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GIS Assessment of Environmental Footprints of the Standard Gauge Railway (SGR) on Nairobi National Park, Kenya

BY

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Declaration

I, **Mildred M. Ambani** hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a degree in any other Institution of Higher Learning.

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Name of student	Signature	Date

This project has been submitted for examination with my approval as university supervisor.

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Name of supervisor	Signature	Date

Dedication

This work is dedicated to my husband; Anthony Songoro who has supported me all the way and whose support made sure that I give it all it takes to finish that which I began. To my children Elvirah, Myles and Handel who have been distressed by this undertaking. Thank you. I cannot quantify my love for you all. May you all be blessed.

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Abstract

Transport infrastructures enhance movement of goods and services and as such promote the production processes in any economy. Additionally, they are developed in space and time and as a result they tend to affect and be affected by other systems. As such, it is required that infrastructural developments are undertaken with due consideration for the abutting natural and manmade features.

The purpose of this study therefore was to use GIS to assess the magnitude of the environmental problems caused by the Standard Gauge Railway (SGR) project on Nairobi National Park (NNP) and hence model GIS aided solutions to the problems. People may know the impacts the SGR has or can have on the park. However, there is no research that has been done to unearth the magnitude of these impacts. It can thus be argued that this is a knowledge gap that needs to be filled. Furthermore, a deeper understanding of these impacts will open up a door for the formulation of the most appropriate solutions for the identified problems.

Relevant spatial and non-spatial data, based on the objectives, were collected for processing and analysis using geospatial technologies to assess the environmental footprints before and after the planned SGR on the Nairobi National Park. The layers were overlaid to identify the most impacted areas and spatial statistical methods used to predict the expected continued impact over 5 years and 10 years.

The results successfully demonstrated how the Standard Gauge Railway (SGR) has and will cause negative environmental impacts on Nairobi National Park by use of the various GIS analysis tools. The SGR-I has indeed encroached on Nairobi National Park occupying an area of 87.29 Hectares and the proposed SGR-IIA will cut across the park carving out an area of 42 hectares. Moreover, approximately 500.61 hectares of vegetation cover will be lost to construction and operation of the SGR.

In conclusion, the noise and air pollution produced due to the SGR construction and operation will disperse the wild animals, affect the herbivores' vegetation, and park workers as well. SGR encroachment into the park particularly affects the wildlife migration routes negatively. Some of the recommendations of the study are wet-spraying of cement and wet drilling to reduce dust emissions during the construction of SGR-IIA; frequent investigations of the construction sites and recommendation that a suitability analysis to locate the best SGR route be carried out using GIS.

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List of Acronyms

CRBC	China Road and Bridge Corporation
EIA	Environmental Impact Assessment
ERS	Economy Recovery Strategy
ESIA	Environmental and Social Impact Assessment
GDP	Gross Domestic Product
GIS	Geographical Information Systems
JKIA	Jomo Kenyatta International Airport
KPMG	Klynveld Peat MMarvick Goerdeler
KRC	Kenya Railways Corporation
KWS	Kenya Wildlife Service
NEMA	National Environmental Management Authority
NNP	Nairobi National Park
SGR	Standard Gauge Railway
UN	United Nations
QRT	Qinghai-Tibet Railway

CHAPTER 1: INTRODUCTION

1.1 Background

Transport infrastructures are some of the most essential components of the built environment. They enhance movement of goods and services and as such promote the production processes in any economy. Additionally, they are developed in space and time and as a result they tend to affect and be affected by other systems. For instance, a transport corridor developed anywhere in space will displace a given extent of vegetation cover or built-up structures in the vicinity. As such, it is required that infrastructural developments are undertaken with due consideration for the abutting natural and manmade features.

A majority of the countries in the developing world have taken keen interest in the need to promote harmony between the built and natural environments. They tend to develop mega infrastructural networks and blend them well with landscaped and aesthetically appealing spaces. Japan for instance, are the front runners in transport and are ranked as number one in the world for their railway infrastructure, famed for their high-speed bullet trains, which can reach up to 200 mph (Renner and Gardner, 2010).

The African region is significantly lagging behind in the development of trade because of the challenges of globalization, predominantly because of lack of reliable and adequate transport. Transport infrastructure and services have been little developed, the physical network poorly integrated, thus the existing transport facilities are completely outward-looking. No wonder Africa is termed as the valley as far as globalization is concerned. A review of 20 years of effort devoted to transport in African countries by the United Nations revealed that the existing transport infrastructure and services are still extremely far from making it possible for Africa to realize socio-economic development and integration (UN, 2009).

According to United Nations (2009), the most cost-effective mode of transport of moving bulk cargo for long distances over land in Africa is the railways, not forgetting their suitability for container traffic between ports and capitals. The rail system has an advantage over the other modes gained from recent economic and technological trends including higher energy prices, the growth of container stations and new increases in flows of bulk trade and traffic. However, the railways in Africa carry only 1 percent of the global railway passenger traffic and 2 percent of the goods traffic, due to very low railway connectivity. In 2005 Africa had a total railway network of 90,320 km or 3.1 km of per 1,000 sq. km.

In Kenya, the transport sector is the major driver of the country's economy; this is due to the provision of the required support to take the country to a middle income country by the year 2030. To ensure the implementation of the economic pillar, the vision 2030 aspires to have a country firmly interconnected through a network of roads, railways, ports, airports, telecommunication, water and sanitation facilities, by prioritizing investments in the nation's infrastructure (GoK, 2007).

The Standard Gauge Railway (SGR) in particular, is a transport project in Kenya involving the development of a railway line which connects Mombasa and Malaba. It was conceived and started in October 2013. Phase 1 of the SGR has been developed from Mombasa to Nairobi and is already operational. Phase 2 (Nairobi to Malaba), has been divided into three phases and is yet to be constructed. Phase 2A, with its section of 6 km stretch cutting across the Nairobi National Park (NNP), passes through Naivasha to Narok. Phase 2B is from Narok to Kisumu while Phase 2C connects Kisumu to Malaba The contractors are China Road and Bridge Corporation (CRBC, Kenya).

The project is expected to have a number of positive impacts. According to Murithi (2015), a major influence on land use and development opportunities along and around the areas where the SGR will navigate is expected. Furthermore, it is envisaged that after completion, the principle of "open access" will be operationalized on the SGR, whereby local entrepreneurs will have the chance to take part in providing railway transport services by investing in locomotives and rolling stock (Murithi, 2015).

On the other hand, it is noteworthy that the project has the capacity to have certain negative impacts which must be sufficiently mitigated against. An expected area of interference is the natural ecosystem.

1.2 Problem Statement

Nairobi National Park is a major park in Kenya which was established in 1946. Despite its proximity to civilization and relatively small size for an African national park, Nairobi National Park boasts of a large and varied wildlife population. It is one of Kenya's most successful rhinoceros sanctuaries, not forgetting the migrating herbivores that gather in the park during dry seasons. It is the main tourist attraction for visitors to Nairobi, given the diverse bird species, cheetah, hyena, leopard, lion and wildebeest and zebra migrations. It has a wildlife conservation education centre, the ivory burning site monument, the safari walk and the animal orphanage.

Migrating animals can reach their southern pastures by traveling through the Athi plains called Kitengela. The park is thus an important asset to the animals since their migration routes are part thereof. However, growth in human population and accompanying need for land due to urbanization threaten to cut off this traditional migration route. The park's migratory species are also threatened by changing settlement patterns, fencing, and their closeness to Nairobi and other industrial towns. Their ecosystem is fragmented, their habitat occupied by the many activities. The diverse flora and fauna is also affected. Nonetheless, the park should not be interfered with in any way whatsoever.

The SGR's current re-aligned route encroaches on 87.29 ha of land of the Nairobi National Park, which is a significant portion of the wildlife habitat. Impacts related to SGR construction activities include vegetation clearance, land burrowing and filling, noise and air pollution. Particularly, the SGR will interfere with the wildlife migration corridors that the animals have been used to for a long time. The SGR design proposes to incorporate culverts and an animal underpass bridge in order to maintain the ecosystem connectivity and allow wildlife movement, but that does not seem to be realistic since wild animals are not easy to train like domestic ones (Murithi, 2015).

SGR-Phase IIA alignment is already proposed and cuts across the park along a 6 km stretch and 70m way leave. The line will be constructed using 187 viaduct pillars occupying and affecting a park area of 2992m² (Habitat-Planners, 2016).

The purpose of this study therefore is to use GIS to assess the magnitude of the above mentioned environmental problems which have been caused by the SGR project and hence model GIS aided solutions to the problems.

1.3 Study Objectives

1.3.1 General Objective

To assess the environmental impacts of the Standard Gauge Railway (SGR) on the Nairobi National Park

1.3.2 Specific Objectives

i. To establish the development details of the SGR project.
ii. To evaluate the level of encroachment of the SGR corridor into Nairobi National Park.
iii. To assess and map out the environmental footprints of the project on the park using GIS.
iv. To recommend a GIS based model for solving the environmental problems identified.

1.4 Justification of the Study

The park is a very important asset to the country and which must be jealously protected. As a natural asset, it is a home to diverse flora and fauna. As an economical asset it serves as a major tourist attraction, has a wildlife conservation education centre, the ivory burning site monument, the safari walk and the animal orphanage. Therefore anything that might interfere with the park must be adequately researched on and effectively mitigated.

Secondly, people may know the impacts the SGR has or can have on the park. However, there is no research that has been done to unearth the magnitude of these impacts. It can thus be argued that this is a knowledge gap that needs to be filled. Furthermore, a deeper understanding of these impacts will open up a door for the formulation of the most appropriate solutions for the identified problems.

The researcher intends to bring a GIS component into the study. This means that the spatial components of the SGR project and the park will come out more strongly and the representation of the issues will be clearer. Thus the study will not only fill a knowledge gap, but will also bring out spatially represented solutions to the environmental problems that the SGR might cause to the park. The research is intended to aid stakeholders in the infrastructure sector in their future developments.

1.5 Scope and Limitations

1.5.1 Scope

The study was carried out in Nairobi National Park. The information used was the extent of encroachment of the SGR project into the park and the existing and future environmental impact on wildlife and nature within the SGR project area in the park. The research focused on noise pollution plus wildlife and habitat loss impacts in Nairobi National Park.

1.5.2 Limitations

During the time of research, the Standard Gauge Railway (SGR) construction and encroachment into the Nairobi National Park was highly contested by the Civil Society and general public, thus obtaining data from the relevant institutions like Kenya Railways and KWS was a great challenge. Therefore the SGR alignment that cuts across the park was approximately adapted and digitized from the design in the Environmental and Social Impact Assessment (ESIA) report. Data on Species distribution in Nairobi National Park was also digitized from georeferenced maps adopted from the ESIA report.

1.6 Report Organization

This report is organized in five chapters as follows:-

Chapter one comprises of the introduction of the research topic, its statement of the problem, research objectives, justification, scope of study, and limitations of the study

Chapter two focuses on Literature review and development of the conceptual framework. The review entailed relevant information in the global outlook, then regional, and local context and finally to the study area. This chapter set the foundation of data collection and analysis.

Chapter three dwells on the methodology of the study including the types of data collected, their organization, integration, analysis and the various methods and GIS techniques used to obtain the final results.

Chapter four contains the results of the study which are in line with the study objectives; these are the results on the environmental impacts of the SGR, their causes and effects on the Nairobi National Park.

Chapter five gives the conclusions and recommendations from the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter looks at previously written works on transport infrastructure and its effects on the environment, both globally and locally, including theories and concepts which influence and determine the location and operation of railway lines in relation to the environment. The written works are analyzed against the principles that underline the provision, utilization and functionality of the standard gauge railway to enhance compatibility and sustainability. Policy documents and standards that guide the location and operation of railway lines are also reviewed and analyzed. Case studies of development on the environment especially habitats for wildlife will be examined. Existing models of Railway designs are considered to help determine and propose an appropriate typology of standard Gauge Railway for the present and future situation of the study area and the country as a whole.

2.2 Transport Infrastructure

Relevant literature about transport infrastructure was reviewed at the global level, African level and Kenyan context.

2.2.1 Global Transport Infrastructure

Louis Armstrong famously saw trees of green, red roses too – marvels of nature that light up people's lives and make them joyfully proclaim: "What a wonderful world". It's an unchanging song regarding the present, but also the future and a delicate expectation that each upcoming generation will be better off than the previous (KPMG, 2014). According to the KPMG global infrastructure report of 2014, infrastructure is characterized by three traits; optimism, social impact and economic value resulting in a better world that is sustained by projects that are to a great extent desirable, those that are speculative and others that are beyond doubt imaginative. In as much as we transform the world through infrastructure development, it has to have a positive impact to the beneficiaries. The economic benefit should be balanced against the social need (KPMG, 2014).

As cities expand worldwide, development of light and metro rail systems obtain great precedence where urban mobility is concerned. China, for example, has expanded her infrastructure speedily including its ports, roads, and railway, thus linking most of its cities with populations of over 200,000. The world's largest high-speed rail system is the pride of Beijing, built using hundreds of billions of dollars. The country is determined to have a line China-Russia-Canada-America running across Siberia for 13,000 kilometers and pass under the Bering Strait through a_200-kilometer tunnel. China boasts of the latest exciting innovations including driverless trains, the superfast Shanghai Maglev train – utilizing magnetic levitation (KPMG, 2014).

2.2.2 Transport in Africa

The United Nations (2009), describes Africa's transport as a very important element of development and socio-economic growth. Transport Infrastructure is still an important development pillar in a fundamentally changing global environment, since it is observed as a means for growth acceleration, national and regional trade access, and poverty reduction. Due to the globalization challenges, there is a significant lag in the development of regional trade in Africa, caused by lack of adequate and reliable transport. Certainly, the physical network is poorly integrated, with little development of the services leaving the available transport facilities for trade utterly superficial-looking (UN, 2009).

The United Nations report of 2009, on the transport situation in Africa alludes to the railways as the most gainful transportation means for transfer of goods that are massive for distances that are long, predominantly container traffic between ports and capitals. The rail system has an advantage over the other modes gained due to the recently trending technology and economy including the growth of container stations, higher energy prices, and enhanced flows of bulk trade and traffic. On the other hand, the railways in Africa carry only 1 percent passenger traffic of the global railway and goods traffic being 2 percent, due to very low railway connectivity. According to United Nations (2009), the railway network in Africa was approximately 90,320 km in the year 2005, which is equivalent to 3.1 km of rail per 1000 square kilometre.

2.2.3 Transport in Kenya

In Kenya, the transport sector is the major driver of the country's economy; this is due to the provision of the required support to take the country to a middle income country by the year 2030. To ensure the implementation of the economic pillar, the vision 2030 aspires to have a country firmly interconnected through a network of roads, railways, ports, airports, telecommunication, water and sanitation facilities, by prioritizing investments in the nation's infrastructure (GoK, 2007). The SGR is one of the vision 2030 flagship projects whose aim is to connect Kenya, Uganda, Rwanda and South Sudan.

Phase one is from Mombasa to Nairobi while phase two is from Nairobi to Malaba. Once completed, the SGR will add to the country's Gross Domestic Product (GDP) by 1.5% while boosting Intra-Africa trade by supporting the tourism industry and reducing the cost of transportation.

2.3 Effects of Infrastructure on Nature

According to Seiler and Folkeson (2006), new habitat edges are created by the physical construction of railways and roads in the landscape. Moreover, hydrological dynamics are altered while natural processes and habitats are disrupted. The environment surrounding the transport infrastructure is often contaminated with various chemical pollutants and noise during maintenance and operation of the railways and roads. Apart from infrastructure inflicting movement barriers to most of the terrestrial animals, it also results in the death of millions of individual animals every year. Not only is there loss and isolation of wildlife habitat, but transport infrastructure also results into landscape and habitat fragmentation.

In Europe, habitat fragmentation is known as a contributor towards biodiversity decline, which occurs when natural habitats and ecosystems split into smaller and more isolated patches. Indeed it is a major concern for the society. The principal cause of fragmentation is transport infrastructure like roads and railways. Due to transport infrastructure, habitat is disturbed and lost in the nearby environment. Movement and dispersal of many species is affected directly by infrastructure, which act as barriers to the habitat. There is also increased mortality risk for fauna caused by traffic generated by infrastructure. Species of greatest conservation concern are those mostly vulnerable to habitat fragmentation because they require large areas or strongly depend on a specific type of habitat (Seiler & Folkeson, 2006).

2.3.1 Primary Ecological Effects

Wildlife is largely affected by infrastructure. There are five key primary effects that are caused by the mere existence of infrastructure link and its resultant traffic namely **habitat loss**, **disturbance/edge effects**, **mortality**, **barrier,** and **corridor** effects (Seiler & Folkeson, 2006).

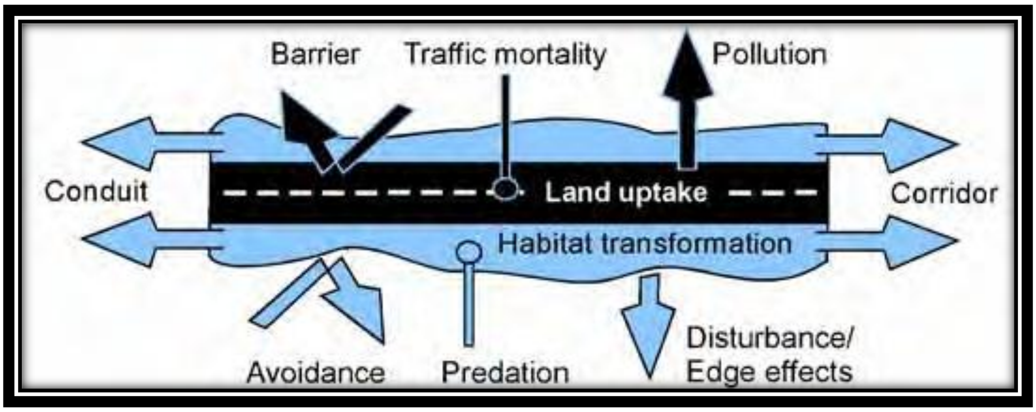

Figure 1: The five primary ecological effects of railway to wildlife

Source: Adopted from (Seiler & Folkeson, 2006**)**

Habitat Loss is the unavoidable outcome from the construction of infrastructure which emanates from the physical occupation of the land under construction. Furthermore, there will be additional reduction in the amount of habitat available for wildlife due to disturbance and barrier effects.

Disturbance Effects are a product of pollution of the physical, chemical and biological environment during construction and operation of the transport infrastructure. A wide zone is usually affected by the toxins and noise emanating from the daily maintenance and operation activities.

Mortality levels of terrestrial animals and individual wildlife linked to the traffic of the transport infrastructure are always increasing. Trains and wildlife always collide, attracting a wider public interest.

Plate 1: Wildlife Casualties- a common view along railways and roads

Source: Adopted from (Seiler & Folkeson, 2006)

Barrier Effects mostly affect terrestrial animals because the animals' range of movement is often restricted by the infrastructure, making the habitats to be inaccessible thus leading to isolation of the animal population as illustrated in Figure 2.

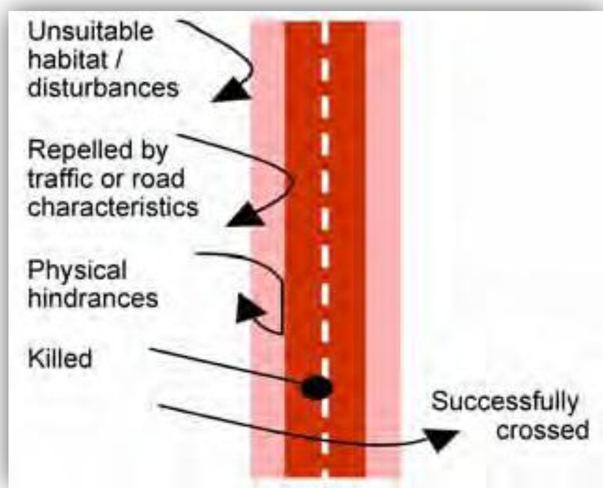

Figure 2: The Barrier Effect of a Railway

Source: Adopted from (Seiler & Folkeson, 2006)

Corridor Effect is whereby habitats along the transport infrastructure are negatively affected whereby non native species invade well conserved natural landscapes.

2.3.2 Measures against the Effects

According to Seiler and Folkeson (2006), to solve habitat fragmentation, principles of avoidance, mitigation, and compensation measures can be taken into consideration. In avoidance measure, the project is abandoned or re-routed; Mitigation minimizes the project residual impacts; while habitats are created, restored or enhanced to compensate for any great losses. When planning roads, railways and waterways, the "ecological networks" concept helps in avoiding critical bottlenecks in the connectivity of habitats, hence mitigation measures are identified.

The Europeans Commission's White Paper (European transport policy for 2001: time to decide) states that sustainability of transport is vital economically, socially, and from an environmental point of view. Environmentally friendly, safe and energy sufficient transport modes are a must. The effects of transport on biodiversity need to be deeply recognized. Biodiversity is adversely affected by land taken for transport infrastructure. During the land use planning process, transport plans should be incorporated to help push transport infrastructure away from protected areas (Stantchev & Davenport, 2009).

2.4 Regulatory and Institutional Systems of Transport Provision in Kenya

The Kenyan government has a framework of regulatory and institutional systems that deal with provision of transport infrastructure including policy framework, legal framework and institutional framework as outlined below:-

2.4.1 Policy Framework

Kenya's Vision 2030

The Country's infrastructure section has a broad vision "to provide cost-effective world class infrastructure facilities and services in support of Vision 2030" (G.O.K, 2007). The Economic Recovery Strategy (ERS) recognized poor infrastructure as a key limitation to carrying out business in the country. The security of the country is enhanced with availability of good transport infrastructure

Infrastructure is highlighted as one of the foundations for the Kenya Vision 2030 pillars which will help in realization of the socio-economic transformation. The 2030 Vision aims for a firmly interconnected country through a network of roads, railways, ports, airports, and water ways, and telecommunications. It should provide water and up to date sanitation amenities to her people. By 2030, there should be no "remote" regions in our country. Infrastructure investments will be awarded top priority to make sure that the main projects under the economic pillar are realized (G.O.K, 2007). The Standard Gauge Railway (SGR) is one of the platforms for achieving this goal. Implement

To achieve a clean, secure and sustainable environment by the year 2030, the Kenyan government aspires to promote environmental conservation to better support the economic and social pillars. Among the specific goals concerning conservation is the aspiration to fully protect all wildlife ecosystem and incorporation of natural resources in the national accounts. Moreover, there are strategies envisioning that the wildlife corridors and migratory routes should be well secured. The changing international and regional trading arrangements influence Kenya's external environment via the Standard Gauge Railway (G.O.K, 2007).

2.4.2 Legal Framework

The Constitution of Kenya (2010)

In Kenya, each and every person has the right to an environment that is clean and healthy as stated in article 42 of the Kenyan constitution, and therefore protection of the environment for the benefit of both the present and future generations is very vital, thus the Nairobi National Park has to be guarded by all means (G.O.K, 2010)

The state shall also ensure a sustainable exploitation, utilisation, management and conservation of the environment and natural resources while ensuring the equitable sharing of the acruing benefits and on the other hand protecting genetic resources and biological diversity (G.O.K, 2010) (Art. 69). Any infringement or threat to the environment is greatly abhorred.

Wildlife Conservation and Management Act (2013)

The wildlife conservation and management act applies to all wildlife resources on public, community and private land, and Kenya territorial waters. The act has a strategy that has the mandate to recommend the principles, objectives, standards, indicators, procedures and incentives for the protection, conservation, and management of sustainable utilization and control of wildlife resources (G.O.K, 2013)

If land is deemed rich in biodiversity and wildlife resources or contains endangered and threatened species, the government has the obligation to declare it a national reserve. This is also applicable if the land is an important catchment area critical for the sustenance of a wildlife conservation area and acts as a vital wildlife buffer zone, migratory route, and corridor or dispersal area.

Environmental Management and Conservation Act, 1999

The Environmental Management and Conservation Act provide a clause on an environmental conservation order imposed on burdened land so that migration corridors for wildlife are created or maintained (G.O.K, 1999)

2.4.3 Institutional Framework

The major institution that deals with the SGR is the Kenya Railways Corporation (KRC), which was established in 1977 as a State Corporation. Kenya Wildlife Service (KWS) is concerned with the conservation and management of wildlife in Kenya, in this case the Nairobi National Park.

Kenya Railways Corporation (KRC)

The rail transport system is governed by the Kenya Railways Corporation (KRC). It was initially referred to as Kenya Railways (KR), after it took over from the East African

Railways and Harbours Corporation (EARC) in 1977 to manage the Kenyan part of the railway, after the East African Community collapsed (G.O.K, 1978).

Plans to develop the Standard Gauge Railway to connect Kenya to other countries like Uganda, Rwanda, South Sudan and Ethiopia started developing in the year 2012 (G.O.K, 1978)

Kenya Wildlife Service (KWS)

The Kenya Wildlife Service has the mandate to conserve and manage wildlife in Kenya plus enforcing the related laws and regulations. Approximately 8% of the Kenyan total land mass is managed by KWS, comprising of 23 national parks, 31 national reserves and 6 national sanctuaries, 4 marine national parks and 6 marine national reserves. Some of the key functions of the service are to formulate policies and guidelines for managing and utilizing of all types of fauna and flora, plus being in charge of the stewarding the national parks and reserves, while ensuring the security for visitors and wildlife as a whole (KWS, 2012).

Genetic resources that could be used in developing new and improved food crops and medications are conserved by KWS through protecting habitat and wildlife. Crops can be made more resilient by inducing genes that make them drought, salt and flood resistant by biotechnology experts. KWS also acts as an agent of the Kenya Roads Board, thus maintaining roads within and outside protected areas. Thus KWS wholly contributes to the national economy of the state through tourism, transport, environment, water, water, fisheries and international conventions (KWS, 2012).

2.5 Case Study: Qinghai-Tibet Railway in China

Branded as the world’s highest and longest railway, Qinghai-Tibet Railway (QTR) is China’s landmark whose project agenda was ‘ecological protection’. It was built in 2005, 1956 km long, connecting Xining (Qinghai’s capital) to Lhasa, Tibet Autonomous Region’s capital city. The Chinese government has protected the area’s ecology by investing an exceptional amount of cash (approximately US$ 3.39 billion) in the QTR, with the environmental protection and restoration of the ecosystem being prioritized (Peng, et al., 2007). Figure 3 shows the extent of the Qinghai-Tibet railway.

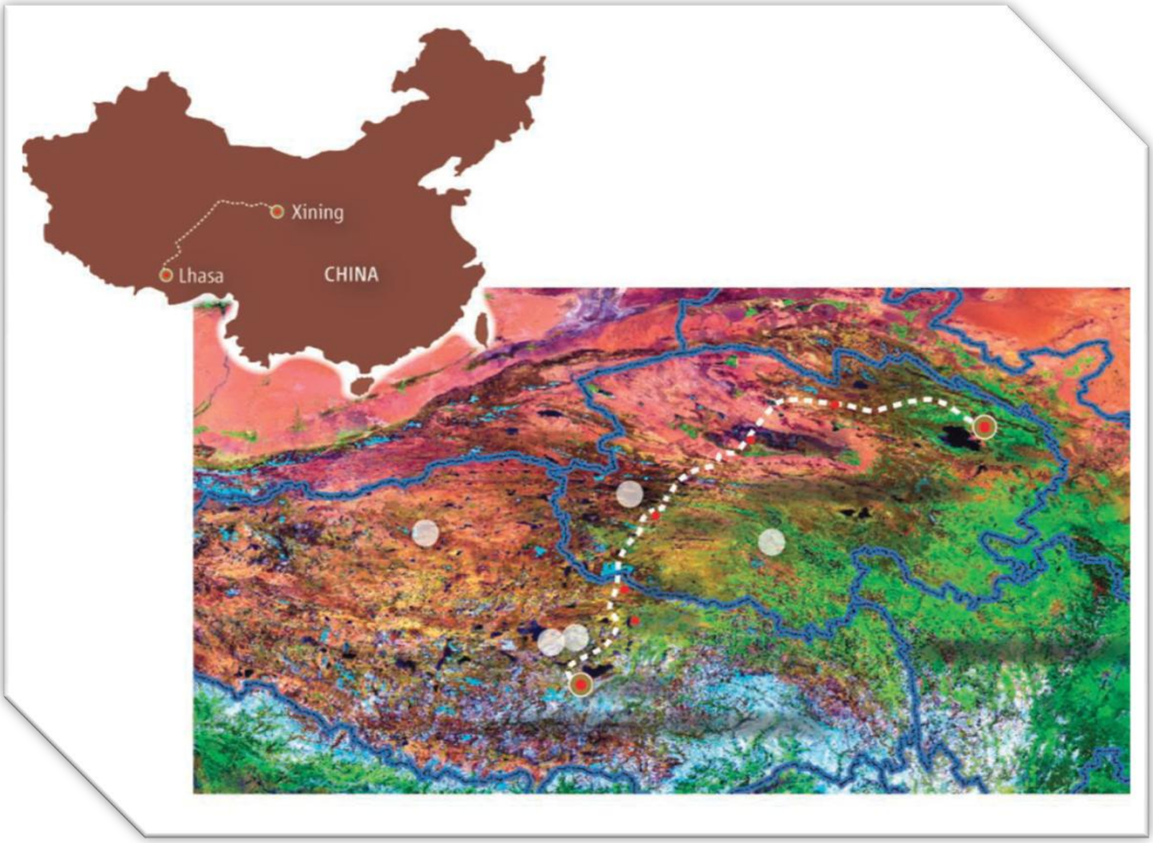

Figure 3: The Qinghai-Tibet railway from Xining to Lhasa (1956 km)
Source: Adopted from Peng *et al* (2007)

2.5.1 An Environment-friendly Railway

According to Peng *et al* (2007), the uniqueness and fragile high altitude ecosystem of the Qinghai-Tibet Plateau in China covering more than 360,000 km², raised major concerns of the potential consequences it would cause to the environment if the railway project was achieved. Thus the Chinese government and local officials keenly dealt with the environmental concerns as the QTR construction took place.

A "Green Policy" was developed by the planners of the railway construction emphasizing on protecting the soils, vegetation, animals and water resources (Peng, *et al., 2007*). The following best practices were encompassed in the policy:-

i) 550km of tracks was laid on permafrost
ii) A network of tunnels was added to the blueprints by the planners in order to avoid interference of seasonal animal migration routes including famous Tibetan antelopes

iii) The negative construction impacts were minimized by the Chinese government through implementation of the following key actions :

a. Careful selection of places where earth was eliminated and construction spots located. The vegetation removed during construction was replaced or restored after completion of the work as seen in Figure 4.

Figure 4: Grass restored

Source: Adopted from Peng *et al* (2007)

b. Construction work was restricted to the minimum area possible nearby the railway and the path of the railway directed to bypass around sensitive natural zones as much as possible.

c. Wherever possible, alternative routes around wetlands and lakes were formulated by planners and when it was impossible, bridges were constructed instead of surface routes thus minimizing the environmental impacts (Peng, *et al*., 2007).

d. To even out permafrost along the railway line, insulation and temperature reducing facilities for frozen layers were used below the tracks.

e. To reduce the impact of human wastes, a few stations were established along the line, while water treatment amenities were sufficiently provided at each station. There was also prevention of recycled water from entering natural water bodies directly (Peng, *et al*., 2007).

f. A third party, environmental inspector (Qinghai Environmental Protection Bureau), was introduced to monitor the railway construction to ensure adherence to the environmental standards (Peng, *et al*., 2007).

g. To guarantee extra safety of the environment, the trains using the railway were fully enclosed.

iv) Moreover, five nature reserves were established by the planners along the route of the railway, namely Kekexili, Qinghai Sanjiaghyuan, Chang Tany, Lin-chou Pengbo, and La-Lu. Six more were also put in the future plan (Peng, *et al*., 2007).

v) Additional bridges and passages for animals were built in sections of the railway that passed through the reserves to help protect wild animals and plants.

2.5.2 Construction Measures

i) To avoid alarming animals, efforts were made to reduce noise during construction process. Areas where animals travelled were identified by the planners and thus more than 33 passageways were built to allow undisturbed migration. In the end, species like Tibetan antelopes were not significantly affected by the construction due to the measures taken. Instead, a larger number of female antelopes were recorded in the area, being the largest ever documented.

ii) Workers used methods like wet-spraying of cement and wet drilling to reduce dust emissions. Water bodies like rivers were protected from sedimentation during the construction of the huge railway bridge.

iii) The Qinghai Environmental Protection Bureau engaged the railway construction unit to sign a letter of responsibility, the first of the kind to be signed in the history of railway construction in China. The letter encompassed the underlying principles of construction, the main tasks and the construction standards and regulations.

iv) Rather than burning local woody vegetation like trees, oil-burning boilers were used by the workers to stay warm, while electrical equipment were powered by solar energy. Builders used non-phosphate detergents and avoided discharge of sewage that is not treated at base caps.

2.5.3 Monitoring

i) There was no evidence of littering found by the monitoring teams because all the waste generated was collected and treated daily by the construction workers.

ii) The state administration of environment protection conducted an investigation on the QTR construction sites, giving a report that showed no change in the water environment, stating that the vegetation and animals in the area were protected effectively.

iii) In order to permit timely improvements and provide warnings in case of any problems developing, long-term monitoring of the wildlife and local environment were suggested.

CHAPTER 3: MATERIALS AND METHODOLOGY

3.1 The Study Area

The study area is the Nairobi National Park which is located in the southern section of Nairobi County. Its geographical coordinates are 1°22′24″S, 36°51′32″E and 1.37333°S 36.85889°E. It measures about 117.2 Km^2 and is mainly composed of vegetation cover. It is located approximately 7 kilometres from the centre of the city and to the south is the Athi Kapiti Plains and Kitengela migration and dispersal area.

Nairobi National Park possesses a large and varied wildlife population. It is one of Kenya's most successful rhinoceros sanctuaries, being a refuge for the migrating herbivores during dry seasons. The wildlife animals move out during the wet seasons, especially the herbivores disperse via the vital migration and dispersal areas at Athi Kapiti Plains and Kitengela. It is the main tourist attraction for visitors to Nairobi, given the diverse bird species, cheetah, hyena, leopard, lion and wildebeest and zebra migrations. It has a wildlife conservation education centre, an ivory burning site monument, a safari walk and an animal orphanage.
Figure 5 shows the location context of the study area.

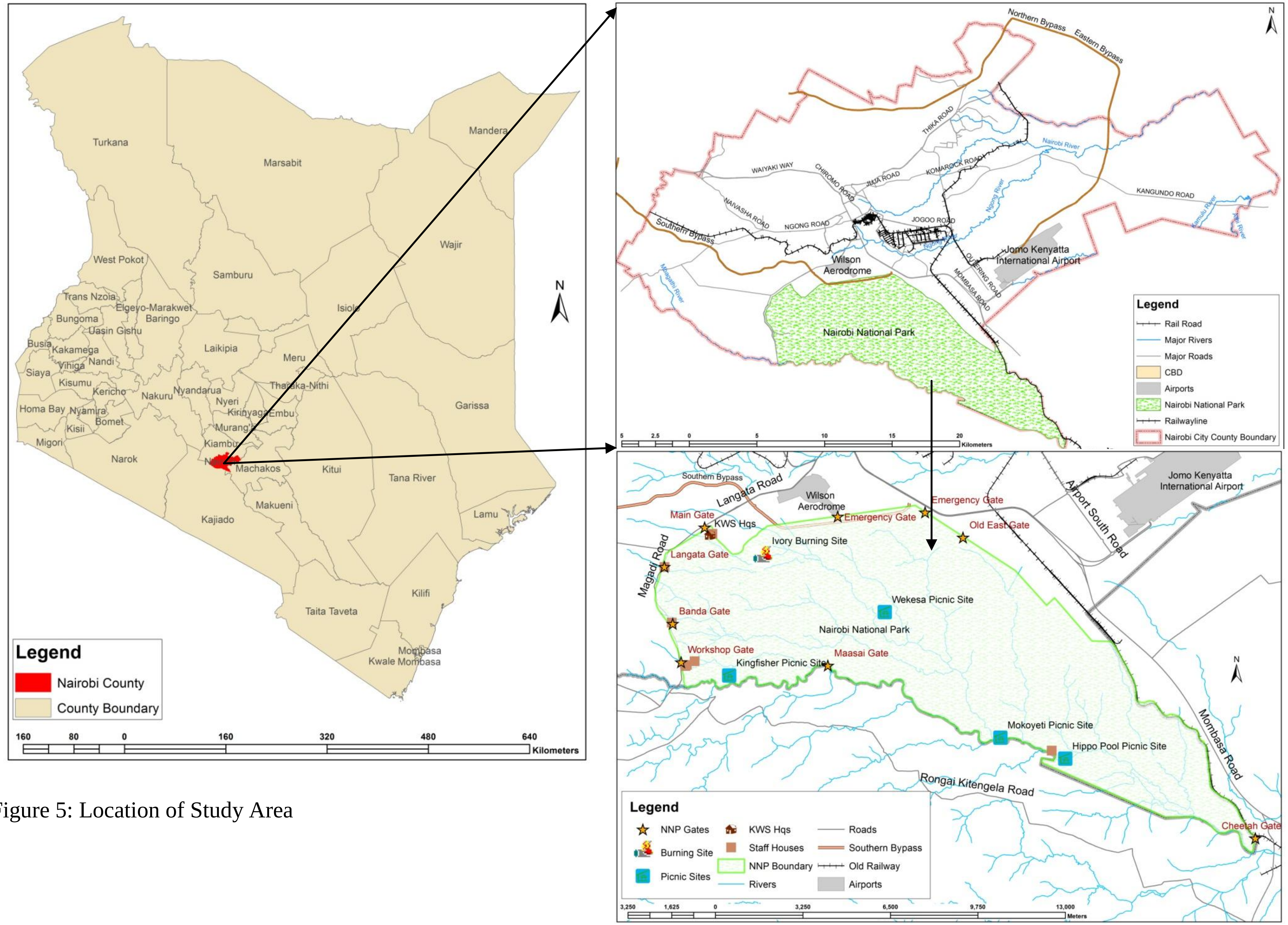

Figure 5: Location of Study Area

3.2 Research Methodology

a) Overview

Research methodology is a collective term for the structured process of conducting research. It includes collecting, analyzing and interpreting information to answer questions, and must, as far as possible, be controlled, rigorous, systematic, valid and verifiable, empirical and critical. Appropriate research methodology ensures validity of research data, ethics and reliability of measures.

This section expounds, in detail on the methods, tools and techniques used to carry out the study. It elaborates on data types and needs, data collection methods, instruments, process, data analysis and presentation techniques. The flow diagram was used to show a summary of the research methodology.

b) Description of Methodology

Relevant spatial and non-spatial data, based on the objectives, were collected for processing and analysis using geospatial technologies to assess the environmental footprints before and after the planned SGR on the Nairobi National Park. The data layers identified included SGR- Phase I alignment, SGR- Phase IIA alignment, Roads data, Rivers data, Boundary data, Noise prediction data, species distribution in the park, and vegetation cover types in the park. The layers were overlaid to identify the most impacted areas and spatial statistical methods applied to predict the expected continued impact over 5 years and 10 years, after which, a GIS based model was identified to solve the environmental problems and appropriate recommendations given.

c) Flow Chart

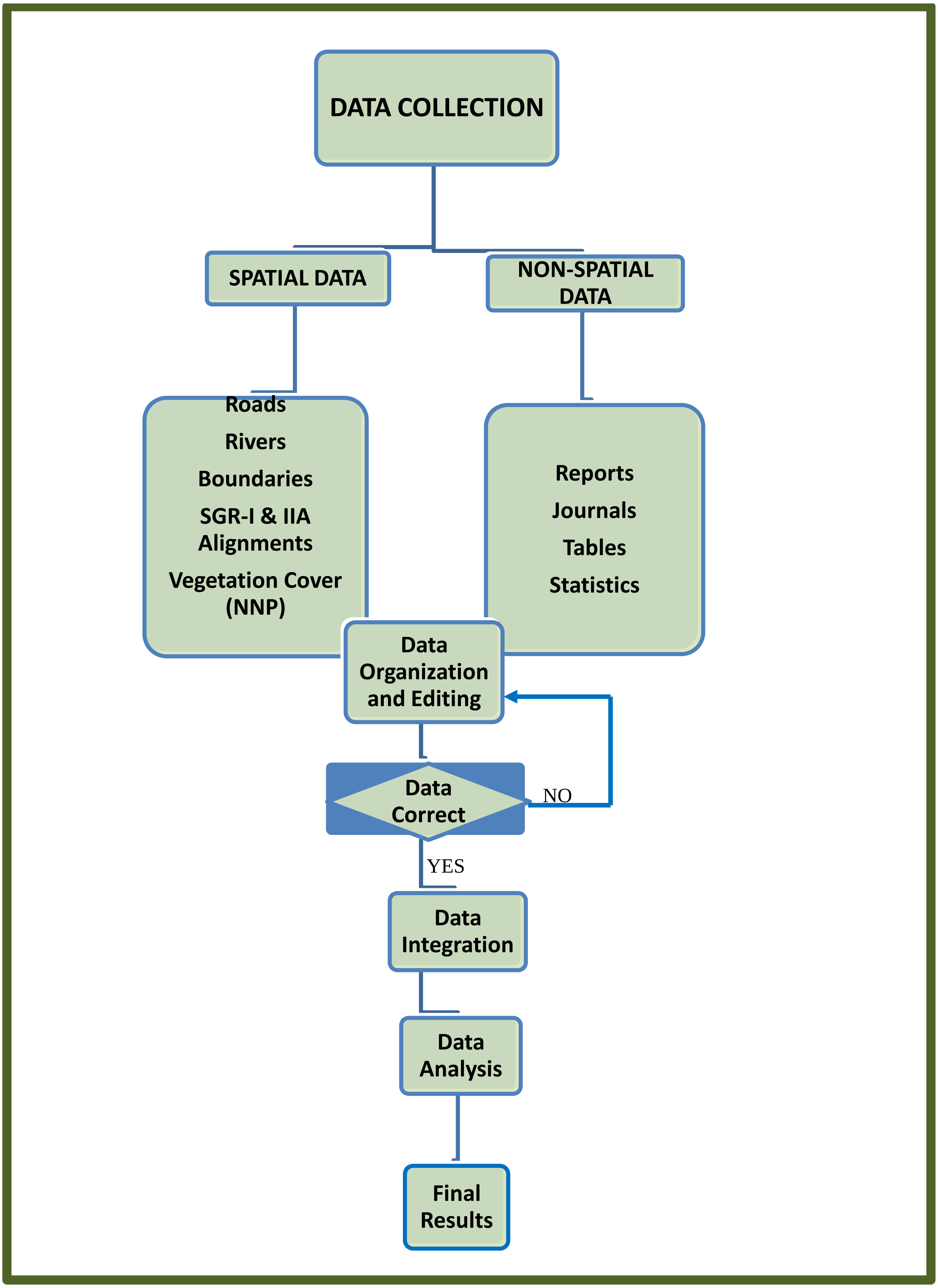

Figure 6: Summary Flow Chart of the Methodology

3.3 Datasets and Materials

The types of data collected were determined by the objectives of the research. Both primary and secondary data sources were used. The primary data included a map of Nairobi National Park from Kenya Wildlife Service; data on the realignment of the SGR route passing into Nairobi National Park from Kenya Railways; biodiversity dispersal areas from KWS; data on wildlife migration routes from Kenya Wildlife Service; and getting data from KWS results from wildlife counts and ecological monitoring information so as to identify distribution of species in Nairobi National Park, especially herbivores.

Secondary data on existing literature about the SGR, effects of development on the environment and the study area information were sourced from publications written by diverse authors, including government documents, scholarly journals, books from the library, theses and dissertations, and papers presented at conferences. Various internet sites were accessed for relevant information.

Table 1: Datasets and Sources

Data	**Source**	**Characteristics**
Airports/Old Railway/Rivers	Columbia-Nairobi Land Use Data	Vector data, 2010
Roads Data	Kenya Roads Board (KRB)	Vector data, 2016
Game Reserves and Parks	NEMA	Scale 1:50,000, 2009
SGR-I Alignment in NNP	Kenya Railways	AutoCAD drawing
SGR-II Alignment in NNP	Adopted from ESIA-Habitat Planners 2016	Schematic Diagram, Jpeg
Vegetation in NNP	Adopted from ESIA-Habitat Planners 2016	Raster Data, scale: 1:50,000 2016
Wildlife Species in NNP	Adopted from ESIA-Habitat Planners 2016	Tabular Data
Satellite Image of NNP	Google Earth Pro	Raster Image, 2017

3.3.1 SGR- Phase I and SGR- Phase IIA alignment into NNP

The SGR-Phase I's current re-aligned route encroaches on 87.29 ha (215.69 acres) of land of the Nairobi National Park, equivalent to 0.75% of the total park area, which is a significant portion of the wildlife habitat. Impacts related to SGR construction activities include vegetation clearance, land borrowing and filling, noise and air pollution. The design of SGR phase I is such that most of the line is built along the boundary of the park. Particularly, the SGR will interfere with the wildlife migration corridors that the animals have been used to for a long time. On the other hand, SGR- Phase IIA alignment cuts across the Nairobi National Park along a 6km stretch, interfering with vegetation cover and species distribution within the park. Conservation has been put in direct conflict with socioeconomic interests due to political and economic priorities. Figure 7 demonstrates how the AutoCad drawing layers from Kenya Railways were overlaid in Arcmap.

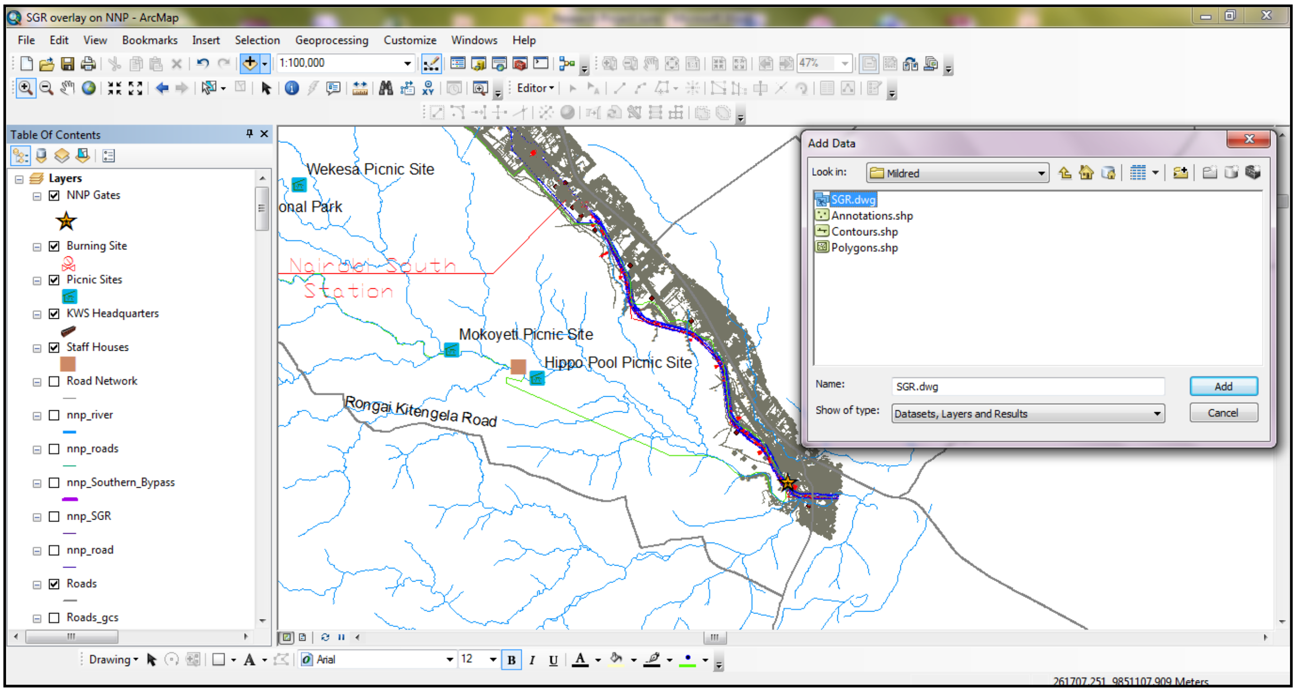

Figure 7: Overlay of SGR Alignment on NNP in ArcMap

(*Source*: KRC)

3.3.2 Severed Areas of NNP due to SGR-Phase I

The area that is severed by the encroachment of SGR- Phase I into the park is 32.5 hectares as highlighted in Figure 8.

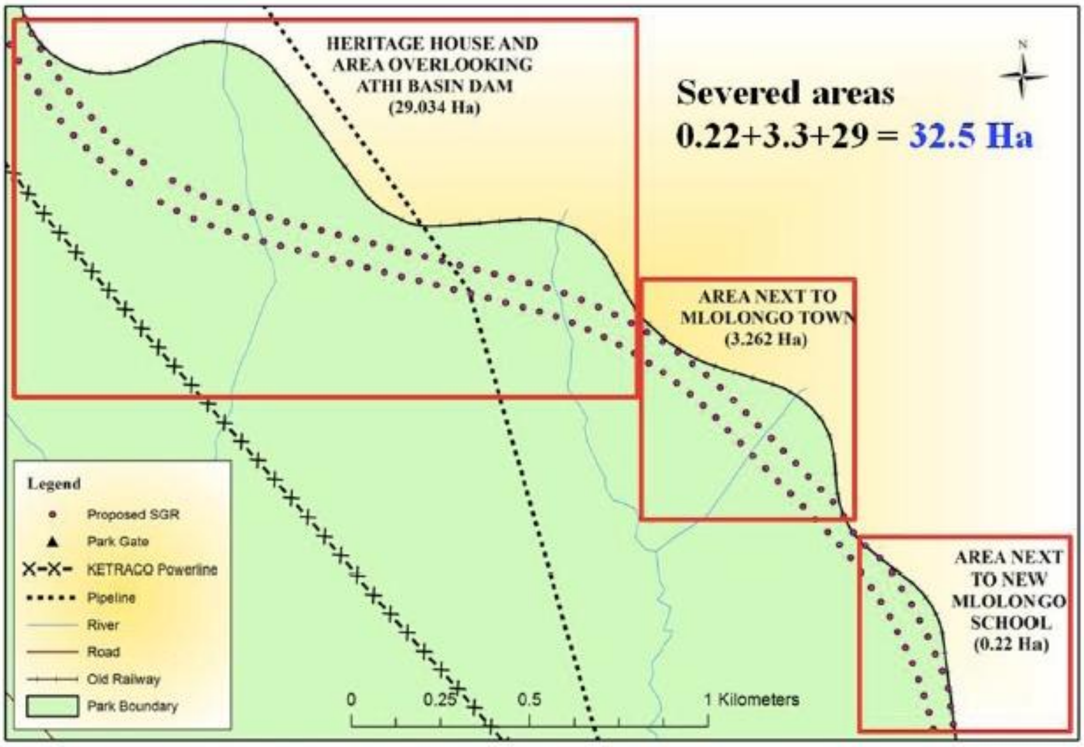

Figure 8: Detailed SGR Phase 1 Alignment and Habitat Loss in NNP
(*Source*: Murithi, 2015)

3.3.3 The 6 Km SGR- Phase IIA Route across the Park

The alignment for the SGR-Phase IIA route, which cuts across the park starts from the Nairobi South Station (DK0+00). The line enters the NNP near the East Gate of the park, crossing over the park through the savannah region in an almost straight line along a 6 km viaduct consisting of precast T-Frame girders of 18m height along a single track way-leave of 15m and exiting the park near NNP's Maasai Gate. According to the ESIA report (Habitat-Planners, 2016), the design of the viaduct is presumed to allow wildlife passage, while ensuring natural water flow in the park. The movement of tourists will also not be disturbed. In order to blend with the surrounding natural environment, the T-frame girders will be designed appropriately to reduce visual intrusion and impact as well, including acoustic noise-deflectors. The 6 km viaduct construction over the park is approximated to take eighteen (18) months in three (3) stages. The schematic diagram of the SGR- Phase IIA is outlined in Figure 9.

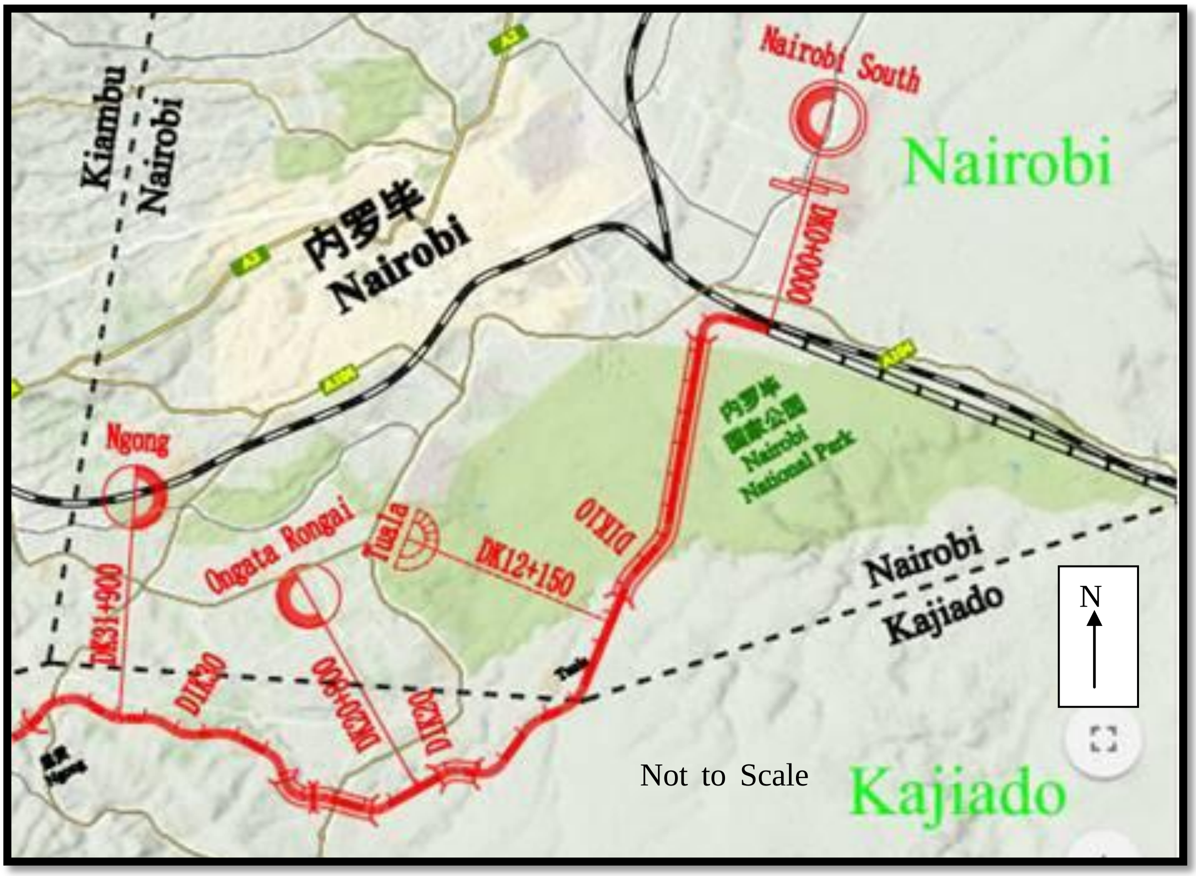

Figure 9: Schematic Diagram of SGR- Phase IIA Cutting across NNP
(*Source*: Habitat Planners, 2016)

3.3.4 Vegetation Types to be affected by SGR in Nairobi National Park

Nairobi National Park harbors nine vegetation types which are very useful to the wildlife habitat in the area, especially the herbivores. These are dense tall forest, forest glade, grassland, open dwarf tree grassland (acacia depranolobium) open dwarf tree grassland (acacia mellifera), open low shrubland, open tall riverine woodland, scattered low-tall tree grassland and riverine vegetation. Figure 10 shows the spatial layout of the vegetation types within the park.

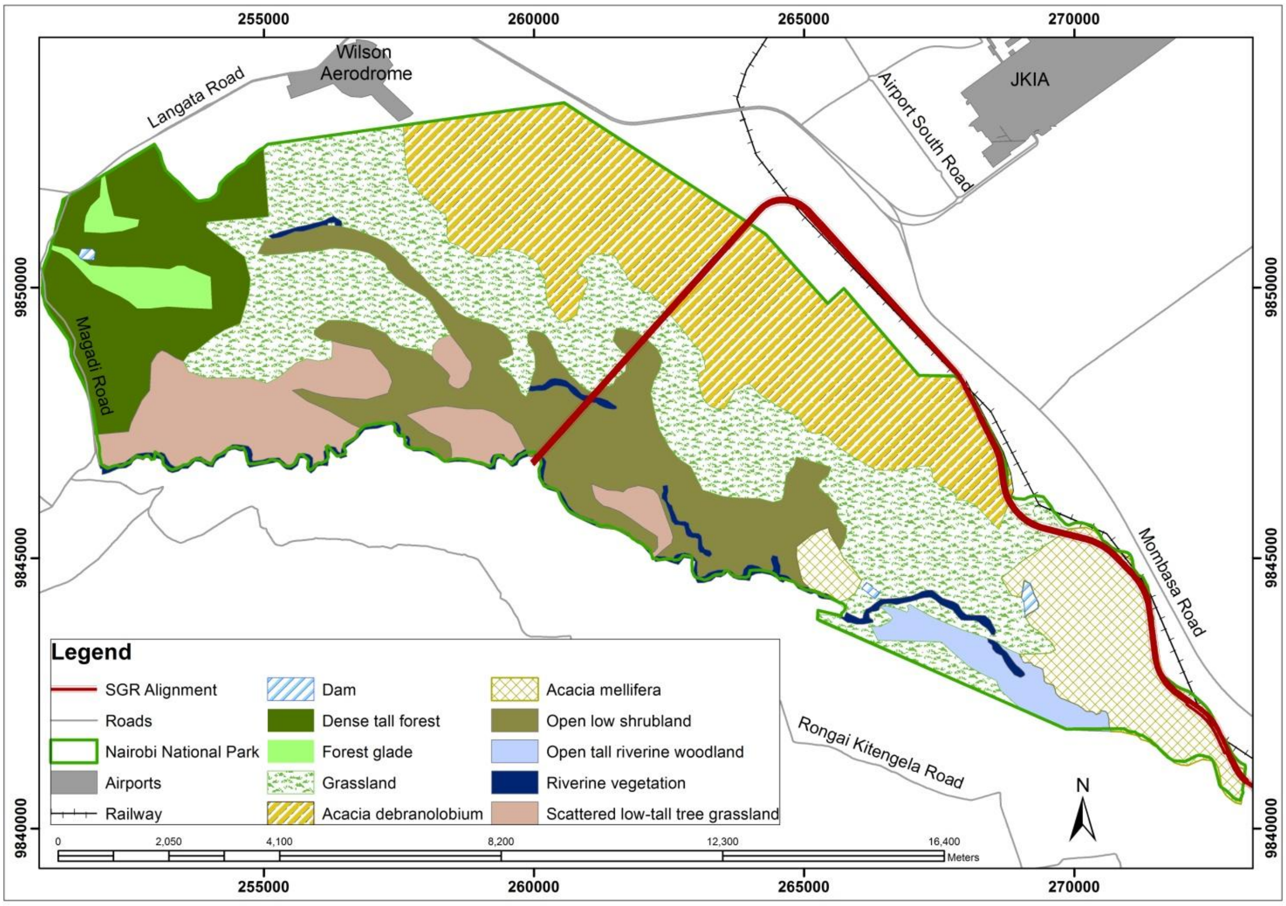

Figure 10: Vegetation Types in Nairobi National Park

Table 2: Type of Vegetation Affected and their Areas

SGR Section	Type of Vegetation Affected	Area (Ha)/ % of Total area
SGR Phase1	Grassland	2.06/0.06%
	Open low shrubland	3.35/0.19%
	Riverine vegetation	0.30/0.08%
	Open dwarf tree grassland (Acacia drepranolobium)	0.72/0.03%
SGR Phase 2	Grassland	1.67/0.05%
	Open dwarf tree grassland (Acacia mellifera)	9.00/1.00%
	Open dwarf tree grassland (Acacia drepranolobium)	7.89/0.32%

Source: (Habitat-Planners, 2016)

3.3.5 Key wildlife species and potential habitat impact (ha) in the SGR-IIA route across the Park

Nairobi National Park boasts of a large and diverse wildlife population. The species that are found in the park comprise of baboons, Coke's hartebeest, Cape buffaloes, Eastern black rhinos, hippopotami, impala, leopards, Maasai lions, Maasai giraffes, ostriches, Tanzanian cheetahs, vultures and waterbucks. Herbivores like the wildebeest and zebra use the Kitengela conservation area and migration corridor to the south of the park to access the Athi-Kapiti plains.

During the wet season, they disperse over the Athi Kapiti plains and thereafter take a refuge in the park in the dry season, thus making the concentration of wildlife high in the park, due to avoiding the dried up areas outside the park. Along the Mbagathi river, there are built small dams which give the park more water resources compared to the outside areas, hence the high attraction of the herbivores which depend on water. A high diversity of bird species are also found in the park, with up to 500 permanent and migratory species. Birds and aquatic species have their man-made habitat in the dams in the park. The following table shows the key wildlife species and potential habitat impact areas in hectares that will be affected by the construction and operation of the SGR Phase IIA.

Table 3: Key Wildlife Species and Potential Habitat Impact (ha.) in the SGR-Phase IIA Route Affected by Construction and Operation

Project Phase IIA	Lion	Black Rhino	Zebra	Wildebeest	Coke's Hartebeest	Grant's Gazelle	Thomson's Gazelle	Impala	Buffalo	Maasai Giraffe	Eland	Total Area (Ha)	Total Species
Construction Area (Ha)	3.08	5.71	6.13	6.13	6.13	0.72	6.13	6.13	6.13	6.13	5.4	57.9	8
Operation (viaduct) Area (Ha)	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	3.19	8

Source: (Habitat-Planners, 2016)

3.3.6 Noise

One of the most irritating disturbances of the environment during construction and operation of the railway lines is Noise. The Standard Gauge Railway is not an exception. Minimizing the impact of this "unwanted sound" called noise by any given development is very important. The units for measuring noise intensity are called decibels (dB).

During the construction of the SGR, noise levels will be mainly caused by the construction machinery and equipment like excavators, bulldozers, pile drivers plus other sources that are stationary. Mobile sources will include transport vehicles, trucks, road rollers and other light sources which can exert noise up to 10 meters from the source of production. Common construction equipment, vehicles and transport machinery have a noise intensity of 76-92 dB(A) in earth and stone stage, piling stage creating 90-109 dB(A), structural construction stage generating 70-90 dB(A) and decoration stage producing 85-95 dB(A).

Operation of the SGR will result in noise impact on the surrounding environment within a distance of 200m exerted on both sides of the railway line. The main sources of the noise will be running and whistling of the trains, shunting at stations, departing/arrival of the trains, and frequent servicing works of the locomotives. Moreover, 30m away from the central line of the outer rail, there is no shelter at the locations, thus noise is predicted for different lines during the day and at night.

Table 4: Predicted Noise Levels for the Proposed SGR Locomotives

Section/Item	**Distance from the Central Line of Outer Rail to the Predicted point (m)**	**No. of Train Pairs (Pairs/Day)**		**Equivalent Sound Levels dB(A)**			
				Day		**Night**	
SGR-IIA	30	Passenger train	Freight Train	Sub grade	Bridge	Sub grade	Bridge
		2	13	58.7	61.4	55.7	58.4

Source: (Habitat-Planners, 2016)

3.3.7 Wildlife Migration Corridors

Data on wildlife migration routes was extracted from the internet and used as a base for digitizing the migration routes, as shown in figure 11.

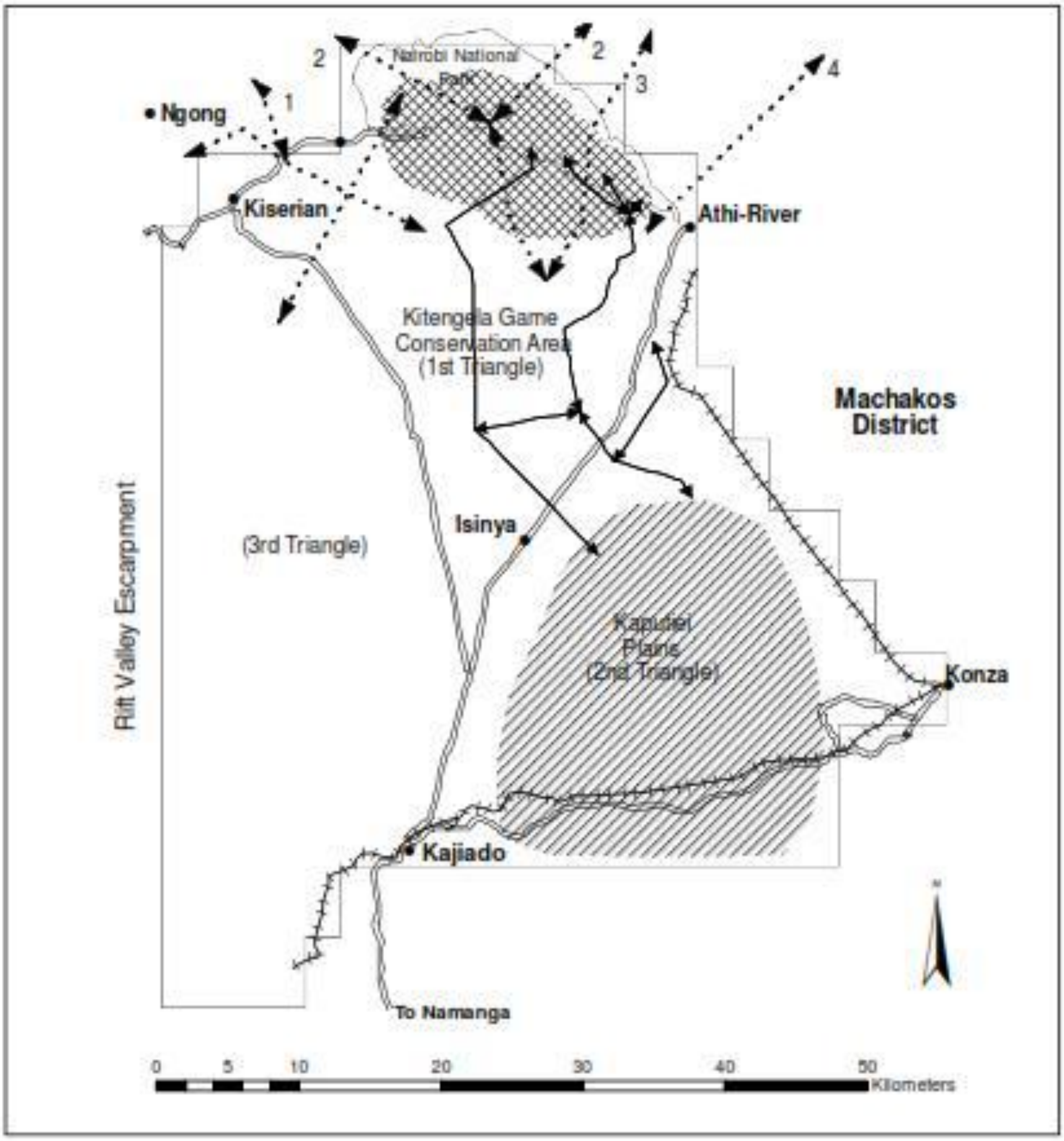

Figure 11: Migration Routes for Wildlife in NNP

Source: (Habitat-Planners, 2016)

3.4 Data Analysis

Research methodology, usually encompasses the procedures followed to analyze and interpret the data that has been gathered. These often use a range of sophisticated statistical analysis of the data to identify correlations or statistical significance in the results. In order to obtain meaningful interpretation of the research findings, the data collected was filtered and analyzed using graphs, tables and pie charts. Qualitative data was analyzed through logical reasoning.

Geographical Information System (GIS) was used to analyze spatial data. The layers of the most impacted areas were overlaid. The Euclidean Distance analysis tool was applied to calculate the environmental impacts that will be caused by construction and operation of the SGR in Nairobi National Park's ecosystem. Calculation of the area of vegetation cover that will be displaced by the construction of the SGR was done and a map of the same prepared. Spatial statistical methods were applied to predict the expected continued impacts over 5 years and 10 years.

3.4.1 Data Analysis Tools

The analysis tools that were used in the research were

i) Euclidean Allocation Analysis
ii) Buffer Analysis
iii) Measurements
iv) Graphs

3.5 Data Presentation and Interpretation Techniques

Presentation and Interpretation of the statistical output is very important, whereby data that are relevant to the research project are interpreted, making sure the output is well understood. After data analysis, data was presented either as categorical or continuous data. Continuous data was presented using line graphs and descriptions, while categorical data was presented through pie charts and bar graphs among others. Spatial data were presented using photographs, maps and 3D models.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Overview

The key findings are provided in this section based on the study objectives informed by the field research carried out in the study area. Data was seamlessly integrated through harmonization of the various GIS datasets in a spatial environment, thus achieving a consistent scale, extent and uniform coordinate system. The issues addressed cut across problems experienced in various natural habitats in the country, where the SGR will be traversing.

Overlays of the SGR alignment in the park, vegetation type, and species distribution are based on a common measurement scale.

4.2 Results

The results obtained with regards to the objectives of the study are outlined as follows:-

4.2.1 SGR Encroachment on Nairobi National Park

The drawing obtained from Kenya Railway was an AutoCAD file which was overlaid on Nairobi National Park layers in ArcGIS and the centre line and edges of the SGR digitized for easier visualization and analysis. The resultant overlay map is shown in Figure 12.

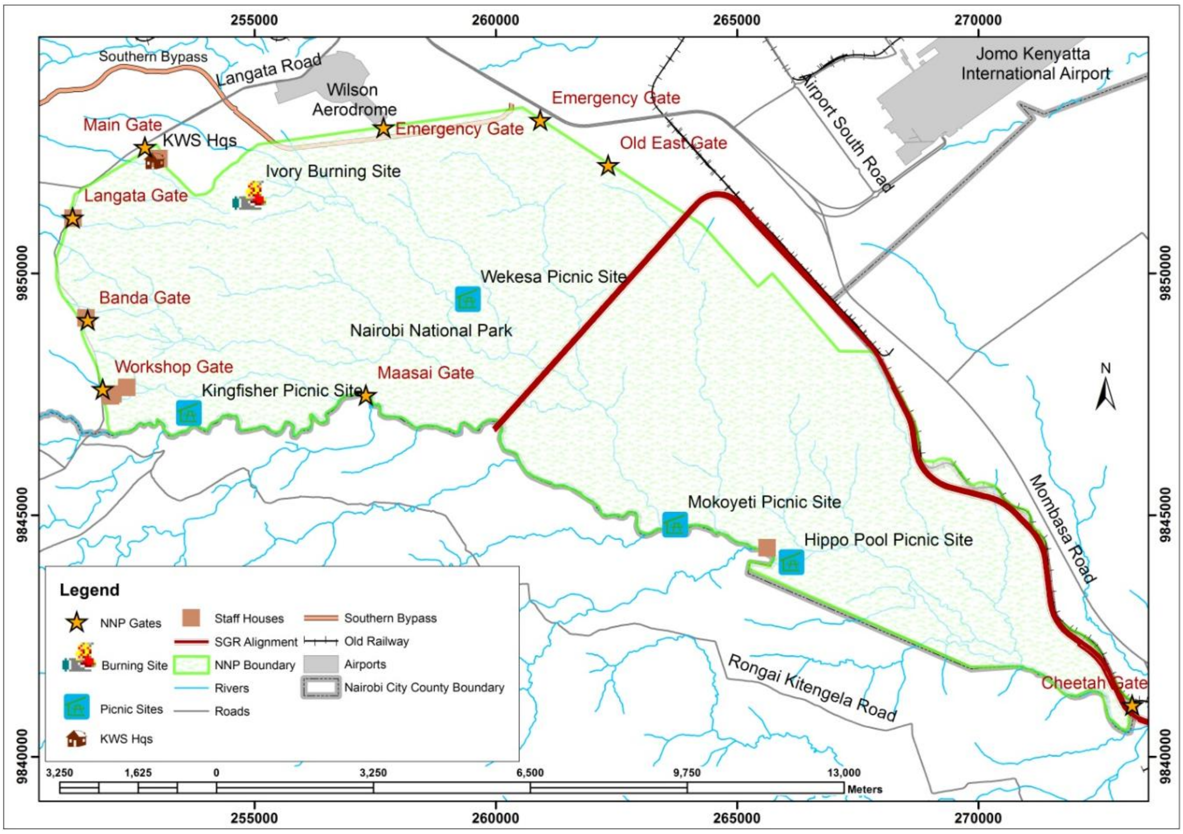

Figure 12: Map of SGR Overlay on Nairobi National Park

4.2.2 Noise Maps

Based on the predicted noise intensity by Habitat Planners (2016) for locomotives to be 64.1 dB(A) during the day and 58.4 dB(A) during the night, while 76-92 dB(A) in earth and stone stage, piling stage creating 90-109 dB(A), structural construction stage generating 70-90 dB(A) and decoration stage producing 85-95 dB(A), the study assumed the highest noise level pressure for both construction phase and operation phase for the SGR to be 109 dB(A). This was the basis on which the Euclidean allocation analysis tool was anchored for calculation of sound pressure level.

The following formula adopted from (Wawa & Mulaku, 2015) was applied:

Equation 1: Formula for Calculating Sound Pressure Level at a Given Distance from a Noise Source

$$Lpd_2 = Lpd_1 + 20 * \log (d_1/d_2)$$

Where:

- Lpd2 = the sound pressure level at the new distance from noise source
- Lpd1 = the sound pressure level at the original distance
- d_1 = the original distance
- d_2 = the new distance

The distance at the source, which is the SGR was assumed to be 30 metres as per the prediction Table 4 in chapter 3. Taking a distance of 5 km from the source, the commensurate sound pressure levels were in decibels were calculated using the formula in equation 1 above and the values obtained were recorded in Table 5 below.

Table 5: Noise Level for SGR Buffers Based on Calculations

Point	Buffer Distance (m)	Lpd1 dB(A)	Lpd2 dB(A)
d_1	30	109	109.00
d_2	500	109	84.56
d_3	1000	109	78.54
d_4	1500	109	75.02
d_5	2000	109	72.52
d_6	2500	109	70.58
d_7	3000	109	69.00
d_8	3500	109	67.66
d_9	4000	109	66.50
d_{10}	4500	109	65.00
d_{11}	5000	109	64.56

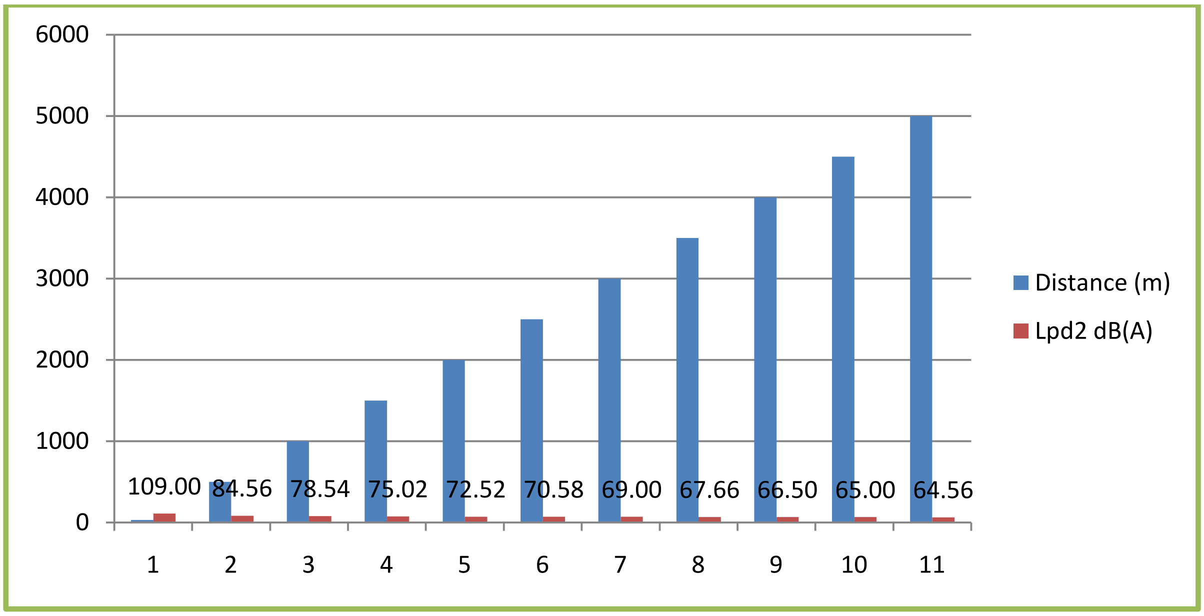

Figure 13: Graph of Distance verses Decibels

The SGR buffers were then analyzed using the Euclidean distance analysis tool in ArcGIS and the results in the maps in Figure 14 and Figure 15 were realized.

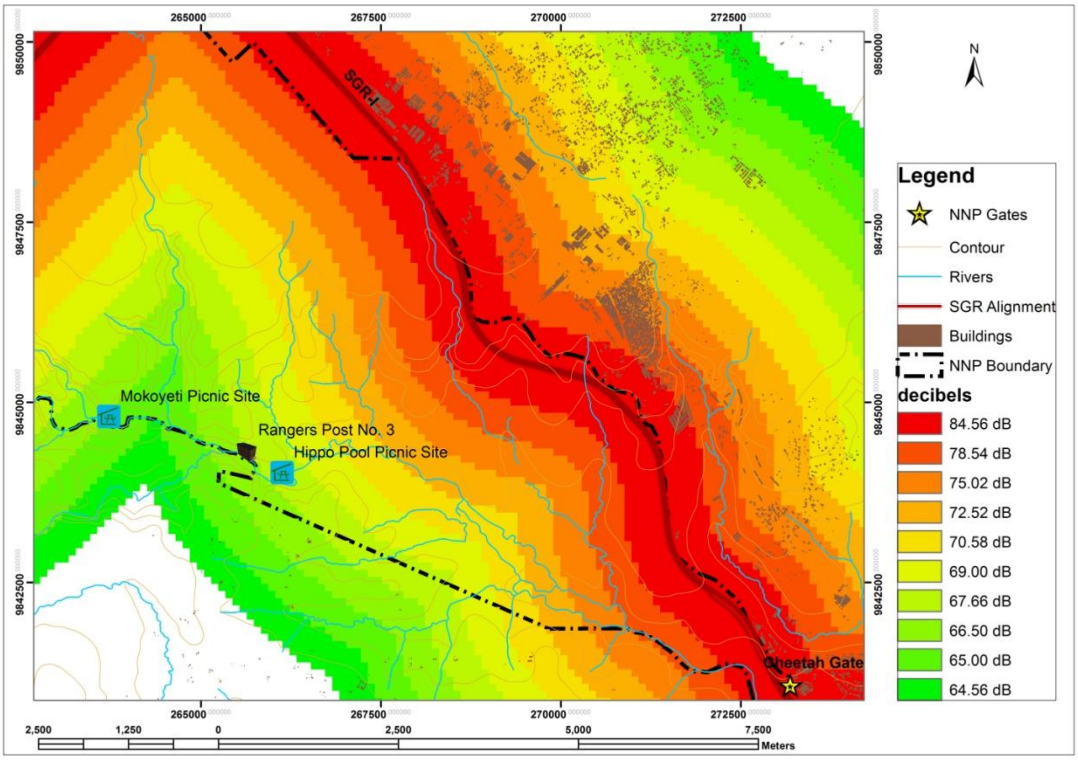

Figure 14: Noise Map of Construction and Operation of SGR- Phase I in NNP

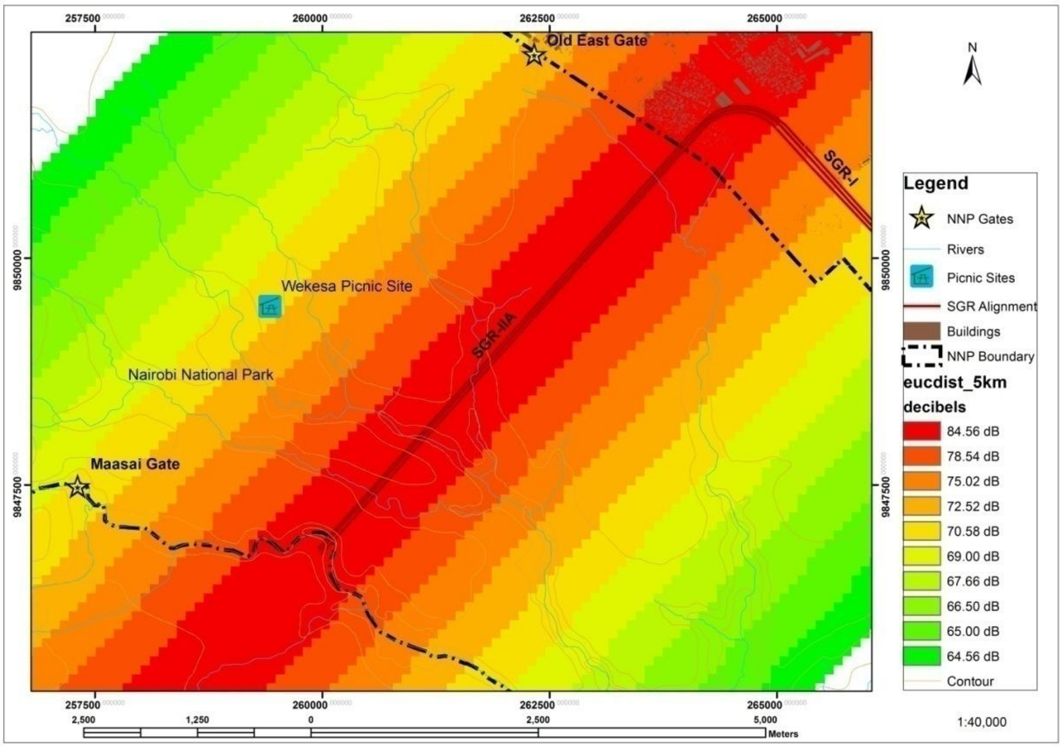

Figure 15: Noise Map of Construction and Operation of SGR- Phase IIA in NNP

4.2.3 Affected Vegetation Cover in NNP

The buffer analysis tool was used to show the 200m extend on both sides of the SGR line. The buffer result was clipped within the park extend to demonstrate the magnitude of the vegetation lost during construction and operation of the SGR. The map in Figure 16 displays the results.

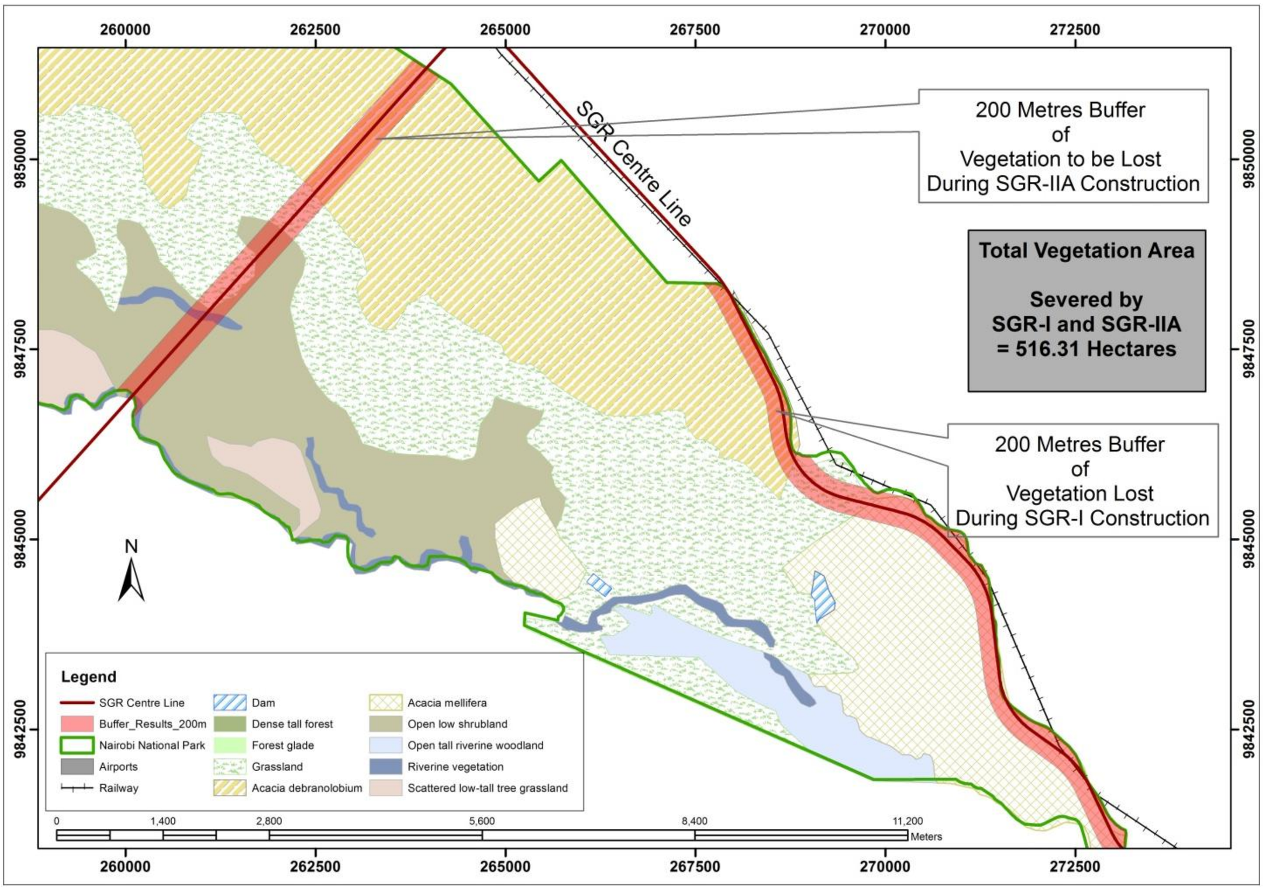

Figure 16: Map of Vegetation Affected by SGR in Nairobi National Park

The specific vegetation types along the SGR path were clipped and their areas calculated in ArcGIS as outlined in Table 6 and displayed in Figure 17. The total area of vegetation loss during construction and operation of the SGR is approximately 500.61 Hectares which is approximately 4.26% of the total park area.

Table 6: Area of Specific Vegetation Loss due to SGR Construction

SGR Section	Type of Vegetation Affected	Area (Ha)	Percentage of Park Area
SGR-I & SGR-IIA	Grassland	95.07	0.81%
	Open low shrubland	84.53	0.72%
	Riverine vegetation	7.03	0.06%
	Open dwarf tree grassland (Acacia mellifera)	161.14	1.37%
	Open dwarf tree grassland (Acacia drepranolobium)	152.84	1.30%
Total		**500.61**	**4.26%**

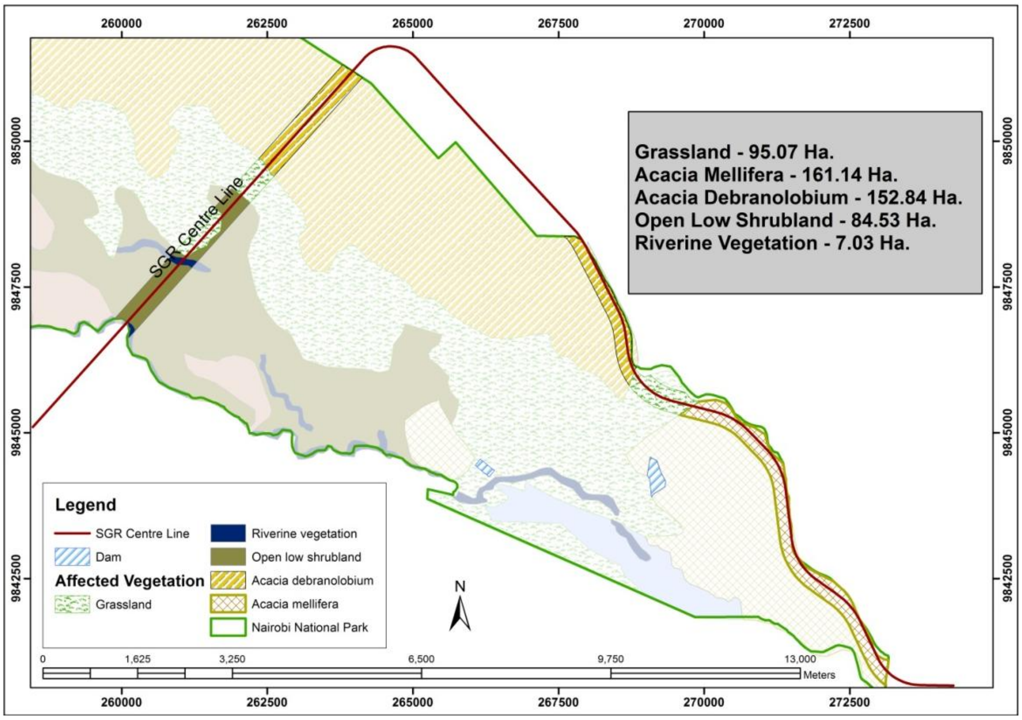

Figure 17: Map of Area of Specific Vegetation Loss in the Park

4.2.4 Fragmented Species

Some of the species that will be fragmented in Nairobi National Park are outlined below as per the KWS annual average count for 2011.

Table 7: A Sample of Species Count in Nairobi National Park

KENYA WILDLIFE SERVICE

Wildlife Census Reports

Annual Average Total Animals Report

2011

Common Name	Annual Average Total Animals
Aardvark	0
Aardwolf	1
African or Cape Buffalo	253
Baboon	35
Banded Mongoose	1
Black Rhinoceros	11
Black-bellied Bustard	3
Blackedbacked Jackal	4
Blue or White Bearded	132
Burchell's Zebra	1091
Bushbuck	20
Caracal	0
Common Duiker	1
Common or Defassa	9
Common Ostrich	79
Common Reedbuck	5
Eland	154
Fringe eared oryx	0
Gemsbok	0
Giraffe	94
Grant's Gazelle	117
Grey Crowned-Crane	11
Hartebeest	526
Hartlaub's Bustard	2
Harvey's Red Duiker	2
Helmeted Guineafowl	94
Hippopotamus	3
Impala	563
Kirks' Dikdik	13

Wildlife Census Reports

Kori Bustard	3
Lion	17
Marabou Stork	14
Martial Eagle	3
Nile Crocodile	1
Nile Monitor	1
Oribi	3
Red Lechwe	0
Rock Hyrax or Dassie	1
Secretarybird	2
Serval	1
Spotted Hyena	1
Spring Hare	1
Steenbok	2
Striped Hyaena	4
Suni Antelope	2
Thomson's Gazelle	222
Vervet Monkey	20
Warthog	17
White Rhinoceros	6
White throated/Sykes' Monkey	10
White-backed Vulture	8
White-bellied Bustard	2
White-tailed Mongoose	1
Yellow-necked Spurfowl	16
	3582

(*Source*: KWS 2011)

4.2.5 Migration Routes

The wildlife migration routes were digitized from existing data and the SGR- Phase I and SGR-Phase IIA alignment overlaid. The SGR- Phase IIA will in particular affect the wildlife migration routes since it cuts through the Athi Kapiti Plains as shown in the map in Figure 18:-

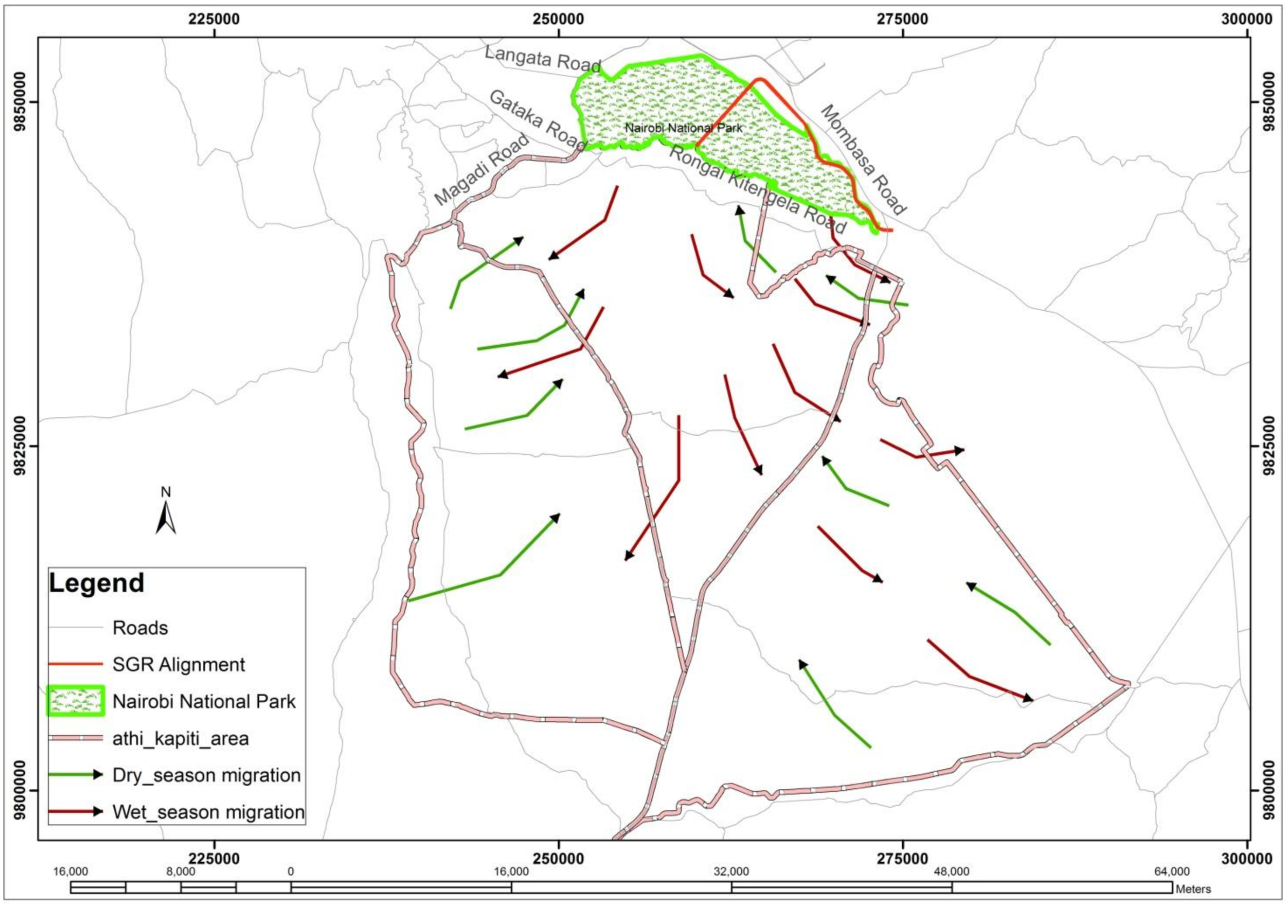

Figure 18: Map of Wildlife Migration Corridors

4.3 Discussion

The overlay of the SGR on Nairobi National Park in Figure 12 illustrates that features like the rivers, dams, roads and other utilities in the park will be interfered with by all means. The natural river flow will be interrupted, the roads re-routed, while the affected dams, which are man-made habitats for birds and aquatic species, will be extinguished in the long run. Phase 1 of the SGR that is already operational has hived off a significant area of 87.29 hectares of the park, reducing the natural habitat area by 0.75%. The section of SGR Phase 2 that cuts across the park divides the habitat into two portions, thus the probability of the wild animals sticking to one side is very high.

Noise pollution maps in Figures 14 and 15 showed intensive noise next to the source, which is the SGR, and a reduction in the noise pressure level further from the source with increase in distance. The graph in Figure 13 further demonstrates the decrease in noise pressure level as the distance increases. Even with the noise deflector acoustics that will be installed in the design of the viaducts across the pillar, the noise produced during construction of the SGR and throughout operation will intensely affect the wild animals in the park plus the personnel and tourists who visit the park. Moreover, combined with the noise produced by the aircrafts to both Jomo Kenyatta International Airport (JKIA) and Wilson airport, the noise levels will be even higher. The aftermath is immense exit of wildlife from the park.

The immense wildlife habitat loss during construction of the SGR was well illustrated by the vegetation types affected analysis in Figure 17, with approximately 500.61 hectares being destroyed. This is a very significant part of the park that will be affected hence, less vegetation for the herbivores animals whose food is reduced. The birds nesting areas will be destroyed when vegetation is cleared during construction of the SGR. Phase 1 of the SGR, which is already operational cut off 87.29 hectares of the vegetation. Furthermore, the good aesthetics of the Nairobi National Park is infringed on by loss of vegetation cover.

Following the results in Table 7 and Figure 18, many of the wildlife species in the park will be fragmented since their migration routes will be encroached on to by the SGR construction and operation. It will take the wild animals a very long time to adjust to the foreign underpasses and bridges that will be provided. Some of the animals will in the long run disappear from the park due to confusion from the goings on.

During construction of the SGR- Phase IIA, foreign species will be carried from outside into the park, affecting the resident species which can be detrimental to the entire ecosystem. As the locomotives operate on a daily basis, solid waste disposal in the park will also be high since it is difficult to control human beings on when and where to litter while on the journey.

There is high possibility of expanding the number of lines of the SGR in future since the current one is only one line. Therefore future extended encroachment on to the park cannot be ruled out.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Chapter five presents the summary of the findings, conclusions and recommendations of the study.

5.1 Conclusions

The following were the objectives of this study:

i. To establish the development details of the SGR project.
ii. To evaluate the level of encroachment of the SGR corridor into Nairobi National Park.
iii. To assess and map out the environmental footprints of the project on the park using GIS.
iv. To recommend a GIS based model for solving the environmental problems identified.

The conclusions below were reached:-

- A demonstration of how the Standard Gauge Railway (SGR) has encroached on Nairobi National Park was achieved by use of the various GIS analysis tools.
- Phase I of the SGR is already operational and therefore the affected land has been fenced off from the park reducing the area of the park by 87.9 Hectares.
- Phase IIA is yet to be constructed but will cut across a 6 km stretch of the park with a 70m way leave as is outlined in the schematic diagram of the SGR alignment, affecting approximately 42 Hectares.
- The vegetation that was lost during construction of SGR-I and that which will be lost during construction and operation of SGR-IIA is very significant to the wild animals especially the herbivores.
- The dust resultant from the construction phase of the SGR is detrimental to the vegetation in the park on which the herbivores animals feed on. The wild animals and workers of the park will also be affected by the dust.
- The noise pollution from the construction phase of the SGR is short term but very intensive to animal habitat since animals respond to the slightest noise possible. Noise produced by the continuous operation of the SGR is a lifetime occurrence and therefore will fragment the wild animals in the park.
- Since the Athi Kapiti Plains is the main migration corridor for wildlife from and to Nairobi National Park, it will suffer interference due to the construction and operation of SGR-IIA.

5.2 Recommendations

The study recommends the following:-

- During construction of SGR-IIA across Nairobi National Park, workers should be advised to use methods like wet-spraying of cement and wet drilling to reduce dust emissions.
- Water bodies like rivers and dams in the park should be protected from sedimentation during the construction of the huge railway viaduct.
- The National Environmental Management Authority (NEMA) should engage the SGR construction unit to sign a letter of responsibility, encompassing the underlying principles of construction, the main tasks and the construction standards and regulations.
- All the waste generated during construction should be collected and treated daily by the construction workers, to avoid littering in the park which is harmful to the wildlife species in the park.
- Investigations of the construction sites should be conducted often to ensure protection of the environment, giving reports showing the state of the water environment, while ensuring effective protection of vegetation and animals in the area.
- There is need to have long-term monitoring guidelines of the wildlife and local environment put in place by KWS to permit timely improvements and provide necessary warnings in case of any problems developing.
- More research should be done on the best route for the SGR to avoid it cutting across the Nairobi National Park. A suitability analysis using GIS would inform the relevant institutions on the best route that is environmental friendly.

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Appendix 1: Research Permit from NACOSTI

NATIONAL COMMISSION FORSCIENCE, TECHNOLOGY ANDINNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

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

Ref. No. **NACOSTI/P/17/98921/17184**

Date: **24th May, 2017**

Mildred Murende Ambani
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"GIS assessment of environmental footprints of the standard gauge railway (SGR) on Nairobi National Park,"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for the period ending **23rd May, 2018.**

You are advised to report to **the Chief Executive Officers, Kenya Wildlife Service and Kenya Railways Corporation, the County Commissioner and the County Director of Education, Nairobi County** 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.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The Chief Executive Officer
Kenya Wildlife Service.

The Chief executive Officer
Kenya Railways Corporation.

National Commission for Science, Technology and Innovation isISO9001:2008 Certified

Appendix 2: Research Permit Card

THIS IS TO CERTIFY THAT:
MS. MILDRED MURENDE AMBANI
of UNIVERSITY OF NAIROBI, 30197-100 NAIROBI,has been permitted to conduct research in *Nairobi County*

on the topic: *GIS ASSESSMENT OF ENVIRONMENTAL FOOTPRINTS OF THE STANDARD GAUGE RAILWAY (SGR) ON NAIROBI NATIONAL PARK*

for the period ending:
23rd May,2018

Permit No : NACOSTI/P/17/98921/17184
Date Of Issue : 24th May,2017
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

Appendix 3: Research Permit from Kenya Railways

P.O. Box 30121-00100, Nairobi, Kenya
Tel: 0709-907 114, 0709-907 000
Cell: 0728-603 581, 0728-603 582
E-mail: info@krc.co.ke
Website: www.krc.co.ke

KENYA RAILWAYS

Ref: HRM. 4/1/1/2

12th June, 2017

Mildred M. Ambani
P.O. Box 52327-00100
NAIROBI

Dear Madam,

RE: PERMISSION TO COLLECT RESEARCH DATA ON THE STANDARD GAUGE RAILWAY

We acknowledge receipt of your letter dated 9th May, 2017 on the above subject matter.

This is to inform you that your request to collect data for research with regard to the Standard Gauge Railway has been approved.

You will be required to conduct the exercise personally.

For any further enquiries, please liaise with our Project Manager - SGR, Eng. Maxwell Mengich on email mmengich@krc.co.ke and tel. No. 0709-907000.

Yours faithfully,

Florence Kanja
Human Resource & Admin. Officer
FOR: HUMAN RESOURCE & ADMIN. MANAGER

All correspondence should be addressed to the Managing Director

Appendix 4: Reference Letter- GST

UNIVERSITY OF NAIROBI
DEPARTMENT OF GEOSPATIAL & SPACE TECHNOLOGY
P.O. Box 30197, 00100 Nairobi, Kenya
Telephone: +254 20 3318262/+254 20 491 3525
Email: surveying@uonbi.ac.ke

Our Ref: F56/80753/2015 **Date:** 03/05/2017

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: MILDRED M. AMBANI - F56/80753/2015

This is to confirm that the above mentioned is a Masters student in the Department of Geospatial and Space Technology, University of Nairobi. She is in her Final Year of study.

I am writing to request you to allow her to collect data for her Masters project from your facility.

She is carrying out a research project entitled **"GIS Assessment of Environmental Footprints of the standard Gauge Railway (SGR) on Nairobi National Park, Kenya".** To be able to achieve this, substantial data is required.

We shall be grateful for any assistance given to her.

Yours faithfully,

CHAIRMAN
GEOSPATIAL & SPACE TECHNOLOGY
UNIVERSITY OF NAIROBI

Dr.-Ing. S.M. Musyoka
Chairman,
Department of Geospatial & Space Technology

SMM/maw