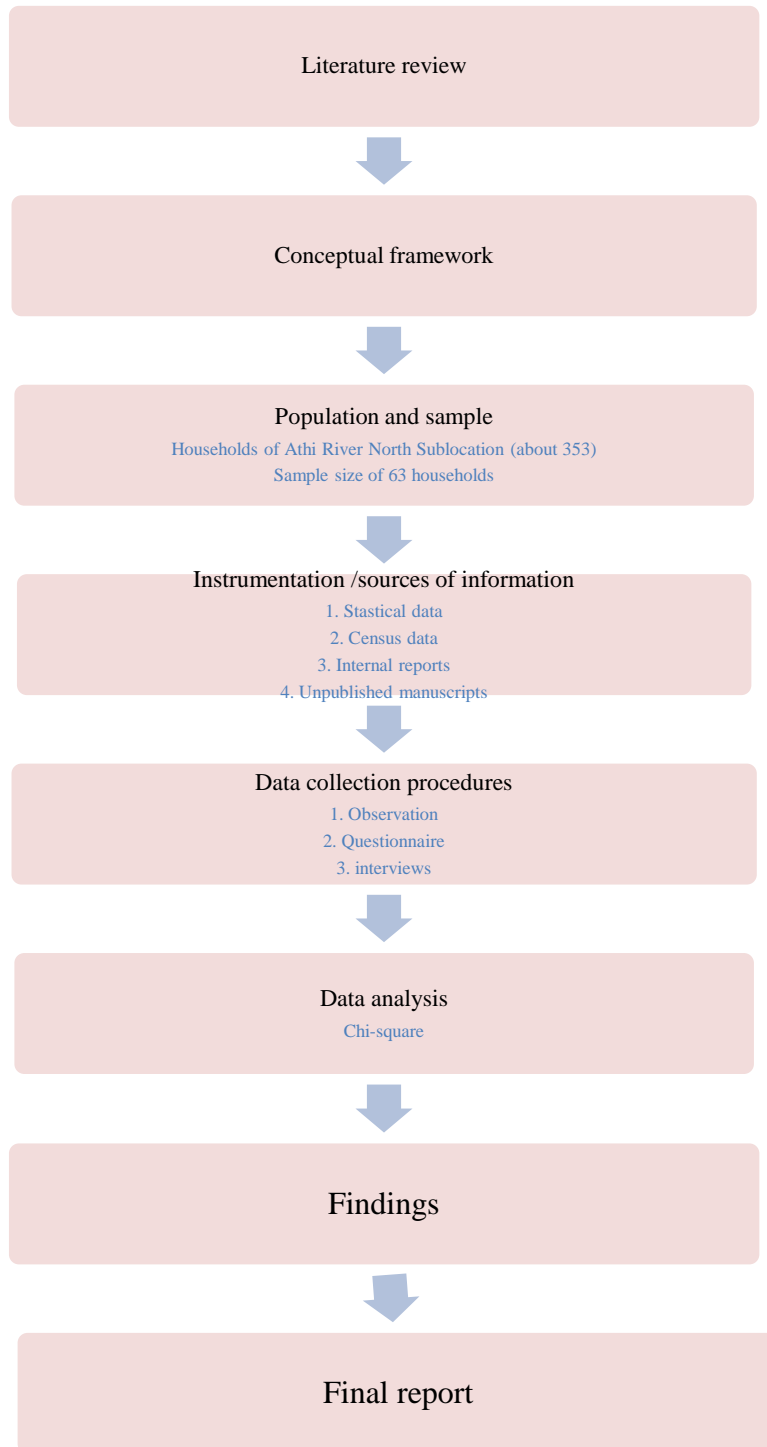
Figure 4: Research design. Source: Author, 2014.

4.7 Research Population

A population is any finite or infinite collection of individual objects (Kendall,et al,1957). It consists of a number of units of inquiry. The participants in this study consisted officials of KWS, African wildlife foundation, Friends of Nairobi National Park, NEMA, Kenya urban Roads Authority, and Physical planning department. The study object is the Wildlife. These include the species which are numerically dominant and major migratory animals in Nairobi National Park. Households residents in Athi River North Sub location were the participants. There were a total of 353 households in Athi River North Sub location according to Kenya population and housing census of 2009. The household residents provided information on the wildlife and how the road would impact the area. The institutions officials provided experts opinion on the roads planning and conservation aspects of the area. The households constitute the population from which sample was drawn.

4.8 Sample Size

According to Mugenda and Mugenda (2003), for descriptive studies ten percent of the accessible population is enough for a sample size. In this case assuming that 353 households (population and housing census, 2009) form the accessible population, the sample size would be about 36 households. A sample of 63 household questionnaires was administered in this survey (Table 1). A simple random sampling method was applied during the administration of the questionnaires.

Household questionnaires	
Research population (total households)	No. of Respondents
353 (Census, 2009)	**63**
Institutional interview schedules	
KWS	9
Physical planning department	4
NEMA	4
KURA	3
African Wildlife Foundation(AWF)	2
The Wildlife Foundation (TWF)	1
FoNNaP	1
UoN (Lecturer- Engineer &physical planner)	1
Total	**26**

Table 1: Sampling plan. Source: Field survey, 2014

4.9 Data Collection

Data collection methods employed are as shown in the figure 5 below:
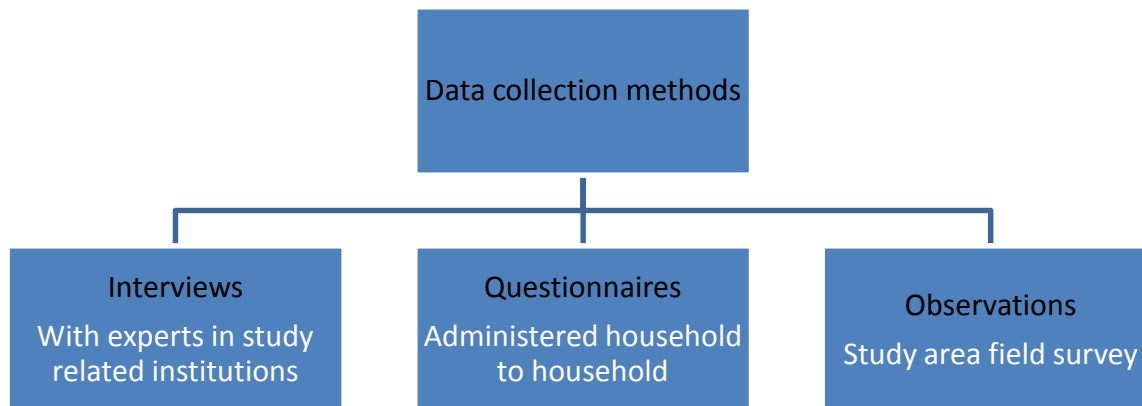
Figure 5. Data collection methods. Source: Author, 2014

Both primary and secondary data was collected;

A. Primary Data

This is the data which was collected on the area of the study by the researcher and his assistants. It was obtained through use of;

i. Questionnaires

These are the major instruments that were used to collect data. Some questions were structured while others were open- ended. The researcher and his assistants guided the respondents.

ii. Observation Reports

Notes were taken by the researcher and his assistants during the field survey

iii. Photographs

During the field survey some information was captured in form of photographs. Photographs included pictures of animals in the migration corridor, homesteads and any other features of importance to the study.

B. Secondary Data

This information was obtained from the written documents either published or unpublished. It was obtained from secondary sources such as, books, publications, government papers, internets, dissertations, maps and theses. Secondary data obtained include population census for households in Athi River North sub location.

4.10 Data Cleaning and Editing Procedures

Data cleaning is the proof reading of the data to catch and correct errors and inconsistent codes. It was done by the computer. Data editing was done during and after coding phase. This ensured checks for errors and omissions as well as ensuring that all questionnaires and interviews schedules were completed as required. The reliability of the interviews and inconsistencies in responses was checked.

4.11 Data Inputting

Data   coding and entry was carried out to enable specific analyses of the data. This was done by the researcher using Statistical Package for Social Scientists (SPSS).

4.12 Data Analysis

Data analysis was done using the Chi-square as the statistical technique to test the hypothesis. This is a non-parametric technique and therefore no assumptions about the data or the parameters in the population were made (Mugenda and Mugenda, 2003).

4.12.1 Hypothesis Testing

The hypothesis of this study is:
H1: The road is likely to negatively affect the migration of wild animals.
H0: The road will have no negative effect on the migration of wild animals

Chi-Square Test.

According to Mugenda and Mugenda (2003), Chi-square (X^2) is a statistical procedure which attempts to establish relationship between two variables both of which are categorical in nature. Chi-square test was used to test the hypothesis as the measurements are nominal and the observations were independent (Appendix III). All the expected frequencies were more than 5 and none was less than 1 (Table 2 and data on table 5).

	Affect negatively	No effect	Total
Road mortality	15 (15.5)	11(10.5)	26
Habit fragmentation	24(15.5)	2(10.5)	26
Human habituation	8(15.5)	18(10.5)	26
Habitat loss	20(15.5)	6(10.5)	26
Increased human use of area	19(15.5)	7(10.5)	26
Alteration of the physical environment	21(15.5)	5(10.5)	26
Modification of the animal behaviour	11(15.5)	15(10.5)	26
Mortality from construction	6(15.5)	20(10.5)	26
Total	**124**	**84**	**208**

Table 2: Relationship between impacts and the effect on migration of wild animals
Note: figures in brackets, e.g. (15.5) are the expected values (computed).

The significance level was set at 0.05

Degree of freedom (Number of rows -1) (Number of columns -1) = (8-1) (2-1) =7

Critical level of X^2 = 14.067

The computed X^2 Statistic = 48.26

Decision $x^2_{computed}$ =48.26 > x^2 expected= 14.067

Ho is rejected, i.e. the road is likely to negatively affect the migration of wild animals. The null hypothesis is rejected and the research hypothesis is accepted.

This study affirms the concerns of Kahumbu and Kent, (2013) that the construction of the GSB as planned will cut off the migration routes for the wildlife in Nairobi National Park. Arising from the accepted research hypothesis, it is evident that adequate mitigation measures must be put in place to enable sustainable transport corridor as well as wildlife conservation. Various experts in both transport planning and wildlife conservation must reach a consensus as to the best approach to address the two important land uses.

4.13 Data Presentation

Tables, charts, figures, and maps are used for illustration and presentation of data. These tools make it easier for special summary statistics to be obtained and presented. The analytical framework for the study is as presented in Table 3.

Objectives	Data needs	Sources of data	Data collection methods	Data analysis	Data presentation	Expected output
Identify and assess wildlife and other environmental concerns in the study area	Wildlife concerns in the area Other environmental concerns	Field survey KWS,NEMA FoNNaP	Literature review Questionnaire administration Interviews Observations photography	Content analysis qualitative and quantative analysis	Report Charts Photos	Identified wildlife and other environmental concerns
Examine impacts of proposed infrastructure development on the environmental and wildlife elements	Impacts of proposed infrastructure development on the environment Impacts of the infrastructure development on wildlife elements	Publications Field survey KWS,NEMA,KURA FoNNaP	Literature review Interviews	SPSS Content analysis	Report Charts Tables	A report on impact of proposed infrastructure development on the environmental and wildlife elements
Establish suitable spatial planning, wildlife and environmental approaches to mitigate against any negative impacts identified for sustainable transport corridor development	Information on environmental approach options The most appropriate environmental option Information on spatial planning approach Mitigations to identified negative impact	Wildlife agencies Transportation planners Conservation advocates KWS,NEMA, KURA, Planning Department FoNNaP	Literature review Interviews	SPSS	Reports Tables	A comprehensive report clearly analyzing spatial, wildlife and environmental approaches to mitigate against negative impacts identified.

Table 3: The analytical framework Source: Author, 2014

CHAPTER FIVE

STUDY FINDINGS

5.1. Background Information

There were 63 fully completed household questionnaires. Eighty three percent of the respondents were male and the rest female of ages ranging from 21 years and above with the majority from 31-50. Majority of the respondents are pastoralists who also practice some farming. These are the main economic activities of the resident community. There were 26 fully completed interview schedules from various experts, including Physical planners, Civil Engineers, Landscape architects, environmentalists, conservationists and Game wardens

5.2 Wildlife and other Environmental Concerns

5.2.1 Wildlife Concerns

Human-wildlife conflicts are the major wildlife concerns in the area according to 98% of the respondents. This is accelerated by the fact that the resident community mainly the Maasai is pastoralists with large herds of livestock. The forms of conflicts are killing of livestock by predators, damage to crops and fences, transmission of animal diseases, competition for pasture and home intrusion (Plate 2a and 2b). According to 51% of the respondents the main conflict is killing of the livestock by predators followed by competition for pasture at 22%, damage to crops and fences at 9%, transmission of animal diseases at 5% and home intrusion by wildlife at 5% (Figure 6).

Plate 2a: Animals and cattle grazing in the study area. Source: Field survey, 2014

Plate 2b: Human –wildlife conflicts - a goat killed by lions and one of the six lions killed by Maasai men in retaliation in 2012. Source: www.pastorist Kenya. Wordpress.com and www. Fonnapwordpress.com/2012. Accessed on 1-4-2014.
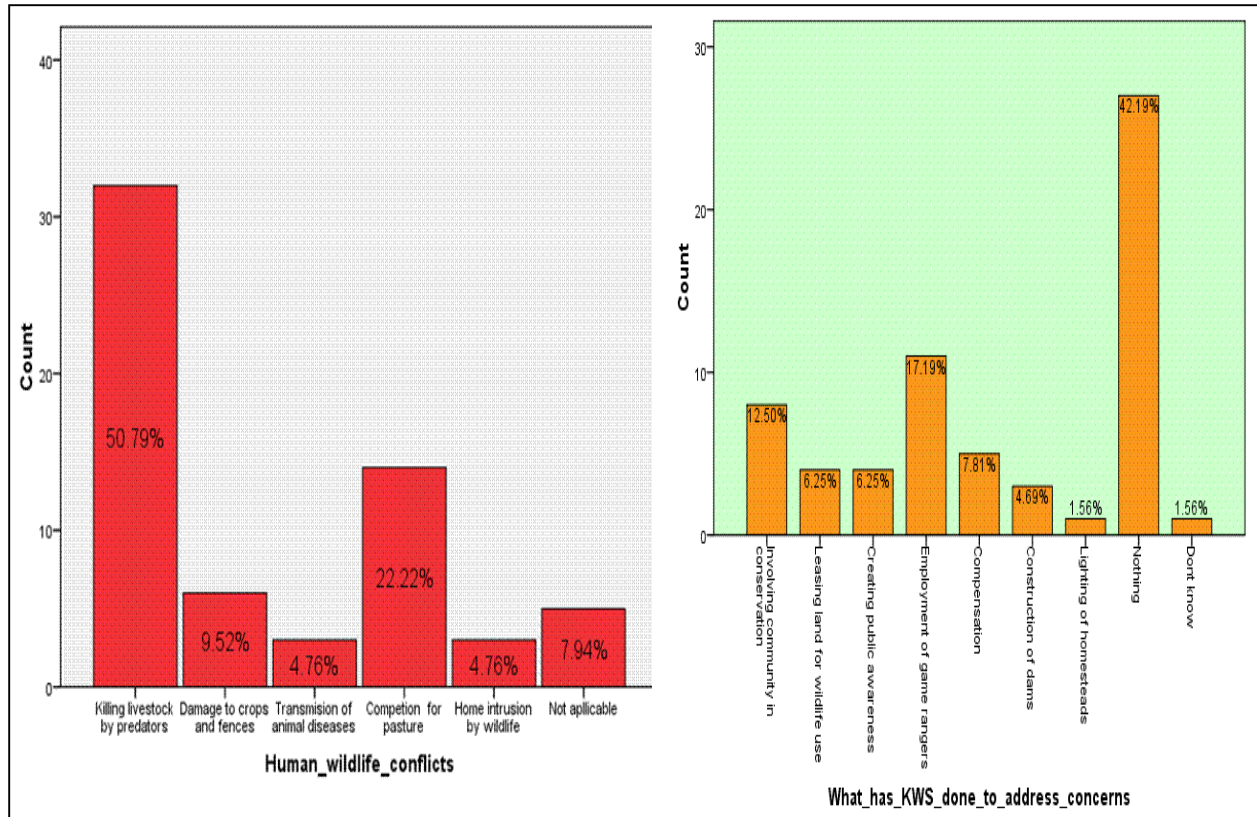
Figure 6: Forms of human-wildlife conflicts and mitigation by KWS. Source: Field survey, 2014

KWS is the main wildlife conservation agency in this area. According to Ninety three percent of the respondents KWS is aware of the conflicts. In mitigation of the conflicts, 42% indicated that KWS had done nothing, 17% KWS has employed more game rangers, 13% involving community in conservation, 8% compensation, 6% leasing land for wildlife use, 6% creating public awareness, 5% construction of dams, 2% lighting of homesteads while 1% do not know (figure 6). The large number of people who indicated that KWS has done nothing in addressing the conflicts clearly demonstrates the reasons for their frustrations when their livestock are attacked and is attributed to their revenge in killing the animals in retaliation.

Fifty four percent of the respondents indicated that there are aware of programmes in which the community is involved in wildlife management while 38% are not and the rest do not know. The programmes carried out include the following function; compensation of killed livestock, leasing of land for wildlife use, creating public awareness and involvement of the locals in conservation

(figure 7). Fifty one percent of the respondents indicated, they do not benefit from wildlife conservation, 22% benefit as source of income, 22% from creation of employment, 4% from construction of education infrastructure and 2% from preservation of natural beauty (figure 7). The large number of locals who believe that wildlife conservation has not benefitted them may not play their role as good partners in sustainable conservation.
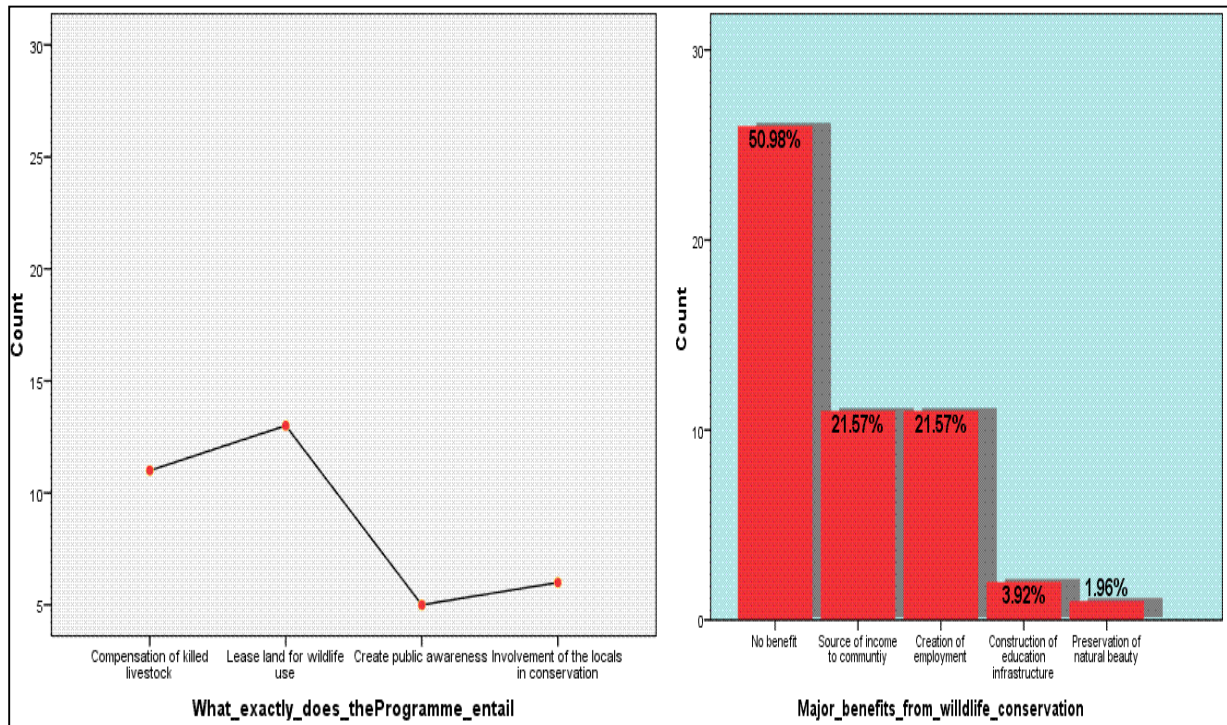
Figure 7: Operations of wildlife conservation NGOs and community benefits from conservation. Source: Field survey, 2014

Seventy eight percent of respondents are aware of the existence of wildlife conservation Non Governmental Organizations (NGO's) operating in the area while 23% are not. These NGO's are Friends of Nairobi National Park (FoNNaP), The Wildlife Foundation (TWF) and African Wildlife Foundation (AWF). The NGO's assist the community by 15% of respondents creating of public awareness, 25% compensation after loss of livestock, 23% mediation between KWS and the community, 11% source of income through lease programme, 8% through employment creation, 4% construction of education infrastructure, while 15% indicate there is no assistance (figure 8). These NGOs are important as they supplement the government efforts in wildlife

conservation and addressing related issues. They play a key role in promoting coexistence between the local community and the animals.
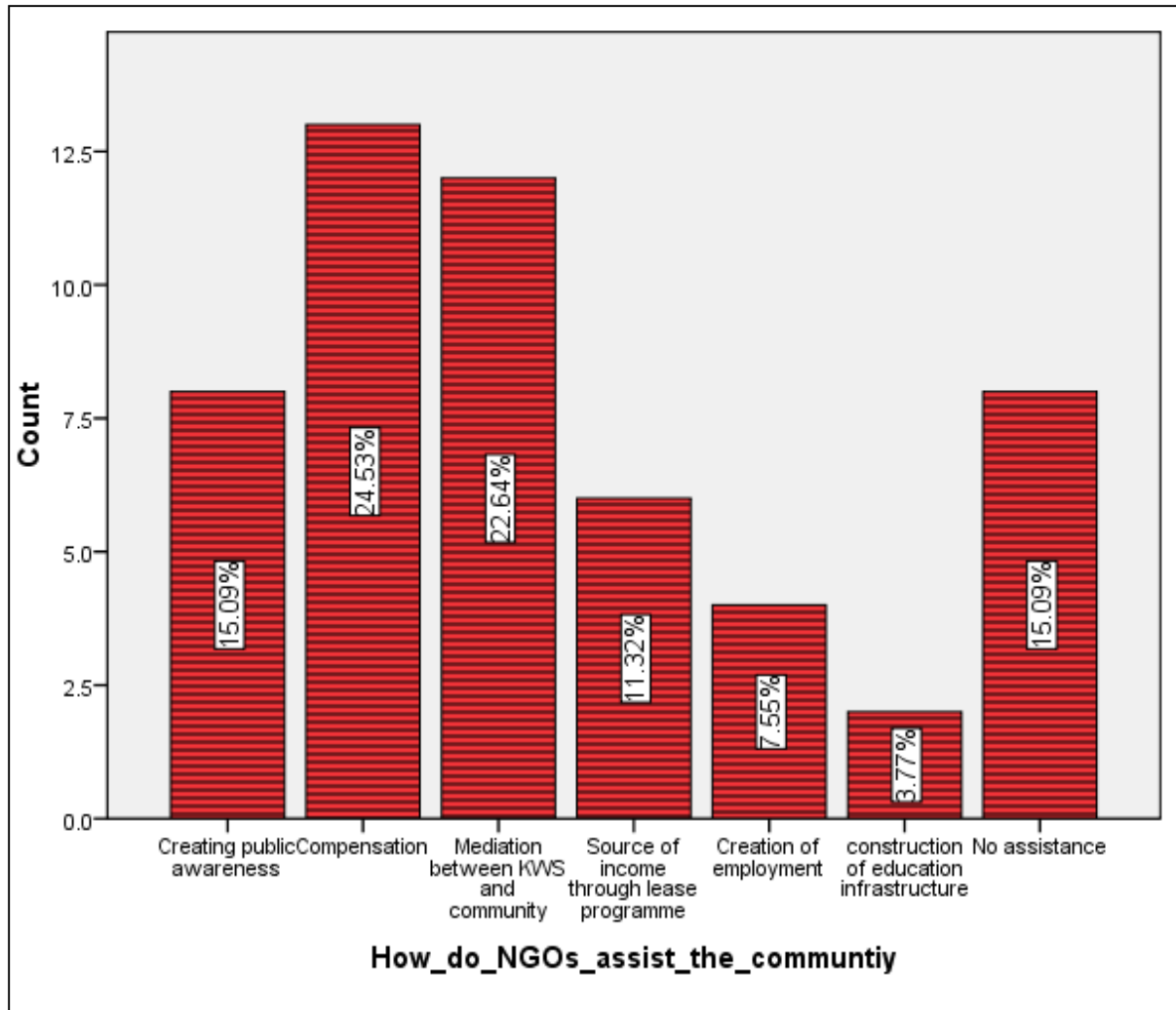
Figure 8: Assistance of NGOs to the community. Source: Field survey, 2014

Respondents had various views of the new road effect on wildlife, 38% resulting noise pollution would scare animals away, 22% would cut off migration, 14% decrease animal population, 12% road traffic would cause air pollution , 8% animal would relocate and 3% slow down wildlife migration (figure 9).
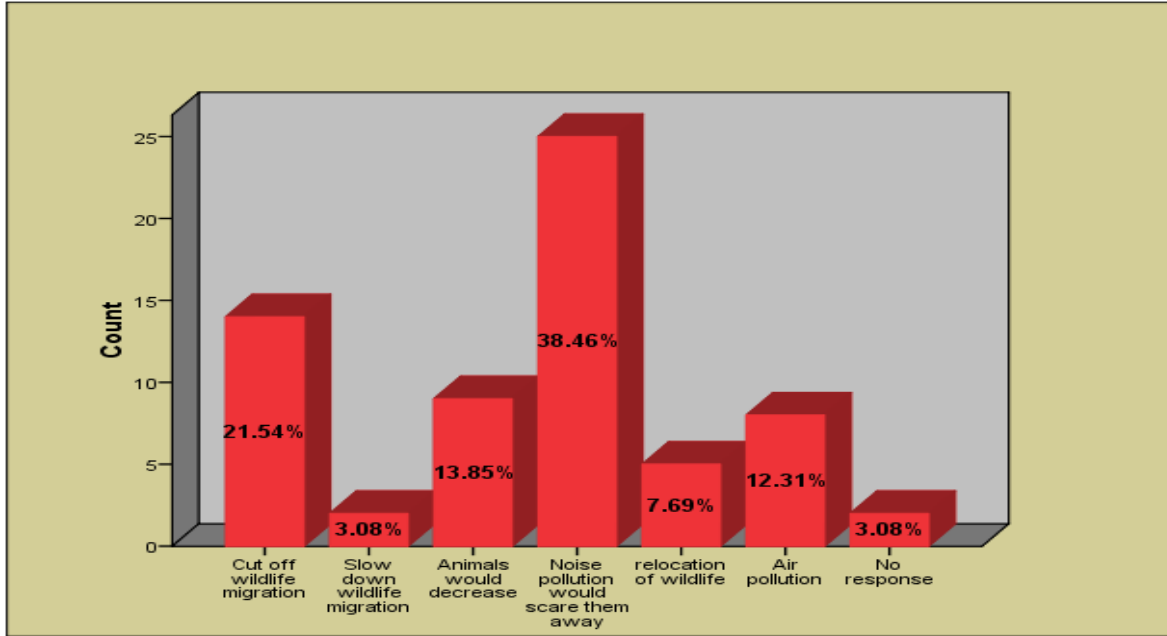
Figure 9: Effect of the new road on wildlife. Source: Field survey, 2014

Eighty percent of respondents indicated that the construction of the road would contribute to the destruction of NNP, while 20 % indicated otherwise (figure 10).
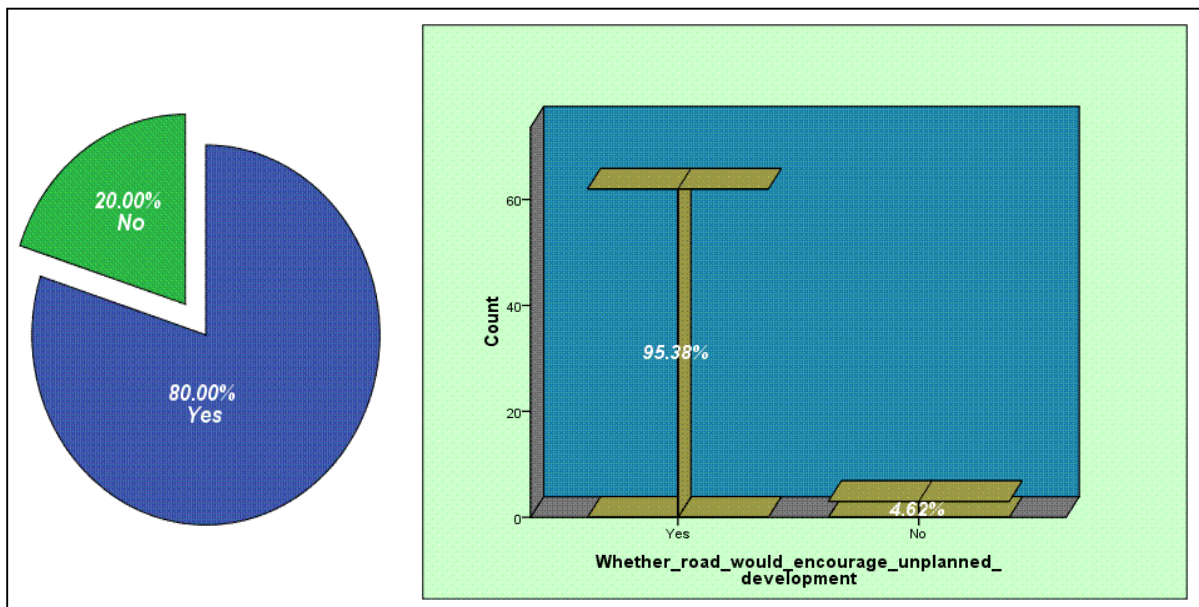
Figure 10: Respondents who indicated road construction will destroy NNP and encourage unplanned development. Source: Field survey, 2014

Eighty five percent are aware of animal migration, while the same percentage indicated that the road would cut off their migration route. According to 83% attempts have been made to secure the wildlife dispersal area, 16% no attempt. Eighty eight respondents indicated that construction of the road would reverse previous gains made towards securing the dispersal area. The road would become a barrier to wildlife movement.

According to 95% of respondents the road would encourage unplanned development as opposed to 5% (figure 10). The developments which include increased human settlement would not only provide a physical barrier to animal movements but also reduce their habitat.

Seventy seven percent of respondents indicated that the road would increase the wildlife and livestock conflict while 23% indicated it will decrease. One of the conflicts according to respondents is, 95% the road will result in compression of the pastures compared to 5% who indicated otherwise. This would introduce competition for the remaining pastures. As a result according to 97% of the respondents the road will put more pressure on the remaining grassland leading to desertification, 3% it will not. Ninety five percent indicated that the road traffic would result in noise pollution which would disrupt wildlife normal behaviour, compared to 5% who indicated otherwise. According to 88% of the respondents, the effect of having no migration route would reduce the number of wild animals, 12% the animals would increase. The effect of cutting off the breeding grounds, 94% animals would decrease, 6 % there would be no effect.

5.2.2 Environmental Concerns
Eleven respondents (17%) reported that their major environmental concern is increased human settlement, 11(17%) soil erosion, 10(16%) Pollution, 9(14%) reduced water quality, 8(13%) deforestation 8(13%) harvesting sand/soil/murram and 8(13%) quarrying (figure 11, Plates 3a, 3b, and 3c). The soil erosion in the area is due to exposure of the ground as the area has limited tree cover. Quarrying activities are very common in the area as the quarries provide raw materials to the various cement factories in Athi River.
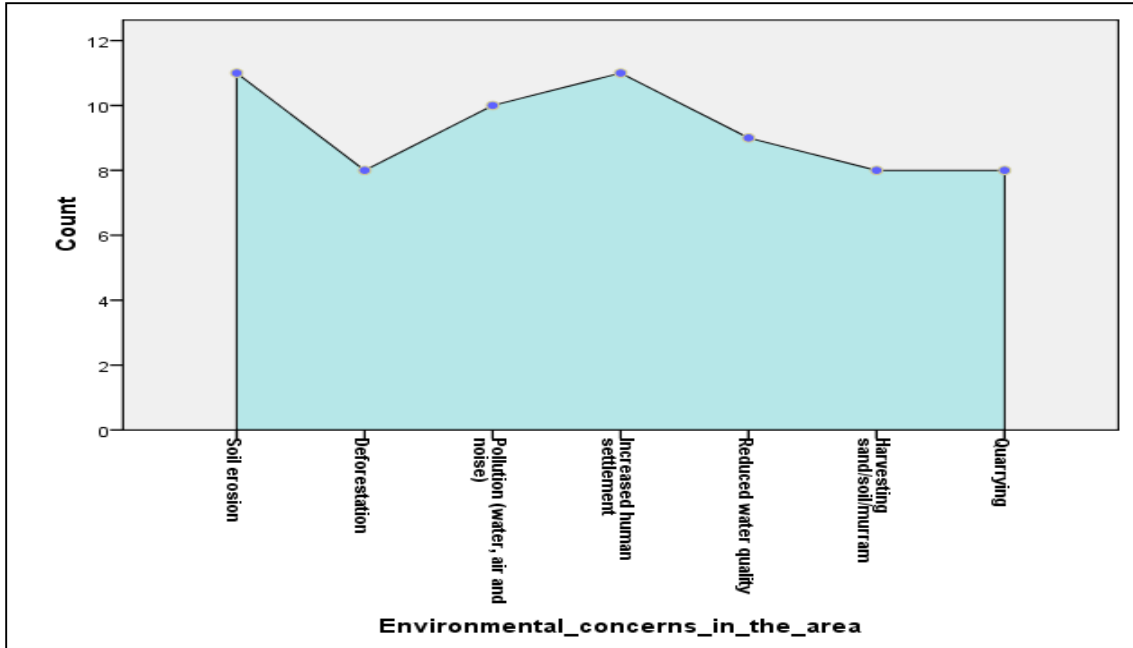
Figure 11: Environmental concerns. Source: Field survey, 2014

Plate 3a: Quarrying activities resulting in environmental degradation. Source: Field survey, 2014

Plate 3b: Environmental degradation is a great concern. Source: Field survey, 2014

Plate 3c: A woman fetches water in the river next to the bridge of the proposed road, sand harvesting is also carried out in the river bank. Source: Field survey, 2014

According to most respondents 68% the government has done nothing to address environmental concerns, 18% is encouraging afforestation, 9% creating public awareness, 3% enacted forest act and 2% is conserving catchment areas (figure 12)
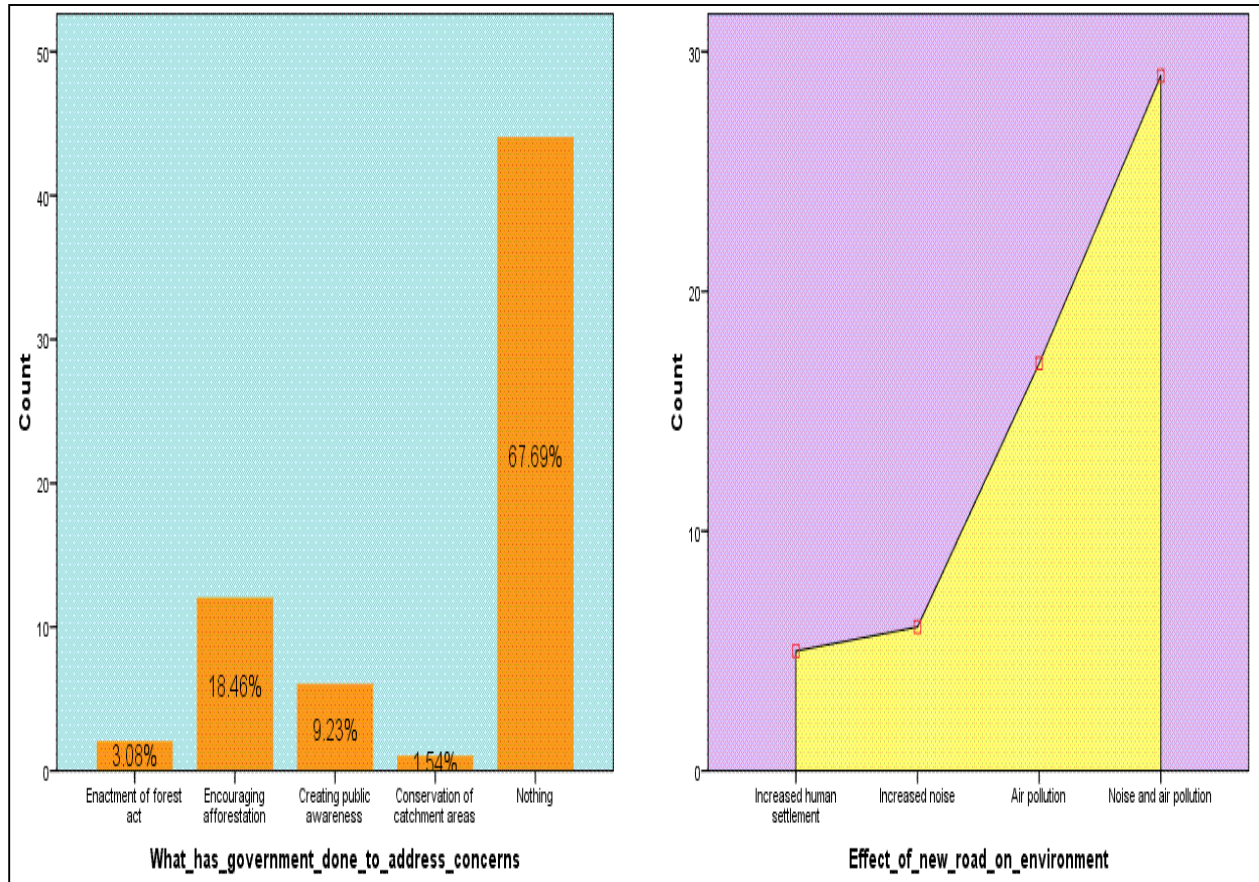
Figure 12: Government efforts to address environmental concerns and effect of new road on the environment. Source: Field survey, 2014

Thirty of the 59 (51%) who responded on effect of new road on the environment indicated noise and air pollution as the main effect, 18(31%) air pollution, 6 (10%) increased noise and 5(8%) increased human settlement (Figure 12).

5. 2.3. Road Network
Only 12% of the respondents reported the condition of the roads network to be good, 25% bad and 63% very bad (figure 14). The roads are very dusty in the dry and almost impassable in the rainy season (figure 14).

Figure 13: Condition of roads*: Source: Field survey, 2014*

Eighty five percent are aware of the government intention to construct the new road while 15% are not aware. All the respondents would like a new road to be constructed. According 49 % of the respondents the road would ease transportation, 28% create employment, 14 % increase land values, 8% reduce human wildlife conflict and 1% attract development (figure 14). These would be the benefits of the new road.
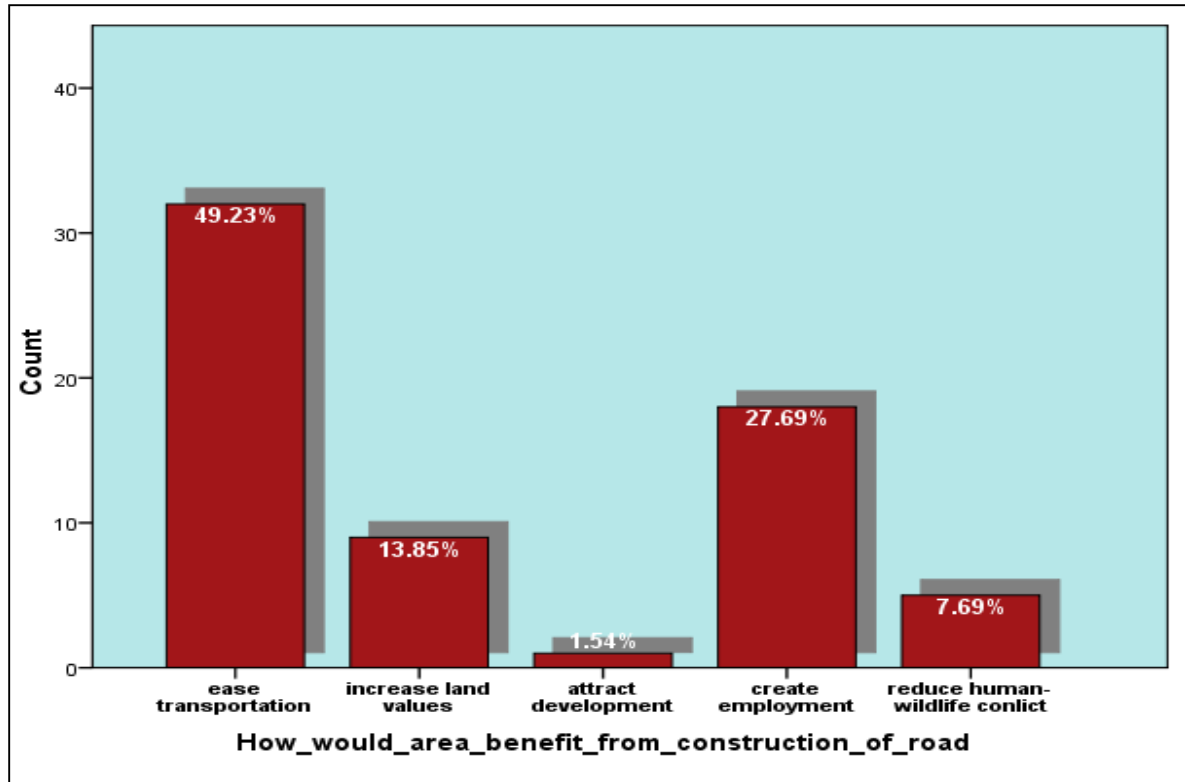
Figure 14: Benefits of the area arising from road construction. Source: field survey, 2014

5.3 Impacts of Proposed Infrastructure Development on Environment and Wildlife Elements

5.3.1 Road Planning in Conservation Area.

Most respondents are aware of the proposed greater southern bypass (92%), compared to 8% who are not. Fifty seven percent of respondents indicated that road designers/ planners consult with conservation agencies when planning and designing new roads, 31% no consultations and 12% do not know (figure 15). Lack of consultations during road planning especially in critical conservation areas would negatively undermine the environmental and wildlife conservation.

Eight of 18 (45%) respondents reported that designers/planners should consult with conservation agencies at planning phase of the road planning, 6 (33%) at project development, 2 (11%) right of way and 2(11%) during final design (figure 15).
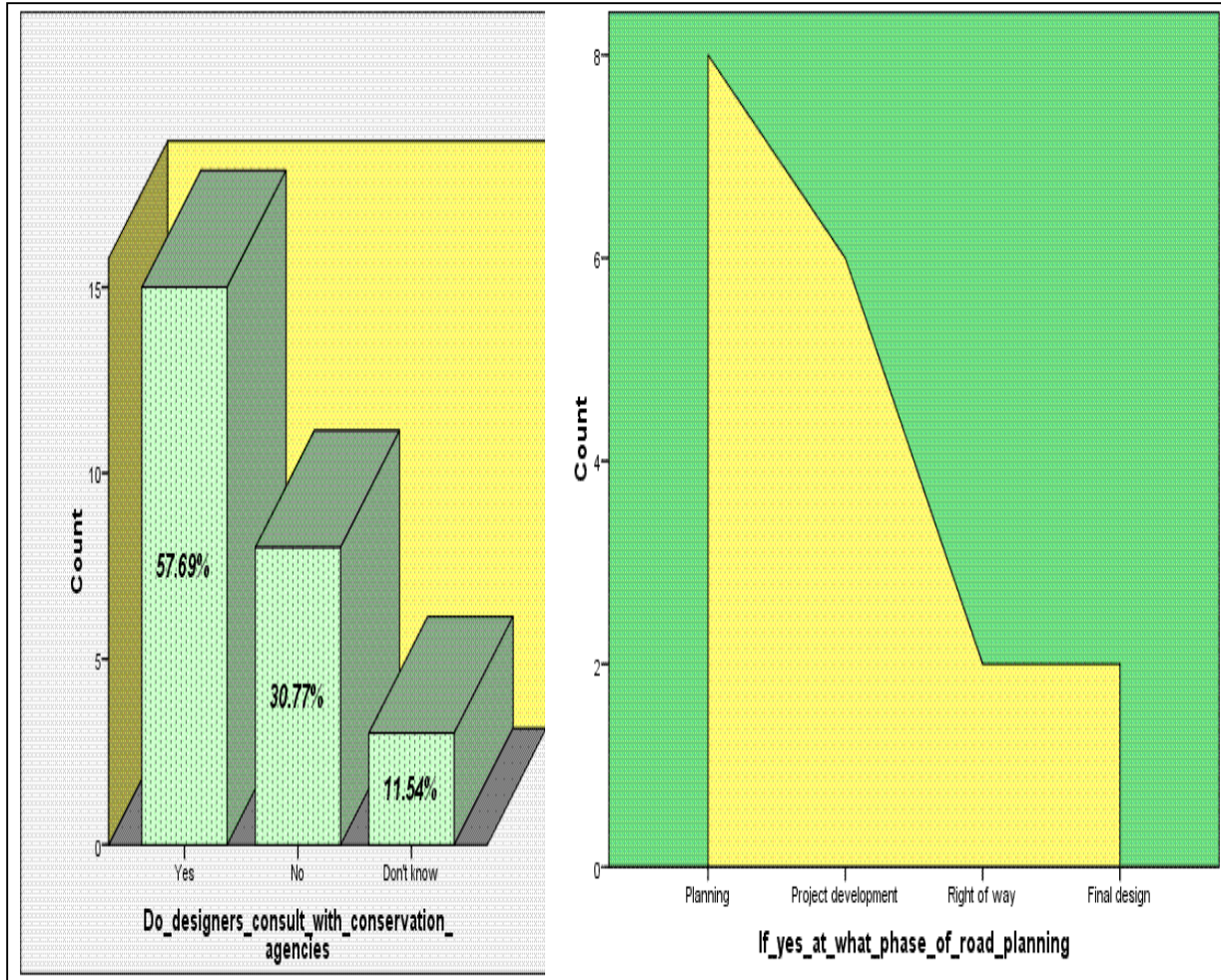
Figure 15: Consultation of designers/ planners when planning and designing new road and the phase of road planning when they should consult with conservation agencies. Source: Field survey, 2014

Seventy three percent of the respondents reported that environmentalists are consulted during the planning of the road, 19% are not consulted, 8 % don't know (figure 16).
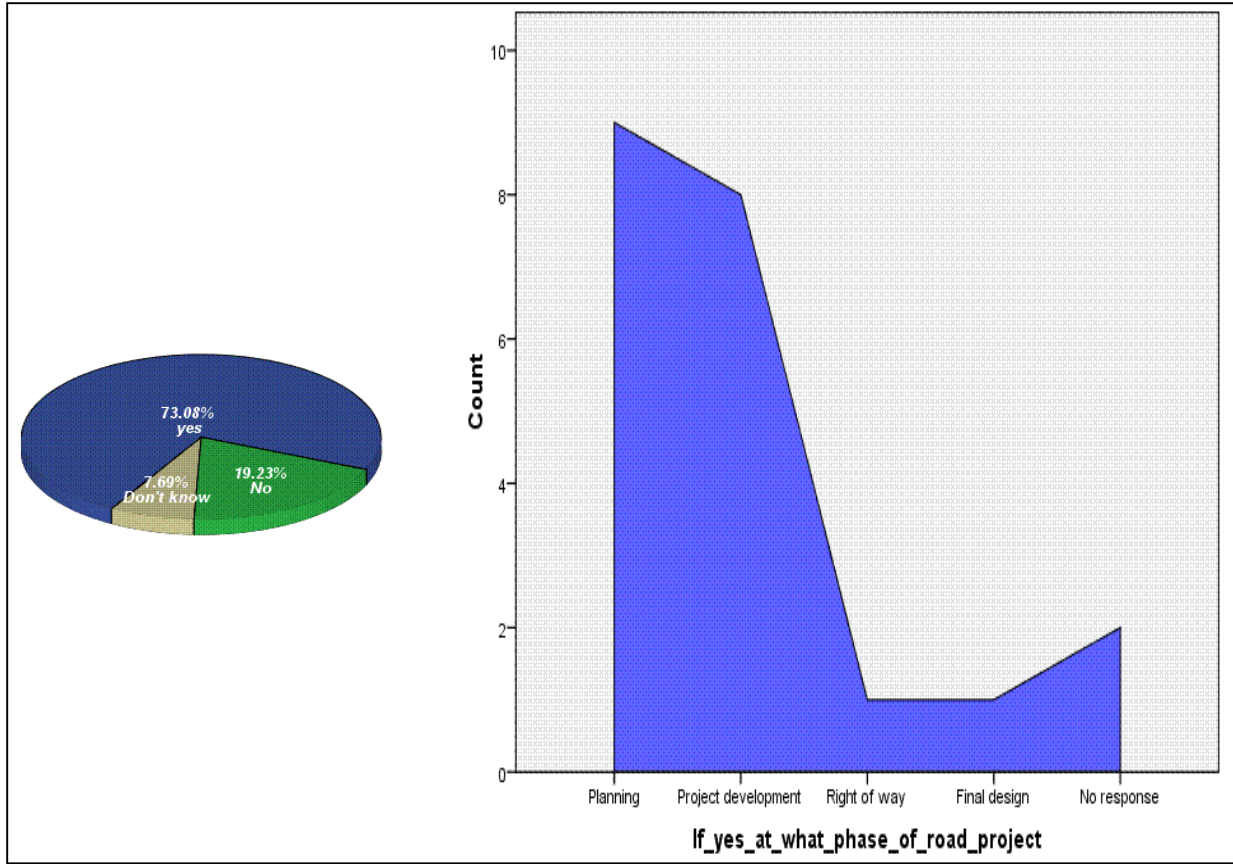
Figure 16: Whether environmentalists are consulted during planning of the road and phase of road project when consultations are done. Source: Field survey, 2014

Nine out of 21(43%) respondents indicated that consultation with environmentalists occurs at planning phase, 8(38%) at project development, 2(9%) did not response, 1(5%) right of way, 1(5%) at final design (figure 16)

In order to accommodate all environmental and conservation concerns in a road project, 18 (69%) of the respondents indicated the ideal phase of the project when environmentalists should be consulted should be at planning stage, 7(27%) project development and 1(4%) all phases (figure 17). When consultations are done the negative environmental and wildlife conservation impacts are identified and mitigation planned for early enough to minimize or eliminate them altogether.
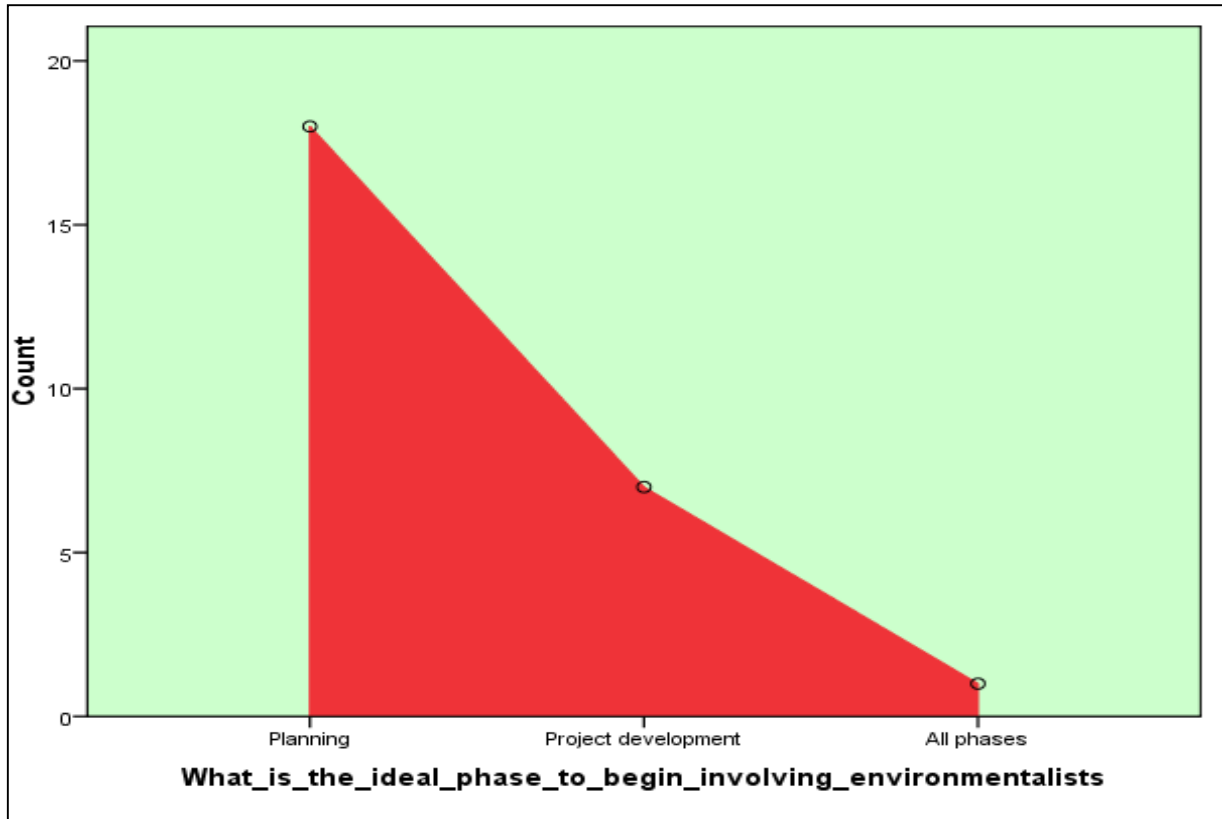
Figure 17: Ideal phase of road project to consult environmentalists. Source: Field survey, 2014

Majority of the respondents (96%) are of the view that wildlife conservation issues should be given priority when planning the road bypass compared to 4% of the contrary view.

Eighty five percent of the respondent reported that there are conservation plans, 8% no and 7% are not sure. These plans according to 56 % of respondents inform the transportation plans, 32% no and 12% do not know. More often, there is lack of consultations with wildlife government agencies such as KWS and conservation NGOs. Various reasons were brought up why conservation plans do not inform transportation plans, 12% no alternatives provided in case of conflicts, 6% conservation is usually compromised, 18% no consultations between relevant government agencies, 6% not adhering to land control regulations, 17% lack of consideration by transportation planners, 6% no conservation plans, 35% no response (figure 19).
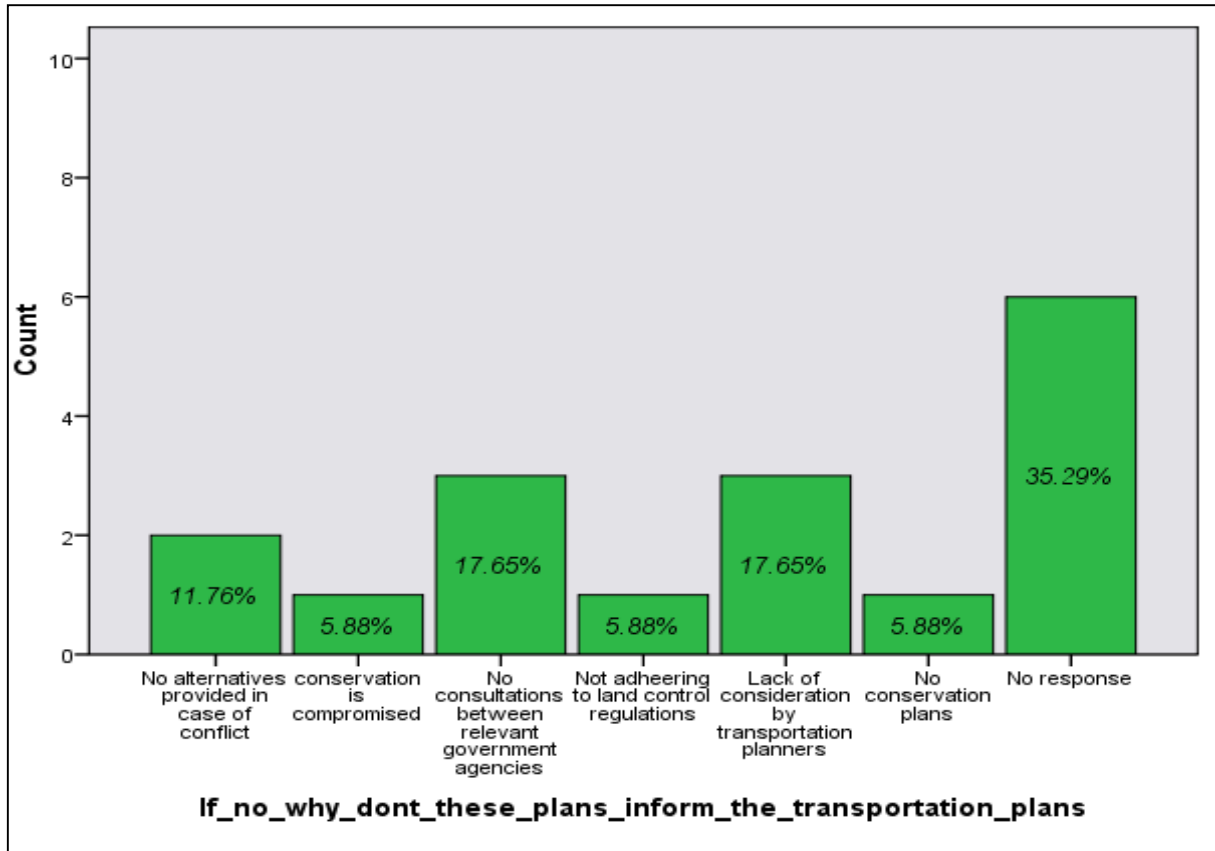
Figure 18: Reasons why conservation plans do not inform transportation plans. Source: Field survey, 2014

Fifty six percent of the respondents reported that wildlife agencies and conservationists share spatial data for habitat and conservation areas with transportation planners, 40% no data is shared and 4% do not know. Sometimes when NEMA puts an advert in the dailies on road construction project, conservationists can share spatial data as a way and means of justifying their opposition to the project in case it is passing through wildlife prime areas. However there are times when no reference is made to the spatial data which in most cases are very comprehensive.

On whether the road project should go on taking into consideration its effect on the wildlife and environment, 73% indicated it should proceed while 27% rejected it (figure 19).
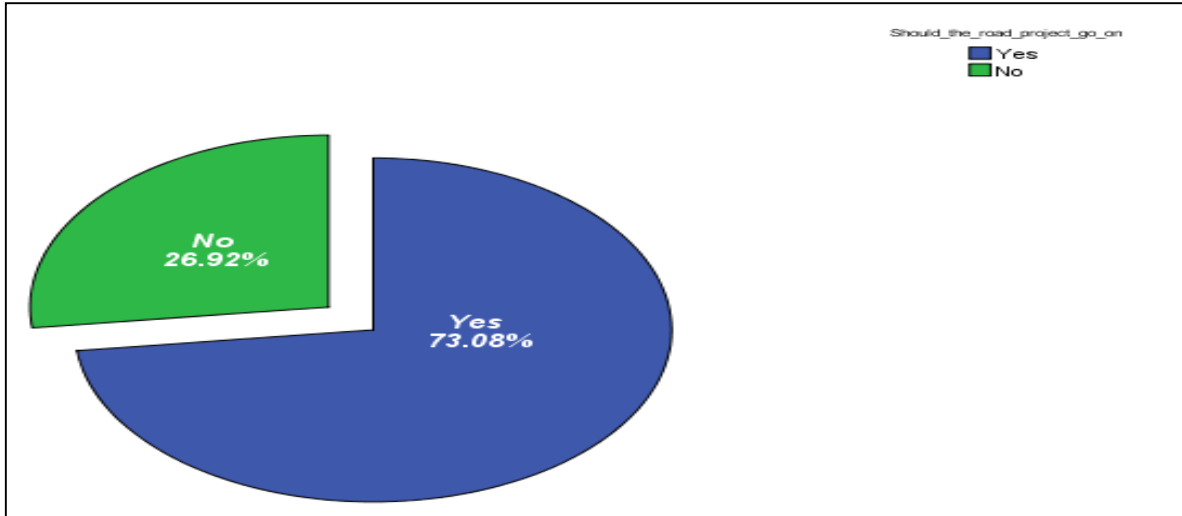
Figure 19: Respondents view on the road project. Source: Field survey, 2014.

Respondents who indicated that the road project should proceed gave the following views, 41% mitigate negative impacts, 18% road would ease congestion, 41% no views (not applicable) (figure 20). Majority were of the view that the project should go on as long mitigation measures are put in place.
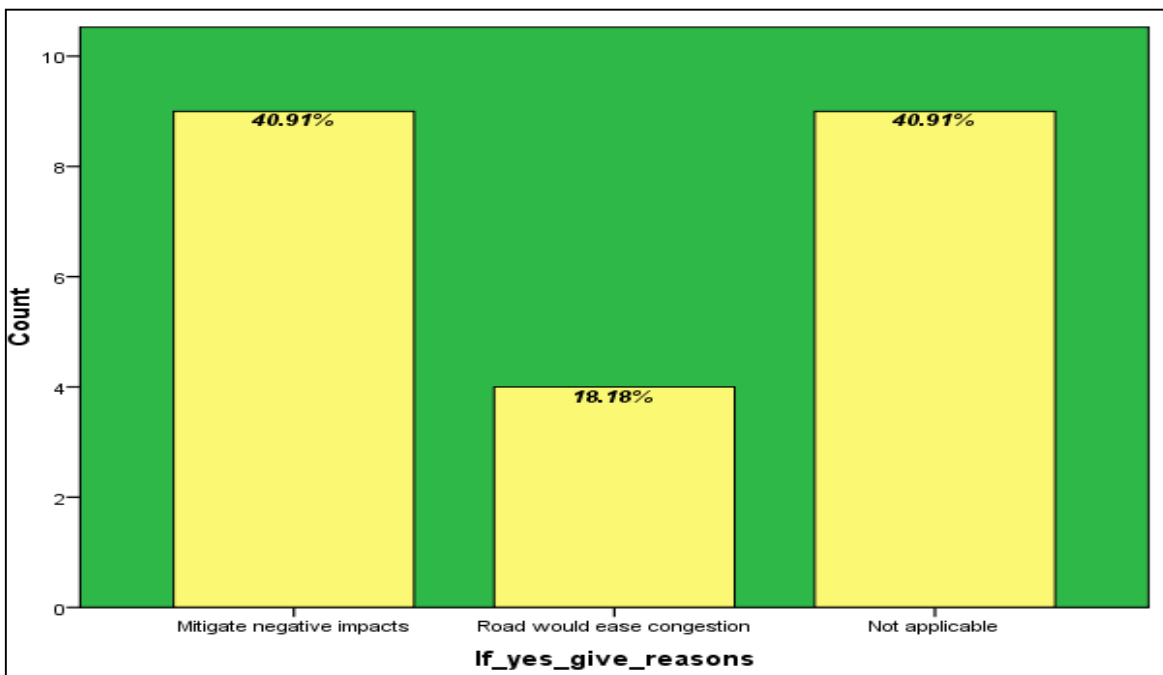
Figure 20: Views on why road project should proceed. Source: Field survey, 2014

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Those who opposed the road had the following views; 23% will disrupt dispersal area, 8% negative impacts, 8% loss of foreign earnings, 4% relocation of road, 58% no views(not applicable) (figure 21).
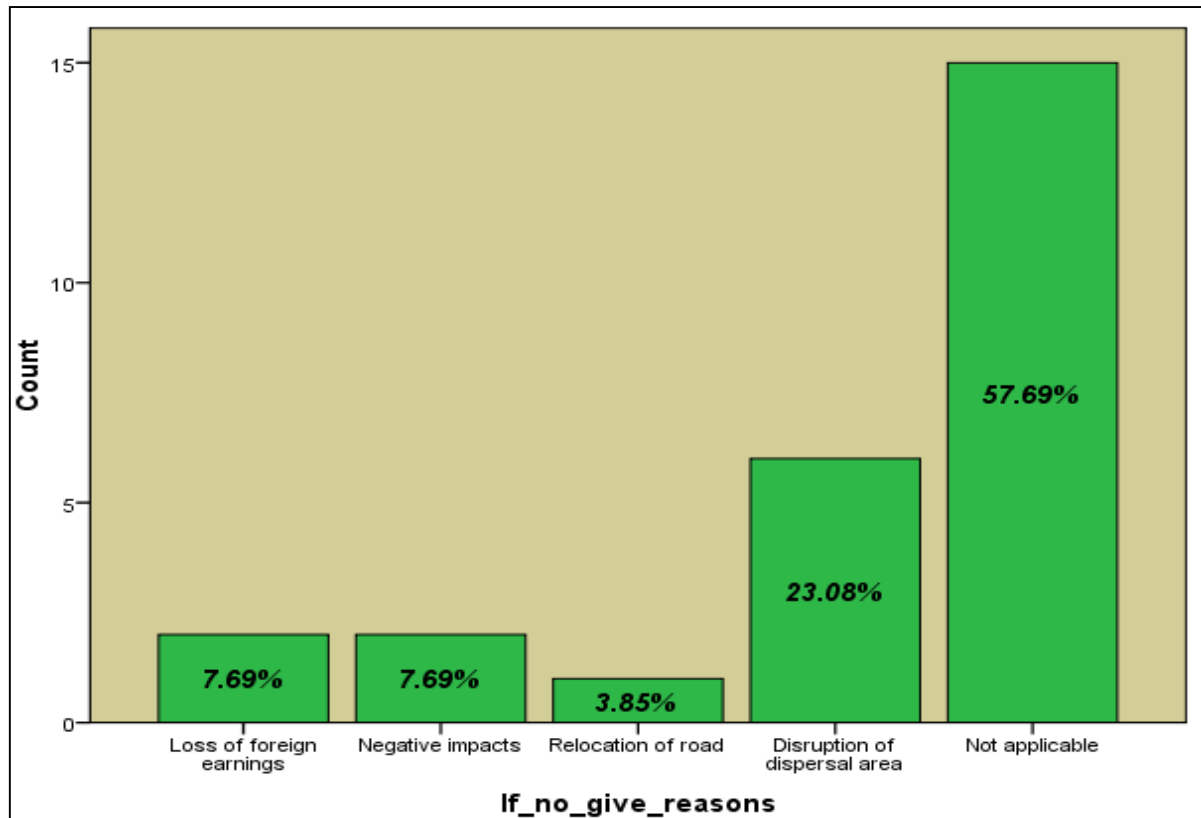
Figure 21: Views on why road project should not proceed. Source: Field survey, 2014

According to all the respondents cooperation between transport and regional planning, wildlife management and nature conservation should be improved. The reasons indicated were; 29% to propagate integrated approach, 29% address underlying issues, 17% coordinated development, 9% involvement of all stakeholders, 8% promote consensus and 8% sustainable development (figure 22).
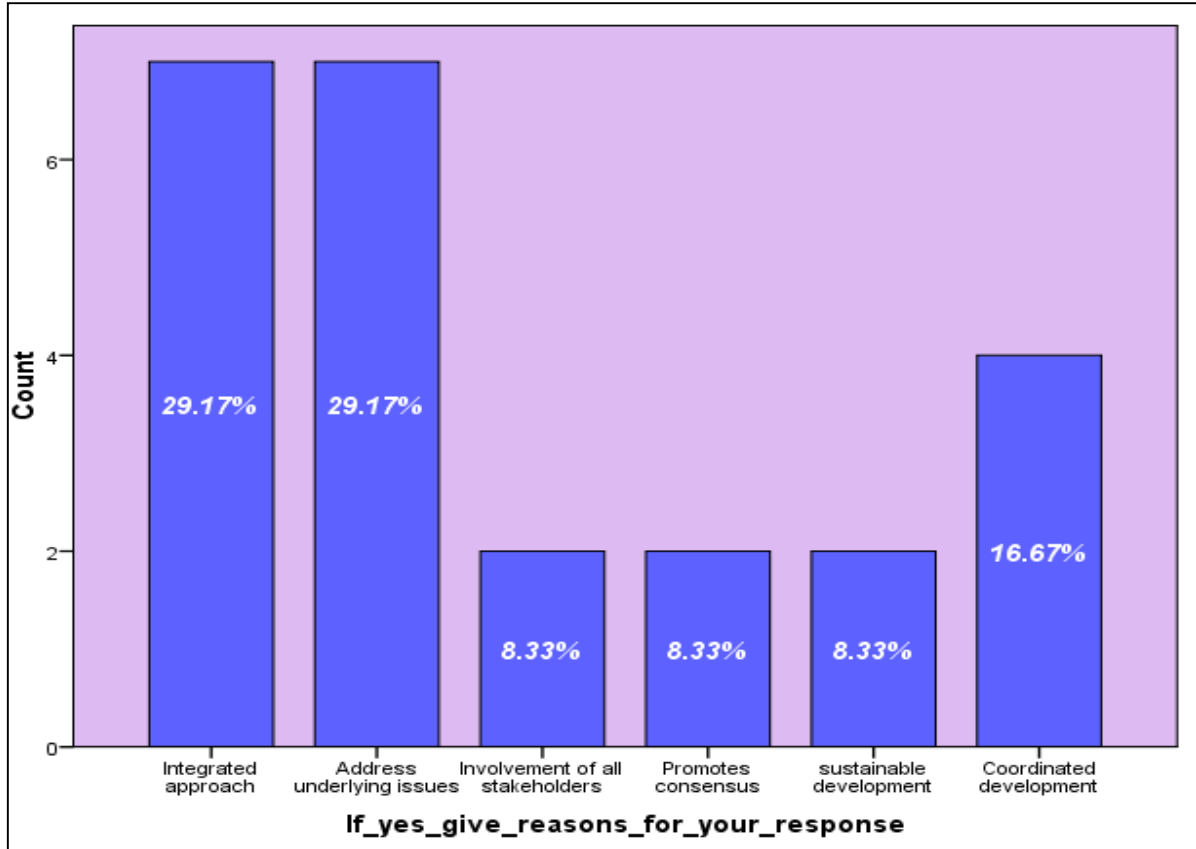
Figure 22: Reasons for enhancing cooperation between transport, regional planning, wildlife management and nature conservation. Source: Field survey, 2014

5.3.2. Impacts of Proposed Infrastructure Development on Environmental Elements

When asked whether the road bypass will have an effect on the environment of the immediately adjacent habitat (respondents could check more than one response), 92% reported it would have while 8% indicated otherwise. All the respondents indicated that pollution as a result of the constructed road would affect the environment, followed by 88% soil erosion, 85% reported it will lead to increased noise, 85 % increased human settlement, 80% drainage systems, 80% deforestation, 73% edge effects, 72 % reduced water quality and 57% increased spread of invasive species (Table 4)

Environmental impact	No. of Respondents recognizing it effects on environment (%) (n=26)
Pollution	26 (100%)
Soil erosion	23 (88%)
Increased noise	22 (85%)
Increased human settlement	22 (85%)
Drainage systems	21 (80%)
Deforestation	21 (80%)
Edge effects	19 (73%)
Reduced water quality	19 (72%)
Increased spread of invasive species	15 (57%)

Table 4: Impact of road on the environment. Source: Field survey, 2014

All the respondents reported that the road would result to an increase in human settlement consequently increasing the land values (Plate 4).

Plate 4: Human settlement next to the proposed transport corridor as animal graze alongside the dusty road with land sale signpost. Source: Field survey, 2014

5. 3.3. Impacts of Proposed Infrastructure Development on Wildlife Elements

When asked on which impact would significantly affect wildlife if the bypass is constructed as proposed (respondents could check more than one response), 92% indicated habitat fragmentation, 81% alteration of the physical environment, 77% habitat loss, 73% increased human use of the area, 58% road mortality, 42% modification of the animal behaviour, 31% human habitation/animal feeding and 23% mortality from construction (Table 5).

Impact of road on wildlife	No. of Respondents recognizing it significance (%) (n=26)
Road mortality	15 (58%)
Habitat fragmentation	24 (92%)
Human habituation/ animal feeding	8 (31%)
Habitat loss	20 (77%)
Increased human use of the area	19 (73%)
Alteration of the physical environment	21 (81%)
Modification of the animal behavior	11 (42%)
Mortality from construction	6 (23%)

Table 5: Impact of the road on wildlife. Source: Field survey, 2014.

Most respondents estimated that the impacts of road mortality (100%), mortality from construction (85%), and increased human use of the area (62%) were the most significant at local level (Table 6). The estimates of the effects of habitat loss and modification of animal behaviour were more evenly distributed, but the greater number of respondents put then at landscape level (42% and 41% respectively). Road mortality had no effect on regional and landscape scale level. Increased human use of the area and mortality from construction had no effect at the landscape

scale. Alteration of the physical environment was also evenly distributed, but the greater number of respondents put it at regional scale (42%).

Impact of road on wildlife	Local Scale (n=26)	Regional Scale (n=26)	Landscape Scale (n=26)
Road mortality	26 (100%)	0 (0%)	0 (0%)
Habitat fragmentation	8 (31%)	11 (42%)	7 (27%)
Habitat loss	8 (29%)	8 (29%)	10 (42%)
Increased human use of the area	16 (62%)	10 (38%)	0 (0%)
Alteration of the physical environment	8 (29%)	10 (42%)	8 (29%)
Modification of the animal behavior	7 (27%)	8 (32%)	11 (41%)
Mortality from construction	22 (85%)	4 (15%)	0 (0%)

Table 6: Estimated level of magnitude of road impacts on wildlife populations. Source: Field survey, 2014

The length of the proposed road is about 32.5 kilometres (Kitengela loop, map 3). Considering the normal width of the bypass at 60 metres, this would contribute to a direct habitat loss of approximately 195 hectares (480 acres).

According to 35% of the respondents speeding contributes to the most road-related mortality of wildlife, 23% night time driving/poor visibility, 23% unpredicted animal behaviour, 11% weather conditions. 8% of the respondents did not answer this question (figure 23).
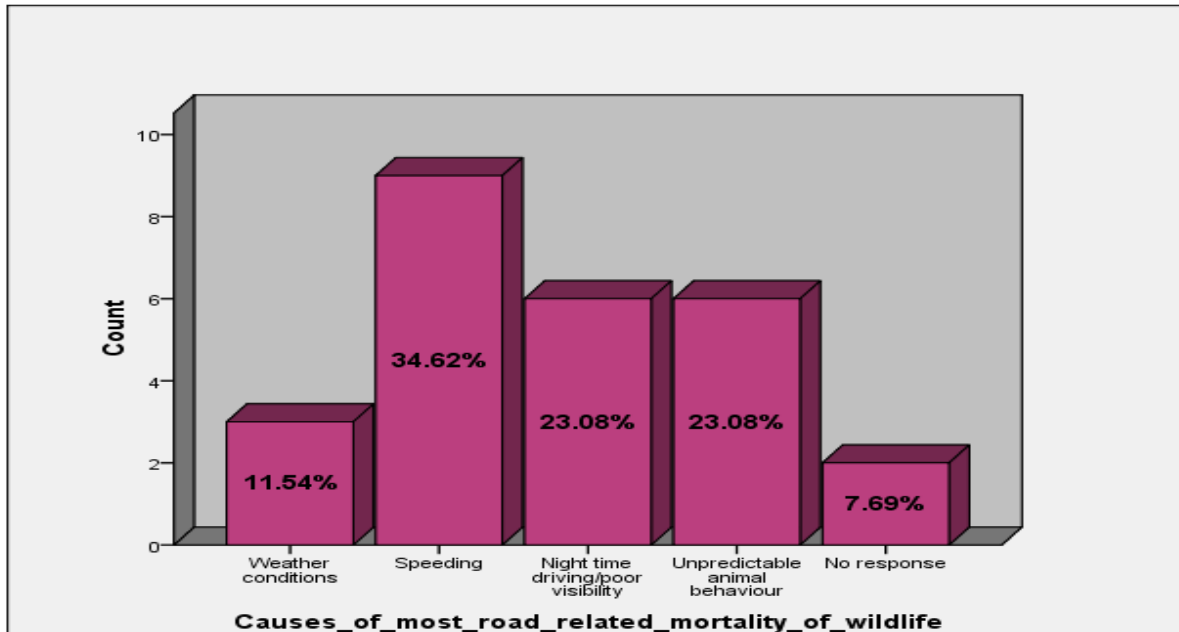
Figure 23: Causes of most road related mortality of wildlife. Source: Field survey, 2014

All the respondents reported that road construction will limit the natural migration of the animals and result in increased animal –vehicle collisions.

Eighty five respondents indicated that the bypass would act as a barrier and reduce migration possibilities to wildlife species, 15% indicated it will have no effect.

Forty two percent of the respondents reported that wildebeest would be most affected by the road bypass, followed by 38% zebra, 8% coke's hartebeest, 8% eland and 4% giraffe.

When asked how the cut off migration corridor would affect the wildlife population, 92% indicated it will decrease and 8% did not answer.

According to 92% of the respondents the wildlife population in NNP is vulnerable to road impacts arising from the construction of the road. Eight percent did not respond to this question (figure 24).
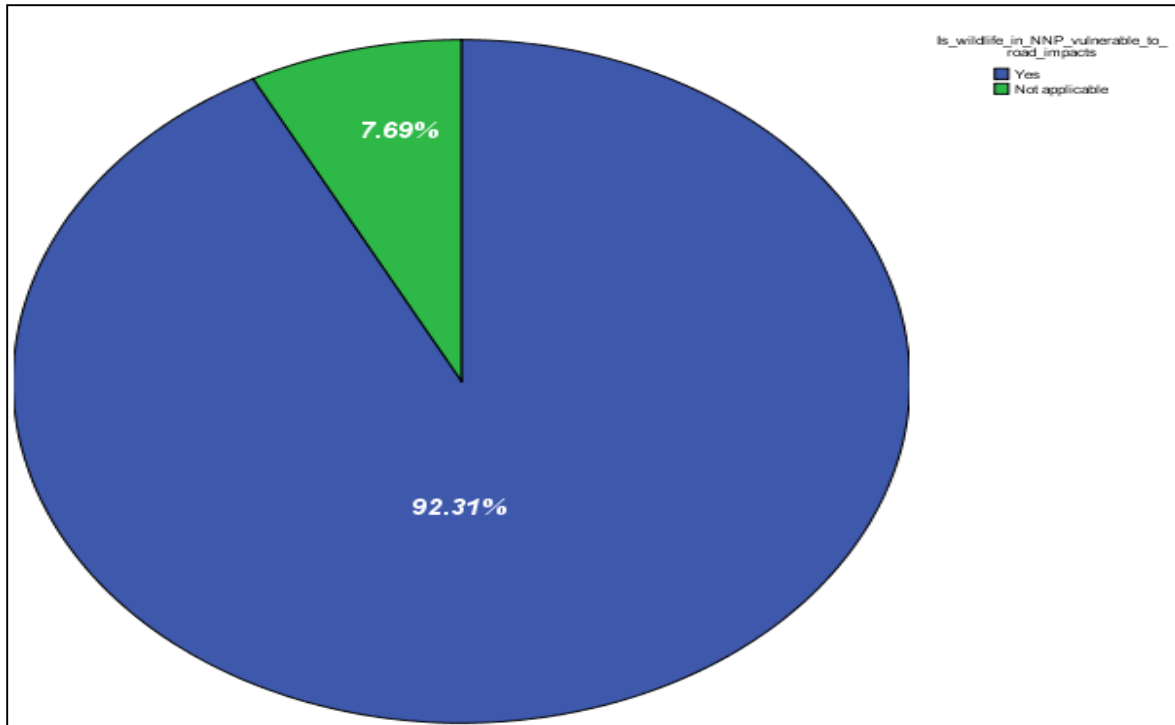
Figure 24: Vulnerability of wildlife population in NNP after construction of road. Source: Field survey, 2014.

The reasons given for the vulnerability of wildlife in NNP are, 22% habitat fragmentation will complicate wildlife management, 22% increase in wildlife mortality, 22% lack of migration will affect breeding, 11% increase in human-wildlife conflicts, 11% loss of habitat, 11% poor gene diversity(figure 25).
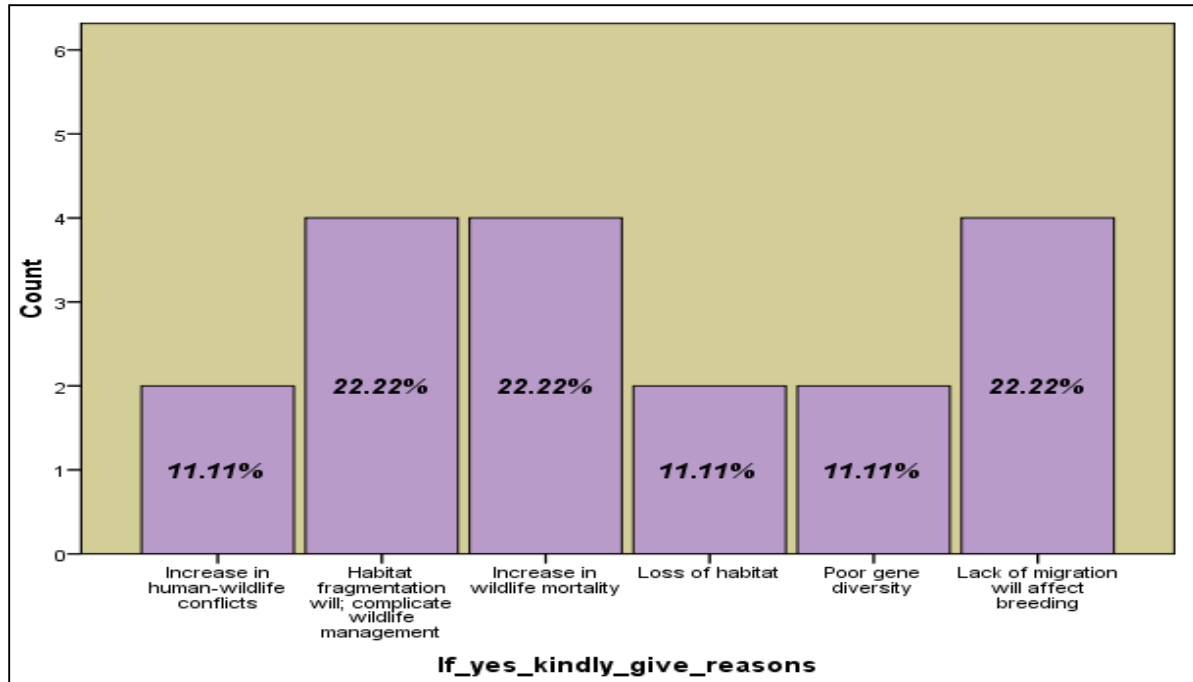
Figure 25: Reasons why wildlife population in NNP is vulnerable to road impacts arising from the constructed road. Source: Field survey, 2014.

When asked about the greatest ecological effect of the road, 27% indicated environmental degradation, 23% direct wildlife mortality, 19 % habitat fragmentation, 16 % habitat loss, and 15% road avoidance behaviour by wildlife (figure 26).
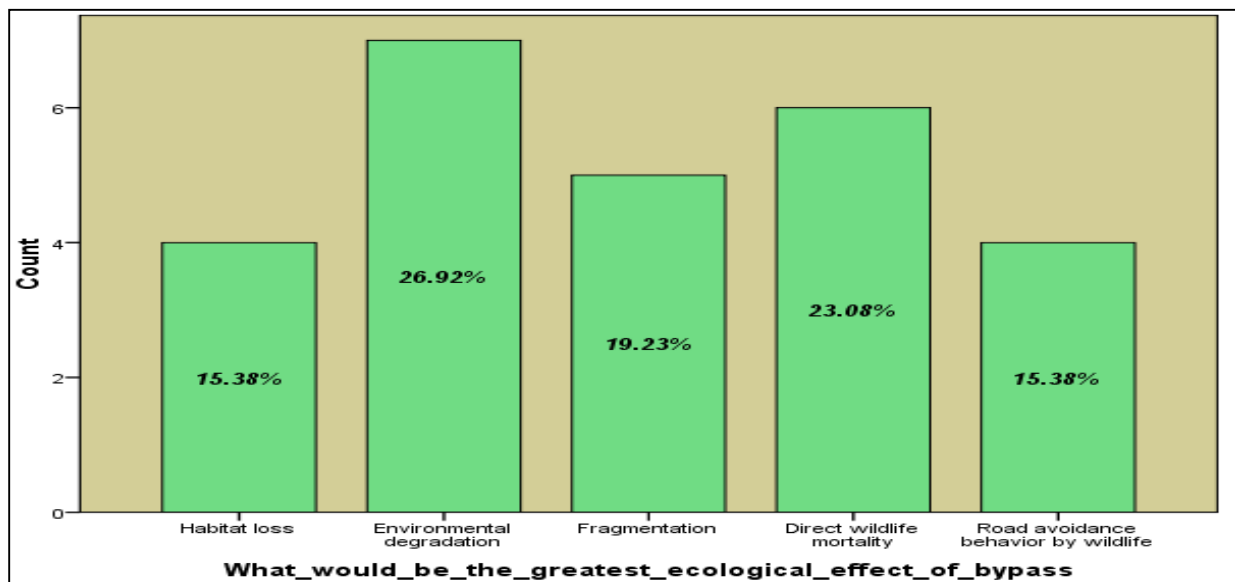
Figure 26: Greatest ecological effect of the road. Source: Field survey, 2014

According to 92% of the respondents habitat fragmentation effects of road can isolate wildlife populations unwilling or unable to cross roads, 8% are of the contrary view.

All the respondents reported that increase in noise and edge pollution make habitat less favourable for many wildlife species. Eighty five percent of the respondent indicated that increase in pollution can make habitat less favourable, 15% did not. Ninety six percent of the 26 respondents reported that the bypass would increasingly affect the ecosystem in terms of degradation, 4% reported that ecosystem degradation would in fact decrease.

5.4 Suitable Spatial Planning, Wildlife and Environmental Mitigation Approaches

5.4.1 Suitable Spatial Planning Approaches

The respondents were asked on the actions that can be proposed to address transportation threats to wildlife. All of the respondents indicated improvement of interagency coordination, continued research and monitoring efforts and incorporating wildlife into transportation planning (Table 7). This was followed by integration of planning efforts and educating the public to create awareness and increase related capacity at 96%. Ninety two percent indicated designing of roads to minimize impacts. Incorporating wildlife into transportation planning is considered to be an all-inclusive approach which would minimize conservation organizations challenging the roads department and NEMA on roads passing through prime wildlife habitat.

Action themes category	No. respondents responding positively (%) (n=26)
Improvement of interagency coordination	26 (100%)
Integration of planning efforts	25 (96%)
Design roads to minimize impacts	24 (92%)
Continued research and monitoring efforts	26 (100%)
Educate the public to create awareness and increase related capacity	25 (96%)
Incorporating wildlife into transportation planning	26 (100%)

Table 7. Actions/themes that can be used to address transportation threats to wildlife migration areas. Source: Field survey, 2014

The respondents were also asked on the best solution to the detrimental ecological effects which would result from the proposed transport corridor. Forty two percent reported alignment adjustment to relocate the proposed road, 35 % reported mitigation if not possible to relocate or avoid proposed road, 19% reported compensation measures to affected area of migration corridor and 4% total avoidance of the road (figure 27).
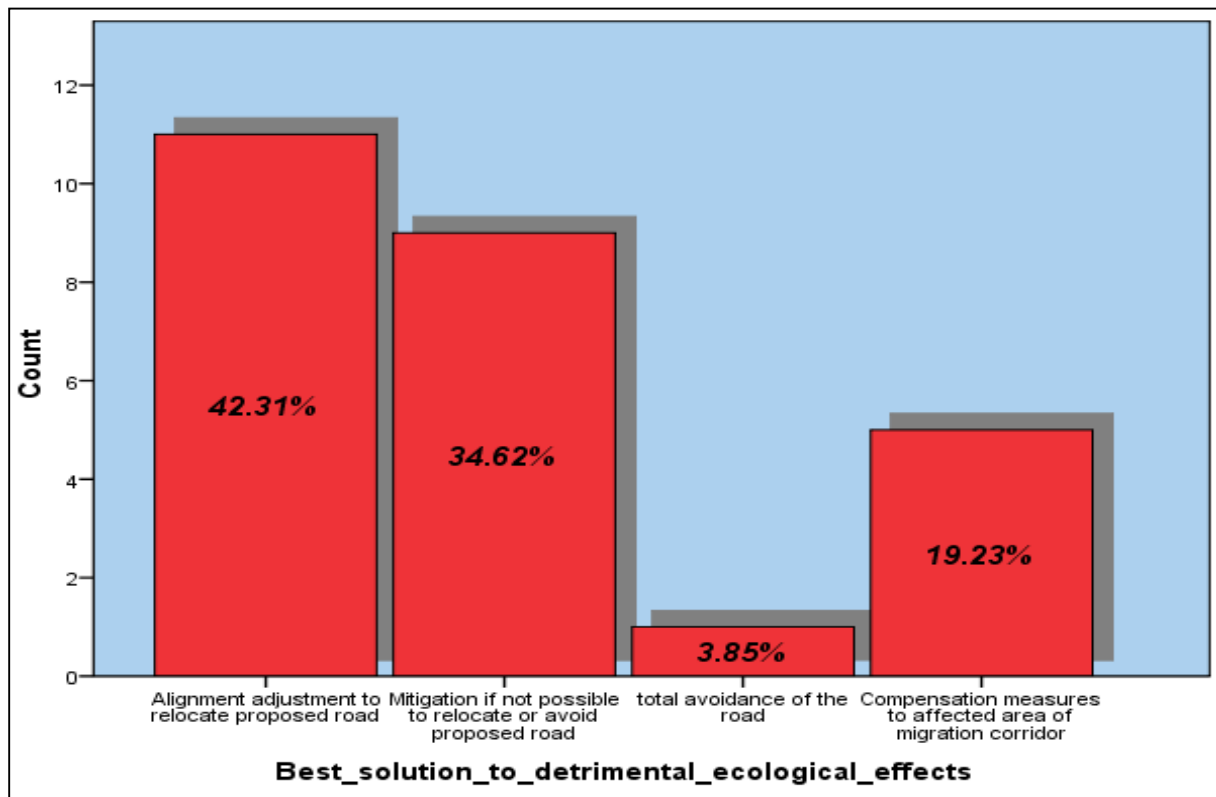
Figure 27. The best solution to the detrimental ecological effects which would result from the proposed transport corridor. Source: Field survey, 2014

5.4.2 Mitigation Techniques for the Wildlife

According to the respondents the most common technique to reduce road impacts to wildlife is animal passages (over or underpass) (85%), followed by wildlife signage (73%), then road design (69%). Others are speed reduction (62%), public education and awareness campaigns (50%) and fencing (31%) (Table 8).

Mitigation techniques	No. of respondents responding positively (%) (n=26)
Animal passages (over or underpass)	22 (85%)
Fencing	8 (31%)
Road design	18 (69%)
Speed reduction	16 (62%)
Wildlife signage	19 (73%)
Public education and awareness campaigns	13 (50%)

Table 8: Types of mitigation technique used to reduce road impacts to wildlife. Source: Field survey, 2014

5.4.3 Mitigation Techniques for the Environment

When asked on mitigation techniques to reduce environmental impacts, all respondents reported that containing surface run off from road and landscaping and planting road side verges would be used as mitigation, followed by buffer zone and filter strips (undisturbed areas and strips) (88%). Other mitigation techniques are avoiding contamination of wetlands (73%) and planting native plants (46%) (Table 9).

Mitigation techniques	No. of respondents responding positively (%) (n=26)
Avoiding contamination of wetlands	19 (73%)
Containing surface run off from road	26 (100%)
Landscaping and planting road side verges	26 (100%)
Buffer zone and filter strips	23 (88%)
Planting native plants	12 (46%)

Table 9: Types of techniques used to reduce environmental impacts. Source: Field survey, 2014

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS.

6.1 Conclusion

Livestock deaths due to predators are the major wildlife concerns expressed by many community members. There is always high presence of wildlife in the dispersal area, including buffalo, zebra, wildebeest and eland which are roaming outside the park. KWS and conservation NGOs play a major role in wildlife management and conservation. The active NGOs include AWF, TWF and FoNNaP. The community benefits from the NGOs mainly through income from the land leasing- project and compensation of livestock killed by animals. It is widely felt by the community that effects of the road would lead to the destruction of NNP. The construction of the road would negate the efforts made to secure the dispersal area and result in rapid unplanned and uncoordinated developments which would be detrimental to the conservation of wildlife. The road would also directly reduce the habitat area by approximately 195 hectares, cause fragmentation hence increasing the human- wildlife conflicts as a result of reduced pastures.

Rapidly increasing human settlement in the wildlife migration area is a concern to the survival of the wildlife. It will reduce the habitat as well as accelerate human-wildlife conflicts as competition for pasture will automatically increase. Quarrying activities to provide raw materials for the many cement factories in Athi River is resulting in massively environmentally degraded sites. Soil erosion is another environmental issue since the area is largely bare and grass fields are exposed. The unpaved roads are very dusty in the dry season. Exposed wetlands and sand harvesting along river banks reduces water quality which is also used for domestic consumption.

The proposed road would affect the environment of the immediately adjacent habitat. Contaminant emissions, noise and other disturbances will extend into roadside vegetation for varying distances, resulting in changes in species composition and contaminated soil, plants, animals and water. Not only do roads themselves pose a threat to wildlife, they also significantly influence future development, which in turn would negatively impact on wildlife conservation.

The anticipated increase in human settlement will result in disturbance of wildlife resulting in habitat effectiveness being degraded.

It is clearly evident the proposed road would impact negatively on the wildlife elements in the dispersal area. Habitat fragmentation, alteration of the physical environment, habitat loss and increased human use of area are the main impacts identified. Other impacts include road mortality, modification of the animal behaviour, human habituation and mortality from construction. Impacts of road mortality, increased human use of the area and mortality from construction would be appreciated much more on the local scale. Habitat fragmentation, habitat loss, alteration of the physical environment and modification of the animal behaviour level of magnitude of roads impacts on wildlife populations would generally be appreciated almost uniformly at local, regional and landscape scale. Animal road mortality would also result from the constructed road. The road would acts as a barrier limiting natural wildlife migration, consequently adversely affecting their population. Environmental degradation would greatly affect the ecosystem.

In order to ensure sustainable transport infrastructure in wildlife migration areas there is need for improvement of interagency coordination, continued research and monitoring efforts and incorporation of wildlife into transportation planning. Integration of planning efforts is required to ensure roads are designed to minimize impacts. Public education is necessary to create awareness and increase related capacity. To avoid destruction of critical migration corridor there is need for road alignment adjustment to relocate proposed road. If it is not possible to relocate or avoid the proposed road then mitigation of identified impacts should be addressed.

The mitigation techniques for the wildlife are necessary, if the road is to be constructed as proposed in order to ensure safe passage of the animals. Animal passages (underpass or overpass) are the most preferred. Wildlife signage, road design, speed reduction, fencing and public education and awareness campaigns are other mitigation techniques to be considered.

Road construction would also result to environmental impacts which would warrant mitigation. The most common mitigation techniques are containing surface run off from road and landscaping and planting road side verges. Buffer zone and filter strips (undisturbed areas and

strips) help contain contaminant emissions, noise and other disturbances. Avoiding contamination of wetlands plays an important role in preservation of biodiversity and water quality. Another mitigation technique is planting of native plants.

The study provides compelling evidence, from the analysis of information collected that roadways impacts to wildlife conservation are a present and future challenge. This study and other similar efforts will help bring together in future all critical professionals at appropriate stages of road development to ensure effective and efficient transportation while conserving critical wildlife conservation areas to sustain wildlife resources in perpetuity.

6.2 Summary of Findings

The study has established that there are many wildlife and environmental concerns in the study area. These concerns present the situational analysis of the area. The major wildlife concern is human-wildlife conflicts. The main environmental issue of the area is increasing human settlement due to its close proximity to Nairobi. Other environmental concerns are soil erosion, pollution, reduced water quality, deforestation, sand harvesting and quarrying. This has consequently resulted in massive environmental degradation.

The impacts of the proposed GSB infrastructure development on the environmental elements would be pollution, soil erosion, increased noise, increased human settlement, drainage systems, deforestation, edge effects, reduced water quality and increased spread of invasive species. These impacts would consequently result in negative effects to the wildlife. The proposed GSB impacts on wildlife elements would be road mortality, habitat fragmentation, human habituation, habitat loss, increased human use of the area, alteration of the physical environment, modification of the animal behaviour and mortality from construction. These impacts would result in decline of the wildlife populations.

The suitable spatial planning approaches for sustainable transport corridor development are improvement of interagency coordination, integration of planning efforts, designing roads to minimize impacts, continued research and monitoring efforts, educating the public to create awareness and increase related capacity and incorporating wildlife into transportation planning. This would ensure that all critical areas of wildlife conservation and transportation corridor development are thoroughly considered and factored in the project. Mitigation techniques for the

wildlife are critical and would entail construction of animal passages, fencing, road design, speed reduction, wildlife signage and public awareness campaigns. Mitigation techniques for the environment include avoiding contamination of wetlands, containing surface run off from the road, landscaping and planting road side verges, buffer zone and filter strips and planting native plants. This is fundamental as environmental conservation is key to the survival of the wildlife.

6.3 Recommendations.

After assessing the wildlife and other environmental concerns, the impacts of the proposed infrastructure development on the environmental and wildlife elements and the suitable spatial planning, wildlife and environmental approaches to mitigate against any negative impacts identified for sustainable development, the following recommendations have been proposed.

6.3.1   General Recommendations

1. KWS as the government agency, tasked with conservation of the wildlife be more empowered and properly managed to handle frequently occurring cases of human-wildlife conflicts. More wildlife conservation NGOs should be encouraged to operate in the area to supplement the work of KWS. There should be a policy framework for management of wildlife corridors/ dispersal areas.

2. Adoption of a landscape-scale planning process that assesses road route alternatives before route selection. Map and secure wildlife migration corridors to enable road planners make informed decision when planning migratory and conservation areas.

3. Involve environmentalist, conservationist and road engineers at all stages of road planning in order to identify all environmental and wildlife impacts, reduce them or avoid them if possible, if not, provide adequate mitigation.

4. Integrate conservation planning into transportation planning

There should be cooperation between wildlife agencies, conservation advocates and transportation planners in designing transportation corridors. Transportation planning provides a key opportunity for conservationists to influence where roads are built, how they are designed and how effectively transportation agencies mitigate for unavoidable impacts. Successfully

designing a transportation system to have minimal impacts on wildlife requires that conservationists get involved in the early stages of planning. Transportation planners should locate and utilize existing landscape-level conservation plans in their own planning efforts. This provides an intervention to ensure future roads and highway projects avoid sensitive and protected areas.

5. Build wildlife crossings where necessary to repair ecological damage and restore habitat connectivity. This can done through conducting habitat connectivity studies to determine where passageways are needed.

6. Comprehensive understanding of the environmental consequences of transportation networks and developing methods to support ecological impact evaluations already at early planning stages

6.3.2 Specific Recommendations

1. The land-leasing project for the wildlife initiated by the conservation NGOs be strengthened to ensure as many people as possible are included and more land is leased in order to promote coexistence of the people and animals. This is the project where local land owners are paid some money annually per acre in return for agreeing to leave their land open to wildlife and not engage in quarrying, fencing, land subdivision and sale or poaching. It is the compensation for the opportunity costs of allowing wildlife movements in the migration corridor within which land is privately owned.

2. An environmental impacts assessment needs to be carried out to assess the impacts of the many quarrying activities in order to propose and enforce mitigation measures to curb environmental degradation. The government should carry out an afforestation programme to curb soil erosion, rehabilitate quarry sites and preserve wetlands.

3. If the road is constructed as planned the wildlife mitigation techniques should be carried out to ensure safe passage of the animals. These are animal passages (underpass or overpass) (Plate 5). The spatial locations of these passageways to be established after conducting habitat connectivity studies. Key wildlife crossing areas can also be identified from a landscape assessment of wildlife connectivity needs along the proposed transportation corridor (map 7). The proposed

locations of wildlife crossings are based on mapped migratory routes of wildebeest. However there is need to consider topographical and other engineering concerns during design before making final decision. Other recommended mitigation techniques are wildlife signage, road design, speed reduction measures, fencing and public education and awareness campaigns.

Plate 5: Artistic impression of road underpass to allow wildlife crossing. Source:www.ewt.org.Za/programmes/WTP/ 2012aPdf. , 2012.
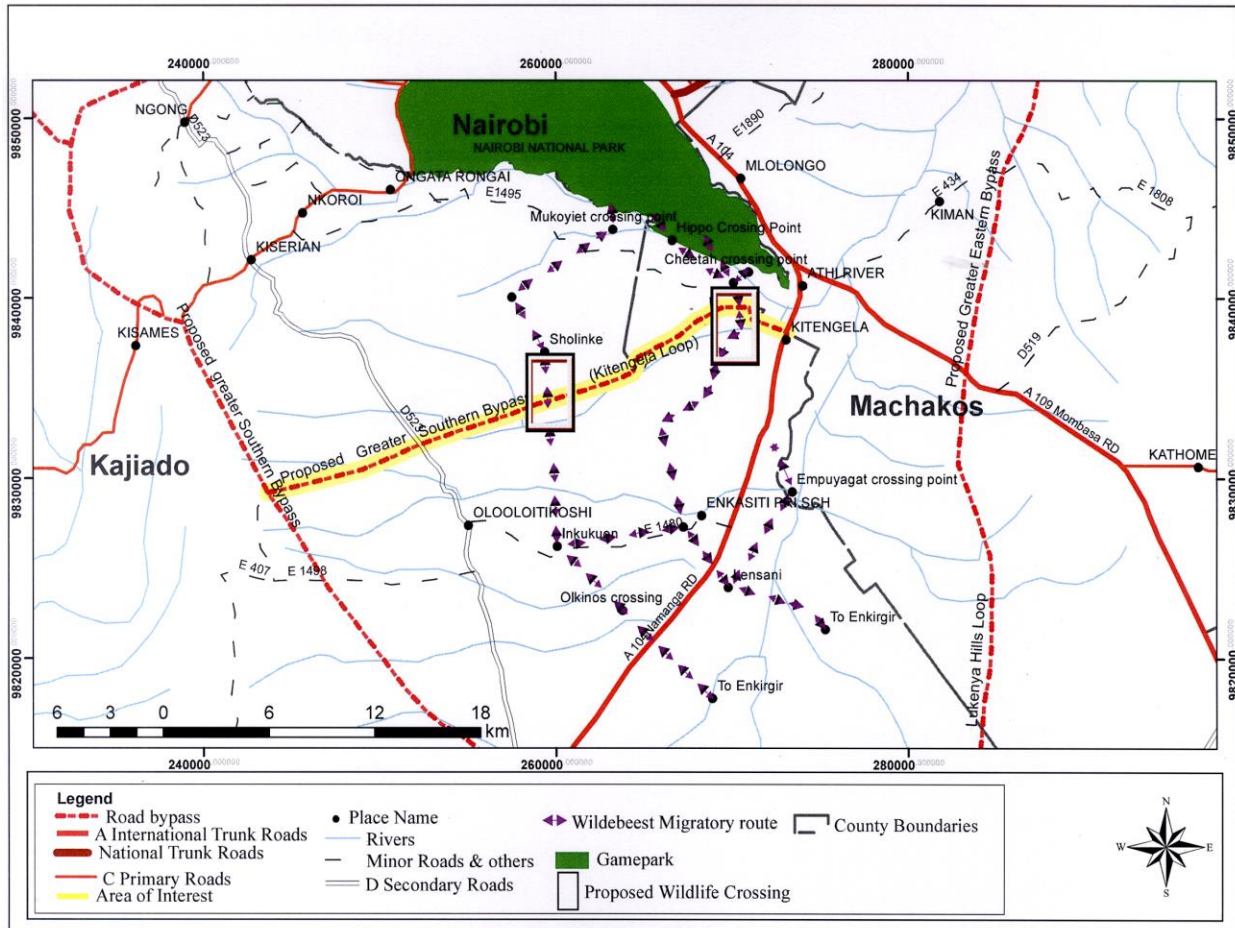
Map 7: Proposed spatial location of wildlife crossings based on mapped migratory routes of wildebeests. Source: Author, 2014.

6.**4 Areas of Further Research**

This study recommends the following areas of further research:

1. The extent and effects of environmental degradation in Kitengela wildlife migration corridor as a result of quarrying activities and its implications on environmental and wildlife conservation.

2. Policy framework to guide management of wildlife migration corridors/dispersal areas in Kenya.

3. The status, preservation, conservation and management of wetlands which are vital for human, livestock and wildlife in the Kitengela migration corridor.

4. The effects of habitat fragmentation by roads on wildlife conservation.

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APPENDICES

APPENDIX I

HOUSEHOLD QUESTIONNAIRE

Questionnaire Number_____ Date_____

Note: The information that you will give here will be used strictly for academic purposes and will be treated with high confidentiality. Your assistance will be greatly appreciated

<u>**RESPONDENT'S DETAILS**</u>

<u>Background information</u>

1. Name of respondent (optional)_____
2. Age (in years) ……………………
3. Sex   A. Male   B. Female
4. How long have you lived in this area? ....
5. What is your occupation?
   A.   Pastoralist   B .Farmer   C. Business D. Employed
   D. Other (Please specify) …………………………………
6. If employed, where do you work?
   A. Athi-river B. Kitengela C. Nairobi   D. Machakos E. Ongata Rongai
   F. Other places (please specify) …………………………………..

<u>Wildlife concerns</u>

7. Are there human- wildlife conflicts in this area? yes [   ] No [   ]
8. If yes what are they?
a………………………………………………………………………………
b………………………………………………………………………………
c …………………………………………………………………………………
d……………………………………………………………………………
9. What do you think are the causes of this human wildlife conflict?
   a. …………………………………………………………………..
   b. …………………………………………………………………..
   c. …………………………………………………………………
   d. …………………………………………………………………..
10. Is the Kenya Wildlife Service (KWS) aware of this conflict?
A. Yes B. No C. Don't know
11. If yes what have they done to address the human wildlife conflicts?
12. Is there a programme in which the community is involved in wildlife conservation and management?
    A. Yes B. No C. Don't know
13. If yes, what exactly does the programme entail?

……………………………………………………………………………………………………
……………………………………………………………………………
14. What has KWS done to address wildlife concerns in this area?
……………………………………………………………………………………
………………………………………………………………………………………..
15. What are the major benefits you experience from the wildlife?..
....
16. Are there wildlife/ conservation NGOs operating in this area?
  A. Yes B. No
17. If yes , which ones
     a……………………..
     b………………………….
     c………………………….
     d………………………….
18. How do they assist the community?...
19. How would the road affect wildlife in this area?
20. In your opinion, if this road is constructed as planned would it contribute to destruction of Nairobi National Park? A. Yes   B. No
21. Do we have animal migration in this area? A. Yes   B. No
22. Would the road bypass cut off the migration routes of the animals which depend on the land south of the national park? A. Yes   B. No
23. Are they any attempts being made to secure the wildlife dispersal area?
     A. Yes   B. No
24. If yes, would the bypass reverse gains made in recent years regarding securing the wildlife dispersal area? A. Yes   B. No
25.   Would the bypass result in unplanned developments in the dispersal area? A. Yes   B. No
26. How will the road affect the conflict between the wildlife and livestock?
     a. Increase
     b. Decrease
     c. Remain the same
27.   Would the road bypass compress the livestock pasture of land owners? A. Yes   B. No
28. Would the bypass put more pressure on the remaining grassland leading to desertification? A. Yes   B. No
29. Would the road construction process itself be loud and frighten wildlife, disrupting their normal behavior? A. Yes   B. No
30. What would be the effect on wildlife of having no migration routes?
     a. Increase
     b. Decrease
     c. No effect
31. What would be the effect on wildlife of having no breeding grounds?
     a. Increase
     b. Decrease

c. No effect

Environmental concerns
32. What are the environmental concerns in this area? (circle all that apply)
a. soil erosion
b. deforestation
c. pollution (water, air and noise)
d. increased human settlement
e. reduced water quality
f. Harvesting sand/soil/murram
g. Quarrying
h. Other (please specify)…………………………………………………
33. What has the government done to address above stated environmental concerns?
…………………………………………………………..
……………………………………………………………………………………………………
………………………………………………………………………
34. How would the new road affect the environment?
…………………………………………………………………..

Road transport network
35. What can you say about the condition of roads in this area?
A. Very good B. good C. Bad D. Very bad
36. Are you aware of the government intentions to construct a road in this area? A. Yes
B. No
37. Would you like a new road being constructed in this area?
A. Yes   B. No
38. How would this area benefit from the construction of this road?
……………………………………………………………………….
…………………………………………………………………..

Thank you

APPENDIX II

INSTITUTIONAL INTERVIEW SCHEDULE

Number_____ date_____

Note: The information that you will give here will be used strictly for academic purposes and will be treated with high confidentiality. Your assistance will be greatly appreciated

<u>RESPONDENT'S DETAILS</u>

Organization's Name _____

Designation of respondent _____

Name of respondent (optional) _____

Year of joining the organization_____

<u>Road planning in a wildlife migration corridor</u>

1. Are you aware of the proposed greater southern bypass? Yes [   ] No [   ]
2. Do road designers/planners consult with conservation agencies when planning and designing new roads? Yes [   ] No [   ] Don't know [   ]
3. If yes at what phase of the road planning?
   a. Planning
   b. Project development (preliminary design)
   c. Final design
   d. Right of way
   e. Construction
4. Are environmentalists consulted during planning of the road?
   Yes [   ] No [   ]
5. If yes at what phase of the road project?
   a. Planning
   b. Project development (preliminary design)
   c. Final design
   d. Right of way
   e. Construction
6. What is the ideal phase of the road project to begin involving the environmentalist?
   a. Planning
   b. Project development (preliminary design)
   c. Final design
   d. Right of way
   e. Construction
7. Should wildlife conservation be one of the first factors to be considered in road bypass planning? Yes [   ] No [   ]
8. Do we have conservation plans? Yes [   ] No [   ]
9. If yes, do the conservation plans inform the transportation plans?

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Yes [ ]   No [ ]

10. If no, why? …………………………………………………………………..

11. Do wildlife agencies and conservationists share spatial data for habitat and conservation area locations with transportation planners?   Yes [ ]   No [ ]

12. Should the road infrastructure project go on taking into consideration its effects on the wildlife and the environment? Yes [ ]   No [ ]

13. If yes, Please give reasons for your response

    a………………………………………………………………………

    b………………………………………………………………………..

    c……………………………………………………………………….

    d…………………………………………………………………………

14. If no, please give reasons for your response

    a………………………………………………………………………

    b………………………………………………………………………..

    c……………………………………………………………………….

    d…………………………………………………………………………

15. In your opinion should there be improved cooperation between transport planning, regional planning, wildlife management and nature conservation Yes [ ]   No [ ]

16. If yes, Kindly give reasons for your response

    a.   ……………………………………………………………………..

    b.   ……………………………………………………………………

    c.   ……………………………………………………………………...

    d.   ……………………………………………………………………

Road impact on the environment

17. Would the Bypass have an effect on the environment of the immediately adjacent habitat?

Yes [ ]   No [ ]

18. Would the constructed road affect the environment in the following areas?

    a. Increased noise   Yes [ ] No [ ]

    b. Pollution   Yes [ ] No [ ]

    c. Edge effects   Yes [ ] No [ ]

    d. Drainage systems   Yes [ ] No [ ]

    e. Soil erosion   Yes [ ] No [ ]

    f. Deforestation   Yes [ ] No [ ]

    g. Increased human settlement   Yes [ ] No [ ]

    h. Reduced water quality Yes [ ] No [ ]

    i. Increased spread of invasive species   Yes [ ] No [ ]

    j. Others (Please specify)…………………………………………………….

19. How would the road affect the human settlement?

    a.   Increase

    b.   Remain the same

    c.   Others (please specify)…………………………………………………..

20. What would be the effect of road on land values?
    a. Increase
    b. Remain the same
    c. Others (please specify)……………………………………………..
21. How would the Bypass affect this ecosystem in terms of degradation?
    a. Increase
    b. Decrease
    c. Remain the same

Roads impacts on wildlife

22. Which of the following issues would significantly affect wildlife if the bypass is constructed as proposed? (Circle all that apply)
    a. Road mortality
    b. Habitat fragmentation (including full or partial barrier effects)
    c. Human habituation/animal feeding
    d. Habitat loss
    e. Increased human use of the area
    f. Alteration of the physical environment
    g. Modification of the animal behavior
    h. Mortality from construction
    i. Other (please specify): ………………………………………………
23. Estimate the magnitude of each impact using the following scale:
(L) = Local; mainly confined to road segments, like a stretch road
(R) = Regional; a watershed or size of a small park
(LE) = Landscape and ecosystem-wide: size of a large park
(Use all that apply)

Impacts	Scale (L, R, LE)
Road mortality	
Habitat fragmentation	
Habitat loss	
Increased human use of the area	
Alteration of the physical environment	
Modification of the animal behavior	
Mortality from construction	
Other	

24. What causes do you believe contribute to the most road-related mortality of wildlife?
    a. Weather conditions
    b. Speeding
    c. Nighttime driving/poor visibility
    d. Unpredictable animal behaviour
    e. Other (please specify): ………………………………………………

25. Would the construction of the road limit the natural migration of the wildlife?
    Yes [   ]   No [   ]
26. Which animal species movement (animals found in Nairobi National Park) would be the most affected by the road bypass?
    a. Wildebeest
    b. Giraffe
    c. Lion
    d. Zebra
    e. Leopard
    f. Coke's hartebeest
    g. Eland
    h. Other (please specify)……………………………..
27. Would the construction of the Bypass result in increased animal-vehicle collisions?
    Yes [   ]   No [   ]

28. Would the Bypass act as a barrier and reduce migration possibilities to some wildlife species? Yes [   ]   No [   ]
29. In your opinion is the wildlife population in Nairobi National Park vulnerable to road impacts arising from the construction of this Bypass   Yes [   ]   No [   ]
30. If yes, kindly give reasons
    a……………………………………………………………………….
    b. ………………………………………………………………………..
    c…………………………………………………………………………..
    d……………………………………………………………………….
31. What would be the greatest ecological effect of the Bypass
    a. Habitat loss
    b. Environmental degradation
    c. Fragmentation
    d. Direct wildlife mortality
    e. Road avoidance behavior by wildlife
    f. Others   (please   specify)
    ………………………………………………………………………….
32. Can habitat fragmentation effects of road isolate wildlife populations unwilling or unable to cross roads? Yes [   ]   No [   ]
33. Can the increase of the following make habitat less favourable for many wildlife species?
    a. Noise   Yes [   ]   No [   ]
    b. Pollution   Yes [   ]   No [   ]
    c. Edge effects   Yes [   ]   No [   ]
34. How would the cut off migration corridor affect the wildlife population?
    a. Increase
    b. Decrease
    c. Others (please specify)………………………………………………….

Spatial planning

35. Can the following actions/themes be used to address transportation threats to wildlife migration areas
    a. Improvement of interagency coordination (e.g. transportation planners, wildlife conservationists and physical planners) Yes ☐ No ☐
    b. Integration of planning efforts.   Yes ☐ No ☐
    c. Design roads to minimize impacts. Yes ☐ No ☐
    d. Continued research of transportation impacts and monitoring efforts
       Yes ☐ No ☐
    e. Educate the public to create awareness and increase related capacity
       Yes ☐ No ☐
    f. Incorporating wildlife into transportation planning so that new roads avoid sensitive areas and habitats to begin with. Yes ☐ No ☐
    g. Other (please specify): ……………………………………………………

36. Which of the following would be the best solution to the detrimental ecological effects which would result from the proposed transport corridor
    a. Alignment adjustment to relocate proposed road
    b. Mitigation if not possible to relocate or avoid proposed road
    c. Total avoidance of the road
    d. Compensation measures to affected area of migration corridor
    e. Other (please specify): ……………………………………………………

    Mitigation of impacts on wildlife

37. What type of mitigation techniques in your opinion would help the wildlife if the proposed road bypass is constructed? (circle all that apply)
    a. Animal passages (over or under pass)
    b. Fencing
    c. Road design
    d. Speed reduction
    e. Wildlife signage
    f. Public education and awareness campaigns
    g. Other (please specify): ……………………………………………………
38. If no, kindly give reasons
    a……………………………………………………………………………...
    b……………………………………………………………………………
    c…………………………………………………………………………….
    d……………………………………………………………………………

Mitigation of road impacts on the environment

39. Which of the following approaches can be used to mitigate negative environmental impacts   from   the   constructed   road   (circle   all   that   apply)
    a. Avoiding contamination of wetlands
    b. Containing surface runoff from the road
    c. Landscaping and Planting road side verges

e.Buffer zones and Filter strips (undisturbed areas and strips)
f. planting native plants

Thank you for your information and opinion

Appendix III

Hypothesis Testing Using the Chi- Square (x^2) Distribution

Step	Description
1.	Record the observed frequencies in a contingency table
2.	Compute and record the expected frequencies for each cell
3.	Make assumptions and meet test requirements
4.	Select the Sampling Distribution and establish the Critical Region Alpha= 0.05 df= (r-1)(c-1)
5.	Calculate the Test Static ▪ Formula x^2 (Obtained)= $\sum \dfrac{(O - E)^2}{E}$
6.	Make a decision and Interpret the results of the Test When **:** x^2 (Computed) $\geq$ x^2 (critical) Reject Null hypothesis x^2 (Computed) $<$ x^2 (critical) Accept Null hypothesis

Source: Modified from University of Western Ontario, (Undated)
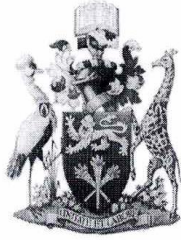
University of Nairobi
Department of Urban and Regional Planning
School of The Built Environment
P.O. Box 30197, 00100 GPO Nairobi, Kenya
Tel: 2718548 Fax: 2718548
e-mail:durp@uonbi.ac.ke

Ref: UON/CAE/DURP/B63/82276/12   **Date**: 10th February 2014

TO WHOM IT MAY CONCERN

RE: JOHN MUGENDI NAZALINO: REG. NO. B63/82276/12

This is to certify that Mr. John Mugendi is a Post Graduate student in this department on M.A. (Urban & Regional Planning) course. He has successfully completed his coursework and at present he is on the thesis part of his study.

His thesis topic is entitled "**Transport Development and Implications on the wildlife conversation: A case study of Proposed Greater Southern Bypass (Kitengela Loop)**"

Any help extended to him on this regard will be highly appreciated. Any information provided will be handled confidentially for academic purposes only.

DR. SAMUEL OBIERO
CHAIRMAN
DEPARTMENT OF URBAN & REGIONAL PLANNING

SO/mao

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NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date:

26th February, 2014

NACOSTI/P/14/8279/809

John Mugendi Nazalino
University of Nairobi
P.O.Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on *"Transport Development and Implications on wildlife Conservation. Case Study of Greater Southern Bypass (Kitengela Loop),"* I am pleased to inform you that you have been authorized to undertake research in **Kajiado and Machakos Counties** for a period ending **31st August, 2014.**

You are advised to report to **the Chief Executive Officers of the Selected Government Agencies, County Commissioners, and County Directors of Education, Kajiado and Machakos Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COMMISSION SECRETARY
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Copy to:

The Chief Executive Officers
Selected Government Agencies.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

THIS IS TO CERTIFY THAT:
MR. JOHN MUGENDI NAZALINO
of UNIVERSITY OF NAIROBI, 30046-100
NAIROBI, has been permitted to conduct
research in *Kajiado , Machakos*
Counties

Permit No : NACOSTI/P/14/8279/809
Date Of Issue : 26th February, 2014
Fee Recieved : KSH 1,000.00

on the topic: *TRANSPORT*
DEVELOPMENT AND IMPLICATIONS ON
WILDLIFE CONSERVATION. CASE STUDY
OF GREATER SOUTHERN BYPASS
(KITENGELA LOOP)

for the period ending:
31st August, 2014

....
Applicant's
Signature

....
Secretary
National Commission for Science,
Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 1089

CONDITIONS: see back page

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KWS/BRM/5001

4 March 2014

Mr. John Mugendi
Department of Urban & Regional Planning
School of the Built Environment
University of Nairobi
P.O.Box 30197-00100
NAIROBI
e-mail: jnmugendi@yahoo.com

Dear Mr. Mugendi,

PERMISSION TO ADMINISTER QUESTIONNAIRES TO KWS MANAGEMENT STAFF

We acknowledge receipt of your letter dated 10 February 2014 requesting for permission to administer questionnaires to KWS management staff on a project titled: 'Transport Development and Implications on the Wildlife Conservation: A Case Study of the Proposed Greater Southern Bypass (Kitengela Loop)'. The study will generate data and information on the impacts of the proposed southern bypass on the ecological integrity of Nairobi National Park.

You have been granted permission to administer the questionnaires from **March to May 2014** upon payment to KWS of academic research fees of **Ksh. 1000**. However, you will abide by the set KWS regulations and guidelines regarding the acquisition and dissemination of information. You will also be required to use the information for research and educational purposes only and that the information will not be passed to a third party without the consent of the Director-General KWS.

You will submit your MA thesis to the KWS Deputy Director, Biodiversity Research and Monitoring on completion of the study.

Yours sincerely,

SAMUEL M. KASIKI, PhD, OGW
DEPUTY DIRECTOR
BIODIVERSITY RESEARCH AND MONITORING

Copy to:
- Head Roads & Infrastructure Development
- AD-SCA
- Head-Environmental Planning & Compliance
- Senior Warden Nairobi N. Park
- SAD- Ecosystems & Landscape Management

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