THE ASSESSMENT OF THE IMPACT OF ANTHROPOGENIC ACTIVITIES ON THE MIGRATORY CORRIDORS OF NAIROBI NATIONAL PARK: A GEOGRAPHIC INFORMATION SYSTEMS APPROACH.

by

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DECLARATION

This dissertation is my original work and to the best of my knowledge has not been presented for a degree in any other University.

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ABSTRACT

The impact of the anthropogenic activities on the migratory corridors of Nairobi National Park was studied from 1990 – 2000. These activities were categorized as the residential areas, industrial areas, commercial activities, farming and communication lines. These anthropogenic activities have been taking pace in the Nairobi National Park neighbourhood.

Primary data was used by conducting field training at the Nairobi National Park using a GPS. Secondary data was also used in form of animal count records from 1990 – 2000, rainfall data (1990 – 2000). This data was used to study the trends in population totals of animals in the park and also the behaviour patterns. The spot image (1995) and the landsat image (2000) were used to assess the anthropogenic changes that have taken place in the park neighbourhood for the last ten years (1990-2000). The G.I.S. was used as a computer tool to assess the impact of the anthropogenic activities on the migratory corridors i.e. Cheetah Gate, leopard cliff and South-western route through Maasai Lodge. Buffer zones were used to show the negative impact of the anthropogenic activities on the migratory corridors.

The findings showed that the most affected corridors are the leopard cliff route and the south-western route through Maasai Lodge. At the same time the wildebeest and the zebra are most vulnerable animals since they have to migrate in and out of the park according to seasons. The study recommends a careful management of the buffer area inorder to sustain traditional animal movements, minimize increasing human-wildlife resource conflict and ensure future existence of Nairobi National Park.

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CHAPTER ONE

1.0 Introduction:

The Nairobi National Park (NNP) is a unique park located a few kilometres from the City centre. The entire park is in Nairobi Province and is bordered by Kajiado District to the south and Machakos District to the east. The Mbagathi River forms the south and southeastern boundaries. Ngene, (2002). The survival of the Park is threatened by the various anthropogenic activities that have been taking place gradually in the park's neighbourhood. The park itself is relatively small, just 117 km^2, but is part of a much larger ecosystem in form of Athi-Kapiti, and home to a wide range of fauna and flora. This includes rhino, buffalo, giraffe, zebra, hippo, more than a dozen types of antelope, lion, cheetah, leopard, crocodile, several hundred of species of birds, countless smaller animals and a vast number of different trees, shrubs, herbs and grasses. (Friends of Nairobi National Park, FONNAP, 2000).

NNP is part of the Athi-Kapiti ecosystem comprising approximately 2000km^2. This is a transitional ecosystem lying in between the highlands and the savannah zones. It consists of the deciduous forests in the well-drained loam soils of the hills around the park headquarters, bush land, grasslands, and wetlands ecosystems. The NNP has the second largest migration of wildebeest and zebras in the country after the Maasai-Mara-Serengeti migration.

The ecosystem of the park and the survival of the wild animals will depend on the availability of the rangelands to the south, which acts as a wet season dispersal area for many of the park's large herbivores. Grasslands on which many of the world's livestock depend on are known as rangelands, Chiras, (1994).

It consists of large open areas used for animal production and which are not suitable for agriculture. If the park were ring-fenced and isolated from the adjoining southern rangelands, 50% of the large mammal species currently found in the park would die out, Mutunkei, (2000). Fencing interferes with the breeding patterns of animals, such as the wildebeest and zebras which have specific calving areas such as Enkirigiri south of Isinya town, and this results to in-breeding where there is no exchange of genes and this could lead to species extinction. The increase in animal population will impact on the food chain. There would be profound changes to the parks` vegetation, FONNAP, (2002).

At the same time, the park is slowly but surely being choked by the anthropogenic activities to the north, east, west, and the southern neighboring areas of the Park, such as Industrial activities along Mombasa Road, Athi River and Kitengela e.g. Cement Industries such as East African Portland, Athi River Mining and Bamburi Portland Cement. There are also residential areas in Karen, Ongata Rongai, and Athi River; farming in Kitengela and Athi River; and informal settlements such as Slums. To this end Geographical Information System models will be used to assess the existing data, categorize and analyze the impact on the migratory corridors.

There are three main wildlife routes to and from Nairobi National Park:

- The southeast from the Athi-Kapiti plains skirting to the south entering the park near Cheetah gate. This route is the most used as animals move towards the Machakos ranches, and also Southwards towards the Athi-Kapiti plains. The animals are currently taking a longer route towards Isinya to avoid the Athi-River, EPZ and Kitengela built-up areas.
- The leopard cliffs route to the south of the park is the least used. This area is completely subdivided and electric fenced.
- The southwest crossing upstream from Maasai lodge, this route is partially used but most of the surrounding areas are already built-up.

1.1 BACKGROUND

Nairobi National Park was established and gazetted as Kenya's first national Park in 1946. It covers an area of117km^2 and is situated 2^0 18' south and 36^0 50' east. It borders Nairobi city to the north, and Machakos and Kajiado Districts to the east and south respectively. The Nairobi National Park is the remnant of a vast area of savanna inhabited by immense herds of plains game that once roamed from Ol donyo Sabuk to the eastern rift wall and from the Machakos Hills to the forested high ground in the northwest. Nairobi National Park has a migratory corridor across the Kapiti and Embakasi plains. Mutunkei, (2002).

In early 20th Century, the white settlers realised that Kenya was rich in wildlife and they started trophy hunting. At the same time being near the city, the park could provide recreation to tourists who would have liked to view game in the vicinity of the city. Later on the animal population started to diminish and there was the need to identify a conservation area. The conservation zone identified started from Nairobi to Tsavo. The conservation activities were interrupted by the onset of the Second World War that ended in 1945.Then immediately after the war, the Nairobi National Park was gazetted in 1946 through Proclamation Notice No.48 of 16th, December 1946.

The entire park is in Nairobi province and is bordered by Kajiado district to the south and Machakos district to the east. The Mbagathi River forms the south and southeastern boundaries. The park's relief is gently undulating with the highest point being to the northwest at an altitude of 1790m above sea level. Several seasonal rivers running in a northeasterly direction also dissect it. Mbagathi River, which forms the south and southeastern boundary of the park, is the only permanent water source in the park. The park has three distinct types of landscapes namely; the open grasslands, which are, interspersed with acacia drepanolobium species; and the riverine forest found along the seasonal rivers. Ngene, S. M, (2002).

The game in this ecosystem were severely depleted in the first half of the 20th century to make room for development such as roads, railroads, the city, towns, industries, farms and ranches. Only to the south of Nairobi where traditional land use continued has the original ecosystem survived most of the anthropogenic activities. However, for the last ten years there has been gradual land-use changes such as settlements, sub-division and fencing of land, industries, commercial farming and quarrying which poses a threat to the only remaining migratory corridor of wild animals from Nairobi National Park south-east to the Athi-Kapiti plains, then to the south and south-west portion to Maasai Mara.

Transitions in land tenure in the Kitengela ecosystem as mentioned above are interfering with the normal seasonal wildlife migratory routes and are also reducing the wildlife ranges and available habitats. The general factors that lead to the migration of animals are behavioural activity to improve their survivorship, breeding, seasonal variations and nutritional value of the grass.

The Kitengela area presents a challenge to conservation. The threats arise from several factors such as increasing population growth and settlement along the Mbagathi River, Ongata Rongai, and the development of the Export Processing Zone (EPZ) next to Kitengela.

Nairobi National Park (117km^2) is only part of the Athi-Kapiti ecosystem comprising approximately 2000km^2. The park has the second largest migration of wildebeest and Zebra in the country after the Maasai-Mara-Serengeti migration. The park is fenced towards the city of Nairobi and open to the southwest where a small river marks most of its boundary. The rolling grass plains south of the park (altitude 1600-1700m) are at present grazed by Maasai livestock and are becoming more and more encroached by local settlements. The groundwater table in the area is lowering due to increasingly unsustainable use. Increase in settlement and population growth in Ongata Rongai, Kitengela and Athi River has led to the sinking of boreholes haphazardly.

While the game depends on Nairobi National Park during dry seasons for water, it disperses further south to the Athi-Kapiti plains during the wet season. This implies that the Athi-Kapiti ecosystem is an important area for the wild game which Nairobi National Park during the dry season. Mutunkei, (2002). The study was aimed at using Geographical Information System to identify the impact of the anthropogenic activities on the migratory corridors for the last 10 years. Buffer zones show the reserve areas, which should be left as migratory and dispersal routes.

1.2 PROBLEM STATEMENT.

This project seeks to look into the impact of anthropogenic activities such as residential settlements, industries, and commercial farming, fencing and informal Settlements, on the migratory corridors of Nairobi National Park. The above activities interfere with animal movement, dispersal points and breeding grounds. The blocking of the migratory routes will impact on the carrying capacity, leading to competition within the park, which could impact, negatively on the ecosystem of the park.

At the same time animals whose survival depends on moving out of the park to breed, such as the zebra and the wildebeest will be threatened. The Nairobi National Park is a unique park located a few kilometres from the city centre. The survival of the park is threatened by the various anthropogenic activities that have been taking place gradually in the neighbourhood. The ecosystem of the park and the survival of the wild animals will depend on the availability of the rangelands to the south, which act as a wet season dispersal area for many of the park's large herbivores. If the park were ring-fenced and isolated from the adjoining southern rangelands, 50% of the large mammal species currently found in the park would die out. There would also be profound changes to the park's vegetation, FONNAP, (2002). Fencing interferes with the breeding patterns of animals, which this results to in-breeding and minimal exchange of genes. The increase in animal population can affect the food chains in NNP. This was traditionally minimized by movement of animals to and from the park involving long distance movement by animals such as Zebra and wildebeest. On the other hand, short distance (1-2km) dispersion occurs within the area.

The Eland, Hartebeest, Thompson gazelles, Grant gazelles, impala move short distances. Most migration occurs during the rainy season and the zebras and wildebeests are the first to move out of the park. Any change of weather usually leads to the concentration of animals in readiness to migrate.

The following are reasons that lead to migratory movement of animals:-

- Behavioral activity, which helps improve their survivorship,
- Animals also move out to breed and calve,
- During the wet season, flat areas are waterlogged and this could lead to foot and mouth diseases, thus the animals have to move out.

The nutritional level of grass outside the park is another contributory factor. Livestock graze on the adjoining rangeland during the dry season, and when it rains these grasses sprout fast and have a higher nutritional value, which attracts the wild animals. The occurrence of range fires outside the park also stimulates the growth of fresh grass during the rains. Wildebeest move out of the park first in the migratory pattern, followed by the Zebra. The zebras have no specific calving point and at times calve at the same point as the wildebeest. The wildebeest moves towards Enkirigiri, the calving place, which is east of Isinya town. This place is preferred because it has adequate cover for the young ones. The place is also calm with very little disturbances from human activities. There is also adequate food and minimal predation effects.

NAIROBI NATIONAL PARK MIGRATION ROUTES

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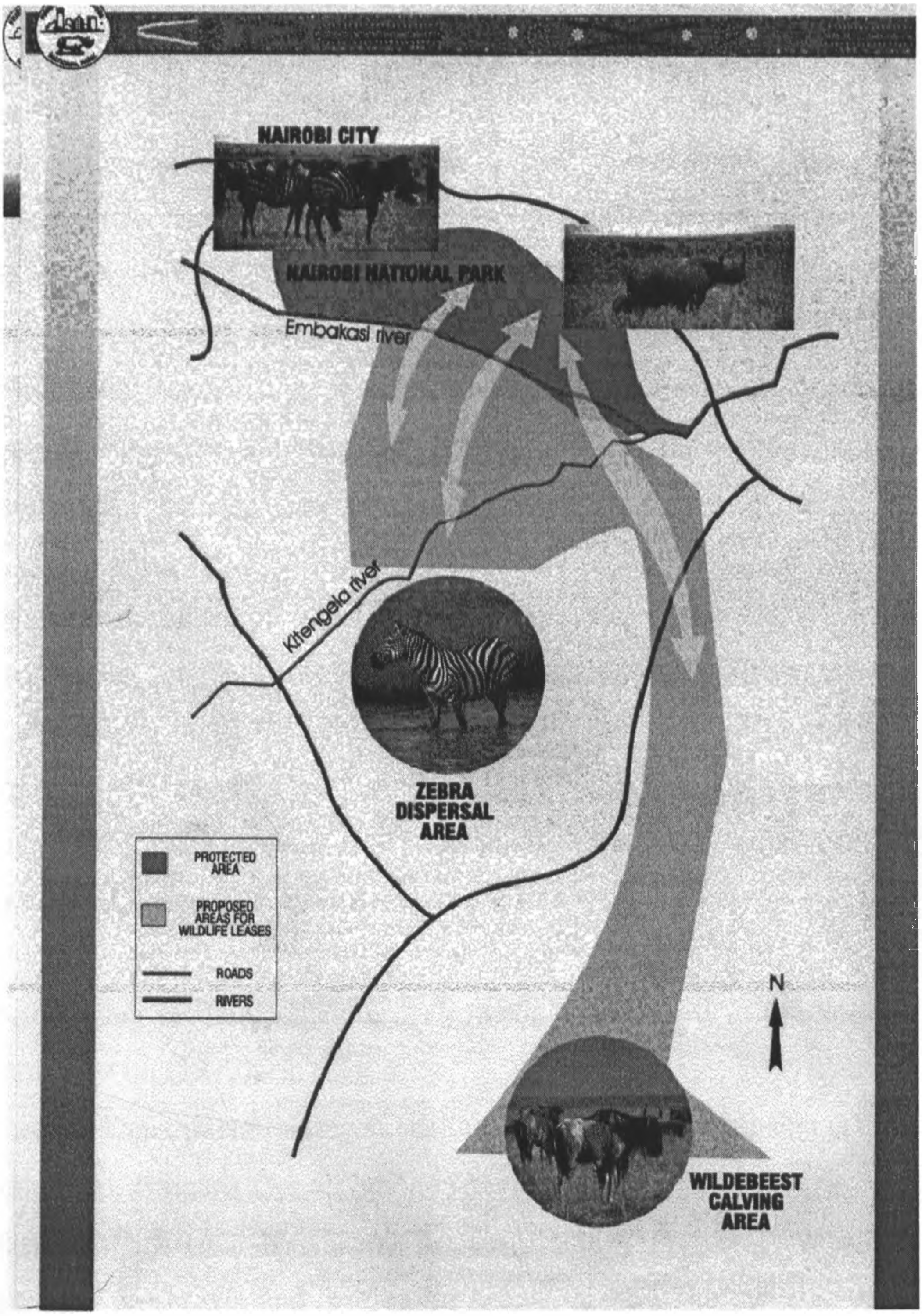


Fig 1. *Source: Nairobi National Park Migration Appeal (FONNAP 2002)*

1.3 LITERATURE REVIEW

A critical review of research works carried out on the impact of land use changes on rangeland and national parks will form a basis for this research project. A study carried out by Serneels & Lambin, (2001), indicates that among the possible driving forces behind the downward trend in the numbers of Mara wildebeest, only land use change showed a clear and non-commitant trend over time. At the same time spatial analyses demonstrated that wildebeest numbers declined more in the mechanized farming area than elsewhere. The expansion of mechanized farming took place on the wet season grazing grounds and calving areas.

The exclusion from part of their wet season range in the Loita plains has caused wildebeest numbers to drop considerably since the early eighties. The reduced wet season range has forced wildebeest to use drier rangelands in the southeastern Loita plains or the Mara area during the wet season. This results in a decreased per capita availability of food and the animals suffer from food stress throughout the year, even when wet season rainfall is plenty.

The following recommendations were made with regard to the wildlife in NNP, Barassa *et al*, (1999):-

- That the Department of Resources Survey and Remote Sensing (DRSRS) with the African Conservation Centre (ACC), Friends of Nairobi National Park (FONNAP) and Kenya Wildlife Services (KWS) should initiate a yearly wet and dry season counts to study the dynamic changes in wildlife and livestock population movements.

- Detailed studies on land use change and their effects on wildlife population and distribution need to be carried out. These studies should also incorporate the changes in land use and their effects on wildlife population particularly in terms of seasonal migration and dispersal areas. The present study may be considered as partial implementation of various recommendations as highlighted by various research work carried out in the area.

To encourage redistribution of livestock and wildlife excreta throughout the rangeland, bomas should be relocated frequently. This would minimize local tracking and erosion, encourage balanced range use, and apply limiting nutrients over larger area. If Nairobi National Park is completely enclosed, the impact on the park could be devastating.

(Katrina *et al*) have come up with three major strategies, which could be used to reduce pressure in a protected area. They emphasized boundary marking, development of park management plans, research, training, maintenance and improved enforcement activities as among the actions undertaken by Integrated Conservation Projects Strategies (ICDPS).

According to Katrina et al, buffer zones are most often conceptualized as a protective band of land, which encircles the protected areas. The principal objective of buffer zones is to protect the park, and provide economic benefits to local people as a secondary benefit. Local people to relinquish their farmer rights of access and to respect the conservation goals of the protected area provide compensation in form of payments, or goods and services in exchange for agreements.

According to Gwyne *et al*, (1978), wildlife has three main values:

- As a scientific material, representative of evolutionary and ecological processes with both a present and an unknown future value.
- It has aesthetic appeal that is of value also to the development of a tourist economy.
- It provides a source of meat or other products that can be used by man.

It is important to note that there is no East African Park or Reserve that is a complete ecological unit. Lake Nakuru is completely landlocked except for the avifauna migration. Game usually move across the borders and competes with livestock outside the reserves which sustain a given protected area. This means that conservation work should cover all the interconnected ecological zones.

Studies by Royal National Park of Kenya (1948, 1956, 1960/61) indicate that during the dry seasons the wildebeest, zebra and hartebeest tend to move north into and around the Nairobi National Park, where there is perennial water in form of dams and streams. During the rainy season, the animals move south and spread out over the plains. The waterbuck is found near streams, whereas the lions and cheetah range over the open grasslands and to some extent follow the herds of migratory antelopes.

Etringham, (1990) identifies that human encroachment into wildlife areas has increased almost exponentially over the past few decades and this has resulted in the disturbance of the larger species. There is also the risk from human settlement outside the park, which often restricts the home range of wildlife or interferes with their migrations.

The migratory behaviour of most wild animals in the NNP dictate that the southern parts of the park are left unfenced Nathan (1994). However fencing of the park boundaries has also been used to reduced human-wildlife conflicts. It has also prevented further encroachment into the park by city estates and industries. The fencing of protected areas is common in some areas of Kenya notably Lake Nakuru and Aberdare's National Parks.

The studies carried out by Wayne & Kioko (2000), produced a vegetation map for Nairobi National Park. A Global Positioning System was used to mark the boundaries of the dominant vegetation types, which were then plotted using GIS computer software. The G.I.S. was used because it allowed for comparison to be made between vegetation types and biotic variables of soils, rainfall and topography.

According to Ngene (1997) the community around the NNP had a negative attitude towards the predator species. The community's attitude towards Nairobi National Park was mainly indifferent. Some members of the community suggested that community analysis and involvement in human-wildlife conflict and resolution is the key to understanding and winning the support of the communities living next to the national parks and reserves.

The Athi-Kapiti ecosystem can be used to identify sites in which to concentrate conservation activities Gichohi, (1996). A migration corridor through the Kitengela to the Kapiti plain would provide access between the wet seasonal dispersal and the dry seasonal concentration area to allow the migration of carnivores. There should be a proper definition of the precise migration routes using well-timed aerial surveys and ground counts.

At the same time the size of the migratory corridor and its exact location would need to be more clearly defined. Inorder to conserve wildlife outside parks, the support of the landowners must be addressed. There is therefore the need to assess ways of ensuring a right-of-way for wildlife and to ensure that migration routes for wildlife in and out of the park remain open.

The World Bank Group in their 1995 fiscal year, identified cause of animal movements as population levels, grazing conditions, availability of water, and grazing seasons.

The two main groups of wildlife in Kajiado district in terms of movements:

- Those which move over small or large distances to utilize changes in water and food availability,
- Those, which are more or less sedentary in habit.

Animals that move extensively in response to changes in habitat within the area are Wildebeest, Zebra, Eland and Elephant.

Mwangi & Warida (1999), suggests the following recommendations for the future management of NNP

- That there is need for an easement/ lease program, which should be carefully evaluated and discussed with the community in critical parts of the ecosystem to help in the conservation efforts.
- A trust or endowment fund can be created and used to pay easement for acquiring critical tracts of land in the critical area.

- Thirdly, conservation organisations should involve young people in conservation activities such as game scouting and management of wildlife related projects that benefit the local people.

According to other writers, there is also need for an integral land use policy upon which Nairobi park, Athi-Kapiti plains, and Ngong hills could be planned and managed as one ecosystem. Those who share their land resources with wildlife must be involved in the process of wildlife management as a means of full cooperation and public participation. Local residents must be paid directly tangible economic benefits from wildlife conservation Omondi, (1984)

Most of the migration routes in the NNP are threatened by human settlement, urbanization and land. The following proposals would enhance the conservation and protection of the above migratory routes: -

i) The Kitengela area should be declared a community "protection area" to enable effective control of incompatible land uses. There is need for innovative approaches to the promotion of livestock and wildlife co-existence, which must build on indigenous knowledge of semi-arid rangelands. It is also important to be aware of the adverse impacts of encroachment on any part of the pastoral resource-use system. In these pastoral reserves, or wildlife corridor areas, agriculture should be controlled in favour of livestock and wildlife.

ii) There should be constant evaluation and monitoring of changes in land use and their impacts on wildlife, vegetation, water resources and other land uses in the short and long-term basis.

iii) At the same time a strategy for increased subsidiary of wildlife ownership to land owners and communities should be enhanced.

FONNAP, (2000) has identified that the availability of rangeland would determine the future well being of the park. In the NNP, neighbours are as follows: -

- To the south are the Maasai people and their livestock. Today most of the land is privately owned, but over 70% of the landowners' still practice pastoralism, depending largely or wholly on their herds and flocks of cattle, sheep and goats for their livelihood.
- To the west, is the affluent Karen and South lands residential areas, while to the north is the Nairobi city.

According to FONNAP (2002), the solution is a wildlife conservation lease programme to provide a financial incentive to encourage the landowners to the south of the park to allow wildlife access to their land. Until now these landowners have derived little or no benefits from wildlife. On the contrary, they suffer from competition for grazing, browse and water resources and sometimes have their crops damaged or livestock killed by predators or are adversely affected by wildlife diseases. Nearly three thirds of these landowners are willing to leave at least part of their land and retain it unfenced if in return they are paid a modest sum of money for hosting wildlife. The foregoing discussion of the various research works carried out on Nairobi National Park shows that there is need to come up with immediate solutions to the conservation of the migratory corridor. This is very important for the survival of the Nairobi National Park ecosystem.

According to The East African, (April 29-May 5th 2002), after nearly 50 years of existence, most of the national parks are now exhibiting stress associated with their preservation in isolation from the larger ecosystems that they were once part of. But since we cannot retrace the historical steps to this past, wildlife managers in East Africa need to adopt new strategies that will imbue the parks with renewed vigour and dynamism.

The stress is severest in small parks, which manifest ecological crises faster than large ones, but which, nevertheless, are also gradually accumulating their own contradictions. The small parks are also among the most significant ones economically. One such park is Nairobi National Park, the oldest in East Africa and the most unique worldwide on account of its “city status”. But it’s heavily weighed down by a plethora of challenges associated with proximity to the city and ecological isolation.

The most formidable threat to Nairobi park today is the imminent blockage of a vital corridor that links it to the wider Athi-Kapiti-Amboseli dispersal area. This ecosystem is the second largest migration of wildebeest and zebra in the region after the Maasai Mara- Serengeti migration, which is one of the biggest wildlife spectacles in Africa. Thanks to this migration, Nairobi park is, occasionally, home to high populations of herbivores and predators. Closing this park, as the settlement pattern portends, will spell the death knell for the park as known today, since on its own it can host only a few sedentary antelopes. The increasing isolation of Nairobi National Park from adjacent rangelands has alarmed conservationists and other stakeholders who coalesce under an active NGO group, the Friends of Nairobi National Park (FONNAP).

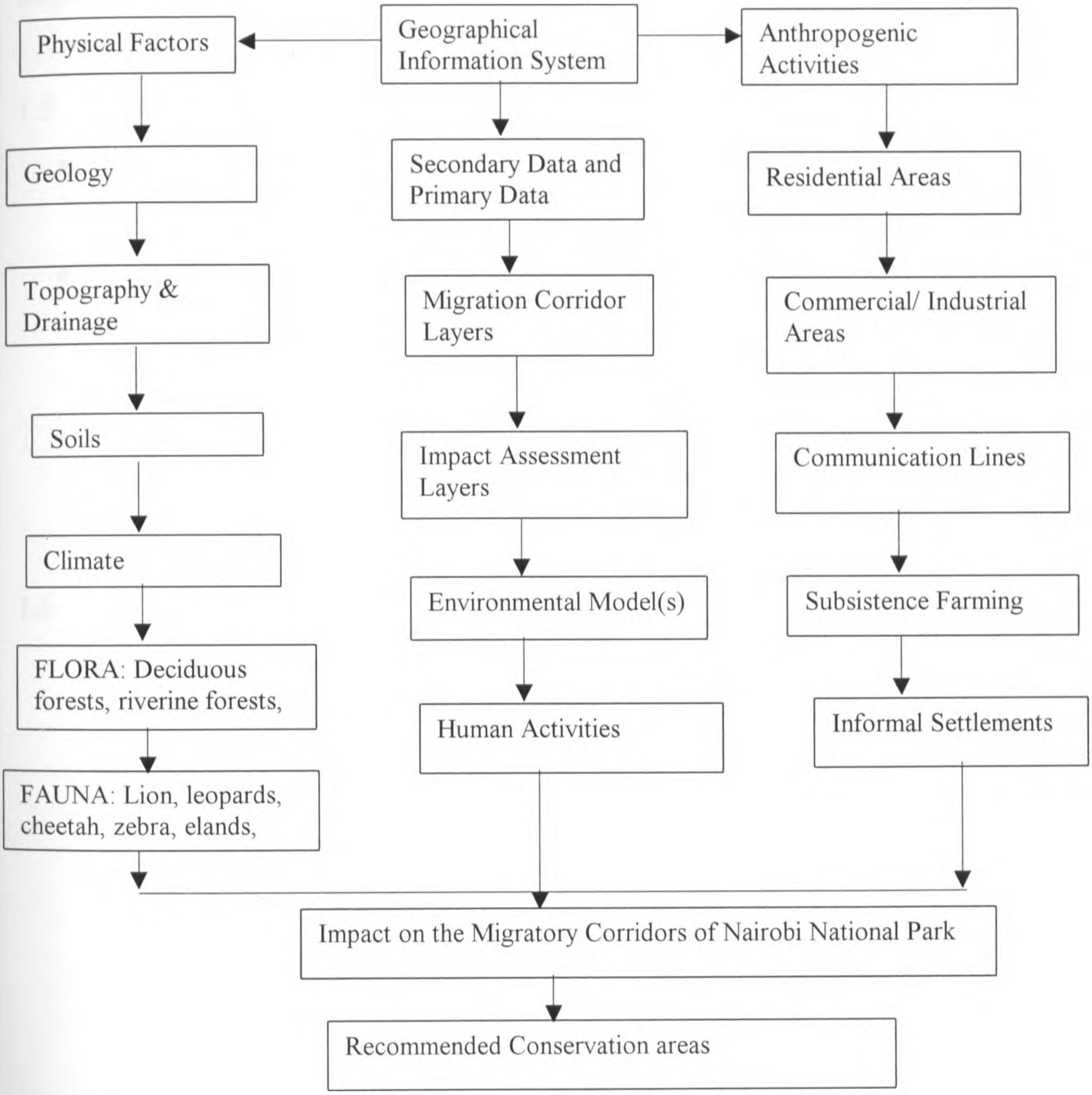
In concert with KWS, FONNAP has been working overtime to secure this vital wildlife corridor. They are doing this through various policy strategies that include raising funds to compensate landowners for not converting the land into alternative land use.

The latest activity in active management of Nairobi National Park was use of fire, once again arrived at after painstaking tightrope of indecisiveness. For the past 20 years, no deliberate fire has been used in the management of the Park, amid speculation that the long coarse grass has been keeping off herbivores from the park, thus minimizing visitor's satisfaction. In the recent past, KWS had to confront several complaints from disaffected visitors demanding, "to see" animals in the national park. In contrast, the privately owned rangelands to the south of the park are heavily grazed and regularly burned, making the grass there more attractive to zebras and wildebeest. Its important to note the use of fire may destroy small mammals for example rodents, snakes and birds affecting the food chain.

To make the park equally attractive to these animals, FONNAP and the Nairobi Park management had to concede to the imperative of fire management to restore habitat suitability to animals. By doing so, FONNAP has set a significant precedent for conservation of national park in East Africa. More and more parks are now expected to embrace the paradigm of active management and discard the past mode of passivity, where natural forces are let to determine the fate of these increasingly vital and popular entities called national parks. But the debate continues: should parks be manipulated by man (agers) or be left to nature's destiny? "The East African, (April 29-may 5 2002).

1.4 CONCEPTUAL FRAMEWORK

INTEGRATED NAIROBI NATIONAL PARK MANAGEMENT SYSTEM



Source: Adopted from Calle Hedberg 1991, Information Systems for Land Resource Management.

The above conceptual framework was used to highlight how geographical Information System incorporated the physical factors and the Anthropogenic activities in the area assessment of the impact of human activities on the migratory corridors of Nairobi National Park.

1.5 OBJECTIVES

- To identify types of anthropogenic activities in the neighbourhood of Nairobi National Park's.
- To analyze and categorise the impacts of the anthropogenic activities on the migratory corridor of Nairobi National Park for the last 10 years from 1990 – 2000.
- To assess animal population trend in NNP for the last 10 years from 1990 – 2000.

1.6 HYPOTHESES

H_0: Anthropogenic activities do not have a significant impact on the animal population and the wildlife migratory corridors.

H1: Alternative

1.7 SCOPE AND JUSTIFICATION

Nairobi National Park is 5km from the city centre. The park has undergone various modifications such as electric fencing of most of the park boundary. The neighbourhood has also changed due to various anthropogenic activities such as farming near Athi River and Kitengela townships, Industrial activities along Mombasa Road, Athi River town, residential settlements in Ongata Rongai, Kitengela and Athi River townships, and communication lines along Lang'ata Road, Mombasa Road, Kajiado Road and Maasai Lodge Road. The roads cut-off habitats and interfere with animal territory. At the same time off-road drives within the park destroys vegetation especially for grazers. The hunting habits of the wild animals are also interfered with.

These new developments have come up gradually and the park is being cut off from the rest of the rangeland. The most affected by the anthropogenic activities is the migratory corridor such that in the year 2001 the wildebeest did not for example migrate into the park. The use of G.I.S in assessing and categorizing these activities in the park's neighbourhood would result to:-

- Delineation of buffer zones showing areas, which should be left as reserve areas for the park.
- Identification of the migratory corridor and if possible buy-back the land for future use by the wild animals.

Nairobi National Park is part of the settled life and expansion towards the Park should be checked. The use of G.I.S was undertaken inorder to provide efficient management through availability of spatial information. The results are expected to help in the environmental management and conservation of the park.

CHAPTER TWO

2.0 STUDY AREA

The study area of NNP highlights the size and location of the park, the physical geography, topography and drainage, geology and soils, fauna and flora.

2.1 Size and Location

Nairobi National Park was established in 1946 and is situated 8km south of Nairobi city. It covers an area of 117km^2. The Park is geographically at an elevation of 520-1700m Deshunuk, (1985), Hillman and Hillman (1977). The Park has been fenced with an electric chain fence in the northeastern, northwestern and southwestern boundary. Mbagathi River forms the southeastern boundary Gitau, (1992). This section is unfenced for wildlife movement to and from the park at different seasons.

2.2 Physical Geography

Nairobi National Park experiences a mean annual rainfall of between 500mm-800mm Gichohi, H. (1996). The highest rainfall (850mm) is received at the western part of the park (forested area), while the lowest (500mm) is received at the Athi River basin towards Cheetah Gate. The annual mean temperature is 19.6^{o}c while mean maximum and minimum temperatures are 25.3^{o}c and 13.6^{o}c respectively, Ngene and Njumbi, (1998)

Hillman and Hillman (1977) determined a rainfall gradient approximately aligned with the attitude in the area. The rainfall gradient of 50-70cm per year is continued into the plains to the south in Isinya and Kajiado with the highest total of 75-100cm being experienced in the north and west of Nairobi and around Ngong.

The area usually experiences two rainfall seasons. The long rains falls in April to May while short rains occur from late October to late December. A distinctive feature of the climate in the area is the occurrence of a marked spell of dry season from June to august before the onset of the short rains.

2.3 Topography and Drainage

Nairobi National Park consists of rolling plains with gently undulating gradient, Gitau, (1997). To the wooded north west of the Park is the highest elevation with the land decreasing towards Embakasi plains in the eastern and central parts of the Park. The land slopes further southeast into Athi River basin through a number of gorges, Ngene and Njumbi, (1998) The Mbagathi River along the southeastern boundary of the park is the only permanent water source. However, several perennial streams drain into the park for which Mokoiyet and Obmany are most noticeable, Wayne & Kioko, (1999). About 9 dams provide water for wildlife in the park though many dry up in the drought years), except three (Hyena Dam, Olmany Dam and Athi Basin Dam) Burchard, (1999).

2.4 Geology and Soils

Volcanic rocks of the middle and upper tertiary form the basis of soils in Nairobi National Park. Phonolite and alkaline trachyte lavas occur across the Park and part of Athi-Kapiti plains. Tertiary sediments cover the southern part of the Park while calcareous and non-calcareous black clay soils divided from colluviums cover most of the rest of the park. Some other areas are characterised by dark grey brown calcareous clay loams associated with old lacustrine deposits. The valley slopes have shallow, yellow brown or reddish clay. The forests have red friable clays. Ngene and Njumbi, (1998)

2.5 Fauna

Nairobi National Park has a high diversity of fauna. The most common among the 400 species recorded since 1946 include the Maasai Giraffe (*Giraffa Camelopadolis Maaica*), Lion (*Panthera Leo*), Leopard (*Panthera Pardus*), Cheetah (*Acynomix Jubatus*), Spotted Hyena (*Crocuta Crocuta*), Buchell's Zebra (*Equus Burchelli*), the Wildebeest (*Connochaetes Taurinus*), Thompson Gazelle (*Gazella Thomsoni*), Grants Gazelle (*Gazella Grantix*), Impala (*Gepyceros Melampus*), Eland (*Tautotragus derbianus*) and Coke's Hartebeest (*Alcelaphus Buselaehus*).

Among the 100 avian species, the Ostrich, Secretary bird, yellow-necked spur fowl, helmeted guineas fowl, and bustards are very common. Crocodiles (*Crocodilus Nilotica*) and hippos (*Hippotamus amphibus*) occur commonly in the park's wetlands. The fluctuations in the wildlife biomass in the park, is due to migration of the zebra, wildebeests, and elands (Rudnai, 1974) following rainfall patterns. Animals migrate out of the park during the wet season and return during the dry spell.

This is mainly attributed to waterlogging due to the landform and the soils. Rainfall, as suggested by Maddock (1979) and Fryxell *et al* (1988) is the main factor, which contributes to wildlife migration to Serengeti and Nairobi National Parks. In Nairobi unlike other areas outside the park there is a permanent supply of water due to the presence of dams. In some other cases, carnivores such as lions and cheetahs move out of the park in pursuit of migratory prey species Foster, 1966; Rudnai, (1974)

2.6 Flora

Past studies have shown that the vegetation types in the park mainly consist of deciduous forests and riverine thorn forests. Shrubs and grass land with scattered trees with bushes cover about 90% of the park area and is mainly in the poorly drained black cotton soils of the plains. The common types of grasses include *Pennisetum mezianum, Themeda triandra, Seteria spp, Bothriochloa insculpta* and *Digitaria macroblefora. Acacia drepanobium* occurs in stands of short bushes (Wayne Vos and Kioko, 2001)

The deciduous forest covers about 4% of the Park area and is found mainly in the well-drained loam soils of the hills around the Parks headquarters the common plant species in this area include *Croton megalocarpus, Olea africana* and *Dombeya burgesiae*. The riverine thorn forest is characterized by *Acacia xanthophloea* and *Acacia kirkii* (Ngene and Njumbi 1998).

The bush land has a variety of habitat including dry streambed, rocky gorges where dominant shrubs are Croton *dichogamous, Grewia similes* and *Hibiscus spp.* A Sample of the vegetation types found in the park is indicated in figure 2 – 8, which shows the vegetation map of the park while other figures show different types of vegetation such as; a forest vegetation, papyrus, riverine vegetation, Acacia forest (near leopard cliff) and sedges.

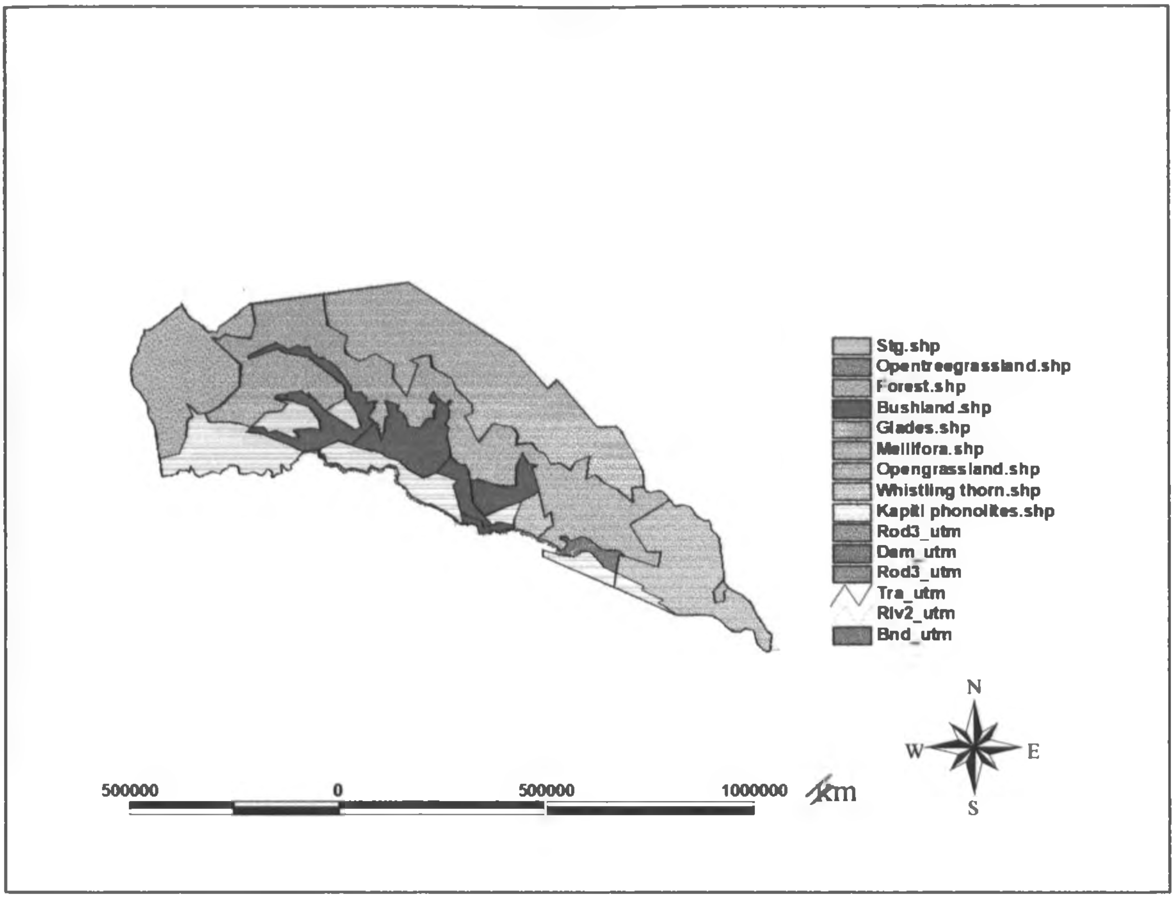


Fig. 2 – Vegetation map of Nairobi National Park

Fig 3 – The Eucalyptus Forest near the Wildlife Club.

Fig. 4 – Papyrus taken in one of the wetlands in the Park.

Fig 5 – Showing Riverine Forest along Athi River

Fig 6 – A swamp within the National Park

Fig 7 –Leopard Cliff migratory route next to Athi River

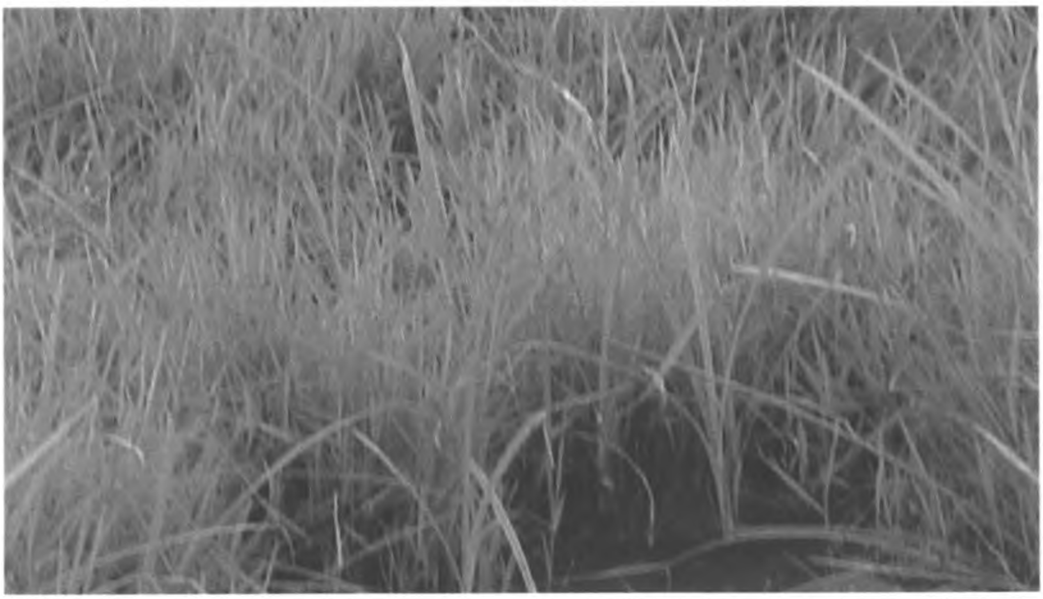


Fig 8 - Sedges in the park

2.7 Human Activities

Nairobi National Park being a protected area is characterised by a wide range of human activities around it. Due to close proximity to the city of Nairobi, pollution is a major threat to the park, Wayne Vos and Kioko, (2001). The main sources of the pollutants are the industries and human settlements to the north and northeastern side of the park boundary. Industrial and domestic effluents find its way into the park's wetlands, while plastics and other litter blows in from areas of heavy human settlements next to the Park.

The local people graze their cattle along the borders of the park in the pretext of watering their cattle in Mbagathi River. This occurs each year during the dry season (August to late October). To the west of the park is the opulent Karen residential area. Land use activities here include intensive vegetable and crop farming, training institutions, shopping centres and recreation areas. The Mombasa railway and highway runs along the eastern boundary all the way from the city of Nairobi to Athi River town separating the park from Embakasi plains. Land use activities in the Embakasi plains include the Jomo Kenyatta International Airport, industries, residential areas, shopping centres, restaurants, slums and grazing land, Ngene, (2002)

The Athi River forms the southern boundaries of the park while Ongata Rongai shopping centre sprawls southwards separating Karen from Kitengela conservation area. Historical evidence suggests that the Maasai grazed their cattle here and had co-existed with wildlife harmoniously. Recently, increased farming and fencing have been observed, thereby making dispersal of wildlife difficult. Ngene, (2002). Refer to figs 9 –14

Fig 9 – Commercial Activities along Magadi Road next to KCCT

Fig 10 – Built-up Area bordering Athi River

Fig 11 – Residential Area next to Athi River

Fig 12 – Industrial Complex along Mombasa Road

Fig 13 – Industrial Pollution along Mombasa Road

Fig 14 – Castle next to Athi River

CHAPTER THREE – RESEARCH METHODOLOGY

3.0 RESEARCH METHODOLOGY.

3.1 Types and Sources of Data

Existing secondary data such as remote sensed data was used in the creation of buffer zones. Digital maps such as the population census maps, vegetation maps, relief, geology and soil maps were used for analyzing and categorizing the data. The types of maps used were in a scale of 1:50,000.The Kenya Wildlife services (KWS) provided data on animal census, rainfall data and also the maps.

Primary data was in form of direct ground truthing the existing data such as remote sensed data, aerial photographs with the situation on the ground. This involved taking photographs of sampled points in the Kitengela area, Ongata Rongai and also within the park. The Global Positioning System (GPS) was used to Georeference , the current vegetation status, migratory corridors and the various types of human activities in the park neighbourhood. A GPS unit is based on a constellation of 24 satellites orbiting the earth at a very high altitude. It uses satellites and computers to compute positions anywhere on earth.

A Geographical Information System (GIS) analysis uses the power of the modern digital computers to measure, compare and describe the contents of the database. GIS is designed to support, capture, manage, manipulate, analyse, model and display spatially referenced data and its associated attributes for solving complex planning and management problems.

3.2 Methods of Data Collection

Primary data collection was used though field investigation or ground truthing using the GPS, digital camera and a still camera. Random sampling strategy was used to identify field-training points of the vegetation zones, relief, watering points, migratory routes and land-use activities in the Nairobi National Park and the Park neighbourhood.

Secondary data in this research involved rainfall data, animal count, vegetation maps, soil maps and cadastral map on land use changes.

3.3 Data Analysis

Quantitative analysis involved using of basic statistics such as the mean, standard deviations, calculation of frequencies and the use of ordinary statistical charts on animal counts and rainfall amount. Advanced statistical analysis for hypothesis testing involved the use of linear regression and correlation analyses. All statistical procedures were conducted using the MS-Excel and SPSS computer software.

3.4 Animal Population Trends

The animal data used was of a ten year period (1990 - 2000) and it involved the following wild animals in Nairobi National Park such as :-

- Wildebeest
- Zebra
- Kongoni
- Impala

- Buffalo
- Giraffe
- Eland
- Thompson's Gazelle
- Grant Gazelle.

Wildebeest records indicated that the average total was about 10,000 animals for all the years except in 1996, when the total count was 20,000, which was the highest count, and 1998, when the totals were less than 1,000.There was a notable decrease in the total numbers of wildebeest in the park over the years. The increase in rainfall was found to be inversely proportional to the decrease in the total number of wildebeest in the park. However, the wildebeest are also known to be targeted for game meat poaching which may also explain the decline, alternatively it is also possible that low return migration in recent years could contribute to the falling numbers.

The zebra count for the period. 1990 - 2002 fluctuated uniformly but on average there was a major decrease in 1998, when the total zebra count was about 3000. This could be attributed to the impact of the El Nino rains. The condition improved in 1999 and the year 2000 due to the onset of the El Nino rains .The total number of zebras has been increasing over the years.

The total numbers of Kongoni on average was above 2000 for all the years except in 1993 and 1998 when the totals were less than 1500 due to the drought years when most of them died. There was a tremendous increase of the Kongoni in the year 2000 and number appears to have stabilized.

The Kongoni records count indicated that there was a fairly stable population within the park. However, in 1998 during the El Nino rains most of the Kongoni died due to water logging in the park. On average the total number of impala counted was above 2000 for most of the years, with a major decrease in 1993 and 1998, when the totals were below average. It is possible that the foot and mouth disease affected the impalas especially during the rainy season.

The total number of buffalos counted fluctuated slightly, but there was a notable decrease from 1996 - 1998, and a big improvement in 1999 – 2000. The worst decline was in 2000 when the total number was only 200.

Nairobi National Park had the highest number of giraffes in 1990 (730) but there was notable decrease in population over the years. The lowest totals were noted in 1997 and 1998 due to drought. On the overall the total number of giraffes decreased to 1000 for the ten-year period but there was a slight improvement in 1999 - 2000.

The total number of eland declined in 1993, 1999 and 1998. The highest totals were observed in 1990, 1991 and 1996. There was an inverse relationship between the increase in rainfall totals and the number of elands. There was a marked decline in eland numbers over the years irrespective of the increased total rainfall, and a slight improvement in the year 2000.The eland are also known to be targeted for game meat.

The total number of the Thompson's Gazelles fluctuated over the ten-year period. There was a marked increase in the number of impalas with the increase in rainfall. However, both totals were not quite equivalent.

This was because when the park got flooded the foot and mouth disease affected the impala. The lowest totals were observed in 1993, 1995 and 1998 but there was a big increase in the year (1999-2000). The total number of Grant Gazelles was evenly distributed over the years, except in 1993 and 1998, when the total numbers were below average. There has been a steady increase from 1999-2000.

The increase in rainfall was found to be inversely proportional to a decrease in the total number of wildebeest in the park. This was because the wildebeest moves out of the park and into the rangelands, where there is always pasture and for calving purposes. During the dry seasons, the wildebeest always migrated back to the park in search of more pasture and water, as the rest of the rangeland dried up. The zebras also moved out of the park at the onset of rains. They migrated out into the rangelands in search of the more nutritious grasses and calving sites. The zebras migrated back into the park during the dry season.
The animal population analysis showed that wildebeest had the biggest percentage of the total herbivores in Nairobi National Park, followed by zebras, impala, kongoni, eland, Thompson's Gazelles, grant gazelles and giraffe respectively. Charts 1-18 give the trends of animal population in the NNP.

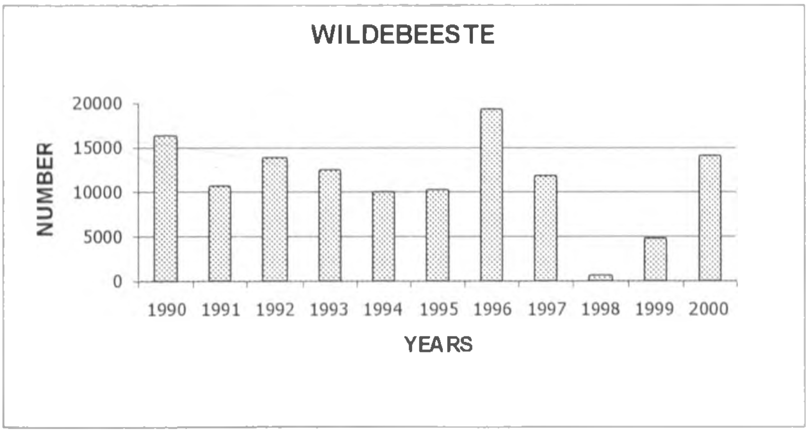


Chart 1 – Total Number of Wildebeest

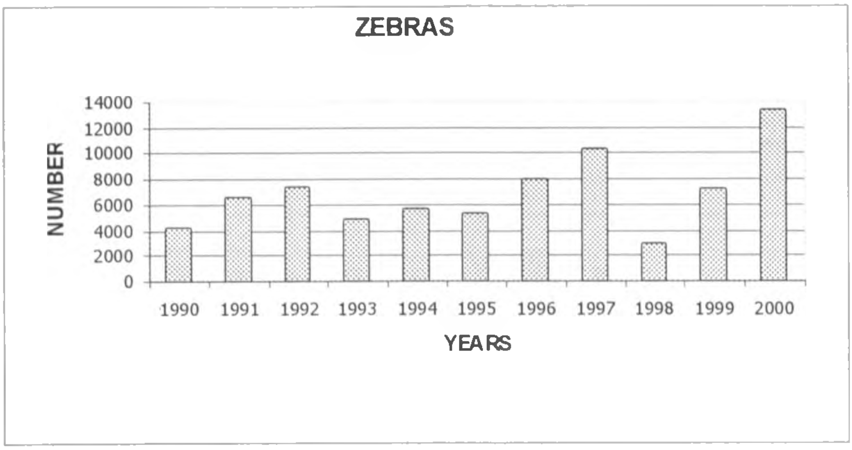


Chart 2 – Total Number of Zebra

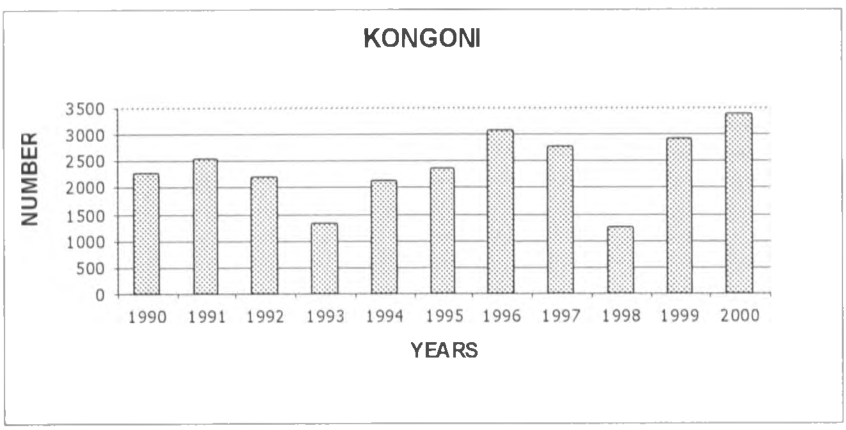


Chart 3 – Total Number of Kongoni

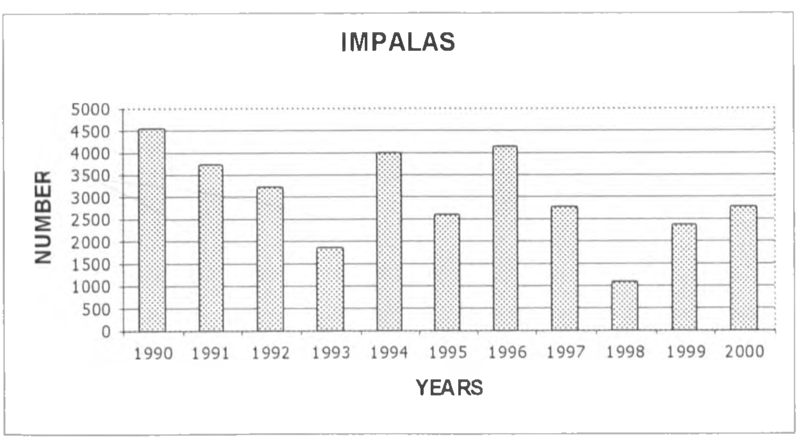


Chart 4 – Total Number of Impalas

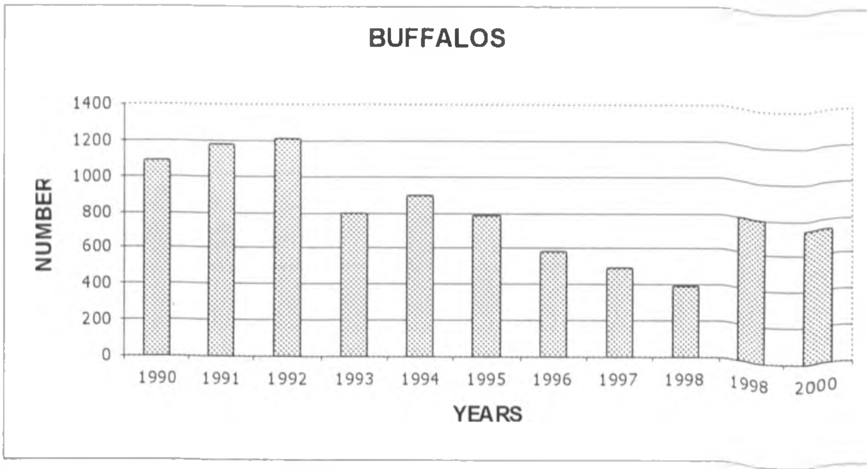


Chart 5 – Total Number of Buffalos

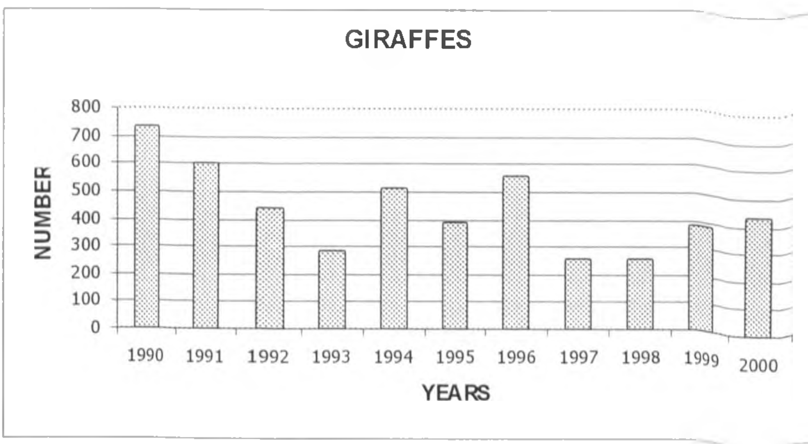


Chart 6 – Total Number of Giraffes

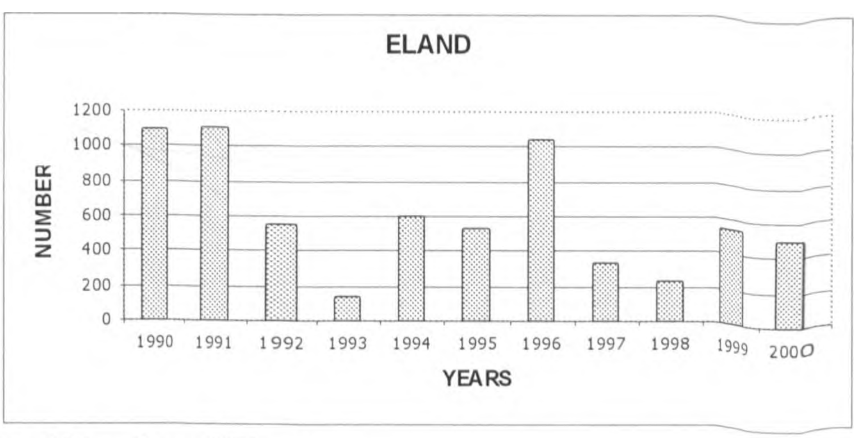


Chart 7 – Total Number of Eland

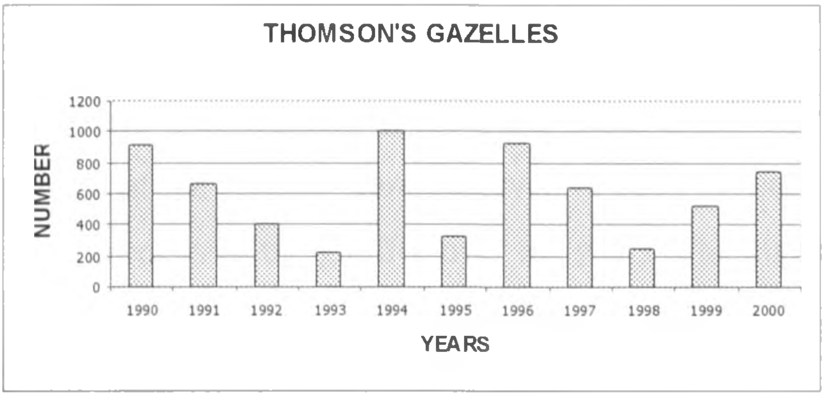


Chart 8 – Total Number of Thompson's Gazelles

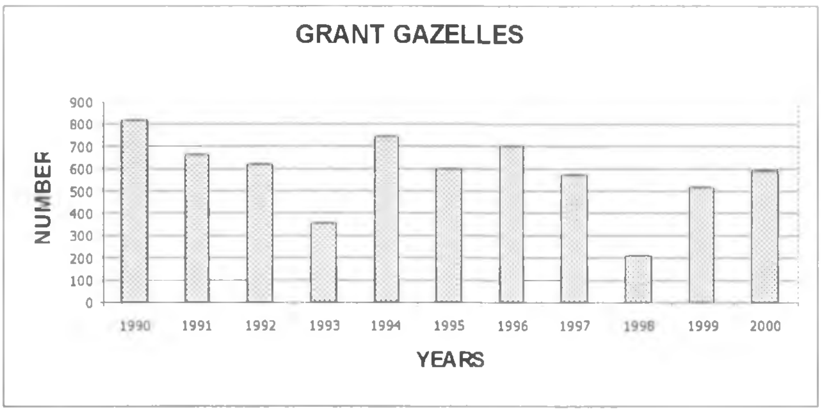


Chart 9 – Total Number Grant Gazelles

The average animal population trend showed that the highest mean was in 1996, while the lowest was in 1998. This was during the El Nino rains. The highest mean was in the year 2000, while the lowest mean was in 1998. The highest mean was noted in 2000, while the lowest mean was in 1993 and 1998.

The highest mean was in 1990; the lowest mean was in 1998. There was an improvement of the Impalas mean numbers in 1999 and 2000. On the average, the mean totals for the buffalos declined to be declining over the years, but there was a slight improvement in the mean totals from 1999 - 2000. The highest mean totals of the giraffes were observed in 1990. There was a general decline in the mean totals of the giraffes over the years. The highest mean total was observed in 1990, 1991 and 1996. The lowest mean total was observed in 1993. The overall mean totals indicated a steady fluctuation except for the years 1993 and 1998 when the rainfall totals were too low.

Charts 10-18 shows the overall trends in the mean population.

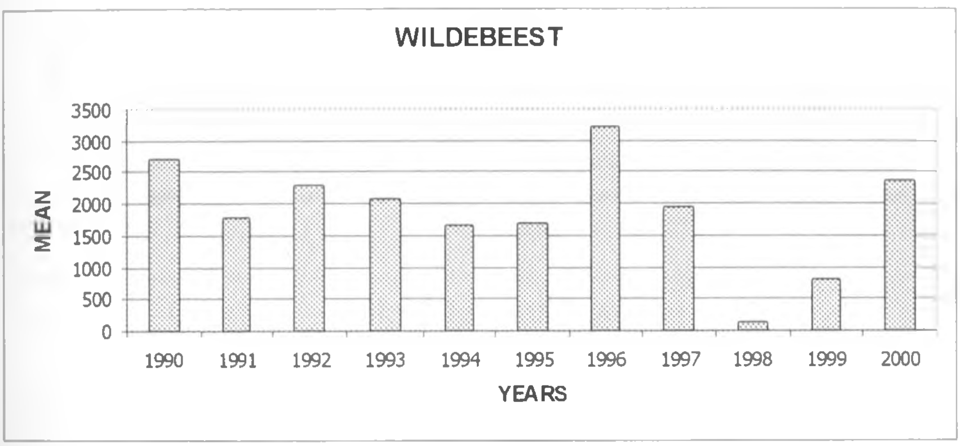


Chart 10 – Total Mean of Wildebeest per year

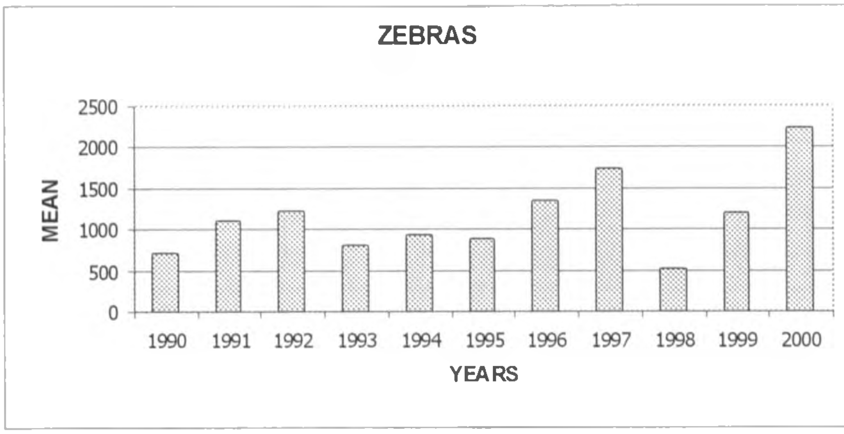


Chart 11 – Total Mean of Zebra per year

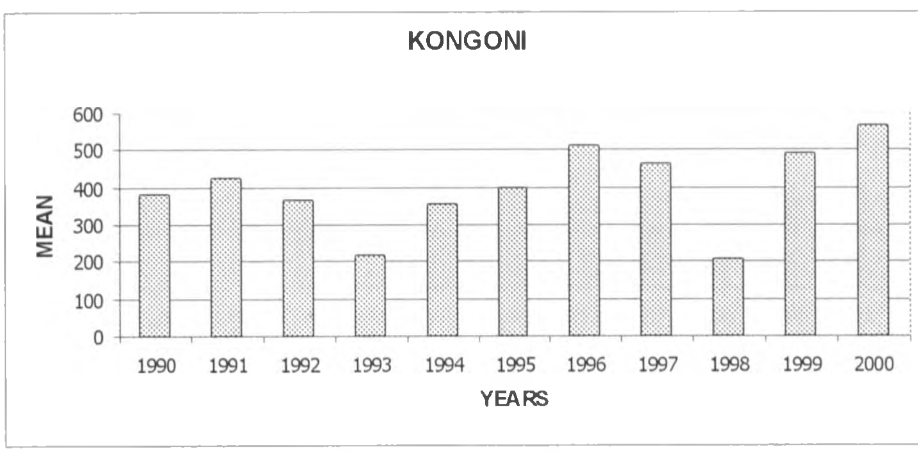


Chart 12 – Total Mean of Kongoni per year

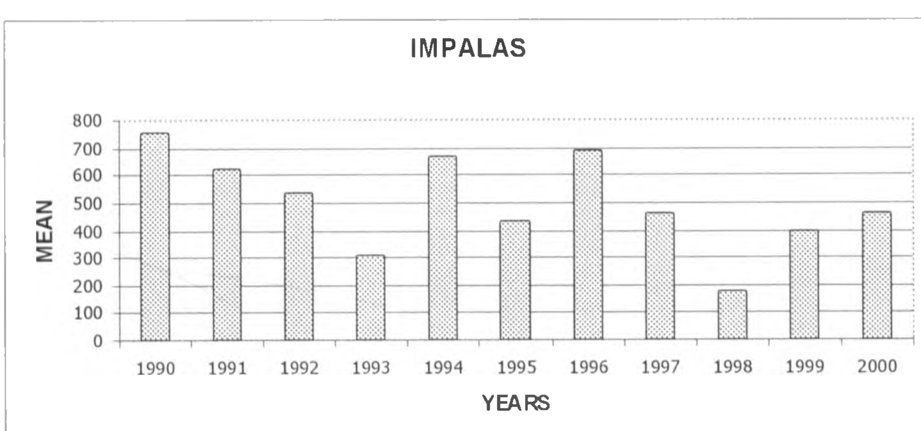


Chart 13 – Total Mean of Impala per year

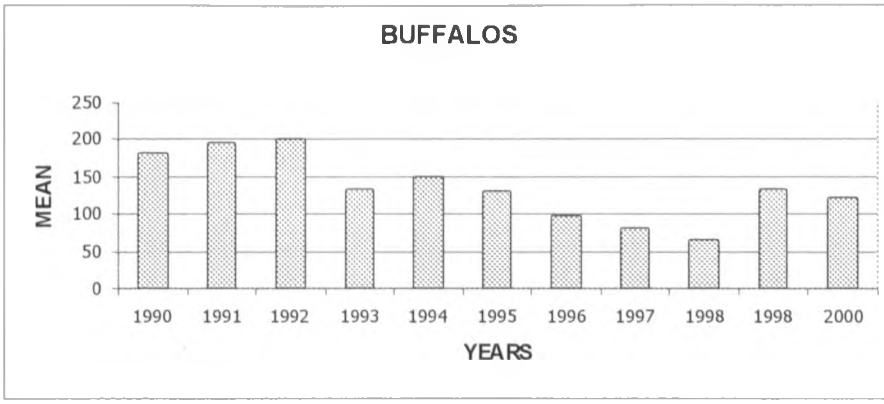


Chart 14 – Total Mean of Buffalos per year

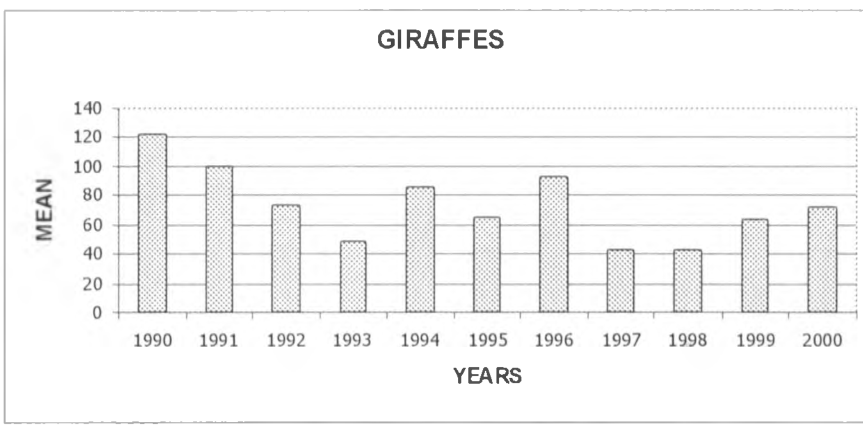


Chart 15 – Total Mean of Giraffes per year

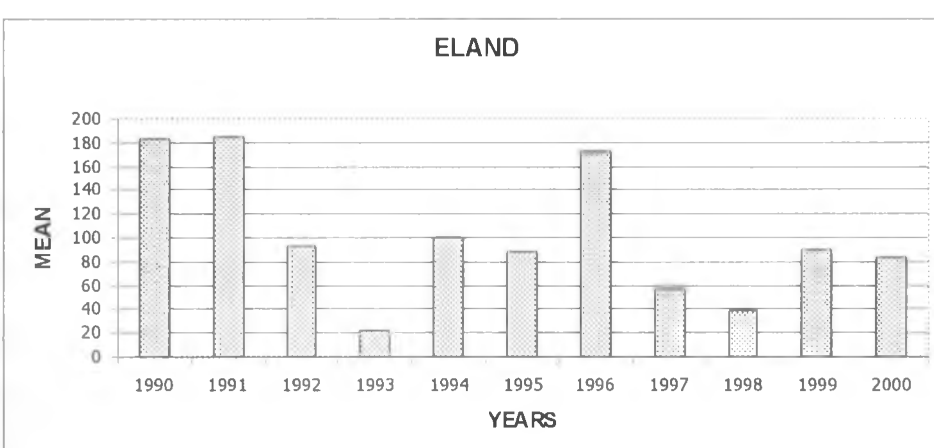


Chart 16 – Total Mean of Eland per year

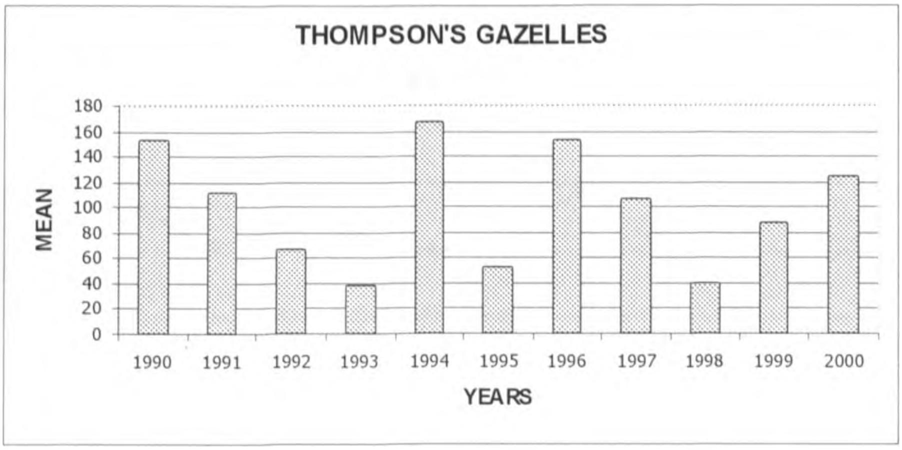


Chart 17 – Total Mean of Thompson's Gazelles per year

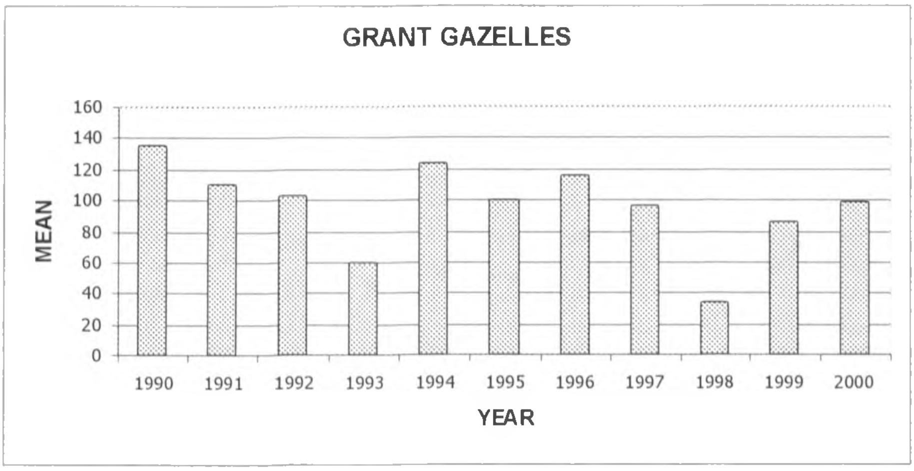


Chart 18 – Total Mean of Grant Gazelles per year

3.5 Rainfall and Animal Variability

The data on rainfall was sampled from three main stations i.e. Wardens Camp, Cheetah gate and Wilson Airport. The following line graphs were drawn to compare animal species count and rainfall amount received for a ten-year period. The results showed that the animal species are affected differently by the seasons. Chart 19-27 shows the correlation profiles of rainfall and animal counts.

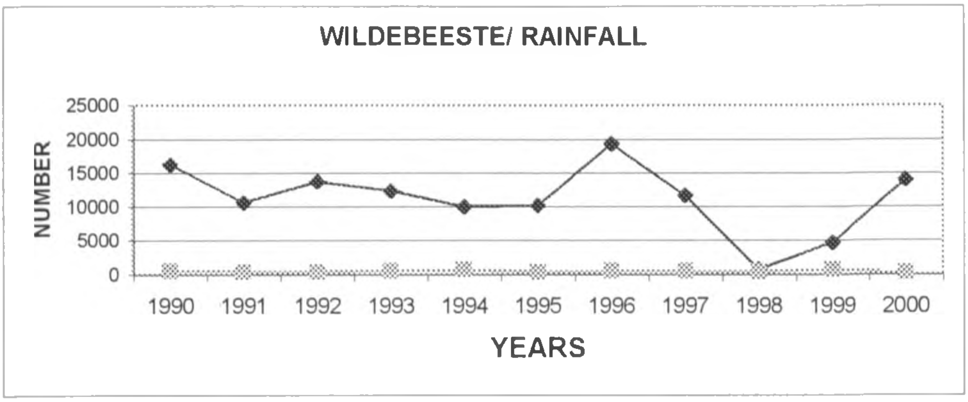


Chart 19 – Comparison of Rainfall data with Wildebeest

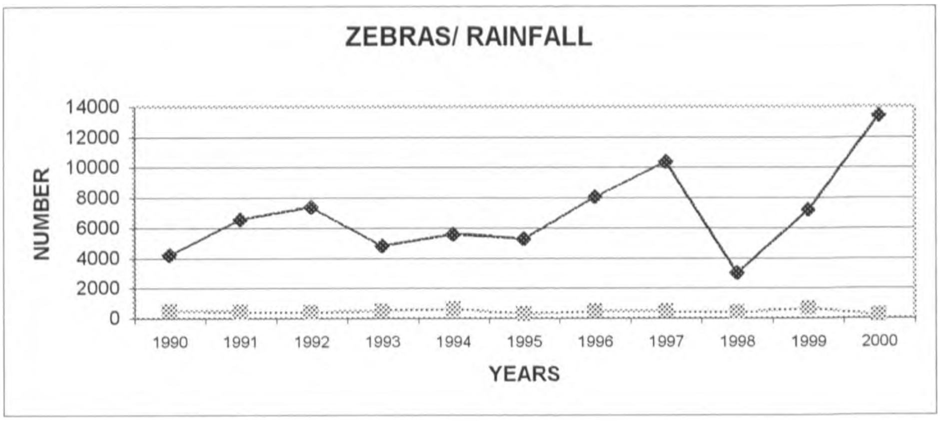


Chart 20 – Comparison of Rainfall data with Zebra

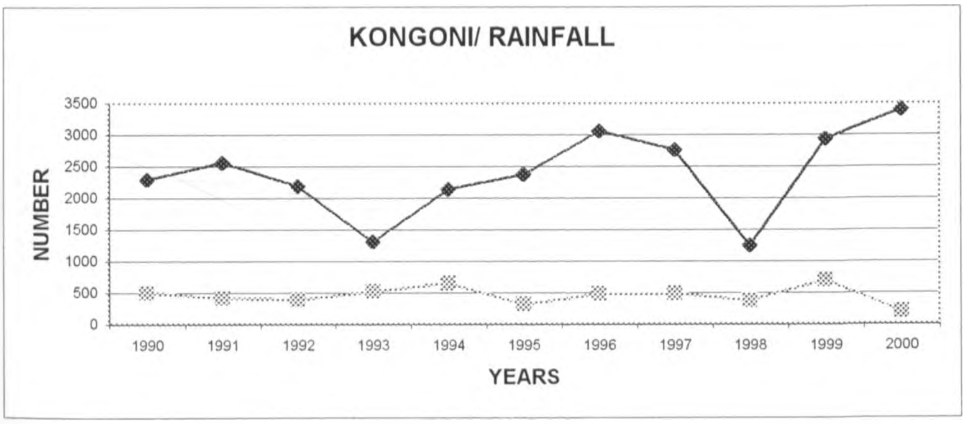


Chart 21 – Comparison of Rainfall data with Kongoni

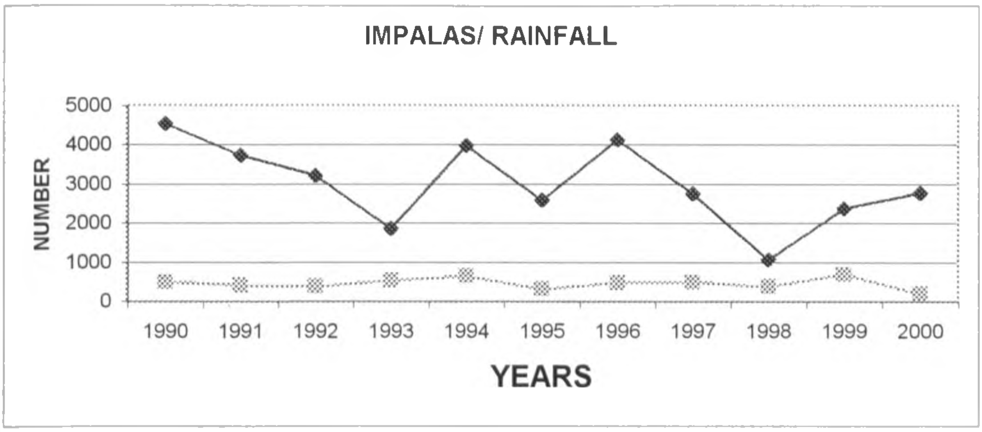


Chart 22 – Comparison of Rainfall data with Impalas

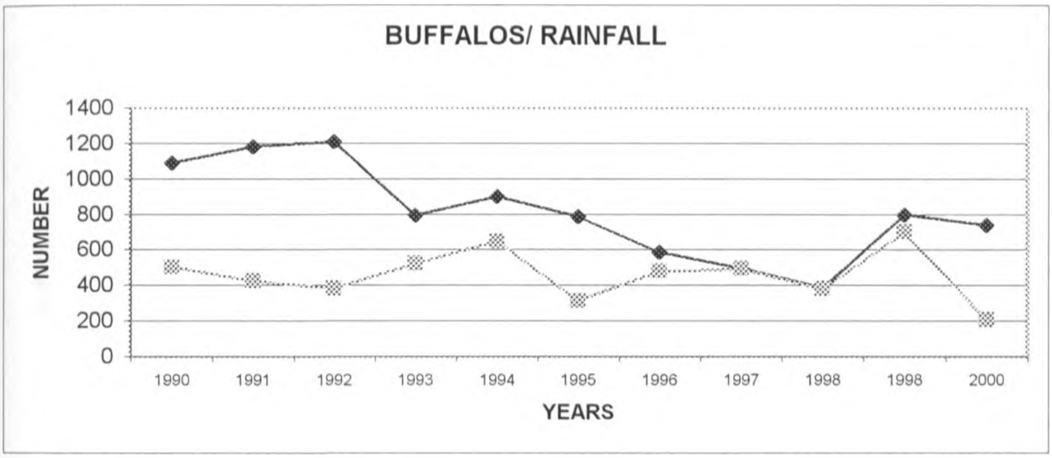


Chart 23 – Comparison of Rainfall data with Buffalos

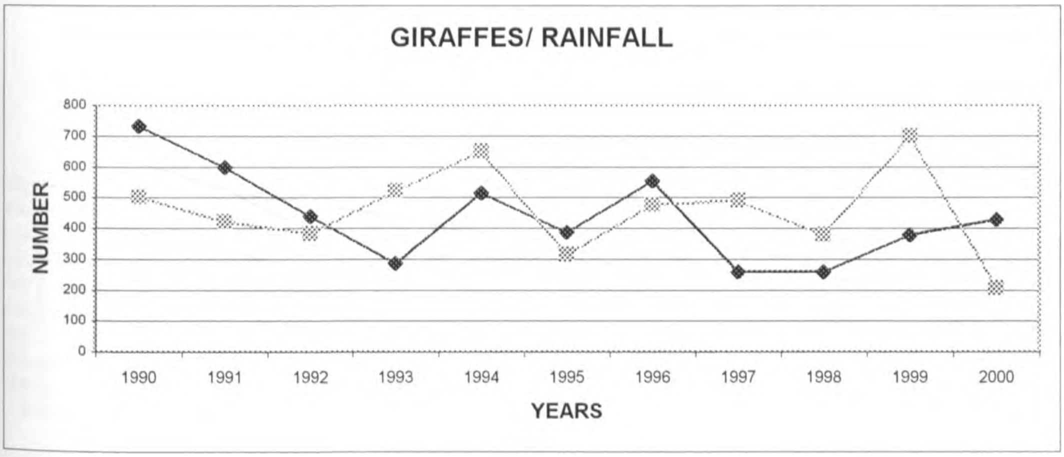


Chart 24 – Comparison of Rainfall data with Giraffe

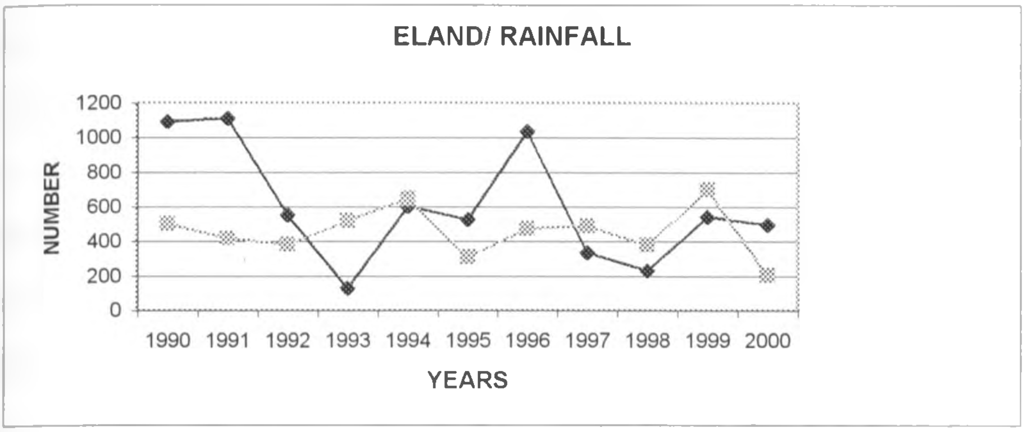


Chart 25 – Comparison of Rainfall data with Eland

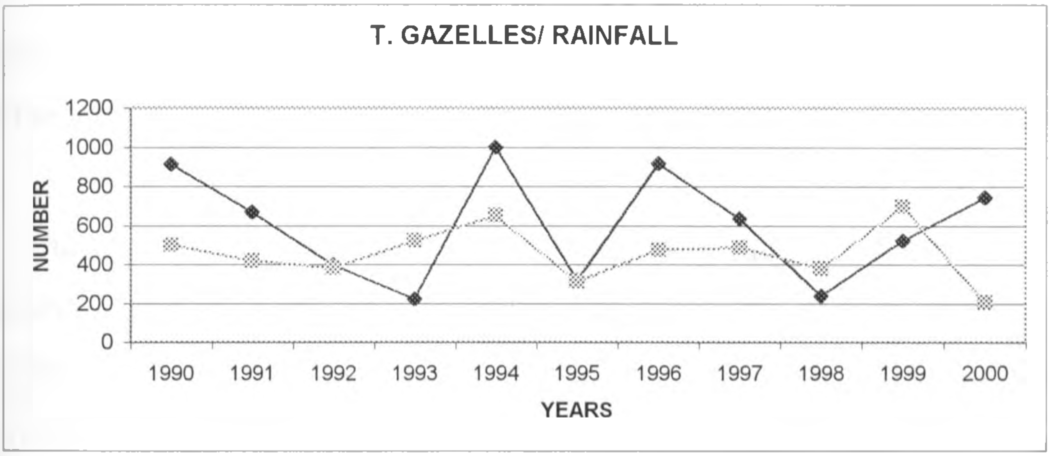


Chart 26 – Comparison of Rainfall data with Thompson's Gazelle

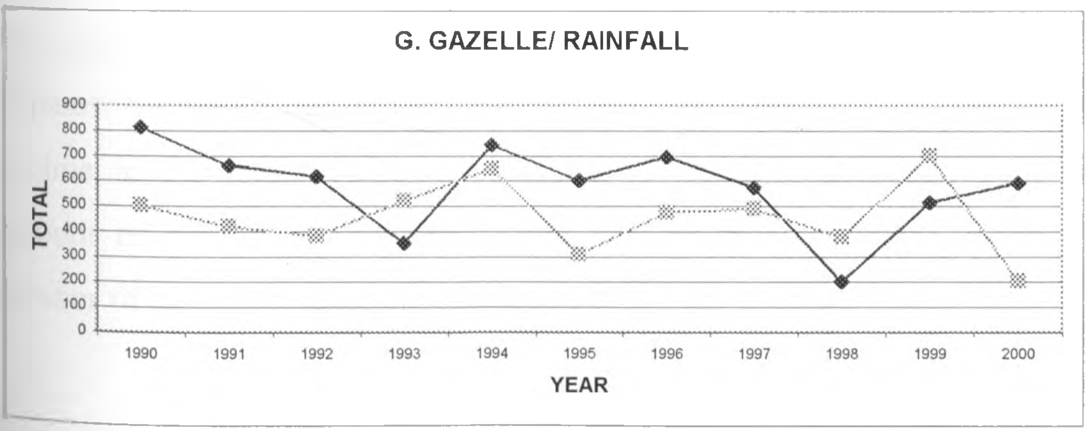


Chart 27 – Comparison of Rainfall data with Grant Gazelle

Both rainfall and animal counts were committed to the step-wise regression analysis. These statistical packages SPSS (Statistical Package for Social Sciences) and Ms-Excel were also used for the purpose. The animal species and rainfall total 1990-2000 indicated how various animals reacted to the rainfall patterns. The increased rainfall was inversely proportional to a decrease in the total numbers of the zebras and the wildebeest in the Nairobi National Park. This was because both animals moved out of the park into the adjacent rangelands where there is abundance of pasture and also for calving purposes. During the dry seasons, both the wildebeest and zebra migrated back to the Park because it had more pasture and water, whereas the rest of rangeland dried up. However, there were some exceptional years in 1993 – 1995 and 1998 when the animal counts were severe negatively affected by the drought.

The analysis of kongoni against rainfall indicated that there is a stable population within the park. The exception was during the drought years in 1993 and 1998 when most of the Kongoni died out of starvation. This was because the Kongoni rarely migrate out of the park. The analysis of impalas against the rainfall showed a marked increase in the total numbers of the animals and increased amount of rainfall. However, both totals were not quite equivalent because when the park gets flooded, the Foot and Mouth disease affect the impalas. Similarly, the buffalo/ rainfall analysis showed that there was a major decline in the total number of buffalos in the park irrespective of the total amount of rainfall. The worst decline was in the year 2000, when the total number of buffalos was approximately 200.

The chart on the other hand indicated that the highest number of giraffe was almost equivalent to the highest rainfall totals. However even during the dry season the giraffes move to the forested parts of the park since they are browsers. All in all there has been a marked decline in the total number of the giraffes in the Park from 1990 – 2000.

The analysis of eland and rainfall data showed a marked decline of the total numbers of animals in the park irrespective of the increase in the total rainfall. A good comparison was the year 1993, when the total number of eland was 133 while the rainfall was 521.7mm. This compared to the year 2000 when the total of eland was 497 against the rainfall total of 206.4mm. The elands are also known to be targeted for game meat.

The analysis of Thompson's Gazelle and Grants Gazelle/ rainfall analysis indicated that both types of Gazelles prefer average rainfall amounts. The highest numbers of Thompson's Gazelles count was 1002 in 1994 compared to the rainfall totals in the same year 650.6mm. At the same time the highest total animal counts of the Grant Gazelles was 815 in 1990, whereas the rainfall totals was 501.8mm. Thus the impact of the rainfall totals is inversely proportional to the total numbers of the both the Grant Gazelles and the Thompson’s Gazelles over the ten year period.

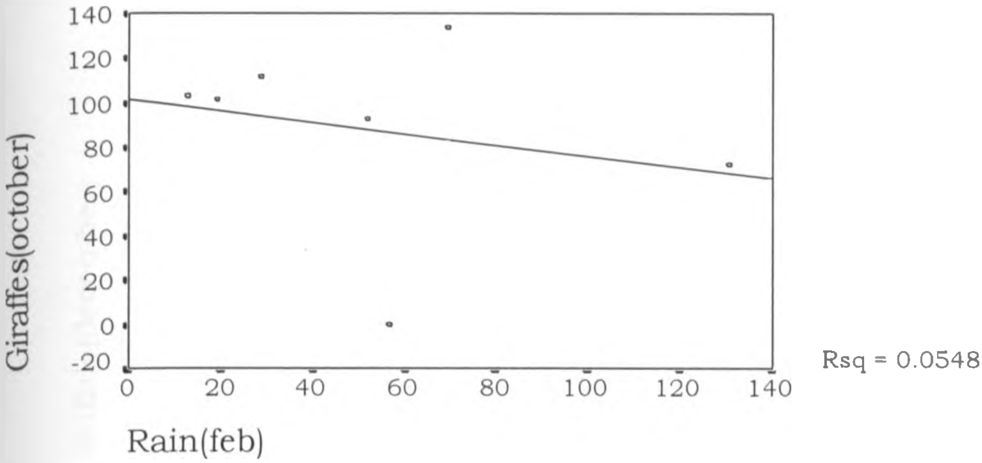


Chart 28 – Giraffe/ Rainfall

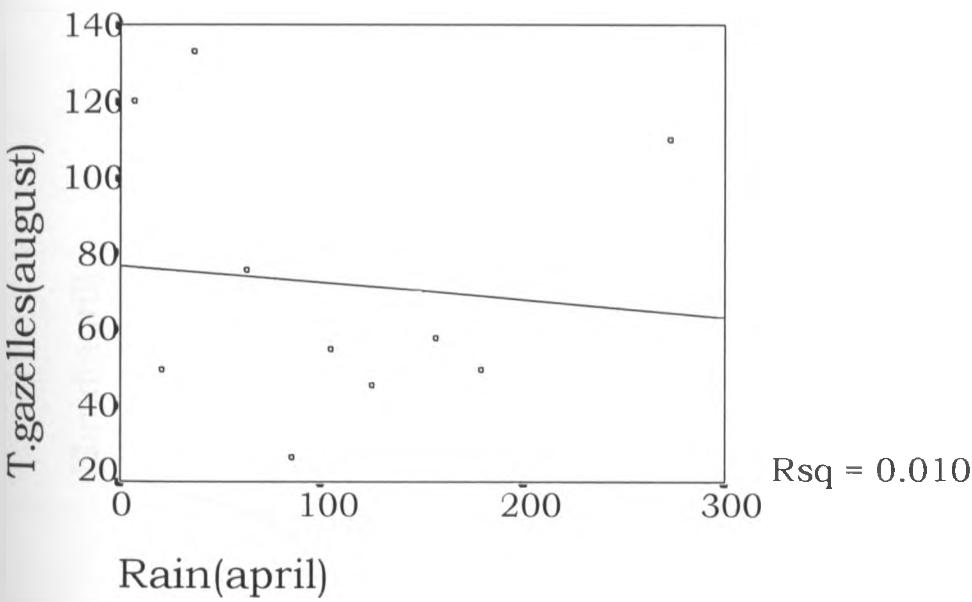


Chart 29 – Thompsons Gazelle/ Rainfall

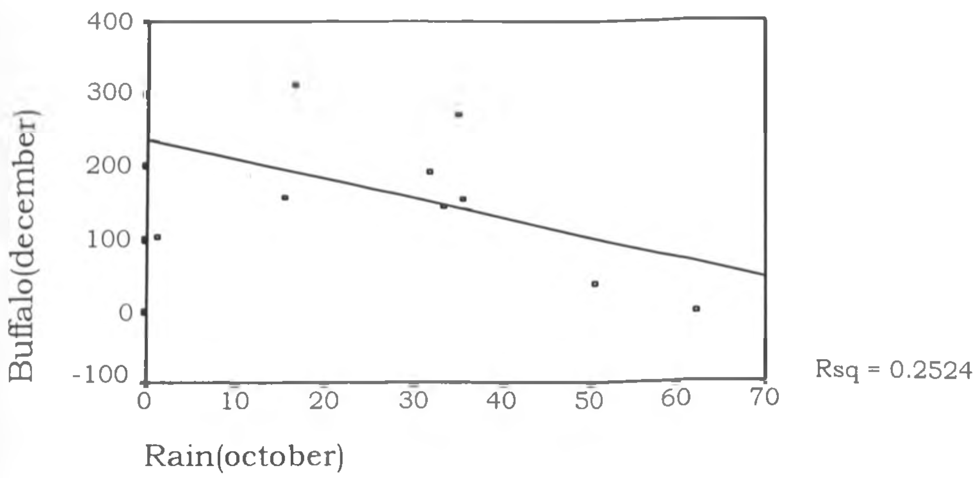


Chart 30 – G.Gazelles/ Rainfall

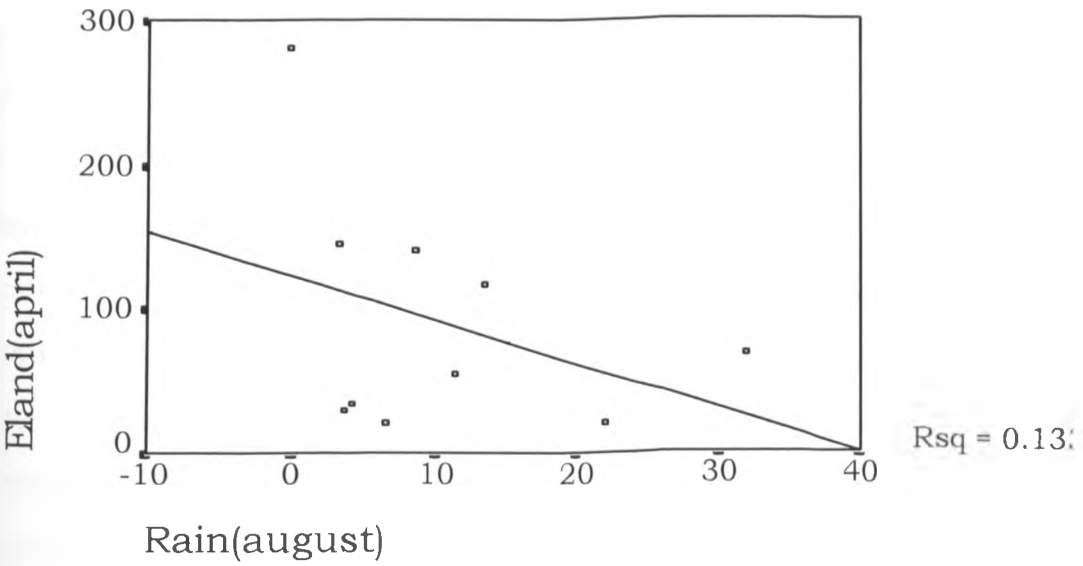


Chart 31 – Eland/ Rainfall

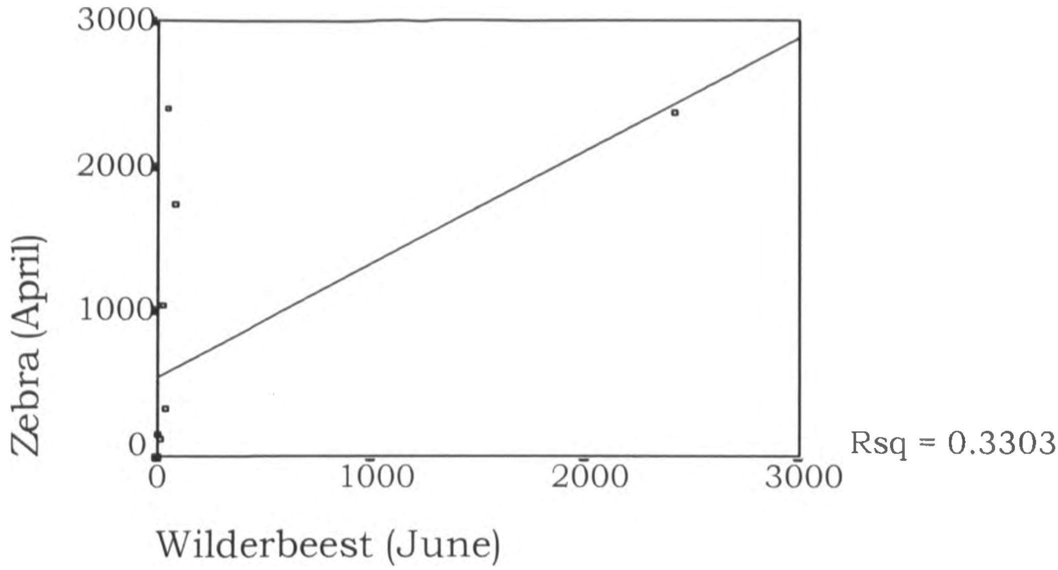


Chart 32 – Zebra and Wildebeest

As indicated in the graphs below the zebra have a positive linear relationship with regression. This was because the population of both animals had increased from the month of April to August since by then they have migrated back into the park. The zebra mostly followed the wildebeest in the migratory cycle. The migration occurred during the rainy season and zebras and wildebeest moved out of the park first. The wildebeest feeding and reproductive specialization enabled it to exploit short grasslands more efficiently than other ruminants to the point where it concentrated them out. The need to drink daily limits the wildebeest to pasture within the community, distance of water approximately 10-15 kilometres. At the same time the perception of a heavy thunderstorm stimulated migratory wildebeest to travel over 50 km to graze the resulting green flush.

Among the zebras, the activities of one group affected other groups leading to mass movements to add from pasture and water or migration. Even the passage of other species such as the wildebeest and Oryx stimulated the zebras to join the procession.

The Thompson Gazelle showed an inverse relationship with increased rainfall because it rarely moved out of the Park. With increased rainfall amount, the Park becomes waterlogged and this affected the gazelles negatively. Secondly, the carnivores turn into the remaining herbivores in the Park since most of them were hindered from following the migratory herbivores due to human activities in the Park neighbourhood. There was a positive relationship between the zebra counts in February and rainfall amounts in October. This was because the short rains started to decline, followed by a dry spell from December, January and by February the Zebras and the Wildebeest migrated back into the park. This was because the park had a variety of vegetation types and more so Athi River forms the southern boundary and there are many watering points.

The increased rainfall amount impacted negatively on the eland. The Eland rarely moved out of the park, and therefore the carnivores predated on it. Water logging in the park also affected the Eland. The increased population of both the zebra and wildebeest between April to August occurred outside the Nairobi National Park. This was in the Kitengela-Athi Kapiti plains where both animals out migrate for calving during the rainy season.

3.6 G.I.S DATA ANALYSIS

3.6.1 G.I.S. Analysis

The G.I.S data analysis involved the use of two Landsat Images such as Landsat 1987 and Landsat 2000. These two images were used to compare the anthropogenic activities in the Nairobi National Park and the neighbourhood from 1990 – 2000.

The Landsat Images were Georeferenced using the GPS (Global Positioning System) points obtained during the field training in the Park. The data was transferred using the Image Georeference tool in Idrisi and ArcView software packages. Georefernece refers to an image to world transformation that converts the image coordinates to real world coordinates. The map of Nairobi National Park was identified from the Landsat images and then it was clipped out. The new image was in TIFF format. The bands used for the 1995 spot images were 1, 2 and 3 while for the 2000 Landsat images the following bands were used i.e. 1,2,3,4,5. The bands were chosen according to the resolutions and principal applications. The bands chosen that is 1,2,3,4,5 are used to show vegetation, soils, and cultural studies.

The spot Landsat images were used to compare the increased human, and also for the migratory corridors. The buffer zone for the Park reserve is 2.5km. Creating buffers along the migratory corridors included some parts of the built up areas. The Park management could either lease land or buy back the sub divided land. This was because the continued subdivision of the Kitengela conservation area could finally block the migration of the Zebra and Wildebeest to and from the Park. This in return would threaten the survival of the said animals.

The map of Nairobi National Park has indicated the following neighbouring districts i.e., to the north, west, north east and the north is Nairobi City, west is the Karen-Lang'ata suburbs, North east is Machakos district, and South and South East is the Kitengela Conservation area. To the southwest is Ongata Rongai.

The city has many anthropogenic activities such as residential areas, industrial areas, communication lines such as roads, airports and a railway line. Machakos District, which has ranches, towns such as Athi River and industrial activities. These human activities have blocked the movement of animals in and out of the Park using the Cheetah Gate migratory route.

To the south and southwest is the Kitengela conservation area and Ongata Rongai that has been subdivided and fenced in most parts. Residential houses, flower farming, subsistence farming and commercial houses have been put up.

Expatriates have purchased land along the Athi River to enable them view wild animals from their homes. This has interfered with the southwest migratory route through Maasai Lodge and also through the Leopard cliff migratory corridor. Whereas the rest of the park has been fenced the southern part has been left open. This indicates that the migration of animals in and out of the park could take place were it not for impact of the anthropogenic activities.

CHAPTER FOUR

4.0 DISCUSSION

The anthropogenic activities in the Nairobi National Park neighbourhood have negative impacts on the park. The comparison of the two Landsat images (1995 and 2000) indicates that there has been a gradual change in the land use activities. These changes are land subdivision and fencing, built up area especially to the southern part of the park, quarrying, and subsistence farming and communication lines. The Environmental Impact of these activities has been in curtailing the migration of animals in and out of the Park.

The Wildebeest and the Zebra normally migrate during the wet and dry seasons. The migratory routes used are the southwest route towards Maasai Lodge, which is almost closed up, the leopard Cliff and the Cheetah Gate route.

4.1 Animal Dispersal

From the foregoing discussion, a sample of nine herbivores in the Nairobi National Park such as the Wildebeest, Zebra, Kongoni, Impala, Buffalo, Giraffe, Eland, Thompson Gazelles, Grant Gazelles were considered for this research. The animal count for the said herbivores for the period (1990 – 2000) was compared against the rainfall totals for the same period of time.

Movement of animals to and from the Park involves migration, which is long distance movement by animals such as the Zebra and the wildebeest. Other animals move for short distances referred to as dispersion such as the Eland, Kongoni, Thompson's Gazelles and Impalas. Migration occurs during the rainy season and the zebras and wildebeest move out of the Park first. The carnivores such as the Lions follow them.

The main aims of this research are to find out the impact of anthropogenic activities on the migratory corridors of the Nairobi National park. The parks neighbourhood is interfering with the animal dispersal to and from the park. (charts28-32).

According to data on animal count and rainfall amount for the last ten years, the total population of animals within the park depends on the seasons, predation, disease and human interference i.e. poaching. However, some animals do not move out of the park and those that migrate out e.g. Zebra and Wildebeest do so either for calving purposes and/ or to graze in the rangelands. The increasing human activities in the Park neighbourhood will curtail the movement of the Zebra and wildebeest. This implies that either the Nairobi National Park will be enclosed and therefore may not sustain these herbivores.

Alternatively, the Nairobi National Park management assisted by Friends of Nairobi National Park either leases land from the community or buys back the land and leave it as a conservation area.

The secondary data used was on animal count and rainfall totals for the past ten-year period (1990 – 2000). The animal count, which is carried out every other month, indicates that there is a strong relationship between the amounts of rainfall received per year. During the drought years most animals died due to lack of food. On the other hand, during the years when there was heavy rainfall some animals were affected by water logging.

At the same time there are animals that migrate out of the park depending on the seasons. The Zebra and the Wildebeest, which form the focus of this study, are good examples. During the wet seasons, the Wildebeest moves out of the park first to feed on the sprouting nutritious grass over the rangelands. The zebra follows next because they are mostly influenced by the behaviours of other animals, but also they feed on the coarser grasses. The migratory out of the park is also influenced by the calving season for both the Wildebeest and the zebra. The former migrates as far as Enkirigiri east of Isinya for calving purposes.

The onset of the dry season leads to the migration back to the park. This is due to presence of watering points, rivers, and vegetation on the higher parts of the park. The animals tend to follow the same migratory routes over the years. Some carnivores such as the Lions follow these herbivores and in the process they may attack anything else on the way.

Along the roadside are various human activities such as kiosks, Kenya College of Communication Technology (KCCT) and a slum village (Bangladesh) next to Athi River. Other activities are residential houses, schools and churches. This indicates that there can be very little movement of the zebras and wildebeest out of the park. At the same time, the park is electric fenced. To the southern and eastern parts of the ark are bordered by Athi River. However, most of the land bordering the river have been sold out to private developers. However, towards Cheetah Gate, the migratory corridor has not been closed up completely but here and there is fenced plots for commercial, industrial and farming activities.

Athi River town and Kitengela town blocked the animal movement toward Machakos and the animals divert the movement along the Kajiado Road and into the Athi-Kapiti plains.

The southwest migratory corridor near Masaai Lodge is almost completely cut off due to fencing of private plots, schools and residential areas. As the lions followed the animals migrating out of the park, they ended up in the Ostrich Farm in Kitengela where they killed several Ostrich. The interference of the migratory corridor by human activities is impacting negatively both on the herbivores i.e. the wildebeest and the zebras, and the carnivores that follow them especially the lions.

Refer Figs. 15 - 17.

Fig. 15 – Showing a commercial complex in Ongata Rongai

Fig. 16 – Showing Maasai Lodge Road

Fig. 17 – Showing Bangladesh slums bordering the park to the south west side

4.2 G.I.S. Interpretation

In reference to the Spot Image (1995), there was a gradual increase of anthropogenic activities, but for the last ten years there has been a tremendous increase in the said activities (Refer to Image I).

A comparison of Landsat Image of 2000 and spot 1995 shows the increase of human activities for the past ten years. Refer to Images 2,3,4. The table of attributes generated from the Landsat image 2000 shows the following: Built-up areas, Forests, grassland, water surfaces, riverline vegetation and scrubland.

A bar graph and a pie chart were drawn to show a comparison of the landuse activities. The chart shows the amount of each category in the area.
The pie chart shows the percentage and frequency of the said categories. A summary statistics was used in the above research inorder to come up withy the total amounts, amount by category and also statistical summary. The bar graph and the pie-chart shoes that the built –up area of the Park neighbourhood has the biggest percentage (46%). This compared to other land use and land cover activities shows that the human activities are interfering with the migratory corridors.

To the west and southwestern parts of the Park are residential and commercial activities. At the same time the Park is fenced along the Magadi-Langata road. To the south and southeast parts of the Park is Athi River. The boundary of the park has been left open.

However, human activities such as residential houses, commercial activities and farming have led to the subdivision and fencing of the land. The buffer zone created around the park shows the 2.5km reserve area, which should not be sold out, to individuals. The Kitengela conservation area is a critical area, which should not be sold and fenced.

The main objectives of this study have been achieved in that the anthropogenic activities in the Nairobi National Park neighbourhood have been identified as follows:- farming, residential houses, industrial activities, communication lines and unplanned settlements. The increase of these activities for the past ten years has impacted negatively on the migratory corridors. The null hypothesis is rejected, while the alternative hypothesis i.e. "Anthropogenic activities have a significant impact on the migratory corridors" has been accepted.

The comparison of the animal count and rainfall amount received for the past ten formed the background of this study. This is because the two herbivores selected for this study i.e. the Wildebeest and the Zebra migrate to and out of the park depending on the season. The population census also indicated a major decline of the animal population in the park either due to environmental factors such as foot and mouth diseases, drought or game meat hunting. The vegetation of Nairobi National Park, Rivers, water points, built up areas and communication lines were used in the creation of Buffer zones. G.I.S has been used as a modern computer tool which makes it easier to assess the impacts on the migratory corridors of the Nairobi National Park. It made it easier to clip off the area required from Landsat and spot images. It also performed overlay operations and created buffer zones.

4.3 Validation

The impact of human activities on the migratory corridors of N National Park could be validated by comparing other studies carri elsewhere. According to D. Thompson *et al* (unpublished) three Landsat were acquired for the year 1975 (Landsat mss), 1985 and 1995 (Landsa The land cover changes were grouped into changes related to:-

i) The expansion of mechanised farming

ii) Subsistence agriculture and development of perr settlements (small holder impact and)

iii) Vegetation growth.

Refer to fig. 18

At the same time the study of Amboseli biosphere: zonation Kar (1991) indicated how G.I.S. was used to come up with areas suitab development of tourists' accommodation in Amboseli biosphere reserv use of buffers came up with a buffer zone. (Fig.19). The above two studie carried out using remote sensed data and geographical information s approach. This has compared quite well with the aforementioned researc has used the same approach in the assessment of the migratory corric NNP.

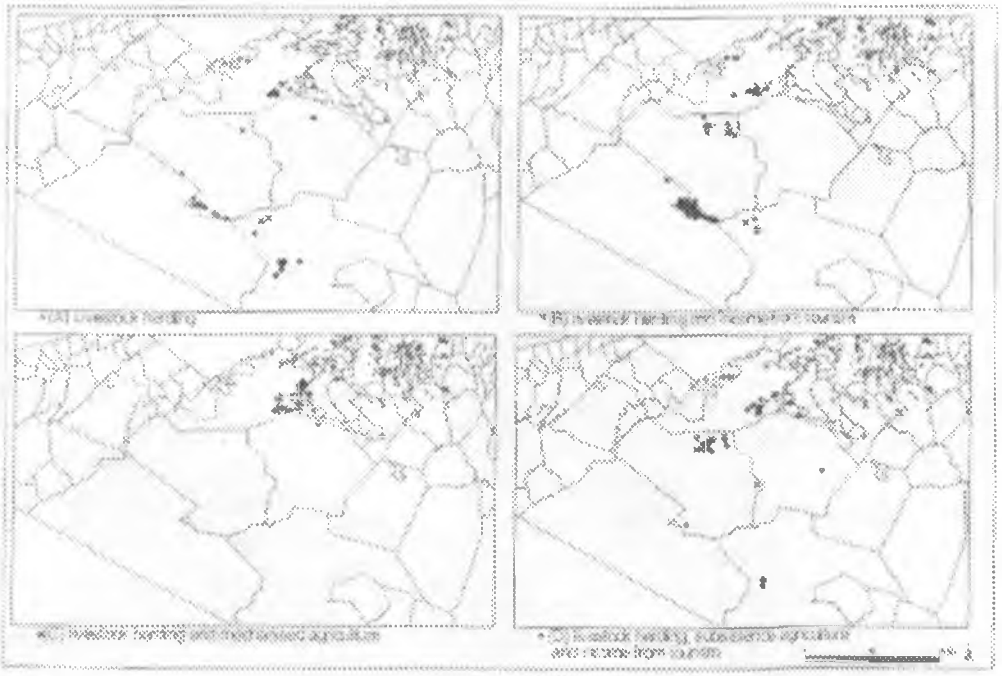


Fig 18 – Spatial distribution of land use strategies in the Mara ecosystem.

Source: D. M. Thompson, S. Serneels and E. F. Lambin

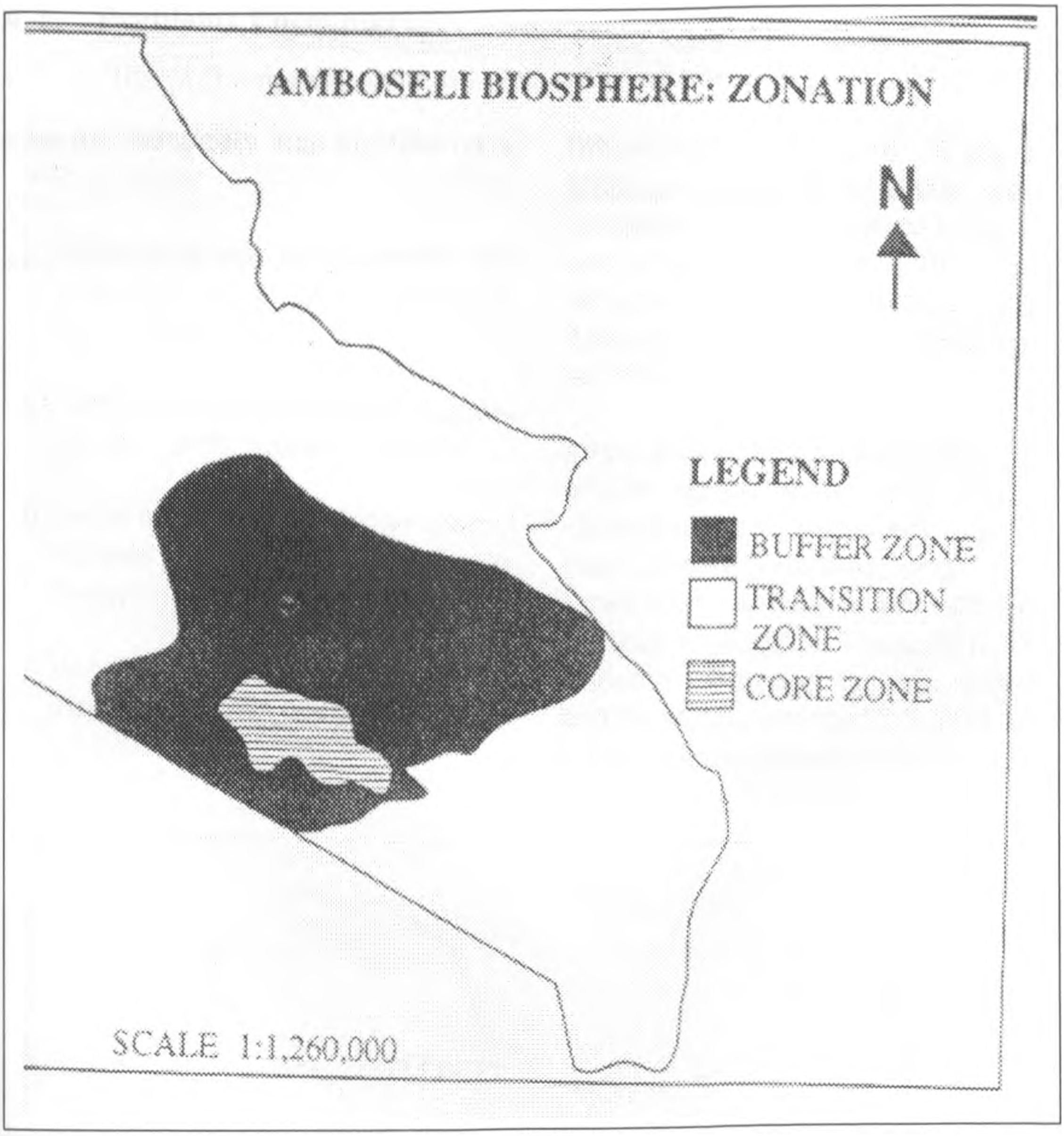


Fig 19: The Amboseli biosphere zonation

Source: Apollo Kariuki – Application of GIS in the Management of Wildlife Resources.

4.4 Problems Encountered

One of the problems encountered was in the acquisition of the spot and Landsat images. Secondly the printing of the said images was not possible with the ordinary printers. The use of a plotter made it possible to print the two images and also the buffered image.

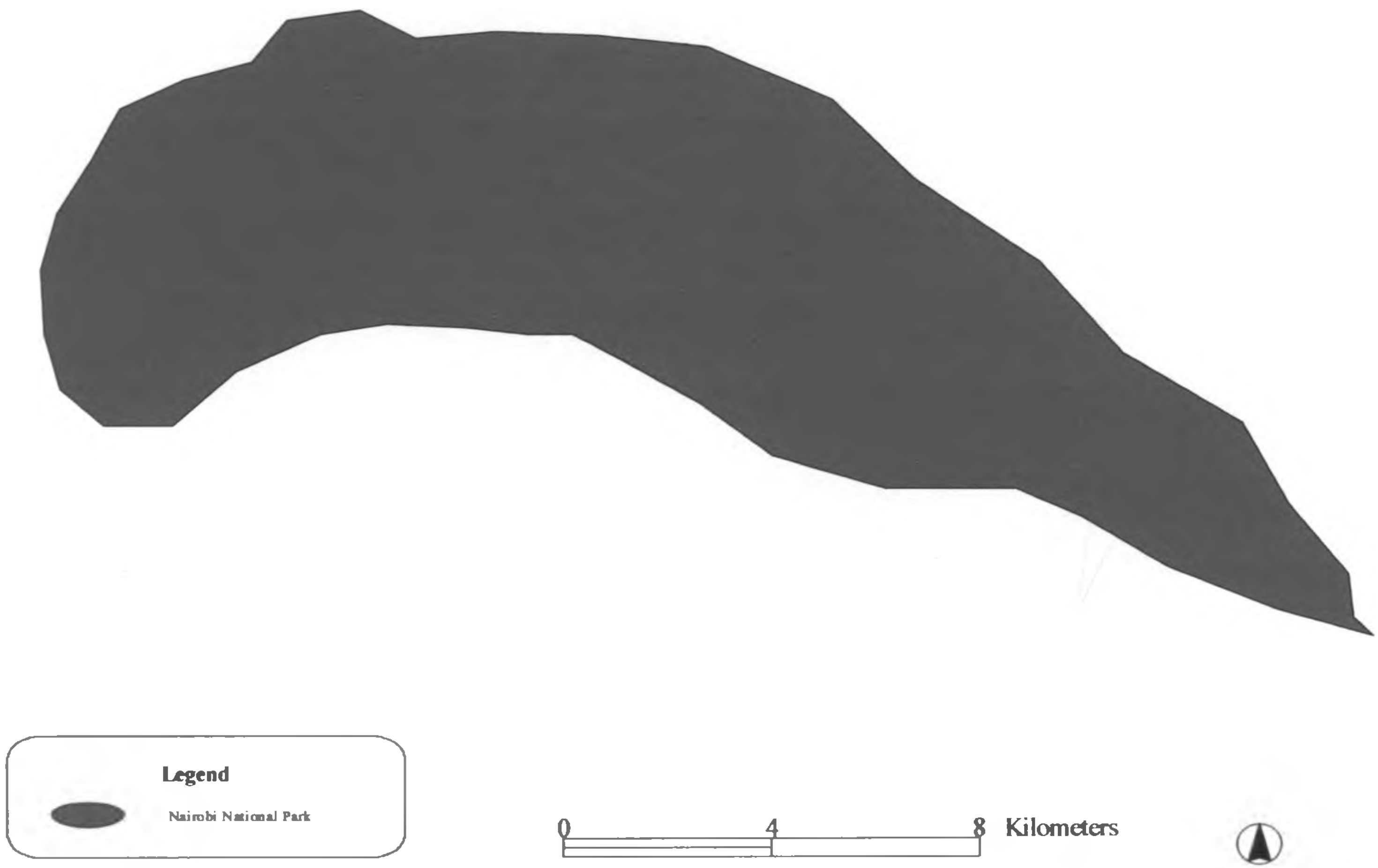


Fig:20 Nairobi National Park Landsat Image 2000

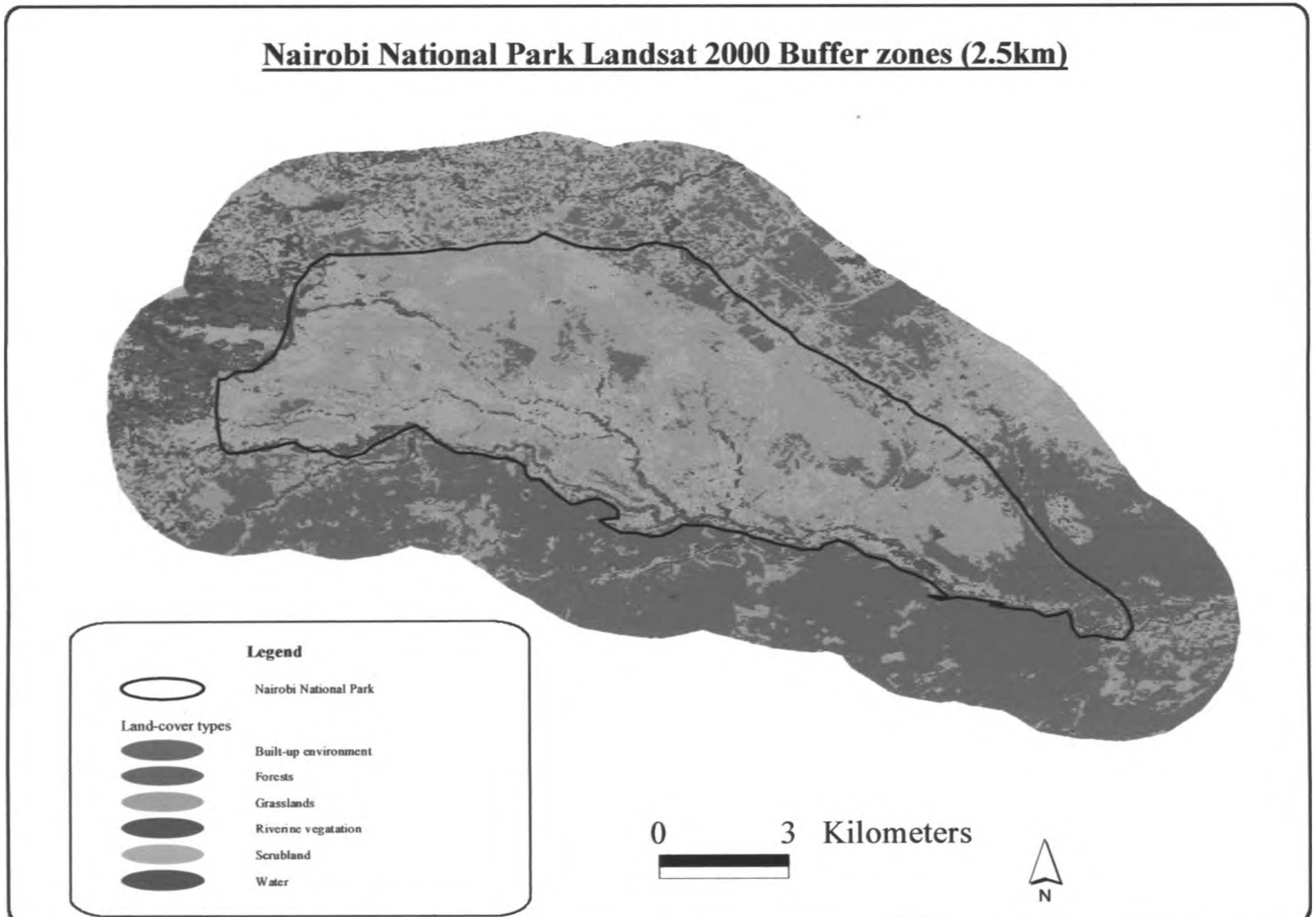

Nairobi National Park Landsat 2000 Buffer zones (2.5km)
Legend
Nairobi National Park
Land-cover types
Built-up environment
Forests
Grasslands
Riverine vegatation
Scrubland
Water
0 3 Kilometers
N

Fig. 21

Table 33 – Showing Land use and land cover at the Park and the neighbourhood.

COVERNAME	COUNT	AVE_AREA_K	AVE_PERIME
Built-up environment	3674	26545.0303	416.0788
Forests	2155	5017.3418	305.7056
Grassland	8538	10074.2738	363.6686
Riverine vegetation	5588	3803.9841	268.1091
Scrubland	9067	5497.5360	300.0063
Water	507	8146.3518	288.1800

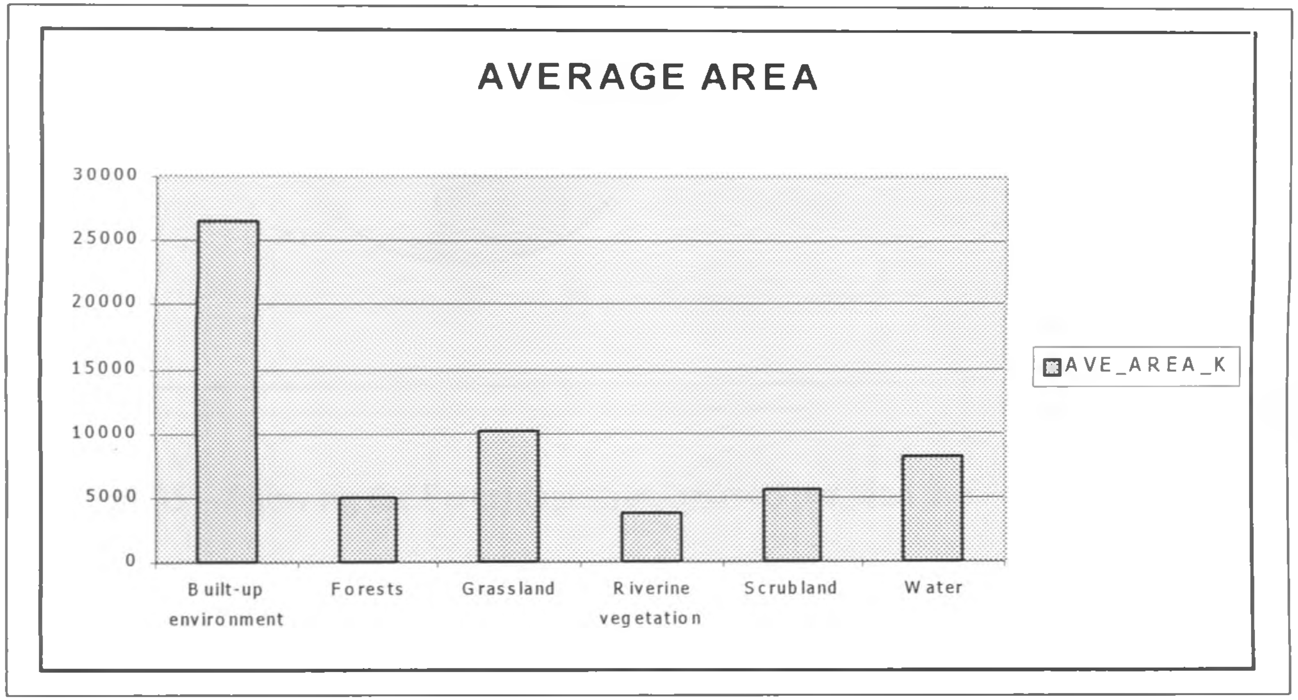
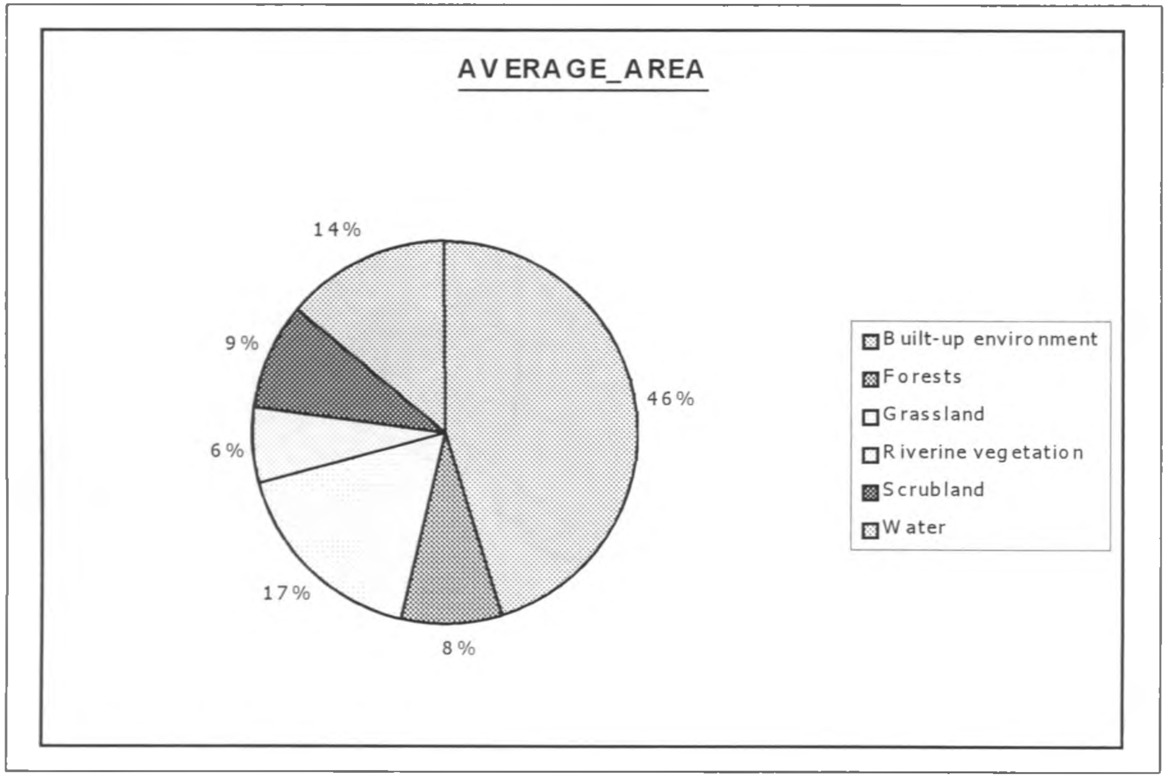
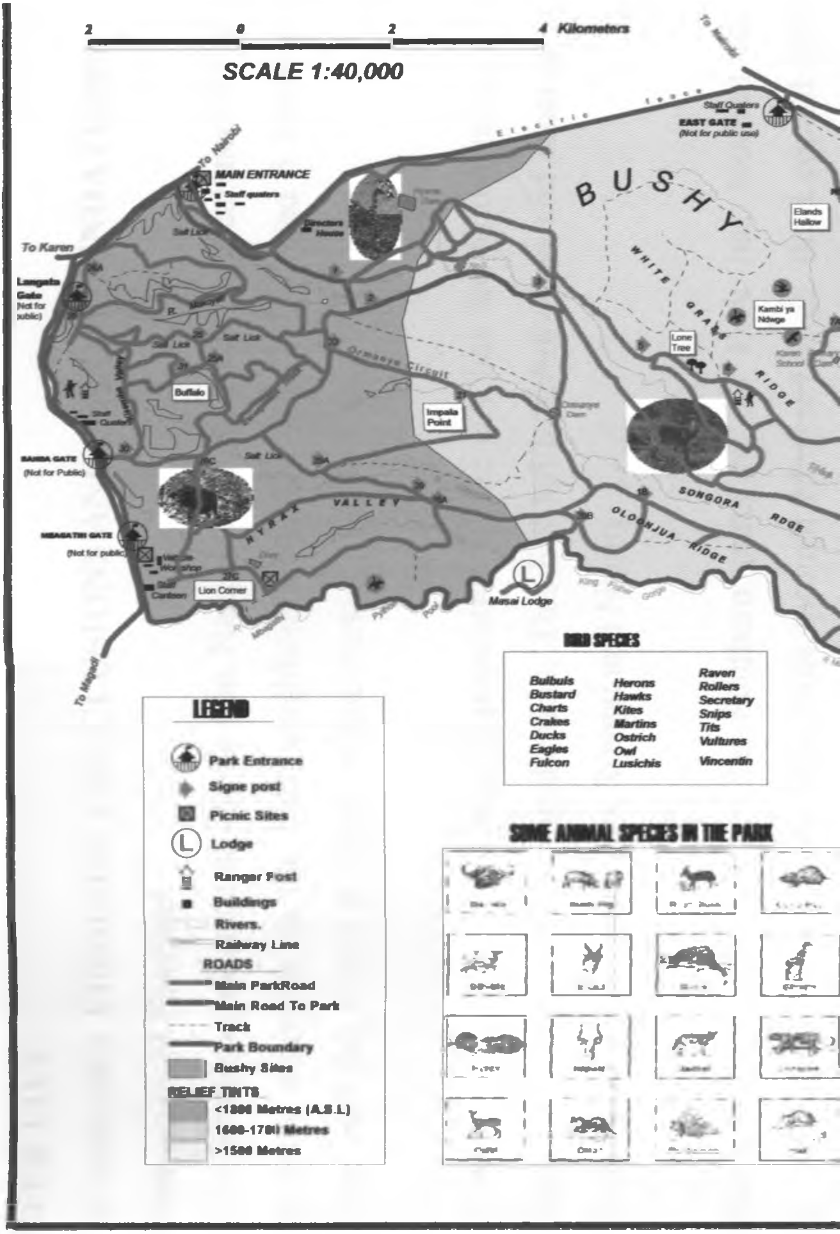


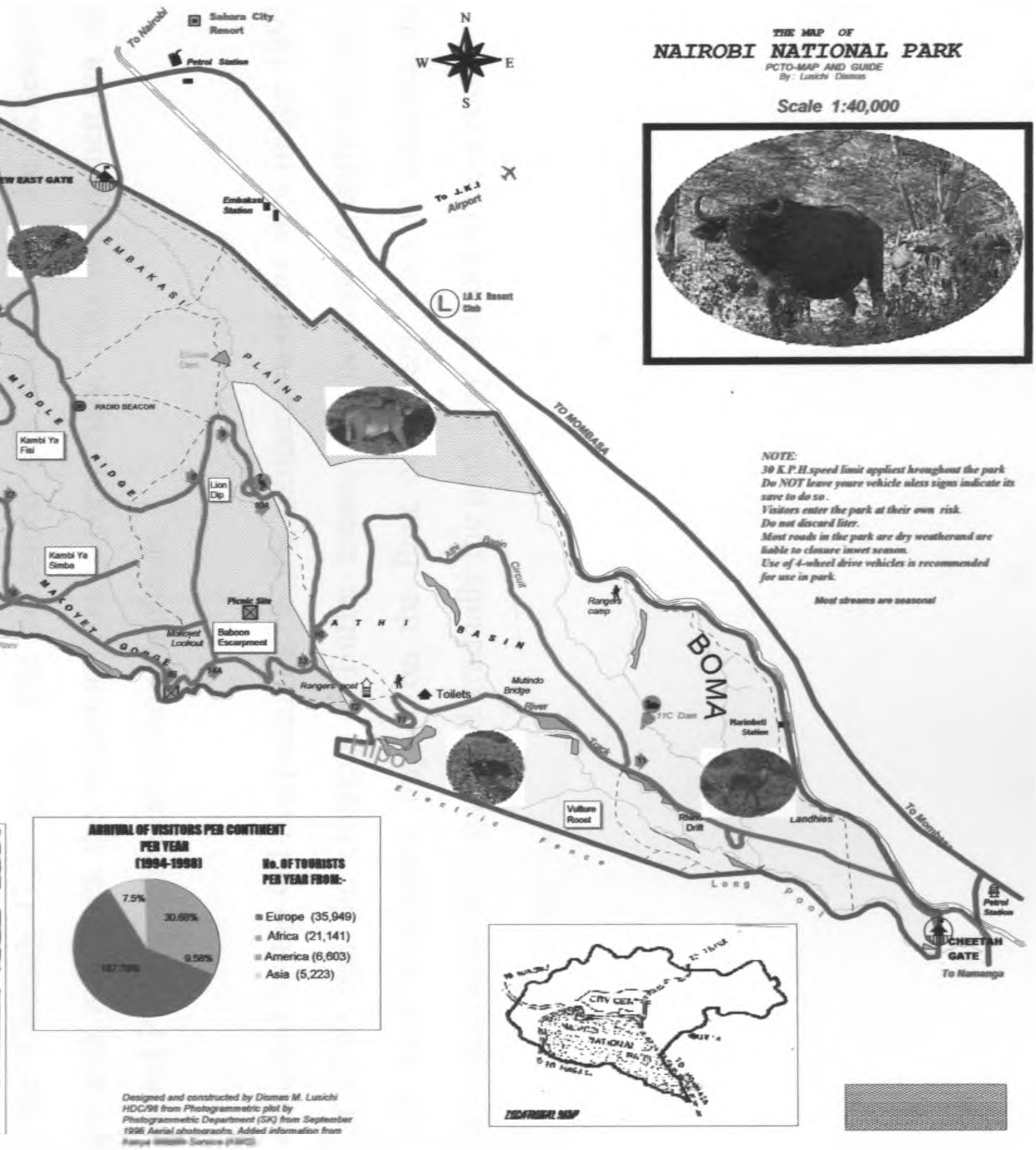
Chart 34 – Average area covered per land use.



Pie Chart 35 – Showing the Percentage area covered per land use



2 0 2 4 Kilometers
SCALE 1:40,000
To Nairobi
MAIN ENTRANCE
Staff quaters
Directors House
Salt Lick
To Karen
Langata Gate
(Not for public)
Electric fence
Staff Quaters
EAST GATE
(Not for public use)
BUSHY
WHITE GRASS RIDGE
Elands Hallow
Kambi ya Ndwge
Lone Tree
Ormanye Circuit
Buffalo
Impala Point
Staff Quaters
BANDA GATE
(Not for Public)
HYRAX VALLEY
MBAGATHI GATE
(Not for public)
Staff Canteen
Lion Corner
SONGORA RIDGE
OLOONJUA RIDGE
Masai Lodge
King Fisher Gorge
Python Pool
To Magadi
BIRD SPECIES
Bulbuls
Bustard
Charts
Crakes
Ducks
Eagles
Fulcon
Herons
Hawks
Kites
Martins
Ostrich
Owl
Lusichis
Raven
Rollers
Secretary
Snips
Tits
Vultures
Vincentin
LEGEND
Park Entrance
Signe post
Picnic Sites
Lodge
Ranger Post
Buildings
Rivers.
Railway Line
ROADS
Main ParkRoad
Main Road To Park
Track
Park Boundary
Bushy Sites
RELIEF TINTS
<1800 Metres (A.S.L)
1600-1700 Metres
>1500 Metres
SOME ANIMAL SPECIES IN THE PARK


THE MAP OF
NAIROBI NATIONAL PARK
PCTO-MAP AND GUIDE
By : Lusichi Dismas
Scale 1:40,000
N
S
E
W
To Nairobi
Sahara City Resort
Petrol Station
EAST GATE
Embakasi Station
To J.K.I Airport
J.K.X Resort Club
EMBAKASI PLAINS
MIDDLE RIDGE
RADIO BEACON
Kambi Ya Fisi
Lion Dip
Kambi Ya Simba
MAKOYET GORGE
Picnic Site
Makoyet Lookout
Baboon Escarpment
ATHI BASIN
Athi Basin Circuit
Rangers post
Toilets
Mutindo Bridge
River Track
Hipo
Electric Fence
Vulture Roost
Rangers camp
BOMA
11C Dam
Marimbeti Station
Rhino Drift
Landhies
Long pool
TO MOMBASA
To Mombasa
Petrol Station
CHEETAH GATE
To Namanga
NOTE:
30 K.P.H.speed limit appliest hroughout the park
Do NOT leave youre vehicle ulsess signs indicate its save to do so .
Visitors enter the park at their own risk.
Do not discard liter.
Most roads in the park are dry weatherand are liable to closure inwet season.
Use of 4-wheel drive vehicles is recommended for use in park.
Most streams are seasonal
ARRIVAL OF VISITORS PER CONTINENT PER YEAR (1994-1998)
No. OF TOURISTS PER YEAR FROM:-
Europe (35,949)
Africa (21,141)
America (6,603)
Asia (5,223)
7.5%
30.68%
9.58%
CITY CE
NATIONAL
Designed and constructed by Dismas M. Lusichi HDC/98 from Photogrammetric plot by Photogrammetric Department (SK) from September 1996 Aerial photographs. Added information from

CHAPTER FIVE

5.0 SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The foregoing discussion shows that Nairobi National Park is threatened by the Anthropogenic activities in the Park neighbourhood. The Park is situated 5 km from Nairobi city and this makes it a very unique Park.

However, the increase in human population in the city has led to out migration and settlement in the neighbouring districts. This has led to subdivision and fencing of land in Machakos, Kajiado, Ongata Rongai and Ngong.

The human settlements to the Southern parts of the Park has blocked the migratory corridors i.e. the south wets route through Maasai Lodge, the Leopard cliff route and the Cheetah Gate route. The continued sub division of the Kitengela conservation area will block the migratory routes completely. This would then cut off Nairobi National Park fromthe rest of the rangelands.

As indicated by the G.I.S. operations i.e. the comparison of the spot image 1995 and Landsat 2000 and the creation of Buffer zones, the increase of anthropogenic activities will have a negative impact on the Park ecosystem. This is because the animals will be enclosed in the park and gradually the park may turn out to be a zoo.

5.2 Conclusion

The foregoing discussion shows that Nairobi National Park being affected negatively by the anthropogenic activities in the Park neighbourhood. The increase of these activities as observed over the last ten years (1990 – 2000) will cut off the Park from the rest of the rangelands leaving it as a zoo. If this happens, then some of the animals in the Park may not survive in the enclosed ecosystem i.e. Wildebeest and the Zebra.

The animal count and the rainfall variability indicate that the seasons contribute to the behaviour of wild animals in the ecosystem. The GIS analysis and interpretation has shows that NNP could be managed well if the buffer zones identified are set-aside as reserve area. At the same time the migratory corridors should be acquired as conservation areas. Therefore the Kitengela area should remain a migration zone for NNP. The most affected corridors are the leopard cliff and the southwestern route through Maasai Lodge.

5.3 RECOMMENDATIONS

The Nairobi National Park management with the assistance of the Friends of Nairobi National Park (FONNAP) could lease the remaining land in the Kitengela conservation area. This could involve creating awareness among the people on the importance of conservation and leaving the land open for migration purposes. The community should also benefit from the income obtained from the tourists visiting Nairobi National Park.

The built up area along the Mbagathi River could also be bought to create room for migration purposes. The Buffer Zones along the migratory corridors could help in identifying how much land should be left as reserve area.

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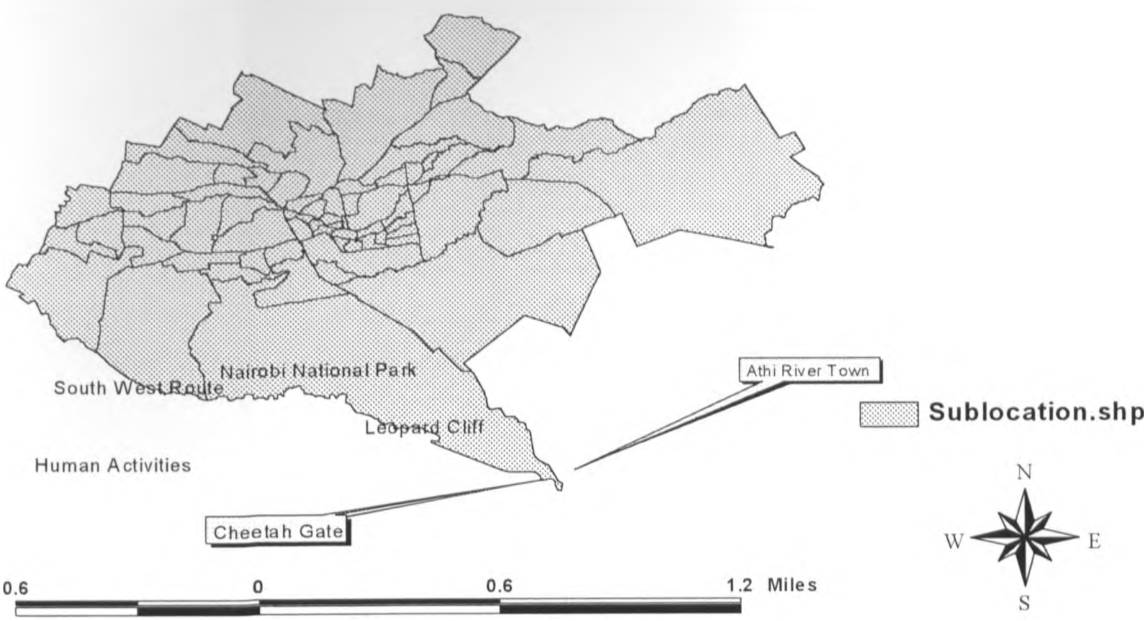
APPENDIX 1

ACRONYMS

1.	A.C.C	-	African Conservation Centre
2.	CWMS	-	Centre for Wildlife Studies
3.	D.R.S.R.S.	-	Department of Resources Survey & Remote Sensing
4.	EPZ	-	Export processing Zone
5.	FONNAP	-	Friend of Nairobi National Park
6.	G.I.S.	-	Geographical Information System
7.	G.P.S.	-	Global Positioning Systems
8.	ICDPS	-	Integrated Conservation Projects Strategies
9.	ILRI	-	International Livestock Research Institute
10.	KCCT	-	Kenya College of Communication and Technology
11.	KWS	-	Kenya Wildlife Services
12.	NGO	-	Non Governmental Organisation
13.	RCMRS	-	Regional centre for Mapping and Remote Sensing
14.	SPSS	-	Statistical Package for Social Sciences

APPENDIX 1

Nairobi City Administrative Boundaries



APPENDIX 2