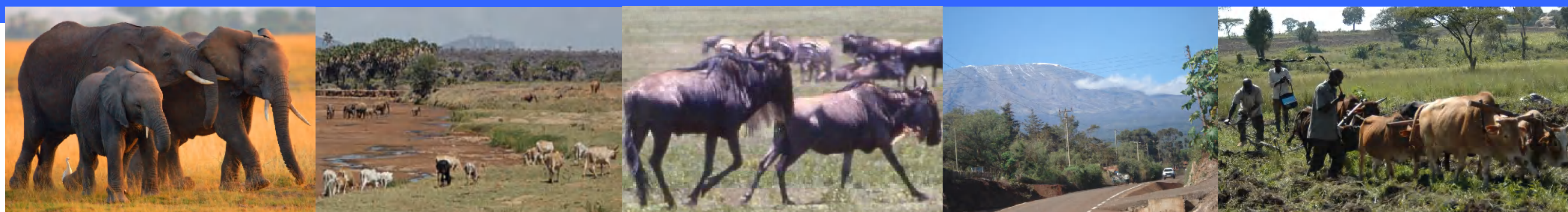
Mapping Wildlife Dispersal Areas and Migratory Routes/Corridors

Southern Kenya Rangeland Ecosystems



CORRIDORS AND CONNECTIVITY FOR CONSERVATION

PART I

Kenya Vision 2030 Flagship Project: “Securing Wildlife Migratory Routes and Corridors”

Ministry of Environment and Mineral Resources - Department of Resource Surveys and Remote Sensing in collaboration with Kenya Wildlife Service, Kenya Meteorological Department , African Wildlife Foundation, African Conservation Centre, and International Livestock Research Institute, Nairobi, Kenya. August, 2012.

Reproduction

ISBN: 000 00 00 00 000 0 (printed)

Report compilation and layout design: Gordon O. Ojwang'
GIS map production: Rose Mayienda, Lucy W. Njino and Joseph Mukeka

Editorial Team
Gordon O. Ojwang', Patrick W. Wargute, Mohammed Y. Said, Jeffrey Worden, Philip Muruthi and Erustus Kanga

Front cover: Matriarch elephant matching, elephants and livestock converge at sandy riverbed for forage and water during the droughts[1], part of the migratory wildebeests in the Mara[2], infrastructure and settlement development in Oloitokitok with snow capped Mt. Kilimanjaro in background[3], and the conversion of wildlife areas to cultivation through ox-plough in Narok County[2]. *Photo Courtesy: Wittemyer[1], GOjwang[2] and LNjino[3]*

Printed and bound in Nairobi, Kenya.

This publication is available in electronic form at http://www.environment.go.ke/ and http://www.vision2030.go.ke/index.php/pillars/project/Social/167

All correspondence

The Permanent Secretary,
Ministry of Environment and Mineral Resources
NHIF Building, 12th Floor,
Ragati Road, Upper Hill
P.O Box 30126-00100, Nairobi, Kenya
Tel: +254 20 2730808/9, +254 20 2725707, +254 20 2725707
Email: psoffice@environment.go.ke, communication@environment.go.ke

Note

ACKNOWLEDGEMENTS

This work was accomplished with the support of many institutions and individuals. The Taskforce and the Ministry of Environment and Mineral Resources (MEMR) through the Department of Resource Surveys and Remote Sensing (DRSRS) is indebted to the late Hon. John N. Michuki, EGH, MP - Minister of the Ministry of Environment and Mineral Resources, and the Permanent Secretary, Mr. Ali D. Mohamed, CBS, for providing the opportunity and resources to undertake this Vision 2030 flagship project on “mapping wildlife dispersal areas and migratory routes/corridors” with a view to addressing and securing lost or fragmented wildlife habitats and corridors for sustainable development.

We are highly grateful to all the stakeholders and especially to the Director of Resource Surveys and Remote Sensing (DRSRS) Mr. Jaspat L. Agatsiva for providing leadership, encouragement and facilities and data (wildlife and livestock database for the Kenya rangelands and land use data); the Director of Kenya Wildlife Service (KWS); Dr. Julius. Kipng'etich provided both the wildlife telemetry and total counts data for Tsavo, Amboseli and Mara ecosystems; the Director of Kenya Meteorological Department (KMD) Dr. Joseph.R. Mukhabana provided rainfall and temperature data that was very crucial for climate change analysis; the President of African Wildlife Foundation (AWF), Dr. Helen Gichohi provided wildlife telemetry and ground counts for Amboseli Ecosystem and the west Kilimanjaro area; the Director of African Conservation Centre (ACC), Ms.Betty Buyu provided wildlife telemetry data and counts for Amboseli Ecosystem, Magadi and Athi-Kaputei areas; and the Director General of the International Livestock Institute Research Institute (ILRI), Dr. Jimmy Smith provided ground counts and fencing data for the Kitengela area and the greater Serengeti-Mara ecosystem.

This report was compiled by many individuals from several government institutions and conservation stakeholders: DRSRS - Patrick W. Wargute, Gordon O. Ojwang', Charles Situma, Lucy W. Njino, Joseph Gathua, Wilfred Nyaga, James Matundura, Henry Roimen and Reuben Kibet; KWS - Erustus Kanga, Apollo Kariuki, Joseph Mukeka and Joycelyn Makena; ILRI - Mohammed Y. Said and Shem Kifugo; AWF - Philip Muruthi and Rose Mayienda; ACC - Jeffrey Worden and Lucy Waruingi; KMD - Barasa Shaban and Ezekiel Muigai; and MEMR - Charles Gachoki. Dr. David Western (Amboseli Conservation Programme) also pointed out the importance of using the landscape approach as the basis for understanding ecosystem processes and functions of conservation connectivity in East Africa. Christian Lambert (UNEP) provide invaluable information and in depth understanding of the conservation issues in the wider Eburu forest reserve and adjacent areas.

We wish to thank KWS and DRSRS for providing the latest aerial survey datasets (2010-12) on wildlife population and distribution in the study area, which was useful for understanding the current states. We are indebted to the pilots, front and rear seat observers, GIS and data analysis teams. Finally, we are gratified to the experts, local communities and many conservation stakeholders for providing invaluable site information and local knowledge.

TABLE OF CONTENTS

LIST OF MAPS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Kenya's development blueprint - Vision 2030, the Constitution (2010) and Millennium Development Goal (MDG) on ensuring environmental sustainability recognize the importance of sustainable natural resource use, reduction of biodiversity loss, and maintenance of ecosystems processes. Kenya's Vision 2030 under its economic and social pillars prompted the undertaking of this flagship project on "securing wildlife dispersal areas, migratory routes and corridors". The urgency of this assessment stems from the realization that over the last few decades massive and far reaching declines have occurred in wildlife populations and their habitats adversely impacted on by a combination of human and environmental factors. These includes but not limited to land use change, poaching and effect of climatic variability, especially the high frequency and severity of droughts. Across the country, the populations of most wildlife species have declined, their range has shrunk and migratory routes/corridors have been severely interfered with or blocked. The impacts of wildlife habitat loss and fragmentation include impaired ecological processes, increased human-wildlife conflicts, loss of species abundance and diversity, and increased livelihood vulnerability.

This study is based on recognition that majority of wildlife in Kenya exists outside protected areas and increasingly exposed to anthropogenic pressures, which have negatively impacted on their populations, dispersal areas and migratory routes/corridors. The specific objective of this Vision 2030 flagship project is to develop a conservation connectivity framework that will facilitate the formulation of inclusive and collaborative strategies for wildlife management, and to identify and map the critical wildlife areas in the country. The aim is to use this information as guide for securing wildlife dispersal areas and migratory routes/corridors, a key step towards achieving Kenya's goal of conserving biodiversity and ecosystems to enhance tourism, reduce human-wildlife conflicts, and ensure sustainable socio-economic development. The initial phase of this project focuses on assessing and mapping wildlife dispersal areas, migratory routes/corridors in southern Kenya rangeland ecosystems, which comprises six contiguous sub-ecosystems - Serengeti-Mara; Lakes Naivasha-Elementaita-Nakuru and Eburu forest conservation and ecological area, Nairobi NP-Athi Kaputei, South Rift, Amboseli-West Kilimanjaro and Tsavo-Mkomazi. Five keystone species - wildebeest, zebra, giraffe, buffalo and elephant were selected for this study on the basis of their body weights, migratory pattern, foraging habits (grazing, browsing and mixed feeding), and conservation and endangered status. The species' abundance and density distributions, movement patterns and expert knowledge was used to map their dispersal areas and migratory routes/corridors, while the trends in population, state of habitats, driving forces and pressures, impacts and responses were used to identify and prioritize the threats and opportunities, and action needs.

Wildlife dispersal areas and migratory routes/corridors are critical for species survival and long-term ecosystems viability. The animals disperse or migrate across landscapes in response to intrinsic factors e.g. breeding and external (environmental) factors including drought, floods, fires and resource competition (water and forage). They also move to access vital resources such as pasture, water, breeding grounds as well as to reduce risks of predation and enhancement of genetic health among others. Migrations are essential for sustaining the resilience of large herds in the face of variable rainfall, which is highly correlated to forage shortage or availability.

Biodiversity conservation through restoration of habitats and maintenance of ecological processes will help to improve ecosystems integrity. Connectivity conservation recognizes the importance of improving ecosystems integrity by securing physical connections and linkages between isolated habitats to increase wildlife space and enhance animal movements. This will increase the effective area available and reverse the effects of habitat loss or fragmentation by restoring ecological processes, which are critical for maintaining species abundance and diversity, and community composition. Connectivity conservation is an essential strategy for the restoration of landscape patterns that promote species survival in environments modified by anthropogenic activities and other elements of nature. Habitat connections and linkages (i.e. wildlife migratory routes and corridors) are key elements of the larger conservation connectivity framework proposed in this study.

In this assessment and mapping of wildlife dispersal areas and migratory routes/corridors, the conservation connectivity framework has employed a variety of data collection and analysis techniques in context of inclusiveness and collaborative stakeholder involvement. The varied data source and scales included space remote sensing, low-level aerial sample and total counts, and ground counts and wildlife telemetry. Auxiliary information included topographic basemaps, expert knowledge and interviews, and literature review. Geographic Information System (GIS) was used for geospatial information analysis and modeling to generate species richness, density distribution and movements, as well as land cover/use, and threats and opportunities maps. Wildlife dispersal areas and migratory routes/corridors were then identified and classified on threat levels based on the above maps and specific habitat characterization as defined by driving forces and pressures, impacts and responses to understand relationships between anthropogenic activities and state of environment as relates to natural resource planning and decision making. This study identified 49 migratory routes/corridors in the southern Kenya Rangeland ecosystems: - Serengeti-Mara (8); Lakes Naivasha-Elementaita-Nakuru and Eburu forest conservation and ecological area (8), Nairobi NP-Athi Kaputei (7), South Rift (8), Amboseli-West Kilimanjaro (8), and Tsavo-Mkomazi (10).

The study has shown that most of the wildlife dispersal areas, migratory routes/corridors in southern Kenya rangelands have been interfered with by human activities to the extent that some are highly threatened or completely blocked, curtailing animal movements. The main threats to habitat connections and linkages are expansion of incompatible land uses and activities to wildlife dispersal areas i.e. agriculture, high density settlements, fences, mining and quarrying, woodland clearing, wetland drainage, high livestock densities, poaching, as well as the impacts of climate variability, especially drought. These have been caused by increasing human population and high levels of rural poverty, which is associated with the rapid changes in land use, sedentarization, subdivisions, habitat degradations and land use conflicts. To address the foregoing adverse impacts on wildlife populations and habitats, the following broad recommendations are provided for conserving connectivity in the Southern Kenya- rangelands:

- *Develop, expand and implement the conservation connectivity framework.* - establish an inclusive and consultative process that will develop and implement the proposed conservation connectivity framework to ensure the protection of biodiversity and maintenance of ecological processes and ecosystems integrity.

- *Identify, prioritize and secure wildlife dispersal areas, migratory routes/corridors* - wildlife dispersal areas and corridors identified in this study should be immediately secured through a prioritized scheme (short-, mid- and long-term action plans) using various legal and economic instruments already in place. An all inclusive consultation with local communities and landowners in areas perceived as migratory routes/corridors is prerequisite to the negotiation of wildlife space outside protected areas.

- *Promote integrated land use planning* - biodiversity conservation planning has to take a holistic approach encompassing a multi-facet landscape dimension that not only considers ecological processes and ecosystem functions, but takes into account the matrix (human, landscapes, natural resources and environment). Biodiversity and other natural resource management plans should be integrated in the master land use plan.

- *Policies and legislation* – the land and biodiversity policies and legislation, wildlife policy and Act, forest policy and Act and other related economic instruments that ensure payment for ecosystem services should be rationalized and implemented.

- *Community participation in biodiversity conservation* - programmes and initiatives involving local communities in the conservation and management of wildlife resources outside protected areas are essential for sustainable resource development. Community conservancies, wildlife scout associations and eco-tourism ventures will guarantee wildlife protection while providing direct benefits to local communities. The planning and implementation of conservation agenda outside parks should involve communities in decision-making.

- *Management of conservation connectivity* - effective management of dispersal areas and migratory routes/corridors require research and monitoring systems, with broader stakeholder collaboration in the forefront at various levels. Habitat connections and linkages are species specific and the most effective management strategy will ensure that connectivity promote ecological processes, enhance species diversity and resilience, reduce human-wildlife conflicts and benefit the local rural communities.

- *Resources for conservation connectivity management* - sufficient resources (funds and highly skilled human resources) should be allocated for the management of dispersal areas and migratory routes/corridors to ensure their viability and sustainability as wildlife habitats.

- *Monitoring and evaluation* – the conservation connectivity framework recognizes importance of regular monitoring and evaluation for effective wildlife dispersal areas and migratory routes/corridors.

FOREWORD

The environment and its biophysical components contributes immensely to human life support systems by providing essential ecosystems goods and services, which include provisioning (food, water and medicines), regulating (climate, diseases, pests and soil quality), cultural (tourism and ethical values) and supporting (nutrient and water cycles, and primary production). Yet, over the years, human beings have unsustainably exploited natural resources and degraded the environment to the extent that ecosystem process have been adversely affected the and led to massive loss of biodiversity. Consequently, this has resulted to the erosion of the nation's natural resource base and increased vulnerability of communities to sustain their livelihoods.

Kenya's development blueprint - Vision 2030 and the constitution (2010) recognizes the importance of sustainable natural resource use, reduction of biodiversity loss and maintenance of ecosystems processes. Under the economic and social pillars of Vision 2030, the flagship project on "securing wildlife dispersal areas and migratory routes/corridors" was identified to promote sustainable tourism and improve the livelihoods of rural communities. Wildlife dispersal areas and migratory routes/corridors are important habitat connections than links wildlife to their resources i.e. food and water, breeding to enhance genetic diversity and predation avoidance among others. The restoration of habitats outside protected areas that are already interfered with or lost to human activities will increase the wildlife space and provide adequate protection to species, thereby reducing human-wildlife conflicts, enhancing conservation and sustainable development.

Biodiversity and especially the faunal component contributes immensely to Kenya's national economy through the tourism industry, which earned the country Ksh 97.9 billion in 2010 and sustains the livelihood of the majority of rural communities among other values. However, over the last few decades, the populations of most wildlife species have declined and their distribution range shrunk in many parts of the country. This has been attributed to a combination of human-induced and environmental factors that include land use change, poaching, diseases and effects of climatic variability - especially the recent frequent and severe droughts.

Most of the country's wildlife populations are found outside protected areas almost all the year round. They exist in the dispersal areas within the pastoral communal lands and private properties, where they are faced with intense pressures from expanding human activities. The increasing human population with proportionate demand for land resources is responsible for the massive conversion of wildlife habitats to agricultural use and high density settlement associated with fences, woodland clearing and draining of wetlands among others. The continued isolation of species and subsequent loss of biodiversity and rampant human-wildlife conflicts in areas adjoining parks and reserves can be blamed on the loss or fragmentation of wildlife habitats.

This report provides a comprehensive synthesis of wildlife dispersal areas and migratory routes/corridors in the southern Kenya rangelands. It has explicitly identified the spatial extents of migratory routes/corridors that has been interfered with or lost to human activities and the conservation connectivity issues and concerns. Furthermore, the report has provided recommendations on action needs, guideline and strategies for securing these migratory routes/corridors. The implementation and actualization of the conservation connectivity framework fast tracking and implementation of existing land use and biodiversity policies and pieces of legislation will pave way while legal and other economic instruments will play a critical role in systematic negotiations with communities and private landowners whose lands are perceived as wildlife areas. Several options of acquiring wildlife space outside protected areas have been proposed in this report including public-private partnerships, payment for ecosystem services and outright purchases. In either way, we must secure wildlife space outside the protected areas to conserve habitat connectivity, which will help in reducing loss of biodiversity and human-wildlife conflicts, and enhancing sustainable development.

Ali. D. Mohammed, CBS,

Permanent Secretary,

Ministry of Environment and Mineral Resources

ACRONYM AND BBREVIATIONS

ACC	African Conservation Centre
ASAL	Arid and Semi-Arid Lands
AWF	African Wildlife Foundation
CBS	Commander of the Burning Spear
CBS	Central Bureau of Statistics
CBD	Convention on Biological Diversity
CCF	Conservation Connectivity Framework
CDM	Clean Development Mechanism
DRSRS	Department of Resource Surveys and Remote Sensing
DPSIR	Drivers, Pressures, State, Impacts and Responses
FAO	Food and Agriculture Organisation
FEWSNET	Famine Early Warning Systems Network
FoNAP	Friends of Nairobi Park
EPZ	Export Processing Zone
GCA	Game Controlled Area
GDP	Gross Domestic Product
GIS	Geographic Information System
GR	Game Reserve
ILRI	International Livestock Research Institute
IUCN	International Union for Conservation of Nature
KARI	Kenya Agricultural Research Institute
KFS	Kenya Forest Service
KMD	Kenya Department of Meteorology
KWS	Kenya Wildlife Service
NEMA	National Environment Management Authority
NMK	National Museum of Kenya
NR	National Reserve
NP	National Park
MDG	Millennium Development Goals
MEMR	Ministry of Environment and Mineral resources
MME	Maasai Mara Ecosystem
MMNR	Maasai Mara National Reserve
PES	Payments for Ecosystem Services
REDD	Reducing Emissions from Deforestation and forest Degradation
ROK	Republic of Kenya
RRI	Rapid Results Initiative
SME	Serengeti-Mara Ecosystem
SOLARO	South Rift Landowners Association
TENP	Tsavo East National Park
TWNP	Tsavo West National Park
UNEP	United Nations Environment Programme
WMA	Wildlife Management Area
WRI	World Resource Institute
WRUA	Water Resource Users Association

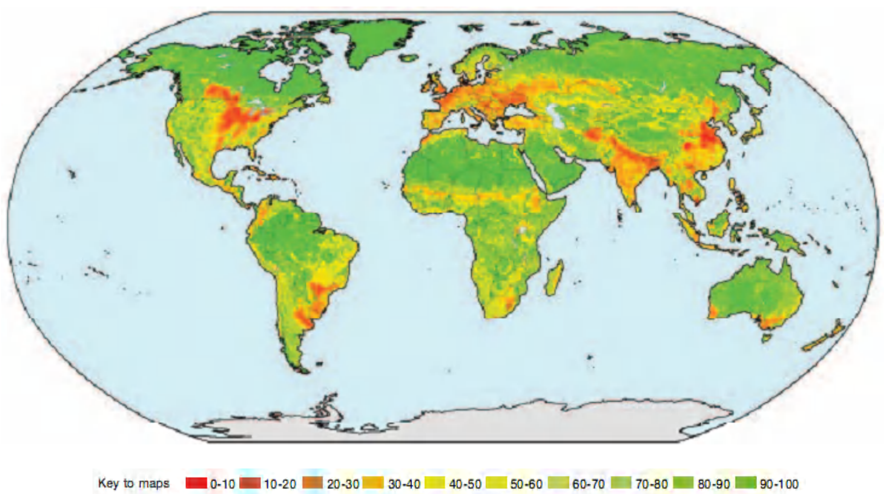
CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1. Global and Continental Biodiversity

Biodiversity is neither uniform nor equally distributed on Earth, however, it is often used as a measure of the health of ecosystems. It is richer in the tropical countries such as East and Central Africa (Map 1.1.2), as conditions are conducive for more species to flourish and to form meaningful ecological relationships. It is lower in polar, extremely cold, dry and hot regions (such as Sahara desert) where conditions support less biomass and fewer life forms. Globally, biodiversity is declining with abundance of vertebrates falling by 31% between 1970 and 2006 especially in the tropics by 59% (CBD 2010) and 23% of world's mammal species are threatened, including terrestrial species and those in Africa that have declined in range and numbers, where 60% of over 100 large mammal species are decreasing (WRI 2005a).

Humans have been causing biodiversity loss and by the year 2000, only about 73% of the original global natural biodiversity was left (TEEB, 2008). The strongest declines have occurred in the temperate and tropical grasslands and forests, where the first human civilizations developed (McNeill and McNeill, 2003). A further 11% (an average including desert, tundra and polar regions) of land biodiversity is expected to be lost by 2050 (Map 1.1.1).



Map 1.1.1: World's mean species abundance 2000. Biodiversity loss in the Cost of Policy Inaction (COPI) study is measured by the mean species abundance indicator recognized by Convention on Biological Diversity.

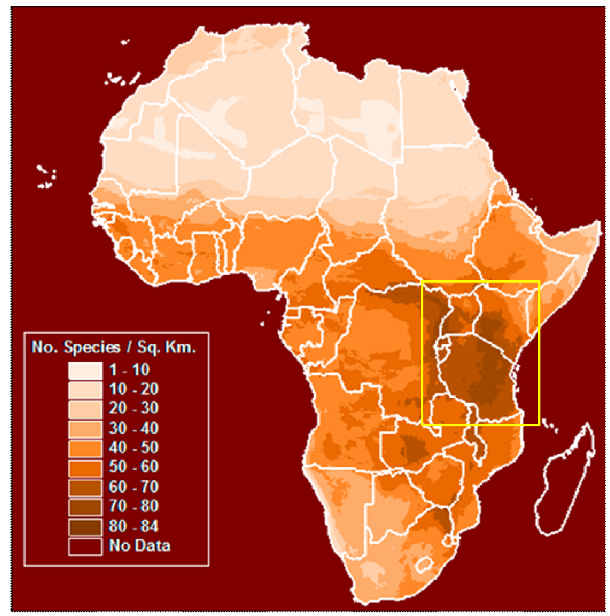
Table 1.1.1: Numbers and proportion of species by major taxonomic group assessed as threatened

Taxonomic Group	Species described (Est. No.)	Evaluated (No.)	Threatened (No.)	Threatened as % of described	Threatened as % of evaluated
Mammals	5488	5488	1141	21%	21%
Birds	9990	9990	1222	12%	12%
Reptiles	8734	1385	423	5%	31%

Source: IUCN 2008 Red List.

Natural areas will continue to be converted to agricultural land, with the on going expansion of infrastructure and increasing effects of climate change being additional major contributors to biodiversity loss. For the world as a whole, the loss of natural areas over the period 2000 to 2050 is projected to 7.5 million km^2 (750 million hectares) (TEEB, 2008). These natural ecosystems are expected to under go human-dominated land-use change in the next few decades and subsequent decline of biodiversity around the globe (Table 1.1.1).

Anthropogenic activities from increasing human population and the corresponding demand on resource base has led to over-exploitation of natural resources (WRI 2005b), which is responsible for the rapid land use changes, climate change, and loss of genetic diversity within and among species. Consequently, the extent of species habitats and ecosystems, and trends in abundance is on the decline (WRI 2005a; CBD 2010), which has been attributed to several factors including habitat degradation (loss or fragmentation), extreme weather conditions (drought and floods) and illegal harvesting among others, which may result in species extinctions.



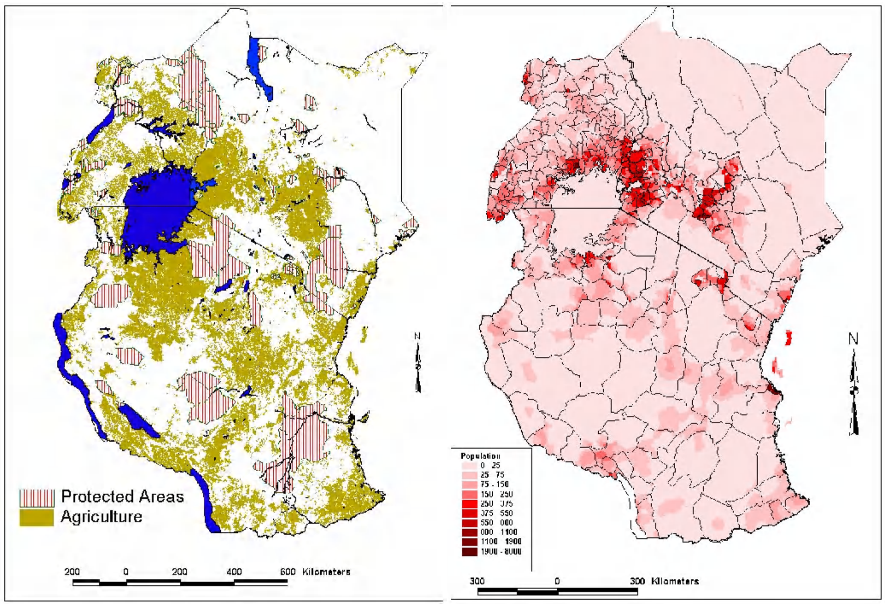
Map 1.1.2: Large mammal density distribution in Africa showing high diversity in East and Central Africa and lower in extremely cold and dry regions.

1.2. Kenya's Biodiversity

Kenya is a mega bio-diverse country with over 35,000 species of flora and fauna (Thaxton 2007). The species diversity is mainly dominated by insects and served by a variety of ecosystems ranging from marine, mountains, forests and savannahs. Kenya's total land area is about 582,646 km^2 (UNEP 2009, NEMA 2011), of which, about 10-12% is designated as biodiversity areas, where Kenya Wildlife Services (KWS) manages about 8% constituting 29 parks, 36 reserves and 7 local sanctuaries (Yeager & Miller 1986; Olindo 1991; ROK 2002; NEMA 2004, 2011; ROK 2008; KWS 2011) and the remaining area composed of forests, water catchments and private sanctuaries are managed by government agencies including Kenya Forest Service (KFS) and National Museums of Kenya (NMK) and other NGO conservation stakeholders (Map 1.1.4). The forests cover is less than 3% (NEMA 2011).

About 34,000 species were recorded in the country by 1992, out of which about 24,000 are animals, 7,000 are plants and 3,000 are microorganisms (NEMA 2011). Hundreds of species have been lost annually through local extinctions, natural attrition, climate change, bio-piracy, over exploitation, and expansion of agriculture and human settlements (IEA Kenya, 2009). The country's forests and savannah are endowed with a rich array of plant and animal life. Some of the species endemic and found nowhere else in the world.

Kenya's rich biodiversity is mainly in the protected areas. These are elaborate systems of national parks, reserves and sanctuaries established to protect and conserve wildlife resources due to their critical ecological functions, scientific, aesthetic and economic values. The majority of country's protected areas are situated in the rangelands, which are composed of natural or semi-natural vegetation and provide habitats that are suitable for wildlife use and livestock production (Pratt *et al.* 1966; Pratt and Gwynne 1977). The Kenya rangeland covers about 80% of the country's land surface and harbors almost 20-25% of human population (ROK 1986, 2002). The rangelands are homes mainly to the pastoral communities, their livestock (over 50% of the nation's livestock production) and almost 90% of large wild herbivores, which resides both inside and outside the protected areas (ROK 1986, 1994, 2002) (Map 1.1.4).

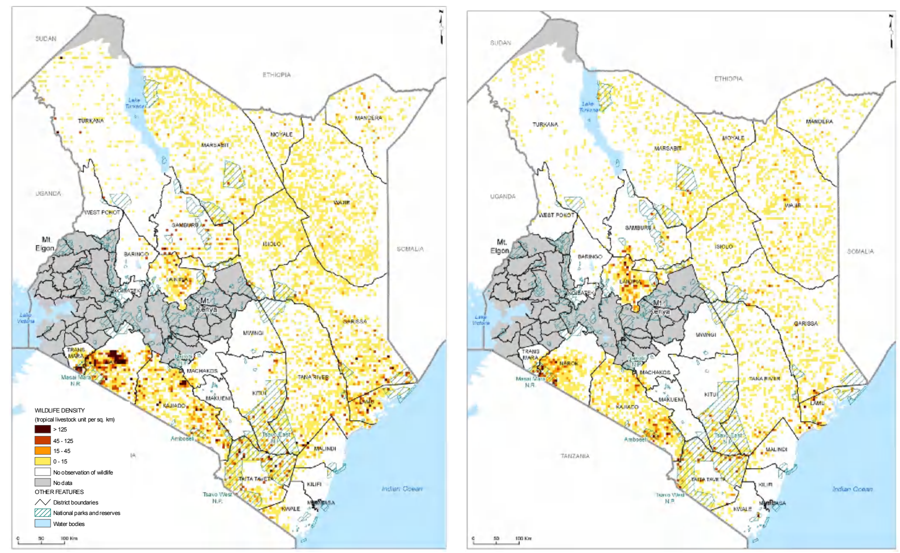


Map 1.2..1: Most of the protected areas in East Africa are surrounded by high human population densities and intensive agricultural activities. *Source: Africover, National Bureau of Statistics.*

The protected areas are increasingly becoming isolated and surrounded by high density settlements, agriculture and high livestock as human population continues to rise and the demand for agricultural land shifts and expands along rainfall gradients into the drylands or rangelands (Map 1.1.3). Furthermore, sedentarization have caught up with the pastoral communities, having been forced to change their lifestyle from nomadism to permanent settlements, which is associated with change in grazing patterns and shift to crop cultivation. The rapid decline of wildlife populations and increase in human-wildlife conflicts over the last few decades is attributed to loss or fragmentation of habitats, and driven by population pressure with subsequent anthropogenic activities (ROK 1989; 1996, 2002, 2010).

Majority (over 70%) of Kenya's large wild herbivores reside outside the protected areas in all year round (Sindiga, 1995; ROK 2002; Wargute 2005; Western, *et al.* 2009). This is due to the fact that in most cases, the delineation of parks and reserve boundaries did not take into account the total wildlife habitats or species ecological needs, which include the wet and dry season dispersal areas outside protected areas (Lusigi 1981). Inspite of traditional land uses outside protected areas, there is increasing realization that wildlife may even thrive better outside the protected areas with proper conservation and management strategies in place.

In East Africa, wildlife has lived side by side with people for centuries, especially in the pastoral communal lands where high concentrations of large wild herbivores occur (Lusigi 1981; Peden 1987; Homewood and Rodgers 1991; Homewood and Brockington 1999; Homewood, *et al.* 2001). Over the years, humans have lived 'harmoniously' with wildlife as resources were abundant and human population was manageable. However, in the recent times, the population explosion has led to overexploitation and the destruction of wildlife habitats. The conservation of biodiversity has therefore to evolve from narrow focus on species and habitat preservation to landscape approach, which takes a holistic view encompassing a multi-facet dimension that not only considers ecological processes and ecosystem functions, but takes into account the matrix (human, ecosystems, natural resources and environment). Ecosystems have to be better understood as providers of critical goods and services necessary for sustainable development and all the management actions including the decision not to take any can affect biodiversity at various scales. The management objective of biodiversity conservation areas should aim to maintain ecological processes and ecosystem functions rather than total numbers as biodiversity has greater scope.



Map 1.2.2 (a, b): A comparison of wildlife densities in the 1970s (a) and 1990s (b) showing widespread distribution in the Kenya rangelands. Wildlife densities have declined in certain areas such as Narok and Kajiado counties, while increased in Laikipia over the same period. High potential area (grey shade) was not surveyed. *Source: DRSRS.*

1.3. Relevance and Importance of Biodiversity

Biodiversity affects development directly even though it is rarely linked to human population indices. According to some reports, about 40% of the global market of goods and services are sustained by biodiversity. The World Commission on Forests and Sustainable Development (WCFSD) views biodiversity as the foundation of human development and continues to focus on long-term sustainability rather than the short term economic growth. Its impacts on natural processes and human life are massive and varied including source of food, shelter, medicines, industrial raw materials, source of genetic resources supporting the biotechnology sector and intangible benefits such as spiritual and aesthetic values, knowledge systems and innovations. Scientists and environmentalists agree to the fact that biodiversity conservation, particularly in primary forests is necessary to stem further loss of species and avert economic downturn in the tropical countries. The green revolution that continues to support agriculture through biotechnology and improvements in crop cultivars or development of new varieties are made possible by harnessing the genes from wild species. Indeed, the interbreeding crop strains with different beneficial traits have doubled the crop production around the world in the last 50 years. It is important to maintain some level of crop diversity to wade off emerging diseases and crop pests, which is critical in adapting to climate change.

Kenya mainly exploits her biodiversity through the primary industry including food processing, tourism, and ecosystem goods and services. The country has a wide latitude to exploit local biodiversity profitably and great potential for its application led by research in bio-prospecting and responsiveness in conservation. Biodiversity forms the main basis for the country's national and regional tourism, and national revenue earning. The faunal component contributes substantially with wildlife being the single most important attraction for tourists. For example, wildlife based attractions contributed 75% of the gross tourism earnings, 5% of the total GDP and 10% of total formal sector employment (ROK 2002; 2007, 2011; Norton-Griffiths 1998). In the recent times, income generated from tourism activities has continued to be reliable source of national revenue with safaris (wildlife-based) generating KSh 97.9 billion in 2011 (ROK 2012).

1.4. The VISION 2030 - "Securing Wildlife Migratory Routes and Corridors"

Kenya's development blueprint-Vision 2030 recognizes the importance of sustainable natural resource use, particularly of land, biodiversity and ecosystems. The Vision accords prominence to a clean, secure and sustainable environment under the economic and social pillars inspired by the principles of ecosystems integrity and sustainable development, and equitable access to benefits. To deliver on the Vision 2030, four main strategic thrusts were identified for the environment sector based on their relationships to economic and social pillars and the identified concrete goals (Fig. 1.1.1).

- *Conservation* - increase current forest cover by 50 per cent; fully protect all wildlife ecosystems to sustain the anticipated growth of the tourism sector; and develop environmentally-friendly mining policy.
- *Pollution and waste management* - reduce hazards related to unhealthy environment to ensure a clean, healthy and secure environment.
- *ASALs and high-risk disaster zone* - reduce the effects of desertification and disasters - substantially reduce losses due to floods and droughts; establish national trends and impacts of climate change on sensitive sectors; and pilot adaptation programmes on climate change and desertification.
- *Environmental planning and governance* - integrate planning approaches and improve overall governance of the environment by increasing spatial data coverage from the current 30 per cent to 50 per cent for land use and 30 per cent to 70 per cent for land cover; enforce all environmental regulations and standards; attract Clean Development Mechanisms (CDM) projects.

The flagship projects envisaged for realization of the Vision under conservation are:

1. *Water catchment management* - full rehabilitation of the five water towers (Mau Escarpment, Mt. Kenya, Aberdare ranges, Cherangany Hills and Mt. Elgon.

2. ***Secure wildlife corridors and migratory routes*** - most wildlife corridors and migratory routes have been interfered with by human activities. It will be necessary to reclaim them if wildlife is to continue providing the basis for revenue from the tourism sector.

3. *Develop a national waste management system* - Include relocation of the Dandora dump site in Nairobi and the establishment of a solid waste management system for Nairobi City on a public-private partnership basis.

4. *Land cover and land use mapping* - calls for accurate and continuously updated mapping of land use patterns in Kenya for tracking developments, and also entail undertaking both livestock and wildlife censuses.

The Ministry of Environment and Mineral Resources (MEMR) has spearheaded the initiative to map wildlife dispersal areas, migratory routes/corridors due to its mandate and institutional linkage with other government agencies, non-government organizations (NGOs), private sector and communities. The ministry constituted a taskforce to develop a conservation connectivity framework, and identify and map wildlife migratory routes/corridors outside protected areas that are already interfered with or blocked by human activities throughout the country. The taskforce comprising of professionals with diverse backgrounds from DRSRS, KWS, KMD, AWF, ILRI and ACC developed a work plan that started by tackling the southern Kenya rangeland ecosystems.

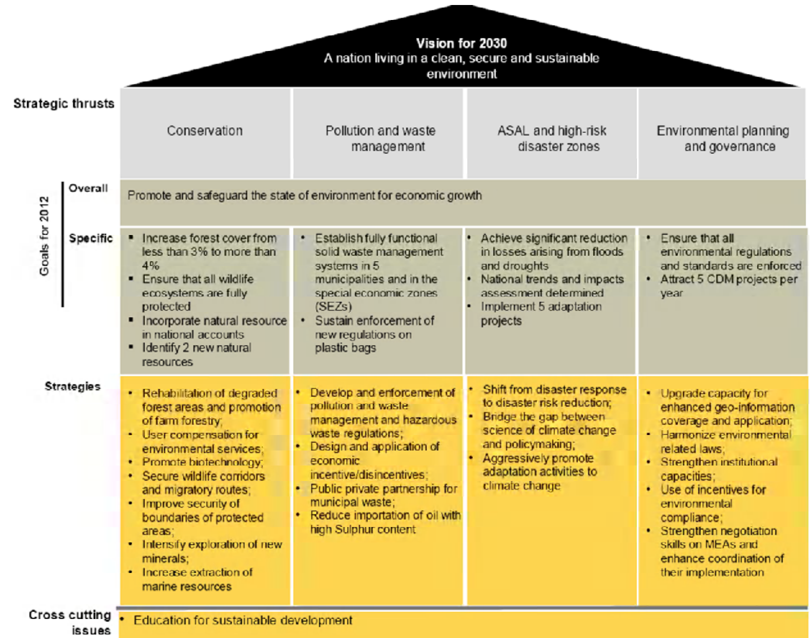


Figure 1.4.1: The overall goals and strategies for MTP 2012 of the environmental goals in Vision 2030.

1.5. Study Approach and Report Organization

A methodological approach to conservation connectivity was developed. The DPSIR system analysis tool for decision-making was adopted to identify and prioritize migratory routes/corridors and threat levels. The report comprises of six chapters i.e. introduction and background, objectives and study area, understanding movements and connectivity, methodological approach for conserving connectivity, migratory routes and corridors for conservation, and concludes by giving the recommendations for each ecosystems studied and the roadmap.

CHAPTER 2

OBJECTIVES AND STUDY AREA

2.1. Objectives

Over the last few decades, the escalation of human population and associated activities has led to rapid land use changes. This has subsequently resulted to the loss or fragmentation of wildlife habitats, especially outside protected areas, increase in human-wildlife conflicts and declines in species populations. The impacts of climatic variability especially the frequent and severe droughts, diseases and poaching have aggravated the situation in many areas. This study is based on the recognition that majority of Kenya's wildlife population is found outside protected areas in most of the year and exposed to anthropogenic pressures that negatively impacts on their populations. Kenya's Vision 2030 flagship project on "securing wildlife dispersal areas and migratory routes/corridors" aims to formulate strategies and reclaim wildlife areas and connections that have been interfered with by human activities. The Medium Term Plan (MTP) - 2008-2012, the initial phase of the Vision is to secure these areas to enhance tourism and reduce human-wildlife conflicts.

This process of identifying and mapping wildlife dispersal areas and migratory routes/corridors aims at providing spatially explicit information on the species habitats, their range and movements, in addition to characterizing the states of habitats, status of populations and identifying the driving forces, pressures, impacts and responses. This study focuses on the southern Kenya rangeland ecosystems comprising of six contiguous sub-ecosystems (Fig. 2.2.1). Five (5) keystone species i.e. elephant, wildebeest, zebra, giraffe and buffalo (Box 1) selected on the basis of body weights, wide ranging and migratory nature, feeding habits (grazer, browser and mixed feeder) and conservation or endangered status were examined. The collaborative effort of various government institutions, non-governmental organizations and conservation stakeholders highly contributed to the mapping process (data and information collation, analysis and geospatial mapping) in the context of ongoing projects in Kenya's biodiversity programme.

2.2. Study Area

The greater southern Kenya rangeland ecosystem consists of six sub-system blocks, namely; Serengeti-Mara Ecosystem, Greater Lake Naivasha-Elementaita-Nakuru-Eburu Forest Ecosystem, Nairobi National Park-Athi Kaputei Ecosystem, South Rift (Lake Natron-Magadi area), Amboseli-West Kilimanjaro Ecosystem and Tsavo-Mkomazi Ecosystem. It lies between latitudes 33˚55′59″E and 0˚14′29″S, longitudes 40˚08′02″E and 4˚43′28″S and covers approximately 98,011 Km^2 in Kenya (Map 2.2.1). The area extends across the entire Narok and Kajiado counties, and parts of Nakuru, Machakos, Kitui, Taita Taveta, Kwale, Kilifi, and Tana-River counties. It stretches widely to the northwest and descends toward the Kenyan Rift Valley to the northwest with a spectacular complex of fault-line volcanic ridges and escarpments, westwards to southern Mau highlands, and south-east to Taita Hills and the coastal lowlands.

2.2.1. Nairobi National Park - Kitengela Area

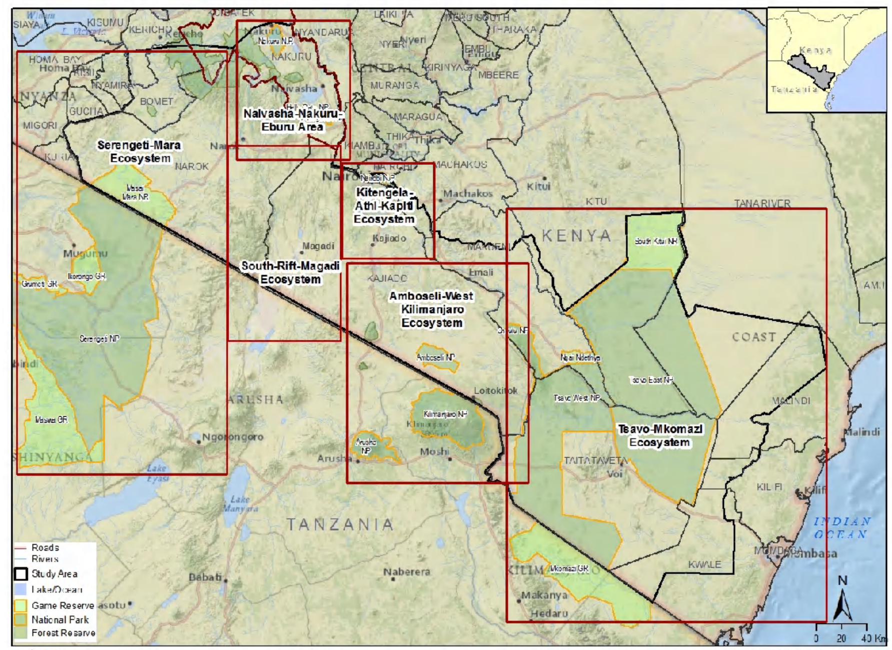
Nairobi National Park is a unique ecosystem, being the only protected area in the world close to a capital city. It is a savannah ecosystem comprising of different vegetation types located only 7 km from Nairobi city centre. The open grass plains with scattered acacia bush are predominant and the western side has a highland dry forest and a permanent river with riverine forest. To the south are the Athi-Kapiti plains and Kitengela migration corridors which are important wildlife dispersal areas during the dry and wet seasons. Man-made dams within the park have added a further habitat, which is favourable to certain species of birds and other aquatic biome.

The Athi-Kaputei plains located to the south of Nairobi city and Nairobi NP is the traditional home to the Kaputei Maasai who depends principally on pastoral livestock production for livelihoods. The plains host sizeable livestock and wildlife populations and critical wet season dispersal range for the wildlife in Nairobi NP. The plains extend to the large commercial ranches in the vast Machakos County to the east and linked to Amboseli National Park to the south by the gently descending Emarti valley. A wide area in the vast plains have recently been subdivided and large number of urban residents have purchased land and converted certain areas to high density settlements, along with the emergent of industries (cement, horticulture, steelworks, export processing zone), which have led to the rapid growth of subsidiary towns near Nairobi such as Athi-River and Kitengela.

2.2.2. Serengeti-Mara Ecosystem

The Masai Mara Ecosystem (MME) in Kenya is renowned for its abundant and diverse assemblage of wild ungulates, and comprised of Masai Mara National Reserve (MMNR) and adjacent group ranches. It is connected to the south by the Serengeti National Park in Tanzania to form the Serengeti Mara Ecosystem (SME), which is defined by the movements of migratory wildebeest (Sinclair 1995). The SME is worldwide known for its migration of 1.3 million wildebeests and 0.6 million zebras and gazelles. The vegetation of Masai Mara National Reserve (MMNR) comprises of mainly grasslands with patches of bushes and trees. Many of the group ranches outside MMNR have been privatized.

The SME faces various threats despite the size of protected area. Wildlife populations have declined in the ecosystem, which has been attributed to, among other factors, increasing loss of wildlife grazing or dispersal areas to crop cultivation, and human settlement. Rampant poaching has also been reported in some areas.



Map 2.2.1: The Greater Southern Kenya Rangelands Ecosystem showing six contiguous sub-ecosystems (red box) defined in the study and extending into the northern part of the Republic of Tanzania.

2.2.3. Tsavo-Mkomazi Ecosystem

The Tsavo-Mkomazi ecosystem covers an area of 44,000 km^2 and occupies the lowland savannah (Cobb 1976). Tsavo is renowned for supporting the largest elephant population in the country. The protected area (Tsavo East and West, and Chyulu National Parks in Kenya, and Mkomazi Game Reserve in Tanzania covers 42 percent of the ecosystem while the rest consists of private ranches. In the heart of the ecosystem lies the Taita Hills - a densely populated and intensive agricultural area.

The rainfall of the ecosystem is bimodal, highly irregular in spatial and temporal distribution with a mean annual varying locally between 250 mm and 500 mm, mostly falling in March-May (highest received between Taita Hills and Kilimanjaro area) and November-December (highest to the north and eastern parts and extends beyond the national parks). June through October is relatively cool and dry season, and exacerbated by desiccating winds. This is the main nutritional stress period for most herbivores (Tyrrell & Coe, 1974, Leuthold, 1978).

The vegetation consists of remnants of formerly extensive *Commiphora-Acacia* woodlands that have been destroyed or thinned out by elephants. Elephants prefer habitats at forest edges, woodlands, bushlands and wooded or bushed grasslands. The tree and shrub densities are generally lowest near rivers, except for local patches of riverine forest or fringe trees along water courses. A detailed description of the vegetation of Tsavo-Mkomazi ecosystem has been provided by Napier Bax & Sheldrick (1963); Laws (1969, 1970); Cobb (1976) and Belsky, *et al*. (1987).

2.2.4. Amboseli -West Kilimanjaro Ecosystem

The Amboseli-West Kilimanjaro landscape comprises the Amboseli Ecosystem in Kenya and west Kilimanjaro region of northern Tanzania. It covers approximately 24,788 Km^2 and extends from the foot of Chyulu hills to Lake Magadi, Arusha National Park, Lake Natron and touches the foot of Mt. Kilimanjaro. The Amboseli Ecosystem covers 8,797 Km^2 and comprises the Amboseli National Park (390 Km^2) and adjacent group ranches namely Kimana/Tikondo, Olgulului/ Olararashi, Selengei/lengisim, Mbirikani, Kuku, Kaputei, Osilalei and Mailua. The dominant vegetation in Amboseli is open grassland with widespread *Acacia* woodland and patches of swamp-edge grasslands and the forest belt of Mt. Kilimanjaro. The spatial and temporal variation in hydrology characterizes the area with surface water found only in few permanent streams, predominantly as a result of the influence of Mt. Kilimanjaro water flowing under gravity and emerging from underground in form of springs to feed the rivers and swamps, and the surface flow from rainfall.

The west Kilimanjaro area (3014 km^2) lies within Longido District of Arusha in Tanzania. The Kenya-Tanzania border from Namanga southeastward to Irkaswa forms the northern extent while the eastern border is defined by the boundary of Kilimanjaro National Park and extends southward to Sanya Juu community. The southern part extends to the west from Sanya Juu to northeast of Arusha National Park and Arusha-Nairobi Road.

Plate 2.2.1: A view of West Kilimanjaro area showing an eroded waterway and grazing land in background.

The area is a complex mosaic of diverse natural communities and extensive grazing lands (Plate 2.2.1), and large agricultural fields at the lower elevation of Mt. Kilimanjaro where the traditional agro-pastoral Maasai communities graze livestock and raise subsistence crops. Several protected areas exist in the neighborhood including Kilimanjaro NP (755 Km^2) and Arusha NP (137 Km^2), and wildlife areas such as Longido Game Control Area (1,700 Km^2) and Ngasurai Open Area (544 Km^2). In addition, two private conservation areas also exist - west Kilimanjaro (303 Km^2) and Endarakwai (44 Km^2) ranches.

2.2.5. South Rift Ecosystem

The South Rift Ecosystem extends from Lake Magadi and surrounding landscapes to Lake Natron in Tanzania. The Lakes Natron-Magadi range is flanked by Lake Magadi to the east, Ngong hills to the north and Ngurumani range in the west and extends southwards to Lake Natron in Tanzania. The Namanga-Magadi area (5,513 Km^2) is comprised of Meto, Torosei, Mbuko, Elangata Wuas, Olkiramatian, Lorngosua and Shompole ranches. The area is gently undulating plains consisting of outstanding hilly landscape and the Rift valley. The soil is "black clay" (grumosolic soils) consisting of a range of "black cotton" soils with calcareous and non calcareous variants. The rainfall is low, bimodal and highly variable, ranging between 400 - 600 mm. The land use is mainly pastoralism by the Maasai and wildlife conservation (Kioko, 2008). The Uwaso Ngiro River is the only permanent water source but there are also several seasonal rivers including Namanga and Esokota Rivers that originates from the Namanga and Meto Hills respectively, and Ol Kejuado River that originates from Ilemelepo Hills and drains into Kiboko River.

Lake Natron area (7,047 Km^2) lies to the west of West Kilimanjaro area. The northern extent is defined by the Kenya-Tanzania border, the western extent is along the east side of Lake Natron to Ngorongoro Conservation Area (NCA) and the southern boundary extends from southeast of NCA to northwest of Arusha National Park. The area also encompasses the hunting blocks of Lake Natron Game Control Area and northern portion of Monduli Game Control Area. It consists of a mosaic of diverse natural communities, extensive grazing lands and predominantly semi-arid savannah interspersed with open acacia-woodlands (*Acacia* and *Commiphora sp*). A unique grazing land characterized by well-drained savannah grasslands and woodlands extends westward from Kiserian-Mriata Ridge and encompasses the grasslands adjacent to Gelai (2,942 m) and Ketumbeine (2,858 m) mountains. Like in West Kilimanjaro, the rainfall is unpredictable and highly variable (less than 350 mm).

2.2.6. Lakes Naivasha-Elementaita-Nakuru-Eburu Forest Ecosystem

The Greater Conservation Area (GCA) refers to the land occupied by the shallow fresh water lake Naivasha and alkaline lakes Elementaita and Nakuru, and immediate riparian and adjacent areas between the Rift Valley lake systems. It extends upward along the lake systems and ascends the landscape at Mt. Suswa, Mt. Longonot, and Eburu forest and the adjoining larger Mau complex. These forests have immense conservation value being a vital water tower and the primary area of protection under Kenya's Vision 2030. The greater conservation area has several protected areas, a number of public lands, private sanctuaries and ranches with substantial wildlife presence. These include Lake Nakuru NP, Mt. Longonot NP, Hell's Gate NP, Lakes Naivasha and Elementaita (Ramsar listed), Eburu forest, Soysambu sanctuary, Kedong ranch, Oserian ranch, Kekopey ranch, Ututu ranch, Crater Lake sanctuary, Hippo Point, Mundui, Marula, KARI and Loldia. The rest of the area has mixture community small-scale holdings and private land under varying uses. Historically, the land use was livestock ranching but this has recently been converted to mix-ranching (livestock and wildlife) and/or agriculture.

The area is a prime tourist destination, although much of the tourism enterprise is uncontrolled and uncoordinated. A real concern of key conservation stakeholders in the region is increasing human population, which is having a visible impact on wildlife populations and their habitats, forests and the lake system. The lake system is a major source of water, however the increasing anthropogenic activities including the expansion of agriculture, mushrooming horticulture farms and industries threatens the biodiversity in the lakes. Agricultural pesticides and industrial effluents have been blamed for the loss of biodiversity. In addition, rampant land subdivisions due to insure tenure and speculations, and fences have continued to fragment wildlife habitats and block movement corridors. Only about 10% of wildlife in the area is found inside the protected areas, and the rest outside require community protection to sustain their population. Rampant poaching (bush meat) has been reported in many areas.

CHAPTER 3

UNDERSTANDING MOVEMENTS AND CONNECTIVITY

3.1. Animal Movements - Dispersal and Migrations

The migration of wildlife population is essential for sustaining large herds and their resilience in the face of rainfall patchiness, disease and predation. Animals migrate or disperse in response to intrinsic factors (breeding and avoidance of inbreeding) and external or environmental factors including droughts, floods, fires, erosion, resource limitation (food and water), competition (food, water, mating), predation, disease (parasitism), (Stenseth & Lidicker 1992; McEuen; 1993). The ultimate function of dispersal is enhancement of survival success (Sinclair 1992).

Migration is defined as a periodic movement of animals from one spatial unit to another with a return trip (Sinclair 1992; Stenseth & Lidicker 1992; Bolen & Robinson 1995). These are regular movements to breeding areas and mostly in search of food and water because of the spatial and temporal variability of rainfall and response of vegetation in terms of quality and quantity (Bolen & Robinson 1995). Fryxell & Sinclair (1988) suggested that migrations of large herbivores in response to seasonal variations in resource availability and quality, as a means of enhancing access to high quality food and reducing the risk of predation.

Dispersal among large mammals is largely viewed as the widespread distribution of animal populations. Animals move on daily basis (local resident movement) and change habitat seasonally (migration, dispersal) because of patchiness within their home ranges (Western 1975; Sinclair 1992). Western (1975a) recognized three patterns or categories of movements, namely, migratory, resident and dispersal systems, where dispersal refers to wet season dispersal and dry season concentration of animals in a range. Today, because of anthropogenic activities discussed elsewhere, the habitats of most wildlife have been degraded, fragmented or lost such that many populations occur in isolation and some have been completely separated. Wildlife dispersal areas and migratory routes/corridors are thus absolutely essential to connect and sustain populations (see later).

3.2. Biological Significance of Animal Movements and Theory

The best documented movement of African ungulates is the seasonal migration (Western 1975a; Sinclair 1979; Fryxell & Sinclair 1988). Some migrants show considerable seasonal movement, while others show strong seasonal concentration and movement within an area (local resident movement). The habitat use and seasonal dynamics of large herbivores have been studied in the Mara-Serengeti ecosystem (Stelfox *et al.* 1986; Broten & Said 1995; Ottichilo 2000, Homewood *et al* 2001) and the Amboseli ecosystem (Western 1973, 1975).

Ungulates usually migrate in response to seasonal changes. Migration occurs in response to water and forage (quantity and quality) availability (Bourliere & Hadley 1970; Pennycuick 1975; Frxyell & Sinclair 1988). Migratory animals must satisfy their nutritional needs by moving sometimes over great distances, to access the best quality food resources available at any given time (Kutilek 1979). Seasonal change in forage nutritional quality also causes seasonal selection of forage and serves as a stimulus for movement (Bourliere & Hadley 1970; Western 1973; McNaughton 1979). However, some ungulates that do not migrate are successful because they utilize a wide range of food resources at one site on seasonal basis (Kutilek 1979).

The distribution of many animals is limited by water as an indispensable resource, which also regulates the quantity and quality of food supply. Wildlife population may increase or decrease dynamically with rainfall. Plenty of rainfall may lead to population increase as improved range condition is enabled by the growth of forage and abundant water necessary for physiological functions. However, excess water as a result of flooding may exterminate populations directly or indirectly through waterlogging of the vegetation and making food unavailable. The *El Niño* weather phenomenon, which brought excessive rainfall in East Africa in 1998, claimed both human and animal life through flooding. The abundance and distribution of wildlife populations will vary with food supply, seasonality, predator activity and a host of other biotic and abiotic factors (Morrison *et al.* 1992).

Water is a critically important resource that determines the survival of any animal, particularly in the arid and semi-arid environments. Lamprey (1964) suggested that water was the most important limiting factor to the abundance and distribution of wildlife in the savannahs of East Africa, especially in the dry seasons. The importance of water to the survival of wildlife has been discussed widely in literature (Western 1975a; Ayeni 1975, 1977; Owen-Smith 1996). The effects of water on wildlife and livestock, and dependence on it have been described (Western, 1975; Owen-Smith, 1996; De Leeuw *et al*., 2001). Most of the water-dependent species are grazers while browsers tend to be water-independent (Western 1975). Western (1975) further noted that during the dry season, most of the wildlife species were concentrated around water sources, while spread out during the wet season. The availability of ephemeral water sources during the wet season permitted the dispersal of animals (Western 1975; Ayeni 1975).

The seasonal movements of large mammals between dry and wet season ranges are attributed to water availability, pasture condition or combination (Western 1975). Dry season concentrations are due largely to water availability. Rainy (1980) noted that most animals were concentrated close to the Ewaso Nyiro River during the dry season. Other factors such as availability of minerals (Child *et al.,* 1971; Ayeni 1977; MacNaughton 1983), avoiding predation and competition (Hitchcock 1996) also influences animal movements. Large mammal communities are ultimately limited by food supply through mortality and reproductive stress (Sinclair 1974; Coe *et al.* 1976; Mwangi & Western 1998). The abundance of large savanna herbivores has been related to rainfall (Coe *et al.,* 1976; Sinclair, 1977; Ottichilo, 2000) as the single most environmental variable affecting ungulates, which determines the amount of food available, particularly in the dry season (Sinclair, 1979).

Changes in rainfall patterns influence vegetation dynamics and hence ungulate populations (Sinclair 1979; Bolen & Robinson, 1995). Droughts have disruptive effects on the vegetation not only through direct selection on species but also lowered primary production (Norton-Griffiths 1979). The movement of animals in response to rainfall and food supply is well documented and reviewed in the Serengeti-Mara ecosystem (Sinclair & Norton-Griffiths 1979; Maddock 1979; Sinclair & Arcese 1995; Ottichilo 2000) where the wildebeest, Burchell's zebra and Thomson's gazelle migrate between dry season and wet season ranges in the Masai Mara Ecosystem in Kenya and Serengeti Ecosystem in Tanzania.

Differences in migratory movement patterns can be related to the differences in food requirements of animals. Food supply determines migratory patterns, which is largely dependent upon rainfall and yearly variation in migration is also related to rainfall. Animals move to certain areas to obtain more protein or energy or minerals (Kreulen 1975, MacNaughton 1976, 1979) and avoid other areas because of floods and pests such as tsetse fly.

Migration reduces competition between animal species, especially the grazers (Maddock 1979) at critical times of the year (Hilborn & Sinclair 1979). Other biological processes that influence herbivore dynamics are competition and predation. Intra- and inter-specific competitions occur when there is same dietary need. The diversity and abundance of herbivore communities in African savannah ecosystems have been attributed to resource partitioning, niche differentiation, and the spatial and temporal use of habitats through feeding strategies - habitat preference or selection (Lamprey 1963; Jarman & Sinclair 1979). Furthermore, the feeding habitats of some species will enhance food availability to others through facilitation (Vesey-Fitzgerald, 1960; MacNaughton, 1983), for instance among wildebeest, Burchell's zebra and Thomson's gazelle during migrations (Jarman & Sinclair 1979; Van de Koppel & Prins 1998). Animal movements (annual, seasonal and daily, and local and long distance) by both wild and domestic herbivores systematically exploit environmental discontinuities (MacNaughton ,1985; MacNaughton & Georgiadis, 1986; Scoones, 1993).

Predation influences the dynamics by regulating populations of ungulates. Sinclair (1985; 1995) suggested that large herbivore populations are regulated more by food supply than predation because of their large size (e.g. buffalo, rhino and elephant), while predators regulate others. Species like the wildebeest escape predation through migration.

Disturbance by human activities such as encroachment by cultivation and settlements causes shrinkage of natural habitats by reducing space for grazing (Sinclair 1979; Ottichilo, 2000; Homewood *et al*., 2001; Thompson & Homewood 2002; Lamprey & Reid 2004). Morrison *et al.* (1992) noted that no single factor had a greater cause for the declines in wildlife population than the loss of habitat, and that habitat fragmentation threatens population viability. Livestock may alter the composition and physiognomy of range vegetation communities at the expense of wildlife. Some plants decrease with grazing whereas others increase.

3.3. Definition and Importance of Corridors

Habitat loss and fragmentation is the greatest threat to biodiversity which poses severe biological consequence to species and population extinctions (Hanski 1998). The loss or fragmentation of wildlife habitats reduces the area for wildlife use, and disrupts dispersion and migration patterns. Quite often it leads to change in community composition and ecological processes, and subsequently loss of species. Habitat connectivity or corridors is away to reduce the adverse impacts of fragmented wildlife areas. Human driven habitat loss and fragmentation are key issues facing biodiversity conservation (IUCN 1980). The identification and maintenance of existing dispersal and migration corridors and restoration of those already lost or interfered with by human activities is necessary for the existence and future survival of wildlife.

Corridors reduce chances of inbreeding and overexploitation by predators. The theoretical basis for necessity of habitat corridors is grounded in the theory of metapopulation extinction (Richard Levins, 1969; Hanski & Gilpin, 1991; Hanski, 1998), the theory of island biogeography (McArthur and Wilson, 1967) and Leopold's law of dispersion in the early 1930s. It is important to note that connectivity is essential for metapopulation stability and sustainability, and that metapopulation is useful in general biodiversity conservation in all landscapes (Hanski 1998).

Corridors are linear landscape features that serve as linkage between historically connected habitats and means to facilitate movement between these natural areas (McEuen, 1993) i.e. connectivity between important habitats. Connectivity is the degree to which the landscape facilitates or impedes movement among resource patches (Taylor *et al.,* 1993 **in** Bennett, 2003). Wildlife corridors are the prime means of physical linkage to habitats, which allow movements of species between otherwise isolated areas. They increase the effective area available and important conduits for reducing interbreeding and improving genetic viability, and accessibility to the larger habitats. Connectivity also ensures predation avoidance, maintenance of ecological processes and the continued viability of populations (McEuen; 1993; Bennett 2003).

However, there are arguments against corridors, including the possibility that they act as an avenue for spreading diseases, fires, hunting and predation, as well as the potential of higher management cost among other reasons (Simberloff *et al.,* 1992). Despite these criticisms, corridors are important and often the best option to protect and conserve wildlife and their habitats (McEuen; 1993). Corridors as a conservation measure have been used in wildlife conservation and management planning, especially in response to habitat fragmentation (Bennett, 2003). They are landscape patterns that promote connectivity for species and communities, and important for the maintenance of ecological processes in environments modified by human impacts (Bennett, 2003).

The design and management of corridors is important for effective conservation. Several criteria should be taken into account when designing a corridor: the type of species (target species) and ecological needs (predation, nesting, breeding/mating, food, shelter, cover, water), the habitat type including vegetation cover and human activities (plant species, land use, barriers), movement pattern (dispersal, migration, home range), length and width of corridor, edge effect (Beier & Loe 1992; McEuen; 1993; Harrison 1992; Lindenmayer & Nix, 1992; Bennett, 2003), and that within such a corridor animals are able to move and reproduce, the vegetation is able to grow, re-colonization and gene flow is possible, and populations can move in response to environmental and natural disasters (Beier & Loe, 1992). Other important considerations are management strategies that include monitoring of human activities and biological needs of the species (Bennett, 2003). Wildlife dispersal areas and corridors are necessary for survival (feeding, breeding), genetic diversity, re-colonization (Newmark, 1993; 1996).

3.4. Wildlife and People - Conflicts and Conservation

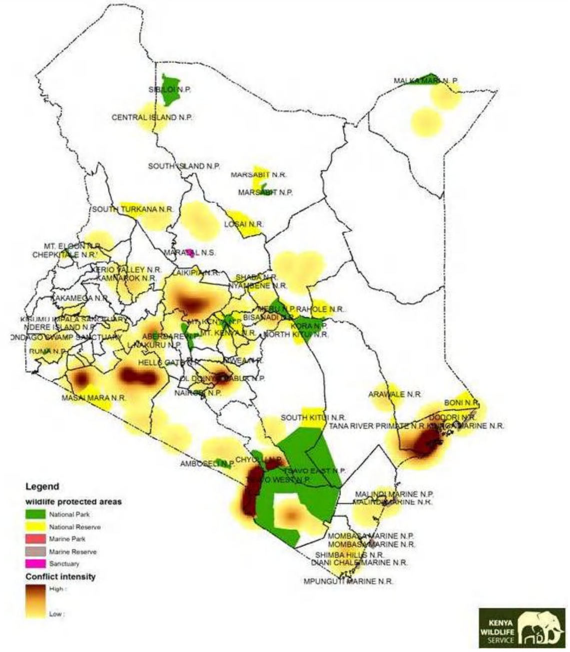
Biodiversity is facing widespread competition with humanity for space and resources (Pimm *et al*., 1995; Balmford *et al*., 2001). Many species are increasingly coming into conflict with people, and this is particularly true for large mammals, some of which such as the large carnivores bear most of the cost and are either critically endangered or have declined rapidly (Woodroffe & Ginsberg, 1998). Others, such as the African elephant inflict considerable impacts on people and are the position of being simultaneously an endangered species (IUCN, 2000) and a pest in other places.

Protected areas, the cornerstone of modern biodiversity conservation has gone some way in protecting species (Bruner *et al*., 2001). However, they do not completely resolve human-wildlife conflicts since they do not always exclude destructive human impacts (Liu *et al*., 2001). Equally, protected areas often only protect a part of an ecosystem or species range, and the dispersal of wildlife from such areas may increase conflicts (Woodroffe & Ginsberg, 1998). Even as alternative forms of land use such as community conservancies are implemented in an attempt to increase wildlife space and derive sustainable benefits from wildlife, conflict may still remain (Roe *et al*., 1997; Goodwin *et al*., 1998).

Although wildlife biodiversity is a national heritage and one of the major economic pillars in the country, today, the wildlife in protected areas are practically confined or secluded by human activities. This has been aggravated by increasing human population, high settlement densities and the expansion of agriculture along rainfall gradients. As the resources dwindle in protected areas, most of the wildlife and especially the large herbivores are compelled to disperse widely and sometimes across human-dominated landscapes in search of forage and water. The large carnivores will also follow suite for their favourite prey and come in constant conflict with pastoralist's livestock. The impacts of change in environmental conditions invariably play a contributing role and mainly the variability of rainfall that often triggers massive movement (migration) of wildlife. In addition, most of the large protected areas are not fenced, leaving wildlife to disperse beyond the confines of designated areas, and come into contact with human activities.

The types of human-wildlife conflicts in Kenya are varied and include crop damage, livestock predation, human injury and even death, among other threats such as zoonotic disease transmission, night crop guarding, etc. All these may lead to animosity towards wildlife and conservation. An analysis carried out by KWS has shown that wildlife conflicts continues to increase around many protected areas - high intensities in Tsavo West-Chyulu, Maasai Mara NR (Transmara and Narok area), Laikipia (Rumuruti area), Ol Donyo Sabuk and Lamu South (Map 3.4.1).

Key to the resolution of human-wildlife conflicts around protected areas is the development of appropriate strategies for securing wildlife dispersal areas and migratory routes/corridors. This may include encouraging the harmonious co-existence of people and wildlife, putting in place mitigation measures and ensures community participation in conservation and deriving benefits, and increasing wildlife space with compatible land uses (Plate 3.4.1).



Map 3.4.1: Human-wildlife conflict "hotspots" in Kenya. Conflict incidences (crop/property damage, livestock predation, human injury/death and wildlife mortalities by elephant, buffalo, baboon, hippo and crocodile from 2008 to 2010. *Source: KWS*

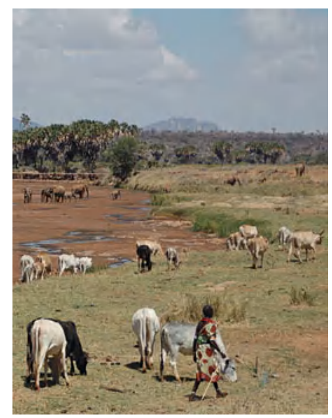


Plate 3.4.1: local herders around Samburu NR are allowed legal access to the protected area during periods of excessive drought, where their livestock share the scarce water resources and forage with wildlife species (elephants in sandy riverbed in the background).

The pastoral communities on the borders of Samburu and Buffalo Springs National Reserves fared far better during the recent two droughts as a result of this partnership with KWS. *Photo Credit: Wittemyer.*

3.5. Box 1. Key Wildlife Species

Wildlife connections and linkages (corridors) are usually designed with "umbrella" species in consideration. In this study, five key species - elephant, wildebeest, plains zebra, giraffe and buffalo were selected to represent different feeding ecologies, migration strategies, body sizes, life history characteristics and vulnerability to human disturbance. The species together with pastoral livestock have large influence on the ecological dynamics of ecosystems and play a critical role in shaping habitat mosaics that underpins species diversity.

3.4.1. African Elephant (*Loxodonta africana* Blumenbach)

The elephant is the largest terrestrial mammal. It once populated the entire Africa continent (Mauny 1956; Douglas-Hamilton 1979, in AWF 1996) and, in the last few centuries, inhabited the entire sub-Saharan Africa. Today, the remaining elephant population in Africa exists in pockets of protected areas and dense forests isolated by human activities and infrastructure development.

The African elephant is a charismatic and gregarious animal, living in herds of 10-50 animals and spends about 16 hours a day feeding. It has a life expectancy of 60 years with males weighing up to 6 tons (6000 Kg) and females (2.7 tons). The gestation period is 20-22 months with calves (born throughout the year) at birth weighing about 120 Kg and weaned at 3-8 years. A cow can give birth every 3-4 years.

Plate 3.4.1: Elephants in Mara National Park. *Photo Courtesy: AWF/Philip Muruthi.*

Elephants are generalized herbivore (mixed feeder) relying on widely distributed resources. Though mainly a browser, they feed on grass, leaves, twigs, terminal shoots, bark, roots, fruits and flowers (Archie et al., 2006; Osborn 2005; Rode et al., 2006; Wittemyer et al., 2007; Feldhamer et al. 2007). Elephants usually require a large home range to satisfy their huge nutritional demands (Galant et al., 2006; Jackson and Erasmus 2005; Whitehouse and Schoeman 2003). Their daily forage intake is between 4% and 7% of bodyweight and drinks up to 160 litres of water.

Elephants are found in woodlands, forests, wooded shrubland and wooded grassland habitats (Simberloff 1998). They play an important ecological role in the savannah and forest ecosystems by maintaining suitable habitats for numerous species (Stephenson, 2007). As a result of behavioral traits of stripping tree barks and pulling them down to access fodder, they will modify the vegetation dynamics leading to the creation of savannah-woodland mosaics (Richmond-Coggan, 2006).

In Kenya, the elephant's range covers some 109, 071 Km^2 of which almost 80% is found outside the protected areas (Hoare 1999; Blanc *et al*., 2003). A part from being widely distributed in the Kenya rangelands, elephants are also found in highland and cold areas such as Mt. Kenya forest, Mt. Elgon forest and the Aberdare range. The elephant population in eastern Africa regions is believed to be increasing due to improved conservation and concerted security measures (Blanc *et al*., 2005; Poole *et al*., 1992). For instance, in the late 1960s the estimated elephant population in Tsavo was between 35,000 and 40,000 animals (DRSRS data, Poole *et al*. 1992), but about 6,000 elephants were killed due to severe droughts in the early 1970s (Leuthold and Sale 1973, Ottichilo 1981) and by 1980, the remaining population was drastically reduced by poaching to approximately 12,000, which had further declined 5,363 animals (KWS, DRSRS, Douglas-Hamilton et al. 1995). The elephant numbers has shown a marked increase since the early 1990s to 10,397 animals in 2005 (KWS counts).

Elephant populations are considered vulnerable and future increasingly threatened (African Elephant Specialist Group 2004) as their survival largely depends on adequate protection and the availability of extensive habitats free from human habitation (Biru and Bekele, 2011). The reduction of elephants' range as a result of habitat encroachments by agriculture has aggravated the human-elephant conflicts in many regions (Afolayan 1975; Kasiki 1998).

Elephant populations have declined in many regions due to land use change (loss of habitat and fragmentation), droughts and poaching for ivory (Feldhamer *et al*., 2007; Hoare and Du Toit, 1999; Areendran *et al*., 2011). The escalating human population poses a major challenge to elephant conservation through increased human activities (high settlement densities, expansion of agriculture, increased livestock numbers, burning of charcoal and wild fires, fences, and pollution of water sources and extraction.

3.4.2. Wildebeest (*Connochaetes taurinus mearnsi* Burchell)

The blue or common wildebeest is a large antelope and can attain a body mass of 168-274 Kg. Wildebeest are territorial, highly gregarious in mobile aggregations or dispersed in sedentary herds (Estes 1991). The females reach sexual maturity at age three and males at age four. The gestation period is approximately 8.5 months, with calves able to stand within seven minutes of birth and run with the herd in less than two hours. Wildebeests are water dependent, requiring a long drink every day or two, and must have water within 15-25 Km radius. They have blunt muzzles which are best equipped for biting short green grasses usually found on alkaline or volcanic soils.

Wildebeests often graze together with other species including plains zebra, Thomson's gazelle, Grant's gazelle, kongoni, etc for mutual protection. Wildebeests and zebras migrate seasonally, although others often remain behind as residents. Their migration generates, through grazing activities, optimal conditions for other species, a process referred to as "facilitation" (Bell, 1970, 1971; Prins and Olff, 1998). The interaction with zebra is particularly beneficial as zebras mow down the tall grasses, leaving the wildebeests to forage preferred newly exposed and more nutritious shorter grasses.

Plate 3.4.2: Resident wildebeests in the Mara. *Photo Courtesy: AWF/Philip Muruthi*

In East African, the wildebeest range is bound by Lake Victoria and the low, arid *Acacia-Commiphora* bush areas east of the high plains (Estes 1991). They are found in open, shrubs and bush-covered savannah, thriving in areas that are neither too wet nor too arid. They occur in dense bushes to open woodlands and floodplains, but prefer grasslands which are sometimes overgrazed. Large herds numbering into thousands may be observed in the Serengeti equatorial plains of Tanzania in their annual migration to Kenya's Mara region. The Serengeti boasts over 1.4 million wildebeests, with migratory individuals moving from the short grass plains after the rainy season to seek higher grasses in wetter areas ranging over a 30,000 Km^2. The grasslands bordering alkaline lakes or pans are particular their dry season habitat choice.

In Kenya, the wildebeests are found in Narok and Kajiado counties, occurring both inside and outside protected areas including Amboseli and Nairobi National Parks, Maasai Mara National Reserve (Wargute *et al* in prep) and the wider dispersal areas. However, in recent years the wildebeest range is continuously declining and populations reducing due to land use change (high settlement densities, expansion of agriculture, fences), increasing livestock numbers (pastoralist sedentarization), drought and bush meat poaching.

The Mara ecosystem resident population declined drastically since 1970s due to land use change and particularly mechanized large scale wheat farming in the Ngorengore (Serneels and Lambin 2001, Ogutu *et al*., 2009). The populations in Nairobi National Park and Athi-Kaputei plains, and Amboseli nearly crashed as a result of the 2009 drought which also affected most of the large wild grazers and pastoral livestock.

3.4.3. Burchell's Zebra (*Equus burchelli* Gray)

The plains or Burchell's zebra is a common species throughout East Africa and numbering up to 0.6 million (Thirgood *et al.* 2004). It weighs up to 350 Kg with males slightly bigger than the females. They are highly social and live in groups ('harems') which consist of one stallion and up to six mares and foals.

Plate 3.3.3: Zebras in the open grasslands. *Photo Courtesy: AWF/Philip Muruthi*

The bachelor males can either live alone or in bachelor groups until old enough to challenge a breeding stallion. The adults drink at least once per day, while lactating females may require two daily trips to water points, which limit their range to vicinity of reliable water sources (Coe 1972).

The plains zebra mainly inhabit the shrub and wooded grasslands, and feed almost exclusively on grasses, but may occasionally eat shrubs, herbs, twigs, leaves and bark. Grasses constitute 90% of the diet (Gwynne & Bell 1968; Lamprey 1963; Grubb 1981). They tend to be the first grazers to move in the grazing succession thereby opening up the herb layer for the other grazers and show low selectivity compared to the other grazers such as the wildebeest and kongoni (Grubb 1981). In the Athi-Kapiti plains, the zebra takes between 17-20 species of grass with a greater variety in the dry season (Casebeer and Koss 1970).

The plains zebra are found in cooler environments with abundant water from sea level to over 4,400m a.s.l. only avoiding the deserts, dense forests and permanent wetlands (Coe 1972; Hack *et al.,* 2002). Most of populations migrate seasonally, traveling hundreds of kilometers annually to track vegetation flushes caused by rainfall - for instance the Serengeti-Mara migration (Maddock 1979). However, some individuals usually remain behind as year-round residents. In Kenya, the plains zebras are found in Narok, Nakuru, Kajiado, Machakos, Kitui, Taita-Taveta, Tana-River, Garissa, Kwale, Kilifi, Lamu, Laikipia, Samburu and Isiolo counties, with highest concentration in the Mara and Tsavo ecosystems (Wargute *et al* in prep).

3.4.4. Common Giraffe (*Giraffa camelopardalis* Linnaeus)

The giraffe is the largest and tallest ruminant, standing at 5-6 m. The males weigh 1.2 tons (1,200 Kg) and females (830 Kg). They are noted for their extremely long neck and legs, and prominent horns. Adult do not have strong social bonds, though they do gather in loose aggregations if they happen to be moving in the same general direction. The males establish social hierarchies through "necking", which are combat bouts where the neck is used as a weapon. Dominant males gain mating access to females, who bear the sole responsibility for raising the young.

Plate 3.3.4: Maasai giraffe with plain's zebras, reticulate giraffe and Rothschild giraffe. *Photo Courtesy: KWS/AWF/Philip Muruthi*

The giraffe is an ideal species for examining the feeding ecology of animals because it can reach for high foliage unavailable to most other herbivores. The giraffe, mainly being a browser, inhabits the savannas, grasslands, and open woodlands. They traverse large distances within their home range and encounter and use a wider variety of vegetation types than other browsers, consuming more than twenty plant species (Parker & Bernard 2005). They prefer the leaves of leguminous plants - members of genus *Acacia*, which they can browse at high heights (Leuthold and Leuthold 1972; Field and Ross 1976; Kok and Opperman, 1980).

The Masai giraffe occur in southern Kenya (Masai Mara, Athi-Kaputei, Amboseli and Tsavo ecosystems and throughout Tanzania). In Kenya, the Masai giraffes have relatively stable populations compared to the other sub-species, although reports highlight decline in recent years (KWS website).The reticulated giraffe is widely found in northern Kenya and Somalia. Data on the numbers and range of reticulated giraffe is limited and incomplete, but as few as 3,000-5,000 individuals may be remaining in the wild. The sub-species may have recently suffered a rapid decline, for instance estimates for the Laikipia County may show consistency with the pattern of decline: 1977 - 6,398; 1990 - 5,419; 1994 - 2,118; 1997 - 2,903 (KWS website). The Rothschild's giraffe (second most endangered giraffe sub-species with less than 670 individuals remaining in the wild) was once wide-ranging across western Kenya, Uganda and southern Sudan. It has now been almost totally eliminated and only survives in a few small and isolated populations. Kenya has about 60 per cent of the global population of the wild Rothschild's giraffe with Ruma NP having the single largest sub-population (130 individuals) in the country. Lake Nakuru NP has 65 individuals, Soysambu Conservancy - 63, Kigio Wildlife Conservancy - 32, and Giraffe Manor-Karen, Mount Elgon NP, Murgor Farm in Iten, Mwea NR, Sergoit-Kruger Farm in Iten, Kitale Farm and Nasalot GR all with populations of less 20 individuals (KWS website). The giraffe is classified as least concern (IUCN), however it has been extirpated from many parts of former range and some subspecies are now classified as endangered.

3.4.5. African or Cape Buffalo (*Syncerus caffer*)

The African or Cape buffalo (*Syncerus caffer*) is a large bovid up to 1.7 m high and 3.4 m long, weighs 500-900 Kg with males normally larger than the females (Nowak 1991, Estes 1991). Both sexes bear horns, although their size and shape is quite variable. Buffaloes may breed throughout the year, but births tend to be seasonal where rainfall is limited (Nowak, 1991). They are highly gregarious, living in mixed herds of 20-40 animals, but sometimes form large herds of several hundreds (Withers and Hosking 2000; Estes 1991). Within the herds are a number of smaller social groups made up of several females and their most recent offspring - up to two years (Buchholtz, 1990; Nowak, 1991).

Plate 3.3.5: Herd of buffaloes in Tsavo East NP. *Photo Courtesy: AWF/Philip Muruthi*

The African buffalo is active throughout the day, spending 18 hours moving and foraging, and drinking usually occur in the morning and at dusk. Buffaloes are grazers preferring areas close to water sources and feed on grass, herbs, swamp vegetation, and occasionally browse on leaves (Buchholtz, 1990; Nowak, 1991; Kingdon, 1997; Wither & Hosking 2000).

Buffaloes prefer grass species including *Cynodon*, *Sporobolus*, *Digitaria*, *Panicum*, *Heteropogon*, and *Cenchrus* (Kingdon 1997), able to subsist on too tall and coarse for most ruminants, and less partial to young tender shoots than most grazers. As a consequence, buffaloes play a pioneering role in the savannah grazing succession, reducing grassland to heights preferred by more selective feeders. The seasonal change in vegetation quality and water availability alters both the buffalo range and feeding habits. The typical buffalo habitats include thickets, reeds and forests, although herds may also live in very open woodlands (Estes 1991; Buchholtz 1990; Nowak 1991; Kingdon 1997).

The buffalo is highly mobile and rarely linger on trampled or depleted pasture as long as good stands of grass are available within their range (Sinclair 1977). They tend to be non-migratory, inhabiting a range which is largely exclusive to the group (Nowak, 1991). Their home range varies in size between 126-1,075 Km^2 depending on herd size and resource availability (Estes 1971). The African buffalo is increasingly threatened by land use change - habitat loss, fragmentation, droughts and hunting pressures (Kingdon, 1997; IUCN Antelope Specialist Group, 2008).

CHAPTER 4

METHOLOGICAL APPROACH FOR CONSERVING CONNECTIVITY

4.1. Overview

The development of a clear, concise, repeatable and robust methodology for conserving ecological connectivity is one of the key steps in implementing sustainable biodiversity conservation. This study outlines a methodology to develop and implement a sustainable, collaborative and integrated strategy to protect Kenya's unique natural heritage through conserving habitat connectivity. The methods described in this chapter builds on expert knowledge and experiences of conservation practitioners around the world while recognizing unique challenges and opportunities in the country. At the heart of the proposed conservation connectivity framework is an iterative and collaborative process that seeks to balance human development priorities with the goal of maintaining healthy ecosystems, biodiversity and natural capital as the essential foundation for human well-being.

4.2. Conservation Connectivity Framework (CCF)

This chapter describes the general method proposed for mapping of wildlife dispersal areas and migratory routes/corridors across the country. There is less emphasis on details of the methods used to generate the datasets for which appropriate references have been provided.

In this case study, the mapping process has adapted varied methodologies to meet specific objectives as detailed in Chapter 2. The proposed Conservation Connectivity Framework (CCF) is a collaborative and consultative strategic process that brings together a variety of data sources including sample and total wildlife counts, high resolution telemetry, habitat status, and expert scientific and indigenous knowledge among others, into a flexible, iterative and adaptive process. The key steps in the identification, development and implementation of this strategy for improved ecological connectivity conservation are described below.

A. Establishing the Context and Purpose - Need for Connectivity

The first step in mapping wildlife dispersal areas and migratory routes/corridors is to establish the context and purpose for conservation connectivity. Landscape patterns that promote connectivity for species, communities and ecological processes are key elements of nature conservation in environments modified by human impacts. Bennett (2003) suggests that emphasis be placed on the values of connectivity rather than the corridors. The concept of connectivity is used to describe how the spatial arrangement and quality of elements in the landscape affect the movement of organisms among habitat patches (Forman 1995).

At the landscape scale, connectivity has been defined as 'the degree to which the landscape facilitates or curtails movement among resource patches' (Taylor *et al.* 1993). The landscape is perceived differently by different species and so is the level of connectivity that varies between species and amongst communities. A landscape or local area with high connectivity is one in which individuals of a particular species can move freely between suitable habitats, such as favoured types of vegetation for foraging or different habitats required for forage and shelter. On the other hand, a landscape with low connectivity is one in which individuals are severely constrained from moving between selected habitats (Bennett 2003).

It should be established how enhanced connectivity between essential habitat patches and key ecosystems will impact ecological and social benefits:

i. Genetic diversity through enhanced gene flow;
ii. Enhanced overall meta-population survival in connected patches;
i. Refuges for predation;
ii. Buffering population fluctuations due to seasonal and inter-annual variation;
iii. Accommodation of range shifts due to climate change; and
iv. Maintenance of ecological process connectivity, including access to key resource areas such minerals, nutrients, dry season grazing, calving and breeding grounds.

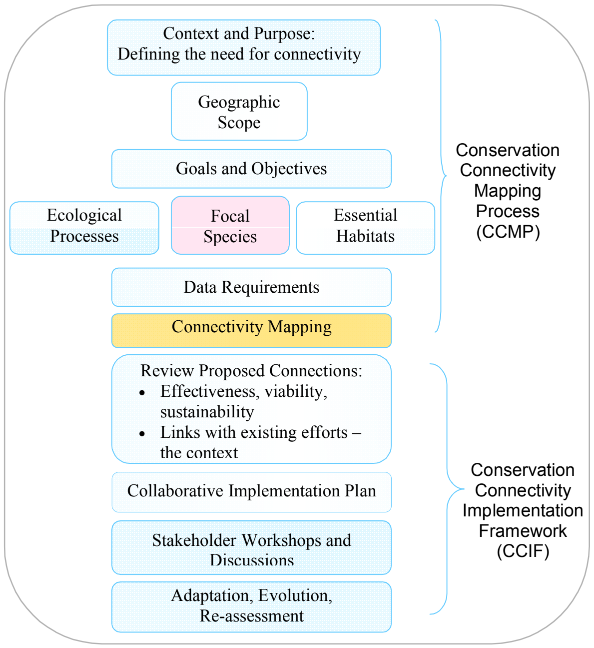


Figure 4.1: The Conservation Connectivity Framework (CCF) - the mapping process and implementation framework is iterative and collaborative procedure.

Beyond the ecological reasons for establishing connectivity, it is critical to establish its social, economic and political imperatives. In Kenya the government and other stakeholders have recognized the need to promote ecological linkages and connectivity for conservation and socio-economic development. Thus the initiative to *"Secure wildlife dispersal areas and migratory routes/corridors"* has been identified as a flagship project in the national strategic plan of Vision 2030.

The provision of security to wildlife areas is beyond the scope of this study, however the identification and mapping of dispersal areas and migratory routes/corridors outside the protected areas is a major milestone towards reclamation and maintenance. The mapping process has been undertaken through collaborative efforts of various government departments, conservation agencies and local communities living adjacent to the protected areas. It has also been done in the larger context of ongoing projects in Kenya's biodiversity programme including the national biodiversity atlas; land reforms; development of land use policy, national spatial plan, climate change mitigation and adaptation; and compilation of Kenya's natural capital among others.

Furthermore, conservation connectivity has social and economic benefits in terms of supporting key ecological processes, provision of ecosystem goods and services and ensuring environmental sustainability. It's potential to enhance synergies with existing land use systems e.g. pastoralists' livestock production in open wildlife grazing areas and allowing multiple land use options should be placed in context.

B. Geographical Scope

The second step is to agree and delineate the geographical scope of the project - what area will be covered. Inherent in this process is the recognition that conservation connectivity is a multi-scale phenomenon with unique challenges and opportunities across scales. This case study highlights the importance of a multi-scale approach to conservation connectivity and involves landscapes with contiguous ecosystems. The detailed analysis of available datasets was done to provide the status of wildlife and threats to habitat connections and linkages in the entire study (regional) and for specific sites (ecosystems). The results and recommendations are presented in Chapters 5 and 6.

The Conservation Connectivity Framework employs a nested hierarchical approach. To effectively and efficiently achieve the overall goal of defining and implementing a National Strategy for Conservation Connectivity (NSCC), the CCF approach assesses patterns and processes at three spatial scales - national, regional and site levels. As part of the Rapid Results Initiative (RRI), the taskforce has developed a preliminary conservation connectivity assessment output for the southern Kenya rangeland ecosystems, with a particular focus on six core study sites - Maasai Mara, Lake Naivasha-Elementaita-Nakuru-Eburu forest, South Rift, Nairobi NP-Athi-Kaputei, Amboseli and Tsavo ecosystems (see Chapter 2).

C. Defining Goals and Objectives - Components of Connectivity (Species, Habitats and Processes)

The Conservation Connectivity Framework provides a process for not only building linkages within the current context, but also recognizes the importance of future and historical scenarios. Indeed, effective connectivity strategies may often require restoring historical connections and taking into consideration the impacts of future changes in climate and land-use. Similarly, an effective long-term strategy for conserving biodiversity and natural capital through enhancing connectivity requires that we look beyond the large mammals.

Large mammals play an important role in determining the structure and function of East African ecosystems, and represent an important part of Kenya's economy, but they are only one facet of our diverse natural heritage. This report highlights a strategy for enhancing connectivity of large mammals in southern Kenya rangelands, but the Conservation Connectivity Framework recommends that this exercise should be extended gradually to include a comprehensive assessment of the following three primary ecological components:

i. Biodiversity (of which large mammals are only a very small subset);
ii. Habitats and Ecosystems - key habitats and communities which represent important movement facilitators; key resources areas with essential minerals, water, dry season grazing, calving and breeding grounds, etc; habitat mosaics and heterogeneity; rare and endangered habitats;
iii. Ecological processes - such as movement, water and nutrient cycle, carbon sequestration, etc.

The Conservation Connectivity Framework is a step by step, evidence based, collaborative process that incorporates diverse datasets and expert scientific and local knowledge to design linkages for sustainable ecological futures. An essential component of the framework is the recognition of the importance of flexibility and role of uncertainty associated with land use, climate change and variability. The CCF process involves the identification of current, historical and potential future areas of ecological importance, ecological movements and flows, threats and opportunities with the goal of ensuring sustainable connectivity. The CCF process is not anti-fragmentation, but essentially pro-connectivity (www.corridordesign.org).

The Conservation Connectivity Framework addresses the status, trends, interactions and spatial configuration (Bennett 2003) of the following key elements: wildlife core areas, dispersal areas, connections/linkages and the matrix. For example, in a model corridor consisting of transitional habitat and facilitating only dispersal and migration movements of passage species - length and optimal width are critical issues. Increasing the length and width beyond optimum levels reduces the chances of dispersers reaching a connected patch (McEuen, 1993). Other essential characteristics of any conservation connectivity design include the assessment of linkage attributes such as width, length, habitat/matrix interactions, boundaries and edge effects, and barriers. In addition, the design process will necessarily include prioritization, viability and sustainability assessment of proposed linkages. A critical examination of the potential challenges, risks and potential negative impacts of connectivity such as spread of invasive species, source-sink population dynamics, disease transmission and maintenance of local genetic variation is also essential. Finally, the Conservation Connectivity Framework advocates for the recognition and evaluation of key social, political, and economic costs and benefits.

D. Ecological Components

Sustainable landscapes and long-term conservation of biodiversity and natural capital require a comprehensive assessment of conservation connectivity for three key ecological components - species and biodiversity, key habitats, and ecological processes. For the purpose of this study, five focal species - elephant, wildebeest, Burchell's zebra, giraffe and buffalo (see Box 1) were selected to represent different feeding ecologies, migration strategies, body sizes, life history characteristics and vulnerability to human disturbance. They have large influence on ecological dynamics of ecosystems and play a critical role in shaping habitat mosaics that underpins species diversity.

While a comprehensive assessment of all species would be the ideal, the logistics of such an analysis would be extremely challenging. As a result connectivity assessments often focus on a few key representative species based on various criteria such as above and including flagship (charismatic), keystone, umbrella, wide or narrow ranging, fragmentation sensitive and habitat sensitive species. Other potentially important characteristics include spatial abundance and distributions, movement patterns and life history traits.

E. Data Needs and Requirements

The development, assessment, and implementation of an effective conservation connectivity design require a variety of data types at multiple spatial and temporal scales. The following section outlines some of the general data and information requirements for developing a sustainable connectivity strategy. The list below highlights some of the key information needs, however the inherent flexibility and adaptive nature of the Conservation Connectivity Framework recognizes the importance of bringing together unique and unusual data sets in novel approaches. Individual data requirements will be driven by the goals and objectives of the overall study (see Chapter 2).

A comprehensive conservation connectivity analysis is a multi-step process which includes: 1) mapping of the abundance, distribution and movement patterns of focal species; 2) assessment of their habitats; 3) assessment of known threats and opportunities; and 4) combination of the above sets of information into a connectivity viability and prioritization layer. Where possible and appropriate each of these steps may be supported by modeling efforts to determine the potential and future patterns such as impacts of compatible land uses and effects of climate change.

The following key datasets were used in the assessment and mapping of conservation connectivity in the southern Kenya rangeland ecosystems:

- *Abundance and distribution* - species population trends and spatial distribution;
- *Habitat attributes* - habitat characteristics and ecological processes.
- *Biophysical Attributes* - biophysical attributes including digital elevation models, river and stream networks, soil attributes, etc;
- *Socio-economic and political* - factors including infrastructure developments (towns, schools, hospitals, roads, etc), human population and settlements, political and zoning boundaries;
- *Movement and migration patterns* - historical and current movement patterns of the focal species including expert scientific and local knowledge.
- *Barriers and obstructions* - boundaries, fences, roads, waterways, etc
- *Land cover/use* - current land cover/use maps such as agricultural activities, natural habitats, livestock densities and including historical, current and projected scenarios.
- ***Climate change and variability*** - climate variability and directional change for incorporation in future scenarios

i. Species abundance, distribution and movements

Wildlife species population, distributions and movement were brought together at different scales. The identification of credible datasets was critical and thus the collaborative effort of various government institutions and conservation stakeholders was highly necessary.

ii. Socio-economic and political

Socio-economic and political data including infrastructures, towns, water points, political and conservation areas boundaries and human population densities were assembled from a variety of sources to establish their impacts on wildlife areas.

iii. Movement and migration patterns

As an initial step, the task force assembled known current and historical movement patterns from scientific literature, expert knowledge (wildlife telemetry and observations) and local knowledge. These data helped to establish and verify the connections, and highlight important linkages that may not be captured with other data types. This report presents preliminary information on the movement pathways, but further research, input from a variety of sources and consultation is required. As noted in the discussion section below, an essential next step will be to engage experts to revise, update and augment the data in a truly collaborative and inclusive process.

iv. Barriers and obstructions

The identification of barriers and obstructions is species dependent. In this report we have include information on infrastructure from topographic basemaps, detailed fence map of the Kitengela area from ILRI, and land subdivisions for Amboseli and Koiyaki areas from topo-cadastre. The non-natural vegetation cover will also restrict the movements of different organisms across the landscape and information on land cover from Africover (2008) was incorporated in the analysis.

v. *Land cover/ use*

The assessment of land use focused on the distribution of agriculture across the southern Kenya rangelands as a key variable that affects wildlife movement and responsible for the massive human-wildlife conflicts, as well as the viability of core, dispersal and linkage areas. The distribution of agricultural fields was derived from Africover (2008). However, the future analyses should supplement this broad scale continental and national dataset with high spatial resolution land cover change data at regional and site (ecosystem) level derived from Landsat TM imagery (30m resolution).

vi. *Climate change and variability*

Climate change and variability analysis is an essential component of any sustainable conservation strategy in today's dynamic and uncertain world. The effects of climate change and variability on the effectiveness, viability and sustainability of the connectivity network proposed was not explicitly assessed, however it was recognized as essential next step (see Section 6.8). The temperature and rainfall data for the climate change and variability analysis across the study area was provided by the Kenya Meteorological Department.

F. Connectivity Mapping and Analysis

At the core of the conservation connectivity framework is an integrated evidence based assessment of wildlife distribution and movement patterns, an analysis of threats and opportunities, and the combination of these assessments into a connectivity prioritization layer. The proposed connectivity layer then undergoes a comprehensive review process (see below). The following analyses were conducted for regional and site (ecosystem) level mapping in southern Kenya rangeland ecosystems. Details of each analysis and interpretations are presented in chapters 5 and 6.

1. Regional and site (ecosystem) level patterns of species richness and densities, and selected keystone species density distributions;
2. Protected areas, wildlife dispersal areas, migratory routes and corridors;
3. Threat surfaces including demography (population and settlements), land use (agriculture and livestock density), distances to protected area boundary, roads and urban centres, and planned and unplanned developments;
4. Current intervention and opportunities such as protected areas, community conservancies and sanctuaries, lease and easements programmes, and REDD+ initiatives;
5. Conservation connectivity surface/landscape - overlays of species distribution and movements, known and proposed connections, and threats and opportunities to produce a variety of surfaces. The surfaces were prioritized e.g. core areas (high value) and high threat status equals high prioritization, viability of connectivity surfaces equals high conservation value and low threat status;
6. Further analyses should include habitat and connectivity/linkage suitability modeling, climate change and sensitivity, linkage viability and polarization assessment (characterization/typology), and sensitivity analysis of weighting and prioritization.

G. Conservation Connectivity Implementation Framework

The conservation connectivity proposed will be reviewed to assess their effectiveness, viability and sustainability. In addition, an all inclusive participatory assessment of ongoing efforts towards the acquisition, securing and management of wildlife dispersal areas and migratory routes/corridors is necessary. The proposed conservation connectivity implementation framework is outlined in Chapter 7.

4.3. Data Sources - Species Distribution and Movements

Kenya has a rich history of extensive wildlife counts across the rangelands. The Department of Resource Survey and Remote Sensing (DRSRS) conducted a total of 73 aerial sample surveys of large herbivores in the dry and wet seasons across the southern Kenya rangeland study sites (Narok, Kajiado and Taita-Taveta counties and Tsavo ecosystem) from 1977 to 2011. Systematic Reconnaissance Flights (SRF) methodology as described by Norton-Griffiths (1978) has been used in all the surveys.

A sampling resolution of 2.5x5 km was used in the Mara and Athi-Kapitei ecosystems, 5x5 km resolution in Kajiado, Taita Taveta and Tsavo-Galana areas, and 2x2 km resolution in Shompole and Magandi areas. A high winged twin-engine (Partinevia 68) aircraft is flown at 400 ft above ground level and stripwidths calibrated at 282m. The population estimates and standard errors are calculated according to Jolly II method of unequal transect lengths (Jolly 1969, Norton-Griffiths 1978).

Kenya Wildlife Service (KWS) conducted total counts of wildlife in Mara, Amboseli-West Kilimanjaro and Tsavo-Mkomazi ecosystems between 2006 and 2011, while the local community conducted ground counts in Kitengela area with facilitation from the International Livestock Research Institute (ILRI). In the total counts, the ecosystems are stratified into sampling blocks which are defined or demarcated by recognizable features e.g. major roads, rivers, escarpments, etc (Norton-Griffiths, 1978; Douglas-Hamilton, 1996). The sampling resolution in each block is 1x1 km, which is designed to ensure that all the large wildlife are sighted and counted. Fixed high wing aircrafts (Cessnas and Huskys) are flown systematically along transects in each block during the counts. The crew consists of a pilot, Front Seat Observer (FSO) and two Rear Seat Observers (RSOs). A hand held Global Positioning System (GPS) is used to mark observation waypoints and animals recorded.

Wildlife telemetry data was used for refinement of species movement patterns by overlaying onto species distribution surfaces derived from the sample and total counts data. The wildlife telemetry datasets used for mapping elephant and wildebeest movements in the study area are:

i. African Wildlife Foundation (AWF) dataset on eight radio-collared elephants (3 bulls and 5 females) in West Kilimanjaro region from 2005 to 2008. These elephants typically cross into the Amboseli National Park (Kikoti, 2009);
ii. Dataset mined from a PDF report on preliminary analysis of the performance of five satellite-linked GPS collars deployed on elephants in Tsavo East National Park. It provided details on outer extent of five elephant's movement between March and September 2011 (Ngene and Njumbi 2011);
iii. African Conservation Centre (ACC) dataset on 2 collared elephants (male and female) in the Magadi area, in addition to tracks and sign data from the local community scouts;
iv. PDF grid referenced maps from Gnu Landscapes Project - "Wildebeest forage acquisition in fragmented landscapes under variable climates" for wildebeest movement in Mara, Kitengela and Amboseli (http://www.nrel.colostate.edu/projects/gnu/resear ch.php). The dataset (May 2010 to November 2011) comprise of 15 GPS collars on wildebeest in Mara and Loita plains, 12 collars in Nairobi NP and Athi-Kaputei plains, and 9 collars in Amboseli NP and surrounding group ranches; and GPS collar tracking study in Serengeti on wildebeest movement in the Mara.

Other datasets included land cover/use - agriculture (Africover 2000 and updated 2008 (WRI, ILRI and DRSRS), human population 1999 Census - Kenya National Bureau of Statistics 2000), distance to roads, distance to protected area, livestock density and fences

5.2. Geospatial Analysis and Modeling

Geographical Information System (GIS) - ArcGIS (ESRI version 9.3) was used in the spatial analysis, integration and modeling of datasets from various sources and scales to create the different surface layers and map wildlife dispersal areas and migratory routes/corridors at regional and ecosystems levels.

5.2.1. Regional Species Richness and Densities

The first step was to delineate the study areas boundary and map the regional species richness (diversity) and densities for wildlife and livestock. The analysis was based on sample aerial census data. The population estimates of wildlife (47 species) and livestock (4 species) for the study area was generated from 1977-2011. The data were merged at 5 by 5 km grid and averaged estimates derived. The population densities and number of species (diversity) observed per grid was re-calculated to produced density and richness surface maps. Densities were calculated based on the tropical livestock (TLU) unit, where one (1) TLU was equivalent to 250 kg. The weights of all the 51 species were derived from literature.

5.2.2. Species Distribution - Regional and Site (Ecosystem) Level

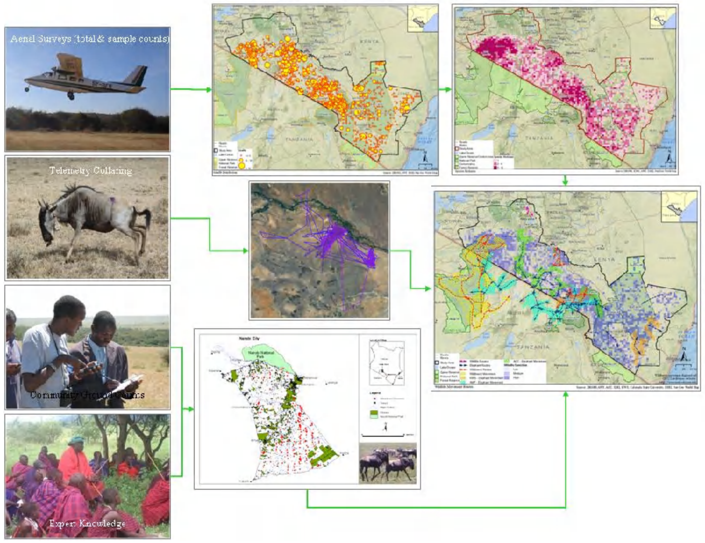
The second step involved detailed mapping of species distributions at the regional and site (ecosystem) levels. The six sites (ecosystems) are Serengeti-Mara Ecosystem, Naivasha-Elementaita-Nakuru-Eburu Forest Ecosystem, Nairobi National Park-Athi Kaputei Ecosystem, South Rift (Lake Natron-Magadi area), Amboseli-West Kilimanjaro Ecosystem and Tsavo-Mkomazi Ecosystem. Sample and total counts of elephants, wildebeests, zebras and giraffes from DRSRS and KWS, and ground counts from ILRI were integrated to derive species distribution surfaces (Schematic Diagram 5.2.1).

5.2.3. Dispersal Areas and Migratory Routes/Corridors

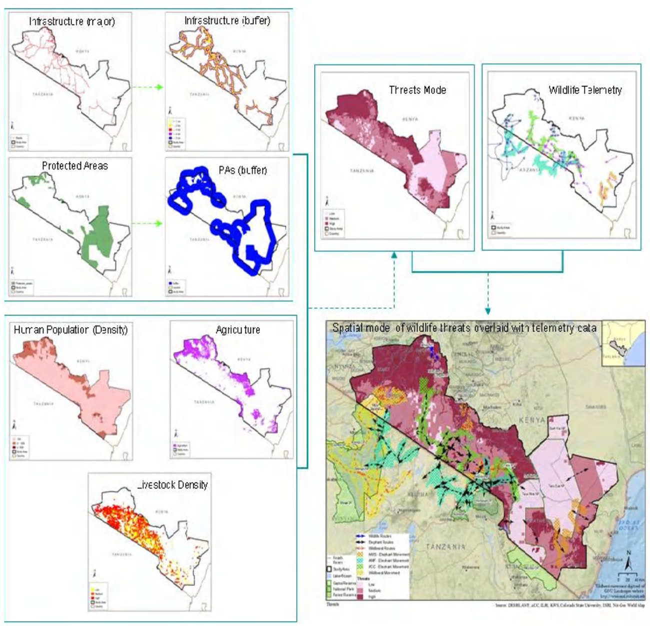
A number of spatial datasets (species richness, density distributions and movement surfaces) were integrated to generate the maps on wildlife dispersal areas, migratory routes/corridors. In addition, we reviewed papers and seek opinions of experts from field and local communities. The wildlife telemetry data for wildebeests and elephants was used to map their movements and depict dispersal areas, corridors and landscape connectivity in real time.

5.2.4. Threats to Conservation Connectivity

In this study, we focused on the main threats to conservation connectivity namely human population density, agriculture, livestock density, infrastructure development and protected area boundary. The threatened wildlife areas were mapped by creating buffers around the parks and major roads, and integrating these with the demography, livestock density and agriculture layers to model threat surfaces in different weights. The weights were from 0 to 1 with zero being no threat and 1 - the maximum threat. The overlay of threats and wildlife telemetry surfaces was used to identify migratory routes/corridors under pressure and assign threat levels (none, low, moderate, high, blocked) (Schematic Diagram 5.2.2).



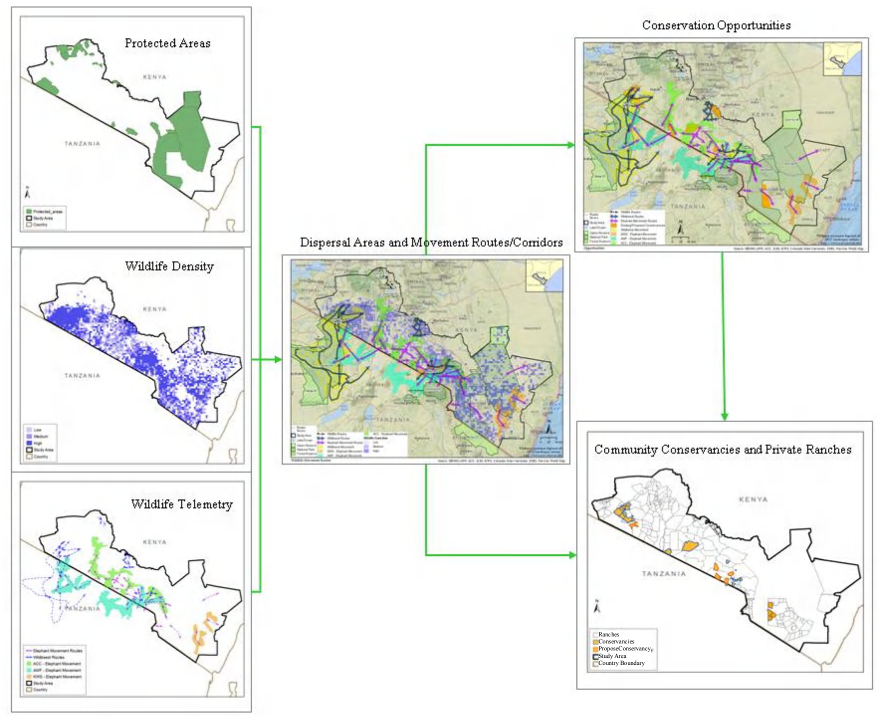
Schematic Diagram 5.2.1: Data collection and spatial analysis to generate maps of dispersal, migratory routes/corridors.



Schematic Diagram 5.2.2: Integration and modeling of spatial datasets to develop the conservation threats surfaces.

5.2.5. Current Intervention and Opportunities

There are number of interventions or conservation programs being implemented by local communities living around the protected areas in southern Kenya rangelands such as development of conservancies and community based wildlife areas, wildlife and livestock ranches, and REDD+ initiatives. The protected area layer was overlaid with wildlife density and dispersal areas/migratory routes/corridors layers to determine the core areas and connectivity outside the parks and reserves. This analysis provided a map of areas that have high conservation potential and yet are unprotected. In most of the cases, these areas formed the connectivity between the critical wildlife habitats that needs to be maintained as dispersal areas and migratory routes/corridors. The local communities have taken advantage of the conservation potential in some of these areas and gone a head in their development as conservancies (Schematic Diagram 5.1).



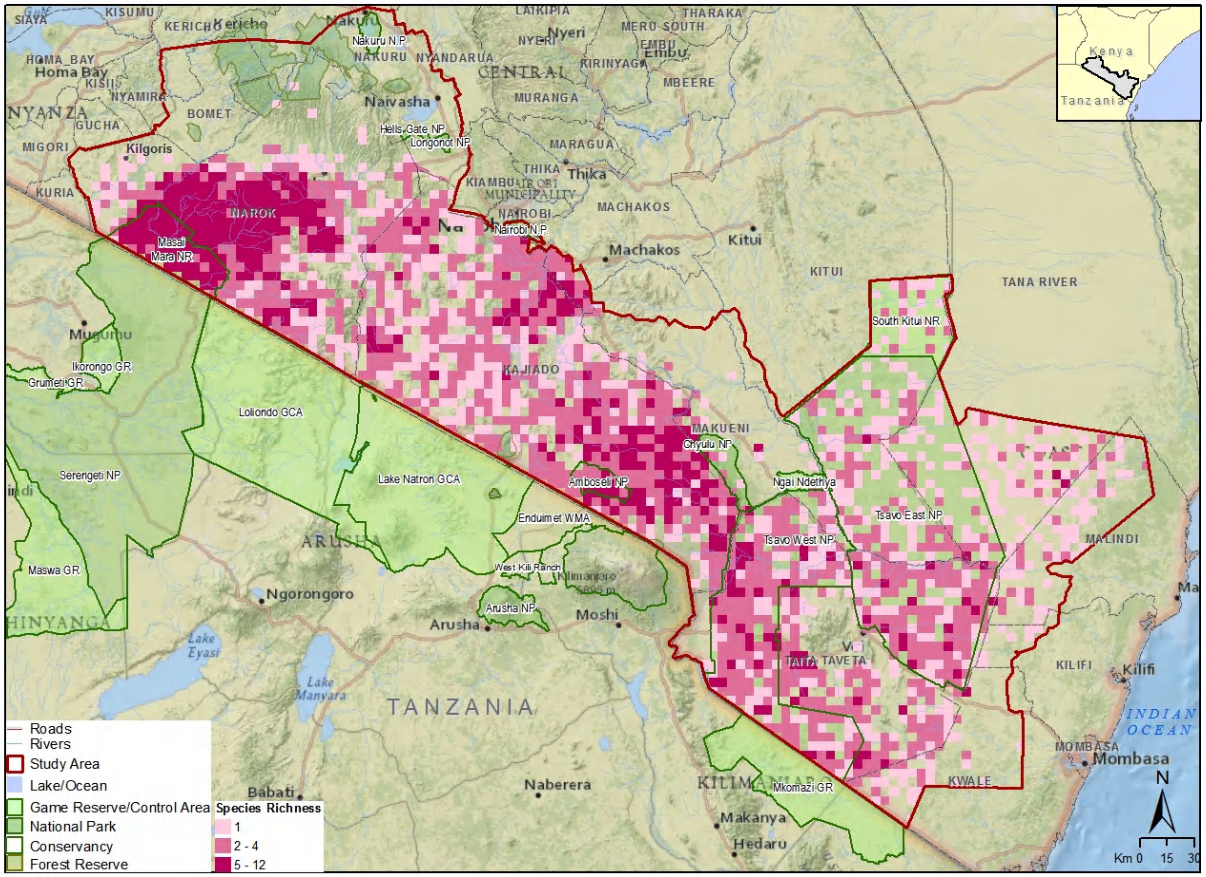
Schematic Diagram 5.3: Spatial integration of data to identify high conservation potential areas outside parks and reserves that can be developed as community conservancies to benefit the local populace and protection of wildlife.

CHAPTER 5

MIGRATORY ROUTES AND CORRIDORS FOR CONSERVATION

5.1. Regional Patterns - Species Diversity, Densities and Distribution

Kenya is endowed with diverse ecosystems and habitats that are home to unique and diverse flora and fauna. It has extraordinary biodiversity of large mammals due to its location across the equator, bimodal rainfall and habitat heterogeneity. The diverse ecosystems and habitats are contained in the vast savannah and represented within the protected area system that comprise about 12 per cent of the country's territory, including 23 national parks, 28 national reserves, 203 forest reserves, four marine national parks, six marine national reserve and four sanctuaries. The patterns of large mammal species richness in southern Kenya rangelands are shown in Map 5.1.1.



Species Richness

Source: DRSRS, KWS, AWF, ESRI, Nat-Geo World Map

Map 5.1.1: Species richness (diversity) of large mammals in the southern Kenya rangeland Ecosystems. The dataset is species diversity on a 5x5km grid resolution from DRSRS sample counts (1978 and 2011).

5.1.1. Regional Species Richness – Large Mammals

In the southern Kenya rangelands, the Masai Mara National Reserve (MMNR) and the surrounding areas (Masai Mara Ecosystem (MME) has the highest species richness in terms of large mammal diversity. The Amboseli ecosystem and Athi-Kaputei area also contain high species richness. The other important biodiversity areas with pockets of high species richness include Nguruman area and Tsavo ecosystem especially in the Tsavo West National Park (TWNP) and southern part of Tsavo East National Park (TENP).

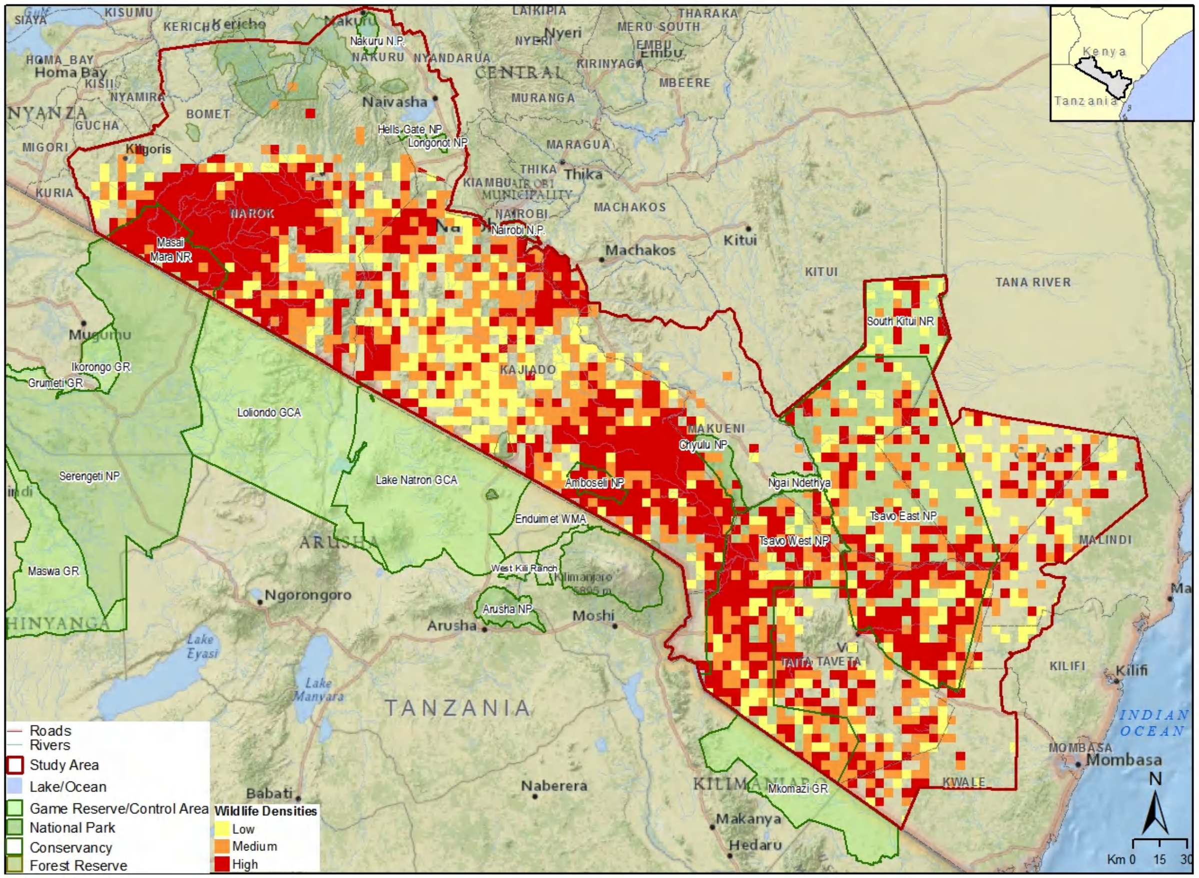
Although high species diversity is concentrated in the core wildlife areas, large populations of wildlife and diversity are still widely distributed outside the protected areas and venture into various land uses, some of which are incompatible with wildlife conservation. These areas (ecosystems) are unique as wildlife habitats due to the diversity of landscapes and varied climatic conditions in the country. However, most of the land outside protected areas is threatened by the increasing human population and associated activities that have led to high demand on land resources and land use change.

REGIONAL SPECIES RICHNESS

5.1.2. Regional Wildlife Densities

The wildlife density map (5.1b) is strongly correlated to species richness map (5.1a), but it also shows the diversity of animal distribution in southern Kenya rangelands. In each of the study sites (Mara ecosystem, South Rift, Athi-Kaputei ecosystem, Amboseli ecosystem and Tsavo ecosystem), there are key species that make the bulk of the densities. In the Mara, Amboseli and Kitengela area - the important species are wildebeest, zebra, giraffe and medium size antelopes (kongoni, impala, Grant's and Thomson's gazelle), while in the Tsavo - the key species are elephant, zebra and smaller antelopes.

In five out of the six ecosystems studied, high wildlife densities were observed in the Mara, Shompole-Nguruman-Magadi area, Amboseli, Athi-Kaputei, Tsavo West NP and south of Tsavo East NP as reflected by the high concentration of animals in the ecosystems. There is a contiguity of species densities in the Masai Mara National Reserve and adjacent (former) group ranches, and Amboseli-Kaputei and Tsavo ecosystems. High populations and densities require a wide heterogeneous habitat for the dispersals and migration of large wildlife species such as the wildebeest, zebra, elephant and other wide ranging antelopes.



Source: DRSRS, KWS, AWF, ESRI, Nat-Geo World Map

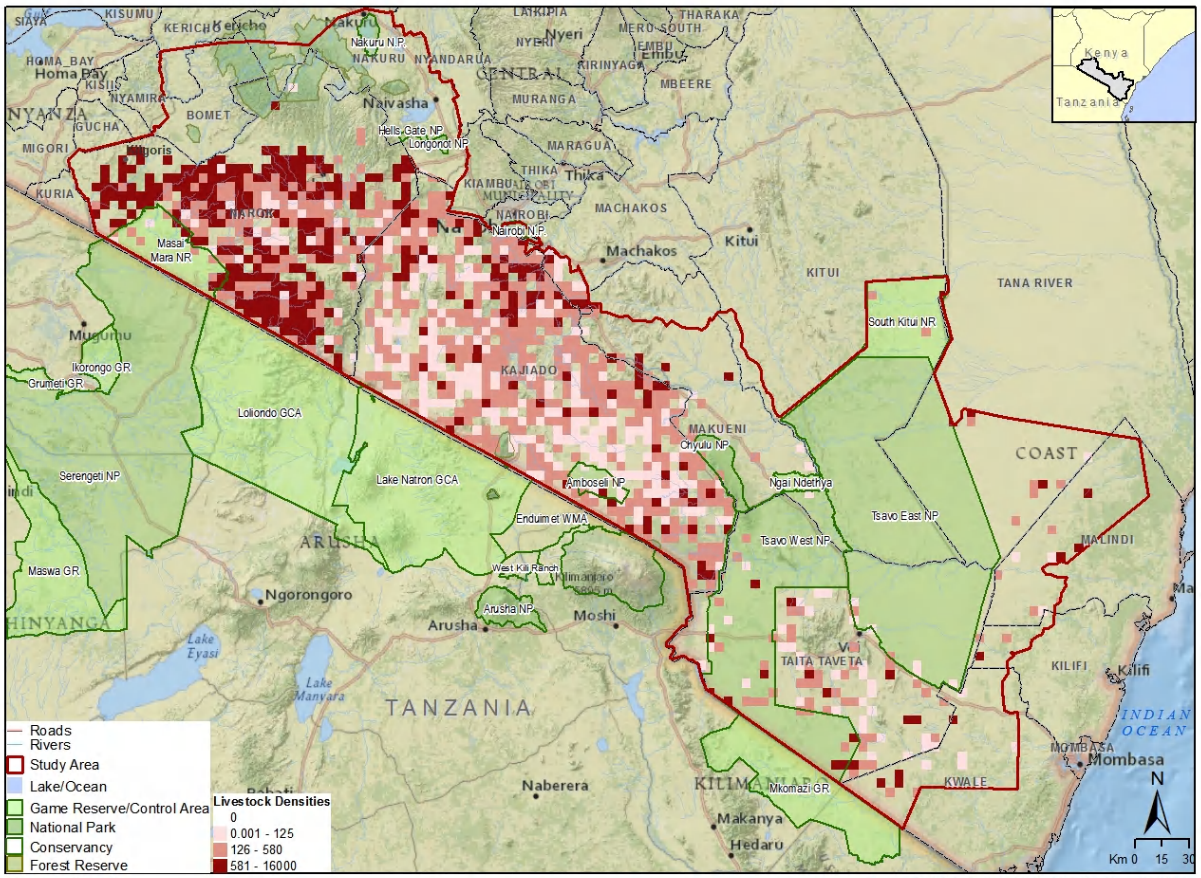
Map 5.1.2: Density distribution of large wild herbivores in the southern Kenya rangelands (1978-2011). The dataset is averaged species densities on a 5x5km grid resolution from DRSRS sample counts.

REGIONAL WILDLIFE DENSITIES

5.1.3. Regional Livestock Densities

The analysis of long-term livestock densities in the southern Kenya rangeland ecosystems indicates high livestock (cattle, shoats and donkey) occurrence in the group ranches within the Mara Ecosystem (Siana, Loita and Koiyaki) and Trans-Mara area in Narok County (Map 5.1c). There are few incursions of livestock on the edges of Masai Mara National Reserve (MMNR). A recent count shows an increase in small stocks (shoats). The last animal survey conducted in 2011 found more than a million shoats (sheep and goats) in Narok County, which represented the highest population in the last 30 years.

High densities of livestock also occur in the Kitengela area with pockets spread widely in Kajiado County. The remaining parts of Kajiado show low to medium densities and few incursions on the edge of Amboseli NP. There are very few livestock in the Tsavo Ecosystem, with the eastern part almost empty. There are some incursions of livestock in almost half of Tsavo West NP, especially in the south of the area between Taita Hills and Chyulu. Livestock can have positive or negative impacts on wildlife depending on its density and management strategies. Human-wildlife conflict may increase sharply in the traditional drought refuges for wildlife and pastoral livestock areas with high density settlements and agricultural activities.



Livestock Densities

Source: DRSRS, KWS, AWF, ESRI, Nat-Geo World Map

Map 5.1.3: Density distribution of livestock (cattle, sheep & goats and donkey) in the southern Kenya rangelands (1978-2011). The dataset is averaged livestock densities on a 5x5km grid resolution from DRSRS sample counts.

5.1.4. Regional Wildlife Population

In the last few decades, most of the areas in southern Kenya rangelands have undergone land use and tenure changes, and experienced the effects of frequent and severe droughts which have negative impacts on wildlife populations and their spatial distributions. In addition, wildlife populations have also suffered from heavy poaching for bushmeat and trophies, as well as diseases that have contributed to the declines in their populations. This section provides a regional synopsis and site level analysis of wildlife populations and compares the populations inside and outside protected areas in various landscapes (Table 5.1.1).

The analysis indicates that wildlife distribution and densities vary across landscapes. The regional analysis of four (4) species (elephant, wildebeest, zebra and giraffe) indicates that 44% of the animals were located inside the protected areas while 56% were outside. However, there is a large variation in species occurrence across the landscapes and the study sites.

The highest population of elephants (2.4%) were located in Taita-Taveta County, wildebeests (51%) and zebra (16.9%) in Narok County, and giraffe (1.6%) in Kajiado County. In Narok 65% of the animals were sighted outside Masai Mara NR, Kajiado (80%) outside Amboseli and Chyulu Hills NP, Machakos and Makueni (93%) outside Tsavo West NP and Ngai Ndethya NR, Tana-River (71%) outside Tsavo East NP, Kitui (23%) outside Tsavo East NP and Kitui South NR, and Taita-Taveta (25%) outside Tsavo West and East NP. Kitui and Taita-Taveta counties recorded more animals inside the protected areas.

In Narok the Giraffe (84%), zebra (69%) and elephant (62%) were more outside protected area. Only the wildebeest population (55%) was more in the park compared to other species. In Kajiado all the species - giraffe (90%), zebra (84%), elephant (75%) and wildebeest (74%) were more outside the protected areas. In Machakos and Makueni, the elephant were more (72%) inside the protected area, while wildebeest (100%), zebra (90%) and giraffe (87%) were located outside.

The situation is different in Kitui and Taita-Taveta counties where all the animals are more inside the park than outside. In Kitui 92% of elephant, 91% of zebra and 62% of giraffe were located in the park. In Taita-Taveta the proportion is much lower, with 81% of elephant, 73% of zebra and 58% of giraffe are found in Tsavo East and West NP. In Tana-River, it is only the elephant (83%) that are more in the park, while zebra (66%) and Giraffe (88%) are located outside the park.

This analysis indicates that most of the wildlife species are located outside the protected areas where land use change, fragmentation and habitat modification are taking place. The increasing human population and associated pressures on natural resource use can have adverse impacts on wildlife dispersal areas and corridors, and subsequently on wildlife populations.

Table 5.1.1: The averaged wildlife population estimates (1978-2011) inside and outside protected areas in the counties (Narok, Kajiado, Makueni, Kitui, Taita-Taveta and Tana-River) that form the southern Kenya rangeland ecosystems, with the exception of Nakuru. The four keystone species considered are wildebeest, plains zebra, elephant and giraffe.

County	Protected Area	Species	Inside			Outside			County	
			Pop. Est.	*Density*	% (In)	*Pop. Est.*	*Density*	*% (Out)*	*% (In)*	*% (out)*
Narok	Masai Mara NR	Elephant	1059	0.61	38	1721	0.11	62	35	65
		Wildebeest	92735	53.02	55	74502	4.64	45		
		Zebra	16986	9.71	31	38361	2.39	69		
		Giraffe	317	0.18	16	1712	0.11	84		
Kajiado	Amboseli NP and Chyulu Hills NP	Elephant	362	0.50	25	1061	0.05	75	20	80
		Wildebeest	5538	7.59	26	15483	0.72	74		
		Zebra	5186	7.11	16	27402	1.27	84		
		Giraffe	532	0.73	10	4601	0.21	90		
Machakos and Makueni	Tsavo West NP and Ngai Ndethya NR	Elephant	66	0.10	72	26	0.002	28	7	93
		Wildebeest	-	-	-	2313	0.17	100		
		Zebra	276	0.43	10	2497	0.19	90		
		Giraffe	79	0.12	13	547	0.04	87		
Kitui	Tsavo East NP and Kitui South NR	Elephant	1306	0.16	92	109	0.005	8	77	23
		Zebra	1478	0.18	91	148	0.01	9		
		Giraffe	1727	0.21	62	1079	0.05	38		
Taita-Taveta	Tsavo East and West NP	Elephant	6501	0.62	81	1488	0.22	19	75	25
		Zebra	8108	0.78	73	3036	0.45	27		
		Giraffe	1203	0.12	58	875	0.13	42		
Tana-River	Tsavo East NP	Elephant	521	0.18	83	109	0.003	17	21	71
		Zebra	1056	0.36	34	2063	0.06	66		
		Giraffe	381	0.13	12	2690	0.07	88		
		Total	**145,417**			**181,822**			**44**	**56**

WILDLIFE POPULUATION (REGIONAL AND ECOSYSTEMS)

5.1.5. Regional Distribution of Wildebeest

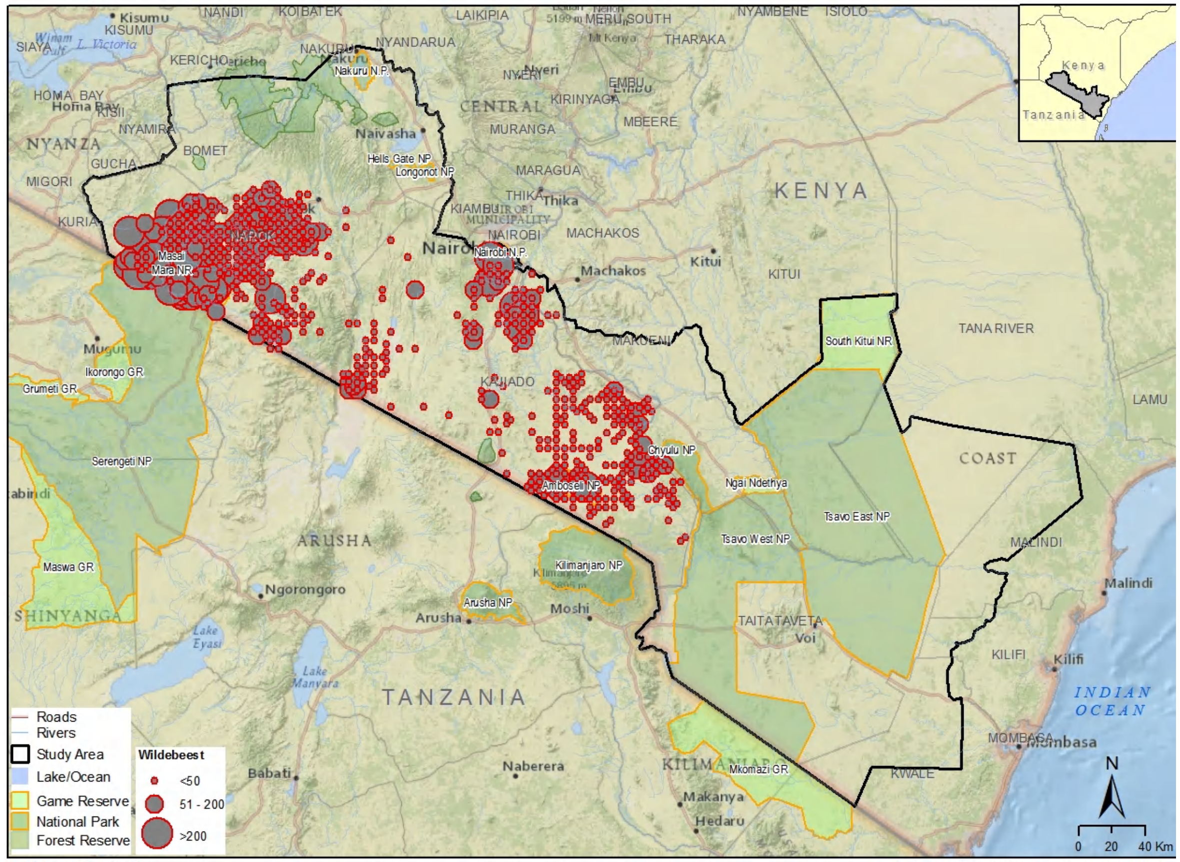
The wildebeest population in Kenya is found in the Mara, Amboseli, Nairobi National Park, Athi-Kaputei and South-Rift ecosystems with few groups widely scattered in central Kajiado (Map 5.1.5). The largest population occurs in the Masai Mara Ecosystem (MME) of about 167,000 wildebeest (average migratory and resident population), out of which 55% were found inside Masai Mara NR. High declines were observed in the resident wildebeest population in the MME (from 150,000 animals to just above 35,000 animals) due to the expansion of croplands into their wet season range.

In Kajiado the average wildebeest population was more than 21,000 animals, with 26% located inside the park and 74% outside (Table 5.1.1). In Machakos, 2,300 wildebeests were found in the ranches (outside protected areas). The heavy decline of wildebeest population from 30,000 to less than 5,000 in Athi-Kaputei ecosystem can be attributed to loss or fragmentation of their habitats due urban expansion, fences and settlements, blockage of migratory routes/corridors and poaching. The recent decline in the Amboseli wildebeest population was mainly due to a severe drought.

Plate 5.1.5(a): Resident wildebeests scramble for safety in a dry period, Kitengela area.

Plate 5.1.5(b): A large herd of wildebeest cut off by the steep edge of the Mara River crossover during a migration.

REGIONAL DISTRIBUTION OF SPECIES



Wildebeest Distribution

Source: DRSRS,AWF, ESRI-Nat-Geo World Map

Map 5.1.5: Regional distribution of wildebeest in southern Kenya rangelands (1978-2011).

5.1.6. Regional Distribution of Burchell's Zebra

The largest population of Burchell's zebra in the country resides in southern Kenya rangelands. The zebra range is almost similar to the wildebeest, but extends beyond the Amboseli ecosystem into Tsavo-Mkomazi ecosystem and the coastal counties of Kwale, Kilifi and Tana-River. The highest densities of zebras are observed in the Mara ecosystem (9.71 animals per km^2) and Amboseli ecosystem (7.11 animals per km^2). On average the Mara ecosystem had about 55,000 zebras with 31% located inside the protected area and 69% outside (Table 5.1.1)).

In Kajiado county the zebra population was 36,000 with 16% inside the park and 84% found outside. In Machakos the population was 2700 with 90% outside the park and similar to Tana-River where 88% was outside the park. It is only in Taita-Taveta where 73% of the 11,000 zebras were found inside the park (Table 5.1.1).

Generally, the regional trends of zebra show population declines, however the rate of decline is not as rapid as for the wildebeest. The zebras compete well with livestock as they can feed on low quality grasses. In the southern Kenya rangeland ecosystems, the population of zebras increases with sufficient rainfall in the preceding years.

Plate 5.1.6(a): Watch my back and I watch yours. Two zebras standing in alert position in an open grassland.

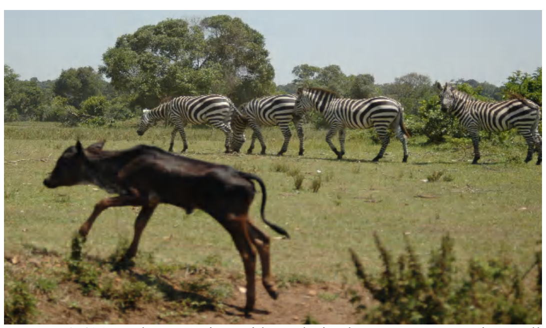
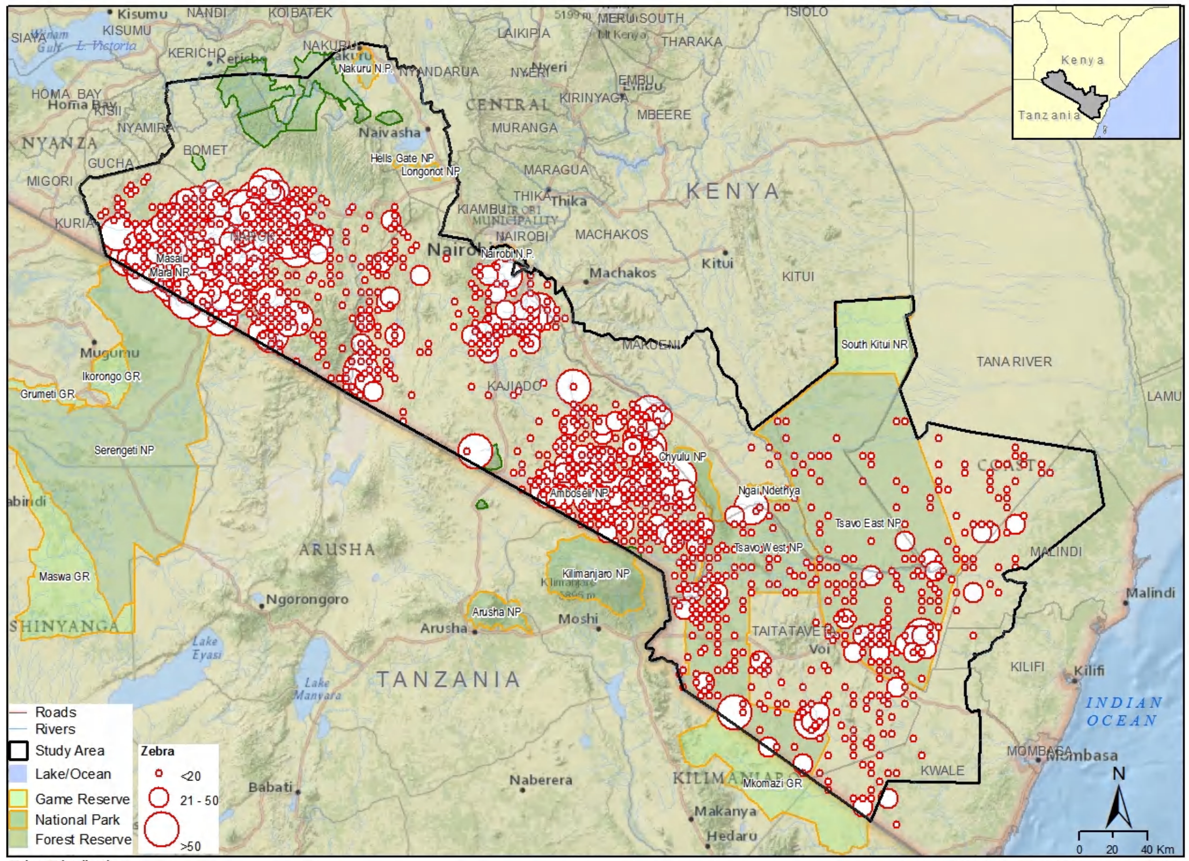


Plate 5.1.6(b): Zebras grazing with cattle in the Mara - competing well with livestock for water and forage. *Photo Courtesy: Gordon Ojwang'*

REGIONAL DISTRIBUTION OF SPECIES



Zebra Distribution

Source: DRSRS,AWF, ESRI-Nat-Geo World Map

Map 5.1.6: Regional distribution of plain's zebra in southern Kenya rangelands (1978-2011).

5.1.7. Regional Distribution of Elephant

The elephant population in the country is slightly above 30,000, of which more than a half is found in the southern Kenya rangeland ecosystems. The largest population occurs in the Tsavo-Mkomazi ecosystem. In the mid 1980s the elephant population was less than 8,000, but in the last 20 years the population has almost doubled to about 16,000 elephants.

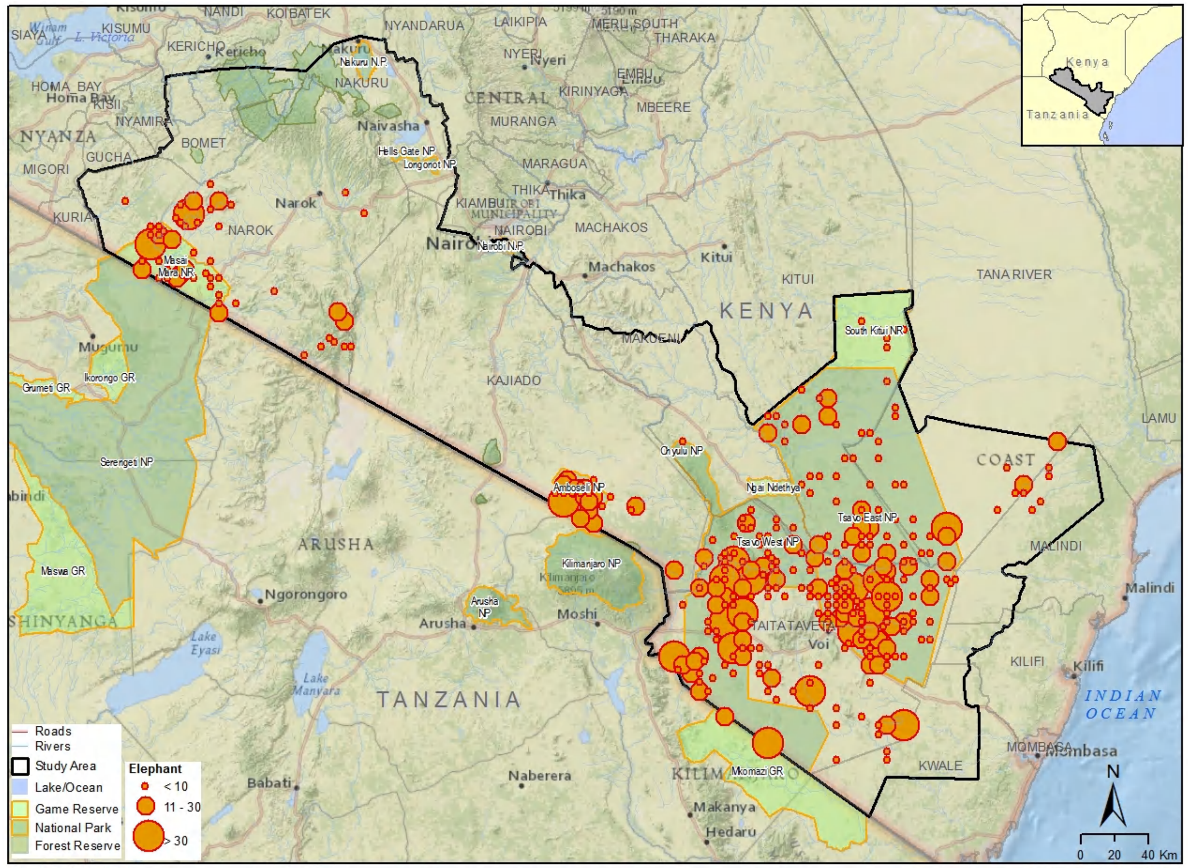
In Taita-Taveta, Kitui, Machakos and Tana River counties the elephants are found mostly in the parks. More than 80% of the elephants in Taita-Taveta County were found in the park. This is in contrast to Mara and Amboseli ecosystems where large populations occurred outside the park. In Narok and Kajiado counties, more than half (62% and 75%) of the elephants were found outside the park respectively (Table 5.1.1). Elephants moves widely outside the parks and may cause human-elephant conflicts including crop damage, vegetation and infrastructure destruction, injury or human death.

Although the elephant densities are high in the Masai Mara NR and Amboseli NP, they have lower elephant numbers due to small size of the protected areas. The recent large decline in the population of elephants in the southern Kenya rangelands have been mainly attributed to heavy poaching within the ecosystems and across the borders.

Plate 5.1.7(a): Elephant family (matriarch) in the Amboseli swamp. *Photo Courtesy: KWS/Joseph Mukeka*

Plate 5.1.7(b): Elephants headed for the lush shrubs in the Mara. *Photo Courtesy: AWF/Philip Muruthi*

REGIONAL DISTRIBUTION OF SPECIES



Elephant Distribution

Source: DRSRS,AWF, ESRI, Nat-Geo World Map

Map 5.1.7: Regional distribution of elephant in southern Kenya rangelands (1978-2011).

5.1.8. Regional Distribution of Giraffe

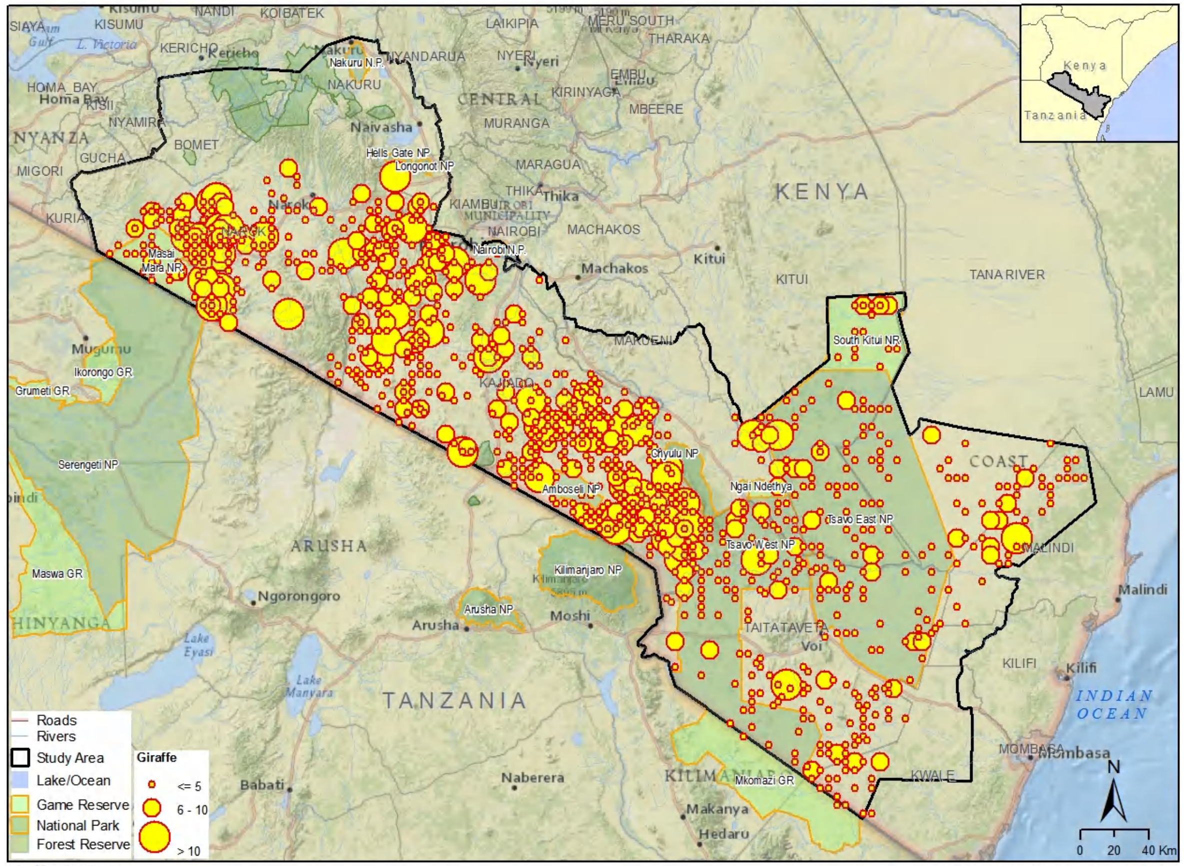
The giraffe is widely distributed through the southern Kenya rangeland ecosystems except in highlands and forested areas. In Kajiado, Narok, Machakos and Tana-River counties, the giraffes are mostly found outside the protected areas. Kajiado had the highest number of giraffes with Amboseli NP having a density of 0.73 animals per km^2 and average population of about 5,300 animals (Table 5.1.1).

In Taita-Taveta and Kitui counties the giraffes were found mostly inside the protected areas, while in Narok almost 84% were found outside. The giraffe key areas in the southern Kenya rangelands are outside the Mara NR in the Masai Mara Ecosystem, the Nguruman escarpment, Magadi area, Olochoro Onyore area, Kaputei North, Kimana, Kuku, Mbirikani, south east Amboseli, widely spread in the Tsavo ecosystem, Galana ranch and South Kitui NR (Map 5.1.7). The Athi-Kaputei ecosystem shows few observations, probably due to the fact that most the area has lost most of its riverine (Acacia) vegetation to charcoal burning or converted to other land uses. Furthermore, the decline of giraffe populations in its former range was attributed to habitat degradation and poaching.

Plate 5.11.4(a): A giraffe family in barren land. *Photo Courtesy: AWF/Philip Muruthi*

Plate 5.11.4(b): Masai giraffes and Acacia trees. *Photo Courtesy: AWF/Philip Muruthi*

REGIONAL DISTRIBUTION OF SPECIES



Map 5.1.7: Regional distribution m of giraffe in southern Kenya rangelands (1978-2011).

5.2. Ecosystem Patterns - Species Densities and Distribution

The southern Kenya rangeland ecosystems contain the highest abundance and diversity of large mammals in the country. It has extraordinary biodiversity of large mammals, which consist of the largest population of wildebeest, zebra, giraffe and elephant among other small antelopes.

We have investigated the distribution and trends of keystone species in the six study sites (ecosystems) namely: the Serengeti-Mara Ecosystem, Greater Lake Naivasha-Elementaita-Nakuru-Eburu Forest Conservation Area and Ecosystem, Nairobi National Park-Athi Kaputei Ecosystem, South Rift (Lake Natron-Magadi area), Amboseli-West Kilimanjaro Ecosystem and Tsavo-Mkomazi Ecosystem.

5.2.1. Distribution and Trends of Wildebeest in Mara Ecosystem

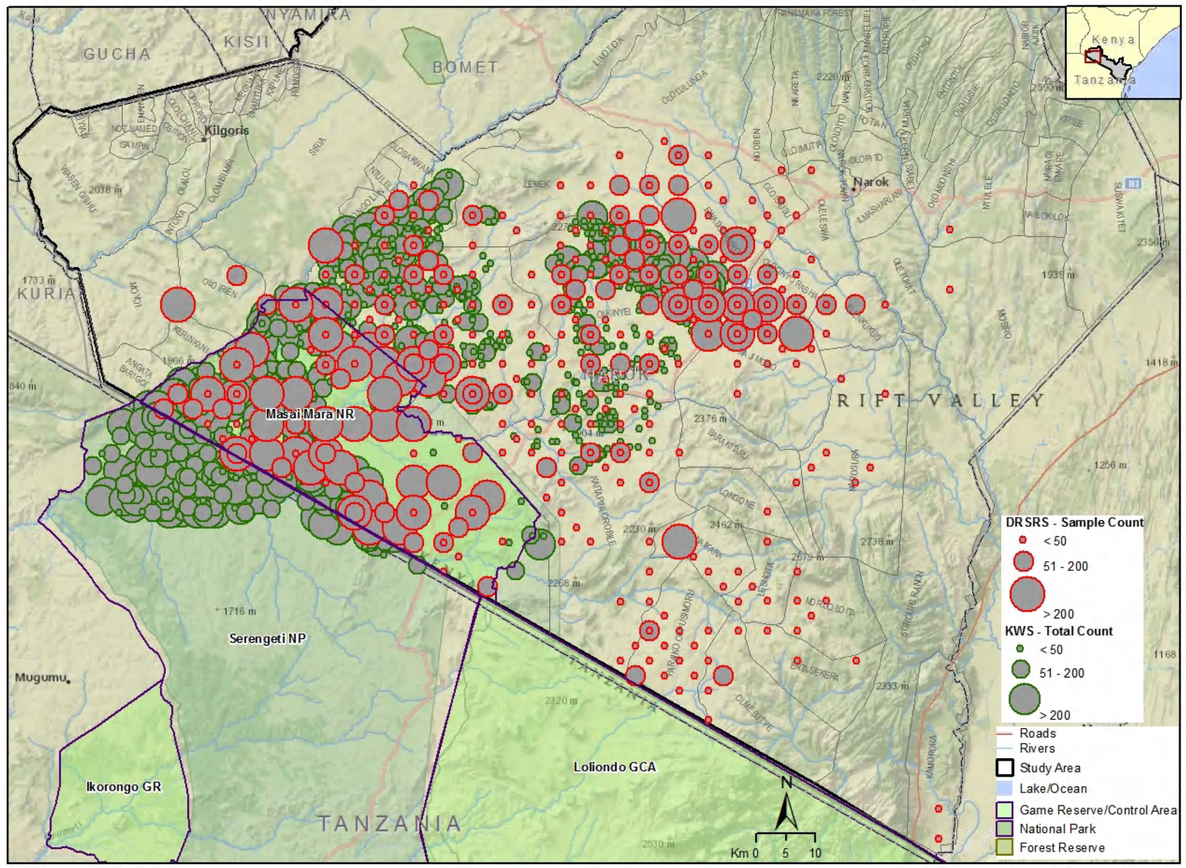
The Serengeti-Mara Ecosystem (SME) is home to some 1.3 million wildebeests and 0.6 million zebras and famous for its wildebeest migration. The wildebeest population crossing from Tanzania to Kenya during the migrations vary from 200,000 to 800,000. The main factor that determines both the annual movements and inter-annual variation in population has been assumed to be rainfall through its effect on food supply during the dry seasons (Mduma *et al,* 1999). The wildebeest migration to Kenya takes place between July and October with heavy utilization of the Masai Mara National Reserve (MMNR) and surrounding group ranches, conservancies and private lands.

There are two wildebeest populations that cover a smaller migration range within the Masai Mara Ecosystem (MME) - the Serengeti-Mara and Loita populations (Stelfox *et al*,. 1986). Serneels and Lambin (2001) found the population in Loita plains being driven mainly by the preceding dry and wet season rainfall. Loita plains is a wet season range and main calving ground for the wildebeest as it has high calcium required by the animals during lactation.

There exists a wide variation in the trends of wildebeest populations in the Serengeti and Mara ecosystems. The population in Serengeti had increased between 1961 and 1978 mainly due to the eradication of rinderpest, but the six fold increase between 1971 and 1977 was facilitated by the dry season rainfall that was consistently more than 250 mm per dry season. The Serengeti population has stabilized at 1.3 million wildebeests. In the Mara, the situation was different, in the late 1970s where the resident wildebeest population was 150,000 animals, which had declined to about 33,000 in 2001 (Serneels and Lambin, 2001). The recent (2011) surveys show a slight increase in the wildebeest population of about 38,000 animals (Ogutu *et al*, 2011).

In the Mara, the main driver of wildebeest's population decline is the development of large-scale mechanised agriculture (wheat farming) in the Loita plains in 1980s and 1990s. The recent abandonment of wheat farms and reverting these areas for grazing by wildlife and livestock have once again led to the recovery of wildebeest populations. The expansion of crop cultivation in wildlife areas is a major threat to conservation. The imminent blockage of wildebeest, elephant and zebra corridors in the Loita is still very high due to pastoralist's sedentarization.

SPECIES DISTRIBUTION AND TRENDS IN THE MARA ECOSYSTEM



Wildebeest Distribution

Source: DRSRS, KWS, ESRI, Nat-Geo World Map

Map 5.2.1: Aggregated distribution of wildebeest in the Mara Ecosystem and northern Serengeti in the period 1978-2011.

5.2.2. Distribution and Trends of Burchell's Zebra in Mara Ecosystem

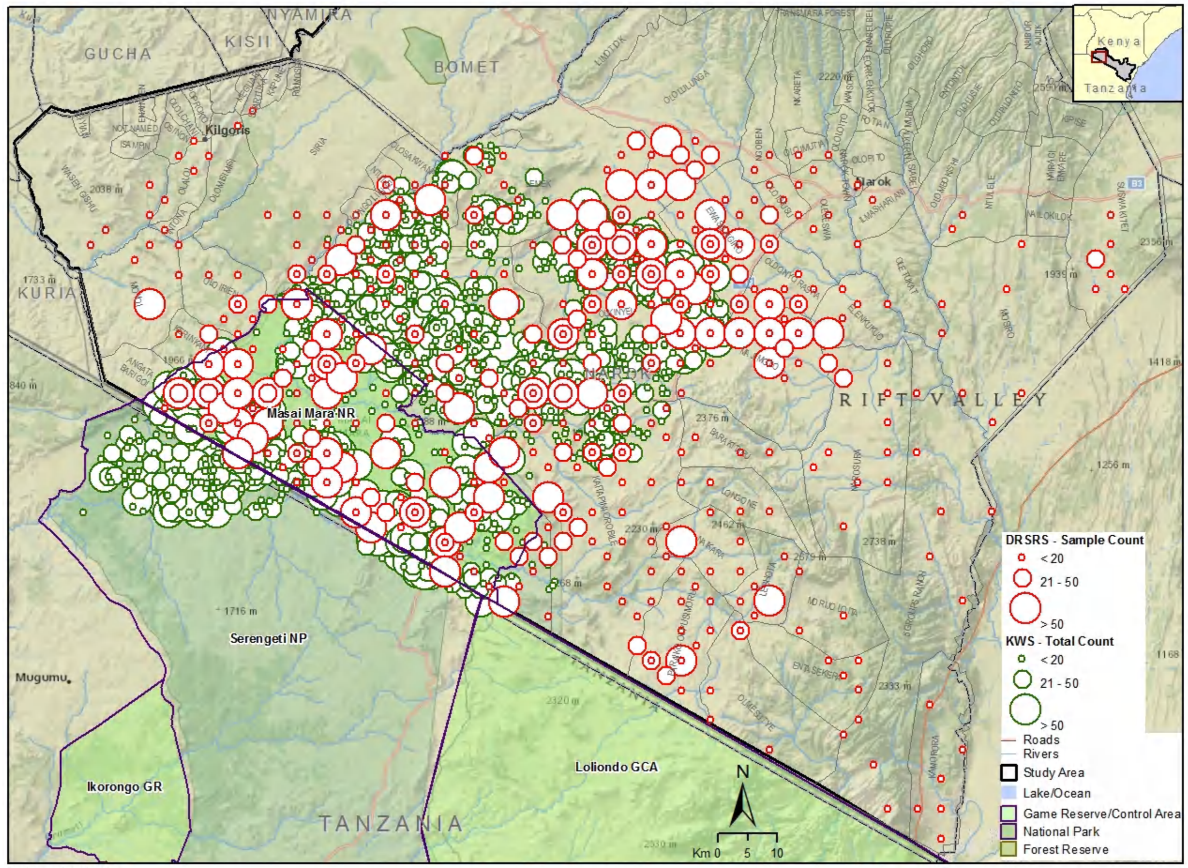
Masai Mara Ecosystem has the highest population of Burchell's zebra in Kenya. The occupancy pattern of zebra in the Mara is similar to the wildebeest as the two species are highly correlated. However, the zebras are more widespread outside the protected area than the wildebeest (see also table xxx). The zebras utilize the Masai Mara National Reserve more during the dry season (July - October) and the adjacent ranches in the wet season (February - May). During the migration both zebras and wildebeests graze the tall grasses creating lawns of short grass. This process facilitates the utilization of short grasses by medium and small size antelopes in the ecosystem. However, wildebeests maybe more sensitive than zebras as their dietary requirement differ given their morphological differences.

The population trends of zebra in the Mara show declining numbers for both the resident and migratory animals. In the late 1970s the resident population averaged 65,000 zebras, and by the early 1980s their numbers had reduced to 47,000 animals, which had declined further to 37,000 by early 1990s. In the late 2000s the population was 36,000 zebras. The decline in population outside the protected area was low (37%) compared to about 76% inside the reserve. In the dry season, a high decline (60%) was observed outside the protected areas and low (41%) inside the reserve. In the late 1970s, the migratory zebra population was about 77,000 animals, which declined to slightly above 40,000 in 2000s (2007-2009).

The plain's zebra is much widely distributed in the Masai Mara Ecosystem (MME) as compared to wildebeest or any other large wildlife species. They are widespread in the entire Narok County, which is mainly composed of shrub savannah except to the north of Naivasha-Narok-Bomet Road and Transmara area occupied by highland agriculture (Map 5.2.2). This is because the zebra can sustain itself on low quality diet than any other grazing ruminant since it has a hind gut. Studies on the dietary requirement of wildlife in the MME indicate that zebra, wildebeest, topi and Thomson's gazelle have a high dietary overlaps. However, they are separated spatially for most of the year, except in the wet season (Hansen *et al*, 1985). Zebras occur in high densities in the dwarf shrubland and grassland of the Loita plains in May and by November they evenly spread out in all the habitats except in the agricultural areas.

As more grazing areas are being lost to agriculture, the zebras will increasingly compete with other wildlife grazers as well as livestock. Already the Masai Mara Ecosystem is experiencing an increasing expansion of crop cultivation land and high livestock densities due to pastoralist sedentarization.

SPECIES DISTRIBUTION AND TRENDS IN THE MARA ECOSYSTEM



Zebra Distribution

Source: DRSRS, KWS, ESRI, Nat-Geo World Map

Map 5.2.2: Aggregated distribution of common zebra in the Mara Ecosystem and northern Serengeti in the period 1978-2011.

5.2.3. Distribution and Trends of Elephant in the Mara Ecosystem

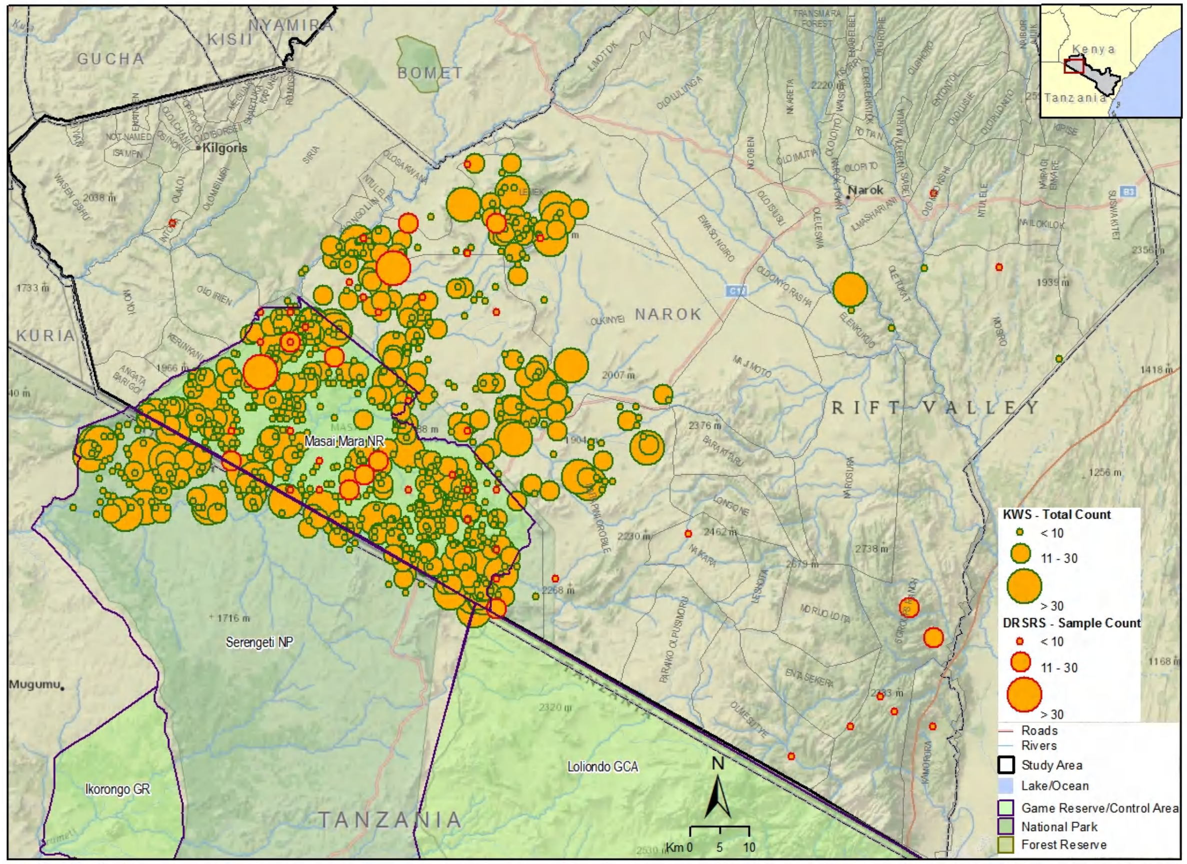
The elephant is keystone species that helps in modifying the savannah landscape of East Africa. In the Serengeti-Mara Ecosystem (SME) elephants have played a major role in opening up the woodlands into shrubland and grasslands. It has been hypothesized that elephants and fire are the cause of multiple stable state of the Serengeti-Mara woodlands. Dublin *et al*, (1990) indicate that fire was the perturbation which changed the state of vegetation - the increased rate of burning followed increased human population and the reduction of wildebeest numbers, but once the woodland densities were reduced to enough low levels, the elephants were able to keep the vegetation in grassland state.

The trends and distribution of elephants in the Masai Mara Ecosystem (MME) have changed over the last 50 years. In the mid 1980s there were about 850 elephants in the Mara, which were widely distributed but contained almost exclusively within the reserve (Dublin and Douglas-Hamilton 1987; DRSRS long-term datasets). The Mara elephant population in the mid 1980s was 19% higher than the mean numbers reported for the period 1965-1977. However, the total for northern Serengeti was 52% lower than the mean of 1404 for the same period (Dublin and Douglas-Hamilton, 1987). This difference was mainly driven by heavy poaching in the Serengeti. The carcass ratio in the Serengeti was 38% and in the Mara was 5%. The high poaching activities drove some of the elephants to the Masai Mara NR, which was more secure as indicated by the high increase in elephant population in the early 1990s (Dublin-Hamilton 1987; supported by DRSRS data on elephants in the Mara).

The distribution range of elephants in the Masai Mara Ecosystem has expanded from the 1980s, 1990s and 2000s. Elephants are found both inside the reserve and outside in group ranches, with high densities occurring in the north-west of the reserve (Map 5.2.3). The elephant population has declined in the entire ecosystem, with the possibility of some animals having moved back into the Serengeti. The movement of elephants between the Masai Mara NR and Serengeti NP is assured by its movement in- and outside the reserve, although elephants face a number of challenges. These include continued human-elephant conflicts which have sometimes led to crop damage, human injury and deaths, as well as the killing of rogue elephants, and poaching..

There is need to secure large areas for elephants as they are wide ranging and require large quantities of forage material and water. However, there is also need to contain the numbers of elephants not to exceed the carrying capacity of an area. This could be done through translocations of elephants to other suitable habitats with fewer animals.

SPECIES DISTRIBUTION AND TRENDS IN THE MARA ECOSYSTEM



Elephant Distribution

Source: DRSRS, KWS, ESRI, Nat-Geo World Map

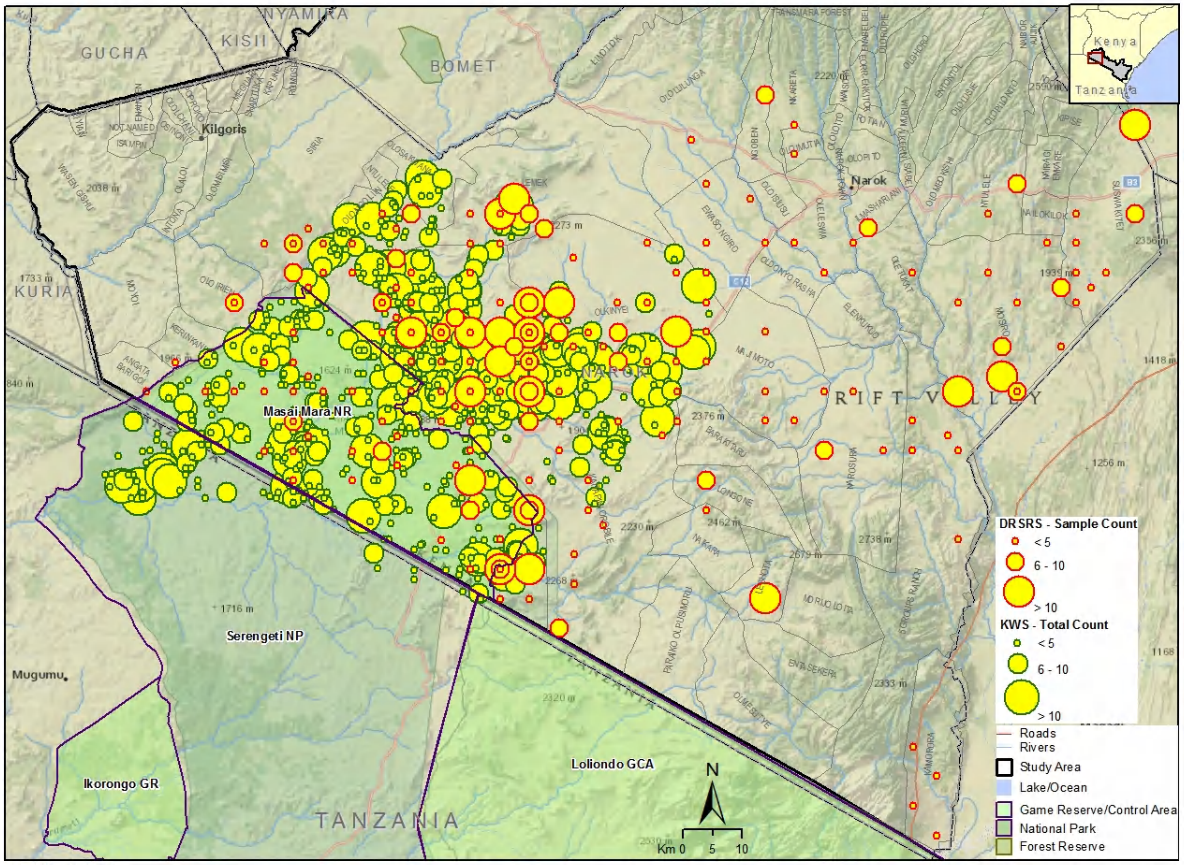
Map 5.2.3: Aggregated distribution of elephant in the Mara Ecosystem and northern Serengeti in the period 1978-2011.

5.2.4. Distribution and Trends of Giraffe in the Mara Ecosystem

The Maasai giraffe is found in the southern Kenya rangelands (Maasai Mara, Athi-Kaputei, Amboseli, Tsavo ecosystems) and throughout Tanzania. The populations of Maasai giraffe have remained relatively stable although reports highlights that their numbers have suffered in recent years (KWS website).

Studies at ILRI found that the population of the Maasai giraffe in the Mara fell by up to 95% between 1989 and 2003 due to the rapid expansion of human settlements around the unfenced protected area the reserve. The area has been traditionally used by wild animals for seasonal grazing but has increasingly been converted to livestock husbandry and crop production.

The giraffes in the Mara strongly prefer the pastoral savanna. According to the 2002 surveys carried out by ILRI, there were more than twice as many giraffe in the group ranches than in the reserve in both 1999 and 2002 (Reid *et al*. 2003). Most of the giraffes occurred in the tsetse-infested belt of Acacia woodlands about 7-10 Km north of the reserve, while those in the reserve clustered along the riverine areas - the only places with significant numbers of trees.



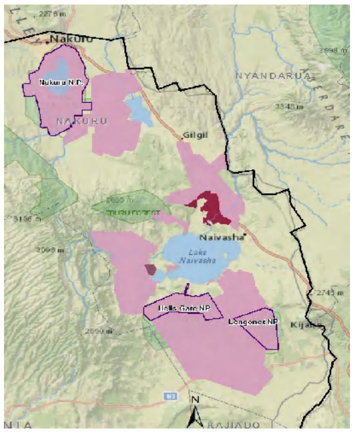
Giraffe Distribution

Source: DRSRS, KWS, ESRI, Nat-Geo World Map

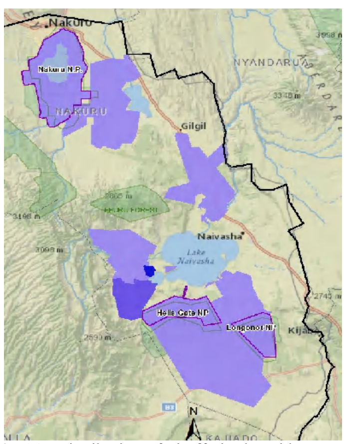
Map 5.2.4: Aggregated distribution of giraffe in the Mara Ecosystem and northern Serengeti in the period 1978-2011.

5.2.5. Distribution of Buffalo, Zebra and Maasai Giraffe in Lake Naivasha, Elementaita, Nakuru and Eburu Forest Conservation Area

The Mau-Eburu forest is one of the 22 gazetted forest blocks that comprise the vast 420,000 Ha of Mau Forest Complex. It forms part of the conservation and ecology ecosystem stretching from Lakes Nakuru, Eburu forest, Naivasha National Park, the Soysambu Conservancy, Longonot and Hells Gate National Parks. The Eburu forest covers 8715.3 Hac of prime indigenous forest with the highest peak - Ol Doinyo Eburu (2,820m a.s.l. forms part of the catchment for Lakes Naivasha and Elementaita.

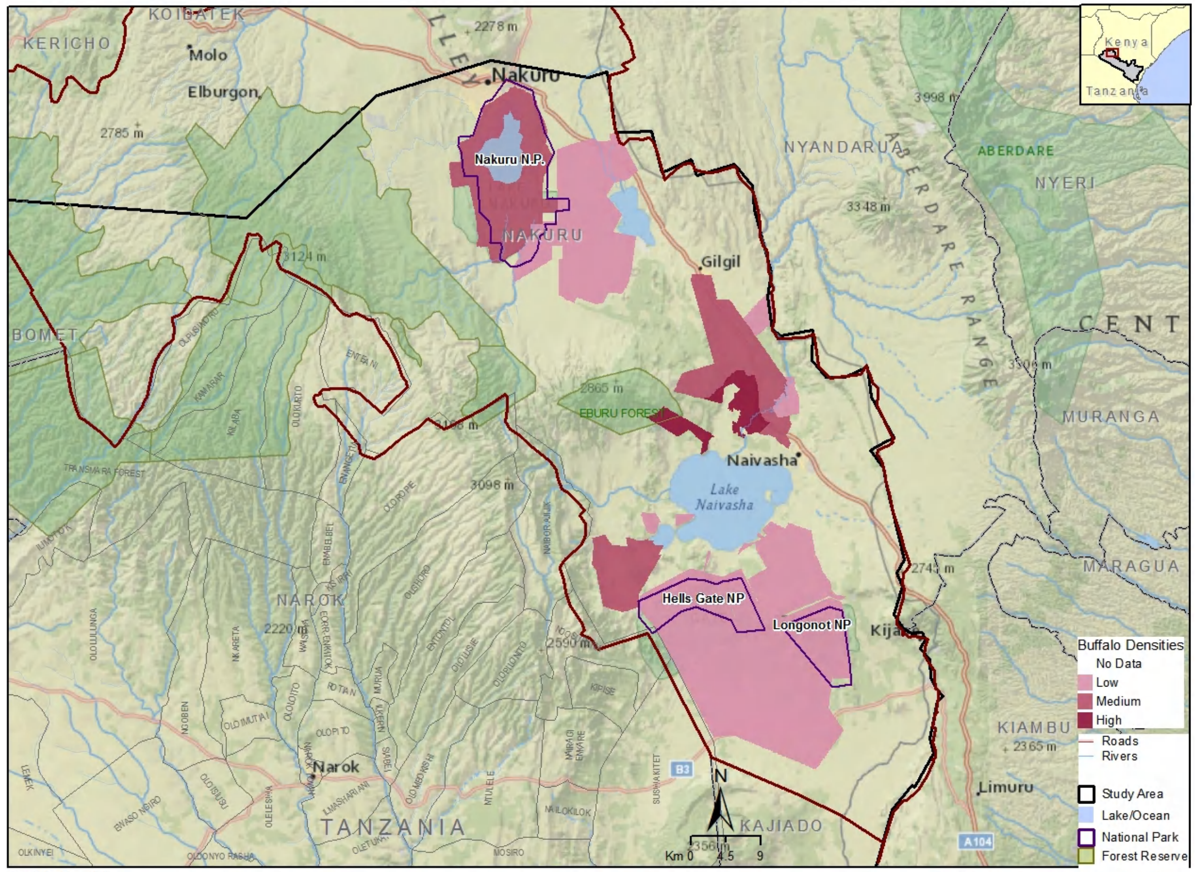


Map 5.2.5(a): Distribution of zebra in the wider conservation and ecology ecosystem.



Map 5.2.5(b): Distribution of giraffe in the wider conservation and ecology ecosystem.

SPECIES DISTRIBUTION IN THE WIDER LAKE NAIVASHA, ELEMENTAITA, NAKURU AND EBURU FOREST CONSERVATION AND ECOSYSTEM



Buffalo Densities

Source:KWS, ESRI, Nat-Geo World Map

Map 5.2.5(c): Density distribution of buffalo in the wider Lake Naivasha, Eburu Forest, Elementaita and Nakuru Ecosystem.

The area features a diversity of flora including various tree species such as Acacia, Allophylus (*Mucami*), Bamboo, Buddleia (*Ruti*), Dombeya (*mukeu*), Dovyalis (*Mukambura*), Ekebergia (*Mununga*), Galiniera (*Mucina-Nguku*), Juniperus (*Mutarakwa*), Maesa (*Mundonye*), Maytenus, Nuxia (*Mucorui*), Olea (*Mucarage*), Olinia (*Mwathathia*), Podocarpus (*Muthengera*), Polyscias (*Mutati*), Prunus (*Muiri*), Rapanea (*Mugaita*), Schefflera (*Muthai*), Solanum (*Githua*), Tarchoranthus, Vernonia (*Muthakwa*), etc.

There are several wildlife species in the wider conservation and ecosystem including the buffalo, zebra, giraffe and the endangered eastern mountain bongo. High densities of plain's zebra are found in Marula (Map 5.2.5a) and giraffe in the western tip of Lake Naivasha (Map 5.2.5b). The rest of the area depicts variable densities. High densities of buffaloes occur in Loldia and Marula areas, while Lake Nauru NP and Kekopey has medium densities and Conclave, Soysambu, Hell's Gate NP, Longonot NP and Kedong depicts low densities (Map 5..2.5c).

5.2.6. Distribution and Trends of Wildebeest in the Athi-Kaputei Ecosystem

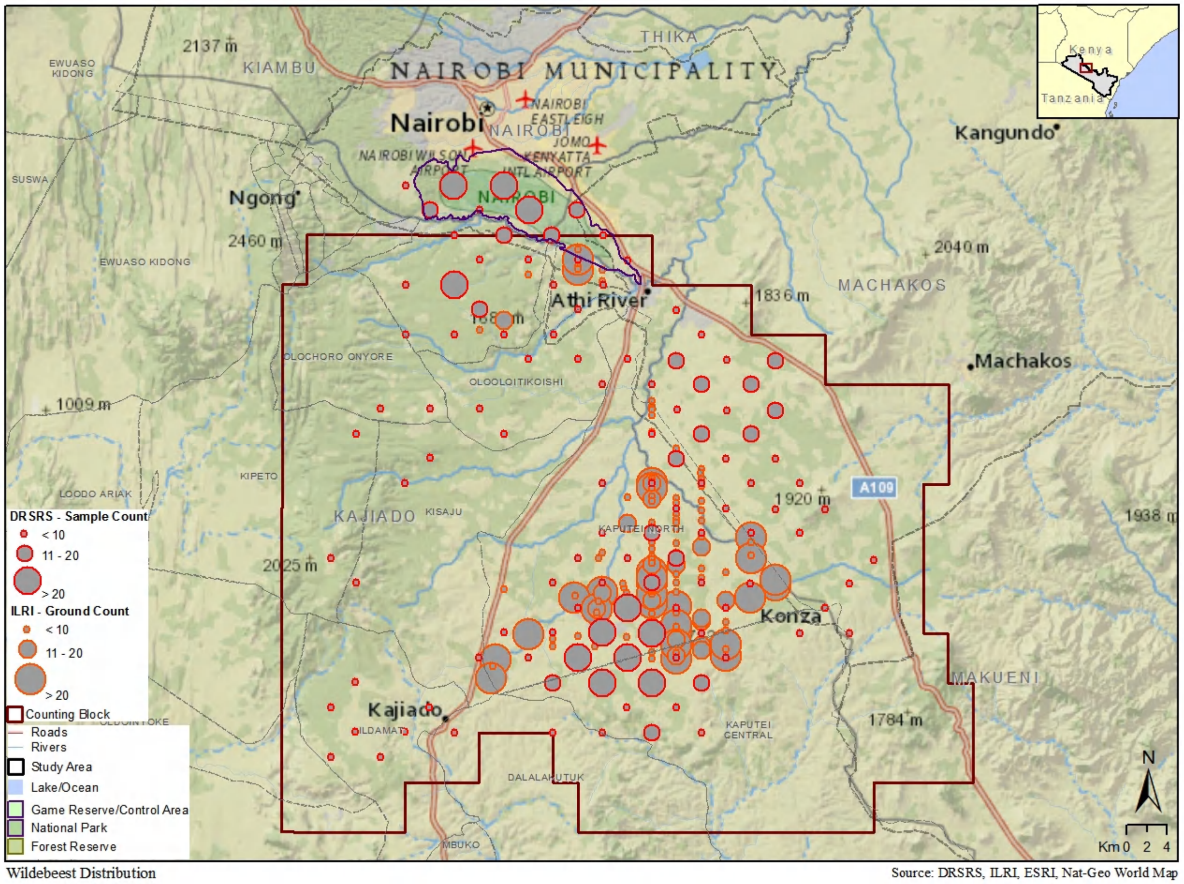
The Athi-Kaputei ecosystem is comprised of Nairobi National Park and Kitengela area and covers about 2,000 km^2, with park covering 114 km^2. In the 1970s, it contained the second largest wildebeest population (around 30,000 animals) in the country (Ogutu *et al*. submitted), but this population has since declined to less than 4,000 (DRSRS, 2011 census). The Athi-Kaputei ecosystem wildebeests and zebras migrate between Nairobi NP and calving grounds in the Athi-Kapiti plains. Nairobi NP is the dry season refuge for a number of large wild herbivores including eland, kongoni, Thomson's gazelle and impala.

The wildebeest migration between Nairobi NP and Athi-Kapiti plains seem to have collapsed from 1961 to 2009, when their population of 5000-10000 had declined to less than 800 animals in 2001-09 (Ogutu *et al*. submitted). A number of corridors linking Nairobi NP and calving grounds in Enkirigirr (Kaputie North) have either been lost to settlements and subdivisions or totally blocked by fences that have curtailed movements.

Historically, the Athi-Kapiti plains provided the corridors for migration and wet season grazing areas for large herds of wildebeests and zebras. The important wildebeest areas border the park, the calving zone in Enkirigirr and Machakos ranches (Map 5.2.6). The current land use change, fencing of properties (more than 20% of the area is now fenced), urban development and gypsum mining have adversely affected wildebeest populations in the ecosystem (Ogutu, *et al* - submitted, Said, *et al* - submitted).

Further collapse of the wildebeests in the Athi-Kaputei ecosystem is imminent unless immediate action is taken to save them by connecting the populations in Nairobi National Park, Enkirigirr and Machakos ranches.

SPECIES DISTRIBUTION AND TRENDS IN THE ATHI-KAPUTEI ECOSYSTEM (NAIROBI NP – KITENGELA AREA)



Map 5.2.6: Aggregated distribution of wildebeest in Nairobi NP and Athi-Kaputei Ecosystem in the period 1978-2011.

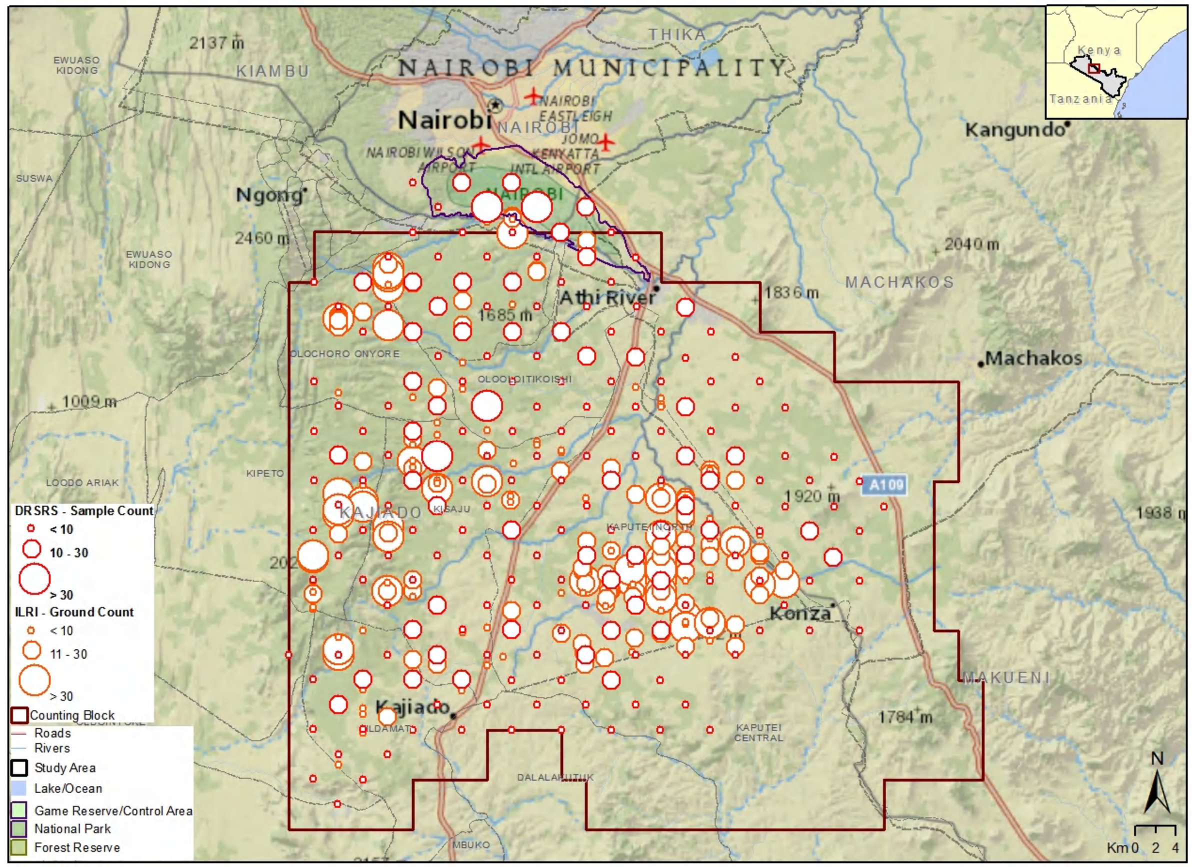
5.2.7. Distribution and Trends of Plain’s Zebra in the Athi-Kaputei Ecosystem

The Athi-Kaputei hosts a large population of plain’s zebra, which are widely distributed throughout the ecosystem. Large groups of zebras were observed around Konza in Kaputei North - the same range where a large concentration of wildebeests also occurred (DRSRS sample and ILRI ground counts). A large population of zebras was also observed along the escarpment on the western sector of the ecosystem and medium densities in Machakos ranches and the south of Nairobi National Park (Map 5.2.7).

The trends of zebra in Athi-Kaputei ecosystem show an increase in population from about 5000 in 1977 to 18,000 animals in 1992. This increase was attributed to high rainfall in the 1980s, but the decline of zebras in other parts of the ecosystem is attributed to increasing fences, high livestock densities, and high incidences of illegal hunting. The decline in zebra population in the ecosystem has not been as rapid as that of the wildebeest due to their high mobility, non-ruminant and bulk feeding style that enables them to utilize poor quality forage (Owaga, 1975).

The pattern of zebra migration between Nairobi National Park and Athi-Kapiti plains is similar to the wildebeest. The zebra population is higher in side the park during the dry season (August-October) than in the wet season. The population had reached high peaks in Nairobi NP during the droughts of 1993, 1996-97, 1999-2000, 2005-2006 and 2008-2009 (Ogutu *et al*. submitted).

SPECIES DISTRIBUTION AND TRENDS IN THE ATHI-KAPUTEI ECOSYSTEM (NAIROBI NP – KITENGELA AREA)



Zebra Distribution

Source: DRSRS,ILRI, ESRI, Nat-Geo World Map

Map 5.2.7: Aggregated distribution of zebra in Nairobi NP and Athi-Kaputei Ecosystem in the period 1978-2011.

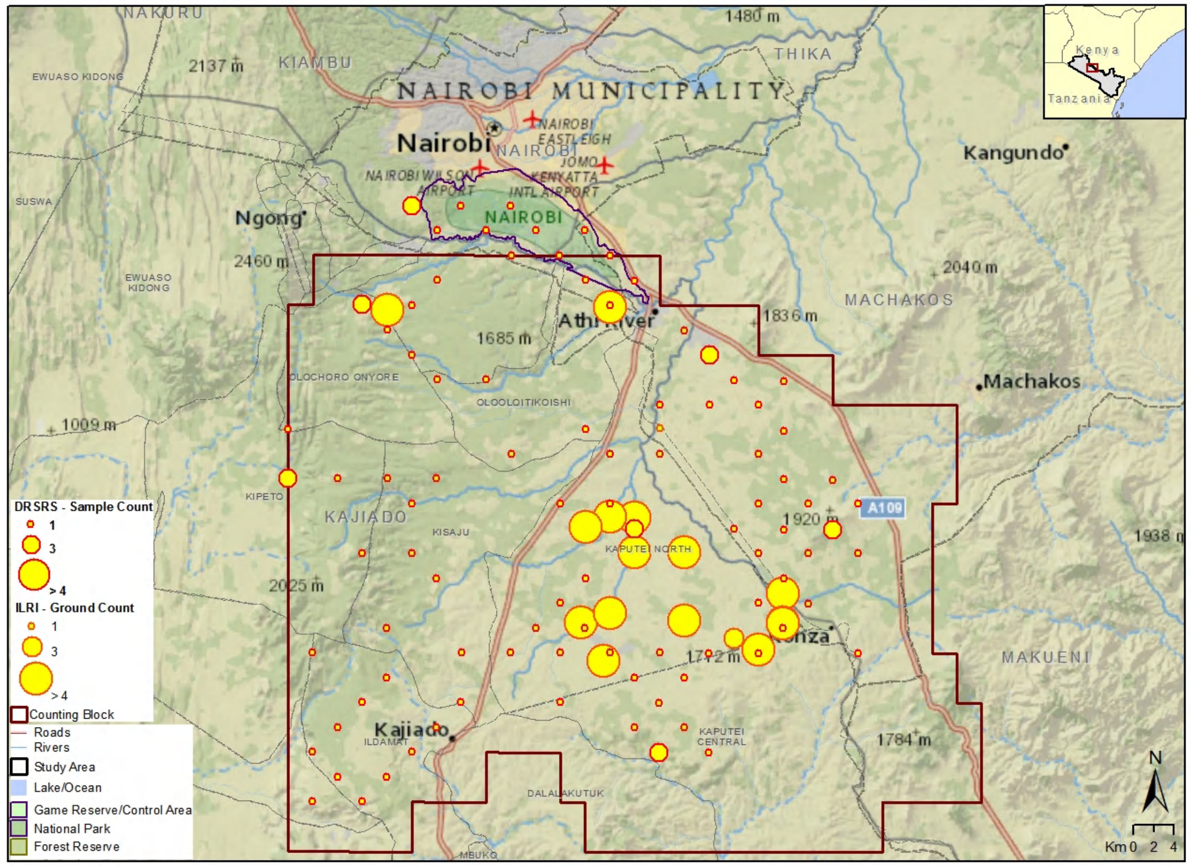
5.2.8. Distribution and Trends of Giraffe in the Athi-Kaputei Ecosystem

The long-term distribution of giraffe in the Athi-Kaputei shows widespread distribution in the entire ecosystem. High population densities were observed in Kaputei North and around Konza and low numbers occurred in the Nairobi NP and Machakos ranches (FoNAP, local communities and ILRI ground count in 2011). Most of the giraffe population was found near the rivers, which supports high concentration of riverine trees and shrubs.

The giraffe population in Athi-Kaputei ecosystem was over 800 animals in the 1970s, but has drastically declined in the more recent years. The giraffe show high sensitivity to change in their environment and the recent land use change in its range has affected the populations, in addition to heavy poaching for their meat and skin. The giraffe numbers inside Nairobi NP (estimated as more than 100 animals) has shown a stable population, however their numbers outside the park shows one of the largest decline in the southern Kenya rangelands.

Apart from the effects of land use change and poaching, the abundance of giraffe in the region does not vary between months and independent of seasonality. Ogutu *et al*. (2008) has shown that the number of newborns giraffes in the Mara-Serengeti ecosystem was best correlated with the late dry-season rainfall averaged over the preceding 5 years, but older giraffes were correlated with the wet-season rainfall averaged over 1-5 years.

SPECIES DISTRIBUTION AND TRENDS IN THE ATHI-KAPUTEI ECOSYSTEM (NAIROBI NP – KITENGELA AREA)



Giraffe Distribution

Source: DRSRS, ILRI, ESRI, Nat-Geo World Map

Map 5.2.8: Aggregated distribution of giraffe in Nairobi NP and Athi-Kaputei Ecosystem in the period 1978-2011.

5.2.9. Distribution and Trends of Wildebeest in South Rift, Amboseli and West Kilimanjaro Area

The Amboseli National Park and adjacent ranches, Kaputei South, Mbirikani, Kuku, Kimana and Shompole are the key wildebeest areas in the South Rift and greater Amboseli ecosystem. Small herds are also widely scattered in Kajiado County (Kenya) with concentrations near Lake Natron and west of Kitu Hills in Tanzania.

In the late 1970s, over 50,000 wildebeests were found in Kajiado County, but this population had reduced to almost half (27,740) by the late 1980s (Ojwang' *et al*., 2006). In the early 1990s the wildebeest population had slightly increased to around 31,480 animals, but again declined to 24,496 animals in the late 1990s. The population had almost stabilized throughout the rest of 1980s and early 1990s but drastically reduced to 13,679 animals by 2000. The recent survey indicates that wildebeests were the third most abundant wildlife species in the South Rift, Amboseli and West Kilimanjaro (KWS, 2010). A total of 7,240 wildebeests were observed with the highest density found in the Amboseli region.

The Amboseli wildebeest population was about 3,098 animals in 2010, which was the lowest observed in more than 30 years (KWS, 2010). The 2009 drought, which was the severest in the country in more than 40 years, had a devastating impact on both wildlife and livestock populations (Western, 2010). The wildebeest population in Amboseli ecosystem almost collapsed as populations in the larger landscape had drastically reduced from 18,538 animals observed prior to the drought (KWS, 2010).

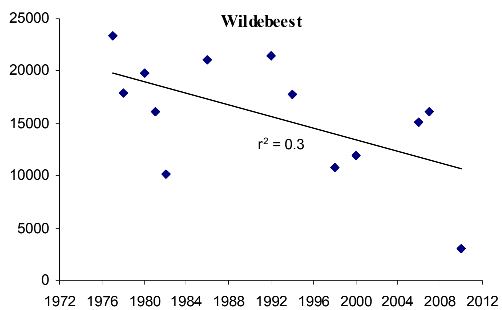
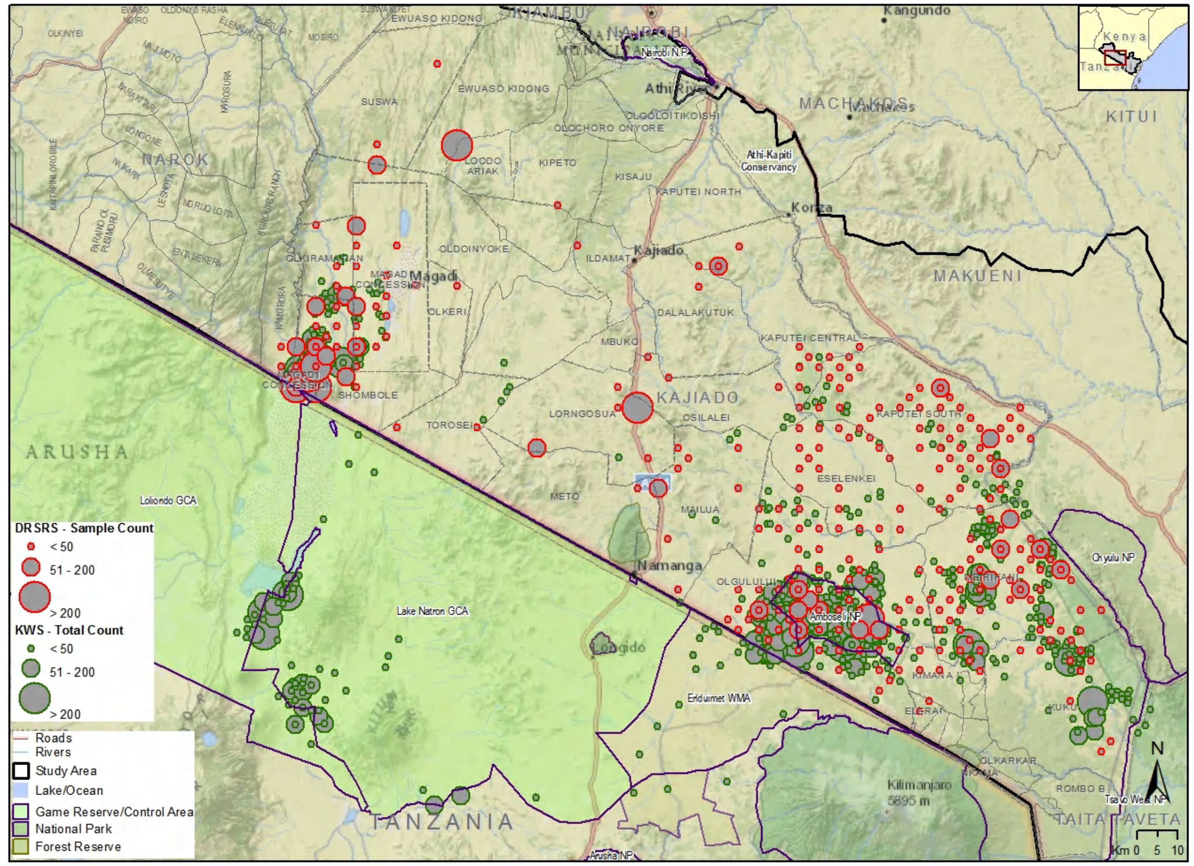


Figure 5.2.9: Trends of wildebeest in the Amboseli. *Source - DRSRS datasets*

SPECIES DISTRIBUTION AND TRENDS IN SOUTH RIFT, AMBOSELI ECOSYSTEM AND WEST KILIMANJARO AREA



Wildebeest Distribution

Source: DRSRS, KWS, AWF, TAWIRI, ESRI, Nat-Geo World Map

Map 5.2.9: Aggregated distribution of wildebeest in Amboseli Ecosystem, Athi-Kaputei, Magadi area and West Kilimanjaro in the period 1978-2011

5.2.10. Distribution and Trends of Plain's Zebra in South Rift, Amboseli and West Kilimanjaro Area

Burchell's zebras are widely distributed in Kajiado County (Kenya) and west Kilimanjaro region (Tanzania), with large concentration in the greater Amboseli ecosystem, Kaputei South, Shompole and Magadi concession areas. A large and widely scattered group occurs around Lake Natron GCA and Enduimet WMA in Tanzania.

Kajiado County contains the second largest resident population of plain's zebra in the country, where almost 24,630 animals were observed in the early 1980s (Ojwang' *et al*. 2006). This population had declined by 2010 to 13,740 zebras in the Amboseli and surrounding areas (KWS, 2010). The report indicates that among the four survey areas - Magadi had the highest population density (0.70/km^2), followed by Amboseli (0.68/km^2), Natron (0.45/km^2) and West Kilimanjaro (0.23/km^2). The impact of 2009 drought had a devastating impact to the zebra population. Furthermore, the range of zebra coincides with cattle, and there is high probability of competition for forage and water resources between the two species.

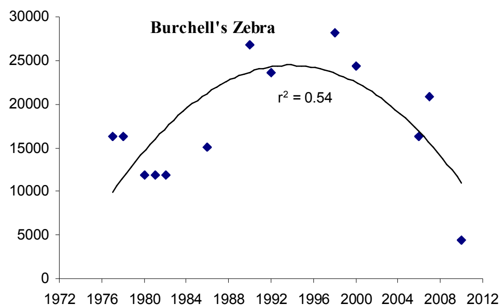
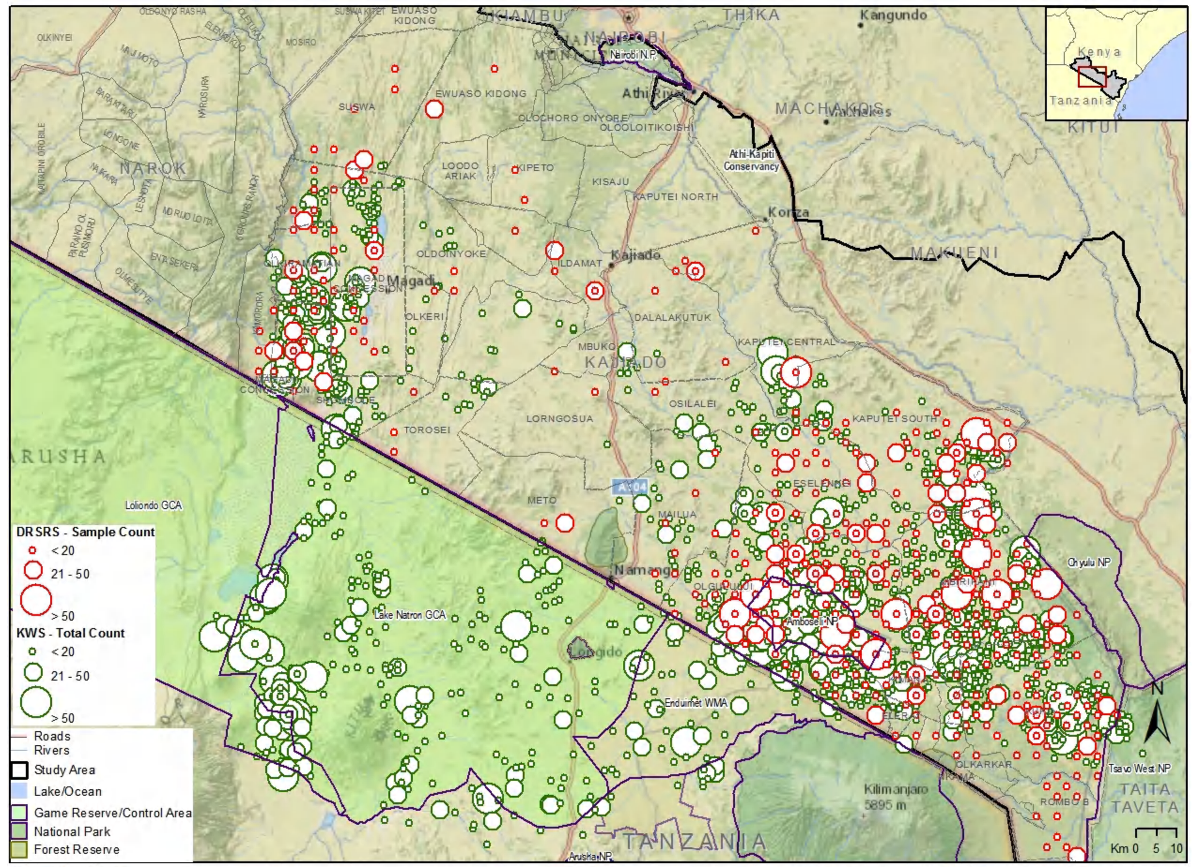


Figure 5.2.10: Trends of Burchell's zebra in Amboseli. *Source - DRSRS datase*

SPECIES DISTRIBUTION AND TRENDS IN SOUTH RIFT, AMBOSELI ECOSYSTEM AND WEST KILIMANJARO AREA



Zebra Distribution

Source: DRSRS, KWS, AWF, TAWIRI, ESRI, Nat-Geo World Map

Map 5.2.10: Aggregated distribution of common zebra in Amboseli Ecosystem, Athi-Kaputei and Magadi area, and west Kilimanjaro in the period 1978-2011.

5.2.11. Distribution and Trends of Elephant in South Rift, Amboseli and West Kilimanjaro Area

The elephant distribution in the South Rift, Amboseli and West Kilimanjaro shows four important ranges - Amboseli, Kimama-Elarai, Mbirikani-Chyulus, Kamorora-Olkiramatian and Enduimet WMA. Elephants mainly use the Amboseli NP and surrounding group ranches including Olgulolui, Elarai, Kuku, Kimana and Mbirikani. Few herds also occur in Enduimet WMA and Lake Natron GCA in Tanzania.

The Amboseli elephant is a subject of long-term studies by many research organizations and their population is well documented (Western and Lindsay 1984, Kioko *et al*. 2006). In the 1970s and 1980s the elephant population in the Amboseli was less than 1,000 animals (DRSRS data; Said *et al*. 1995), but since 1990s the population has steadily continued to increase. Recent surveys show a relatively stable elephant population in the region with an averaged mean of slightly above 1,000 animals. The estimated populations were 1,087, 1,090, 967 and 1,266 in 2000, 2002, 2007 and 2010 respectively (KWS 2010).

The elephants in Amboseli traverse wide areas and make seasonal movements outside the park (KWS, 2010). The movements from Amboseli to other areas including Tsavo, Chyulu, Magadi, Nguruman, West Kilimanjaro and Lake Natron GCA has been mapped by radio collared elephants (KWS, 2010). The threats to Amboseli elephants include displacement by people through habitat conversion, impacts of recurrent droughts and poaching.

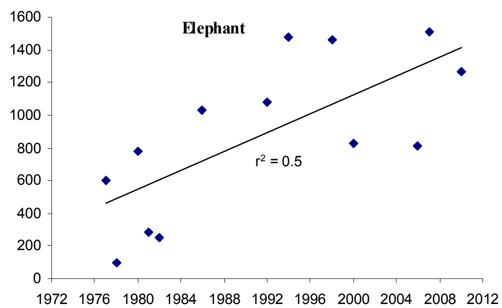
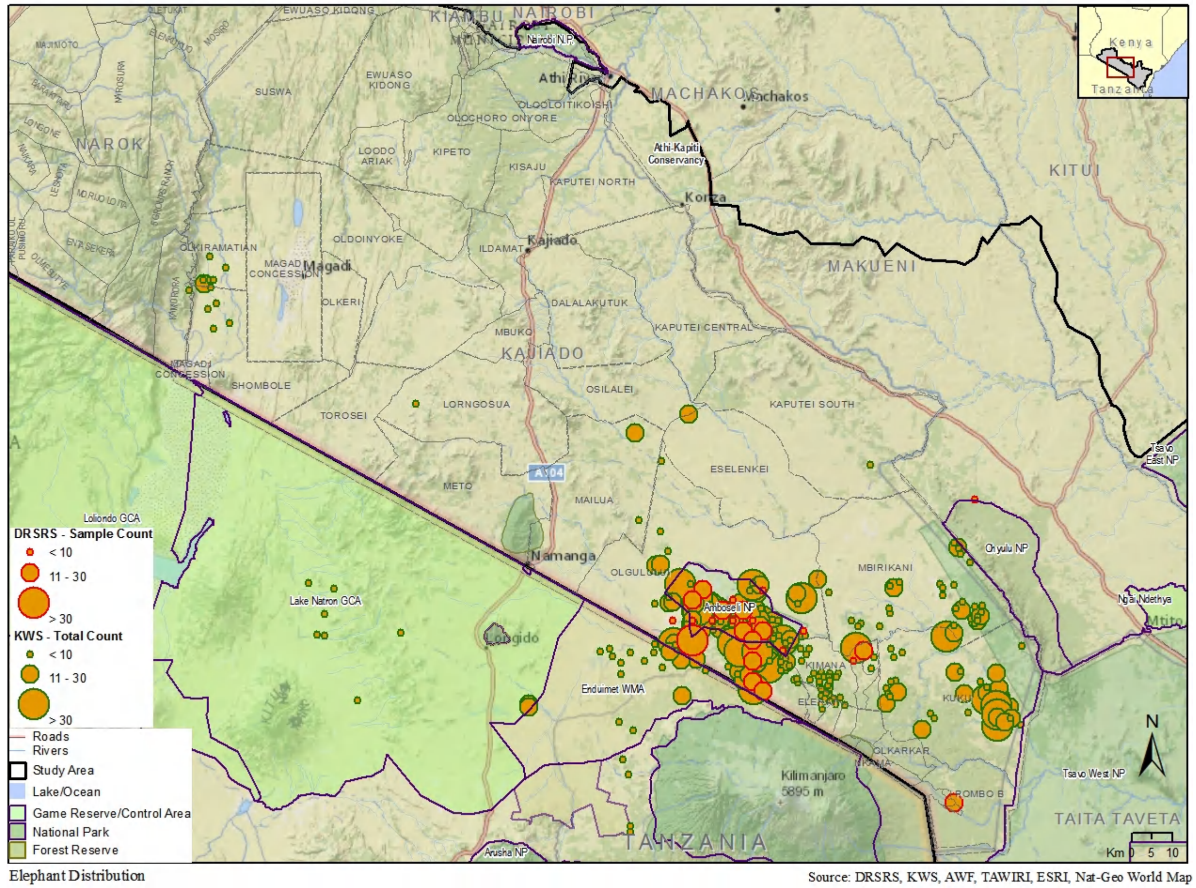


Figure 5.2,11: Trends of elephant in Amboseli. *Source - DRSRS datasets*

SPECIES DISTRIBUTION AND TRENDS IN SOUTH RIFT, AMBOSELI ECOSYSTEM AND WEST KILIMANJARO AREA



Map 5.2.11: Aggregated distribution of elephant in Amboseli Ecosystem, Athi-Kaputei, Magadi area and West Kilimanjaro in the period 1978-2011.

5.2.12. Distribution and Trends of Giraffe in South Rift, Amboseli and West Kilimanjaro Area

The giraffe is widely distributed in the entire Kajiado County (Kenya) and West Kilimanjaro (Tanzania), but the populations are highly concentrated outside the Amboseli NP and in group ranches includings Kuku, Mbirikani and Kaputei South and Magadi Concession Area, and Lake Natron GCA and Enduimet WMA in Tanzania. Based on the total counts of 2010, the highest giraffe numbers were recorded in the Amboseli (2,283 animals), which was followed by Lake Natron GCA (838 animals), Magadi (780 animals) and West Kilimanjaro (263 animals) (KWS, 2010). The densities were highly variable between the areas i.e. Amboseli had 0.26 animals/km^2, Magadi 0.14 animals/km^2, Natron 0.12 animals/km^2, and West Kilimanjaro 0.09 animals/km^2 (KWS 2010).

Based on DRSRS datasets, the long-term trend of giraffes in Amboseli indicate the population was about 7,500 animals in the late 1970s, which had declined to 2,499 by 1981. An increase in population (6,963 animals) was observed in 1981-91, which had marginally declined to 5,021 giraffes in 2007 (DSRRS datasets and KWS 2010). The severe drought of 2009 had a great impact on giraffe population in the Amboseli as their numbers dropped to 1,991 individuals in 2010, which represented 61% reduction (KWS 2010).

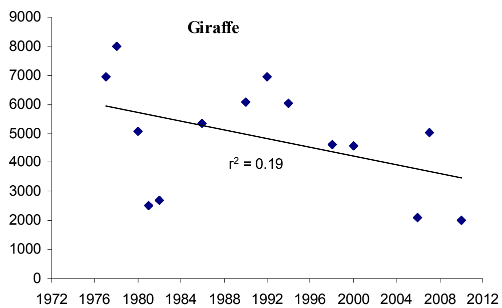
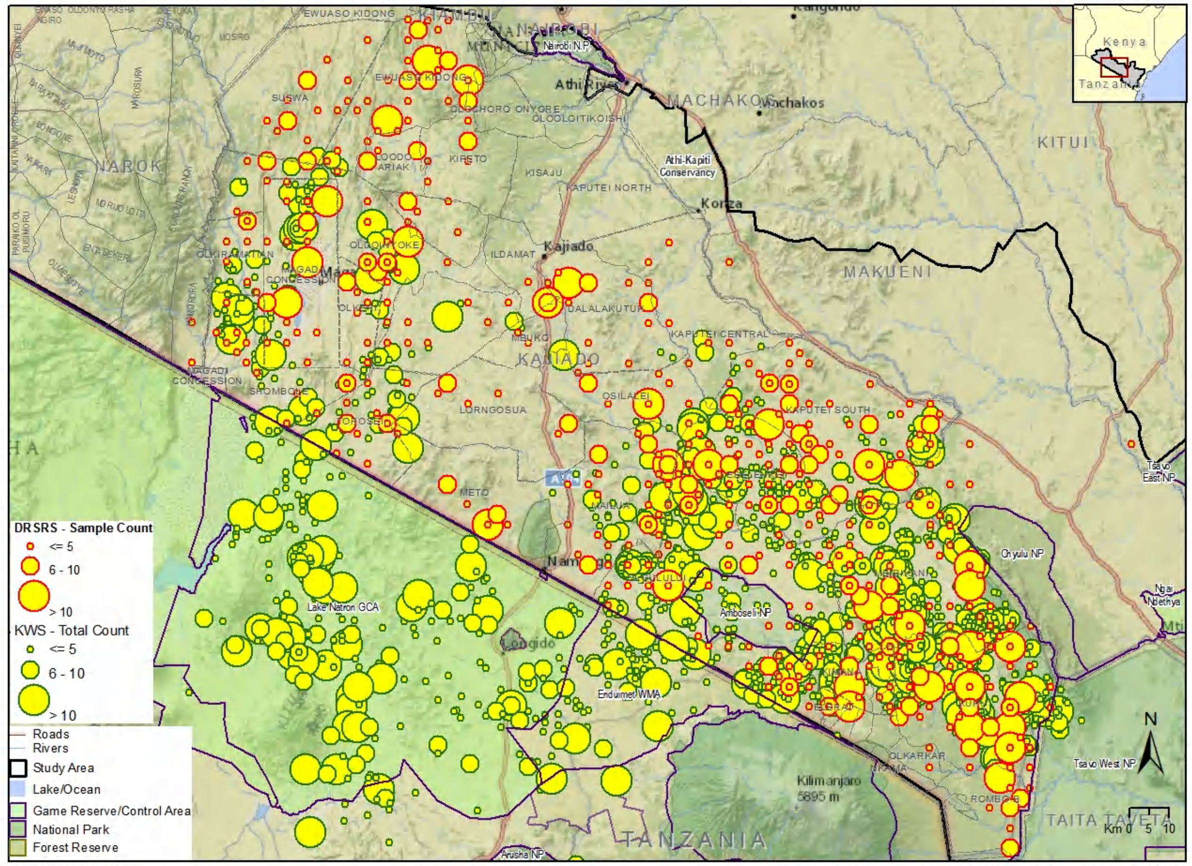


Figure 5.2.12: Trends of elephant in Amboseli. *Source - DRSRS datasets*

SPECIES DISTRIBUTION AND TRENDS IN SOUTH RIFT, AMBOSELI ECOSYSTEM AND WEST KILIMANJARO AREA



Giraffe Distribution

Source: DRSRS, KWS, AWF, TAWIRI, ESRI, Nat-Geo World Map

Map 5.2.12: Aggregated distribution of giraffe in Amboseli Ecosystem, Athi-Kaputei, Magadi area and West Kilimanjaro in the 1978 - 2011

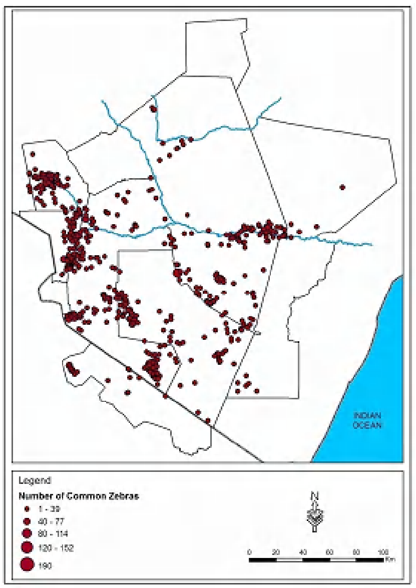
5.2.13. Distribution and Trends of Zebra in the Tsavo Ecosystem

A summary of the common zebra population observed in the Tsavo-Mkomazi ecosystem in 2008 and 2011 is given in Table 5.2.13. The parks contain the highest number (71%) of zebras with 33% appearing to thrive well in Tsavo West NP in dry seasons (Ngene *et al*.., 2011).

Table 5.2.13: Population of Burchell's zebra in Tsavo Ecosystem (2008 & 2011). *Source: KWS total counts*

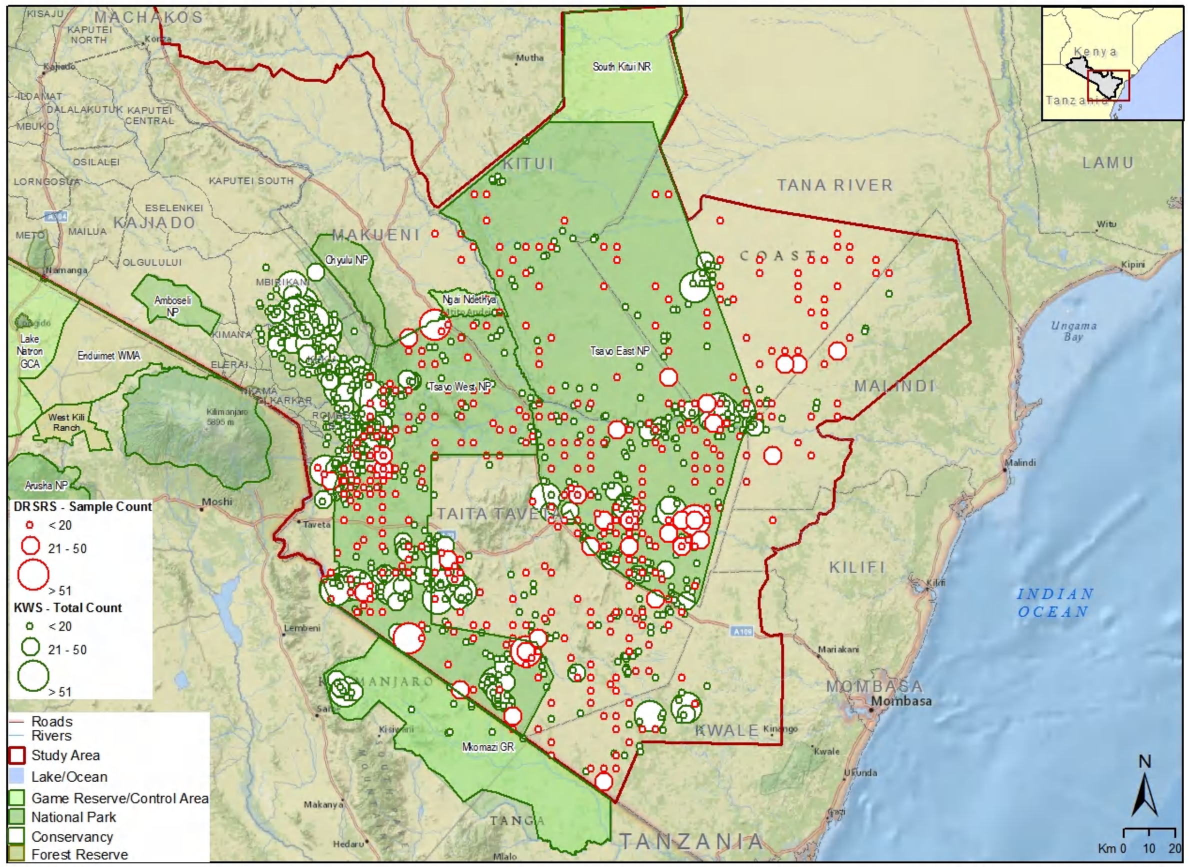
Census Area	2008	2011
Tsavo East National Park (north)	317	494
Tsavo East National Park (south)	885	955
Tsavo West National Park	2532	2248
South Kitui National Reserve	231	195
Galana Ranches	134	124
Taita Ranches	532	960
Other Blocks	745	835
Outside	32	25
Total (Parks)	6833	4782
Total (Non-parks)	1443	1944
Totals	**8276**	**6726**

The zebra population had declined drastically by 69% between 2008 and 2011 in Chyulu National Park. Although zebras are widely dispersed in the ecosystem, the majority were concentrated in the southern part of Tsavo East NP, Galana River and Tsavo West NP.



Map 5.2.13 (a): Distribution of zebra in the Tsavo-Mkomazi ecosystem (February 2011). Large herds were observed along the Galana River and Tsavo West NP. *Source: KWS total counts*.

SPECIES DISTRIBUTION AND TRENDS IN THE TSAVO-MKOMAZI ECOSYSTEM



Zebra Distribution

Source: DRSRS, KWS, AWF, ESRI, Nat-Geo World Map

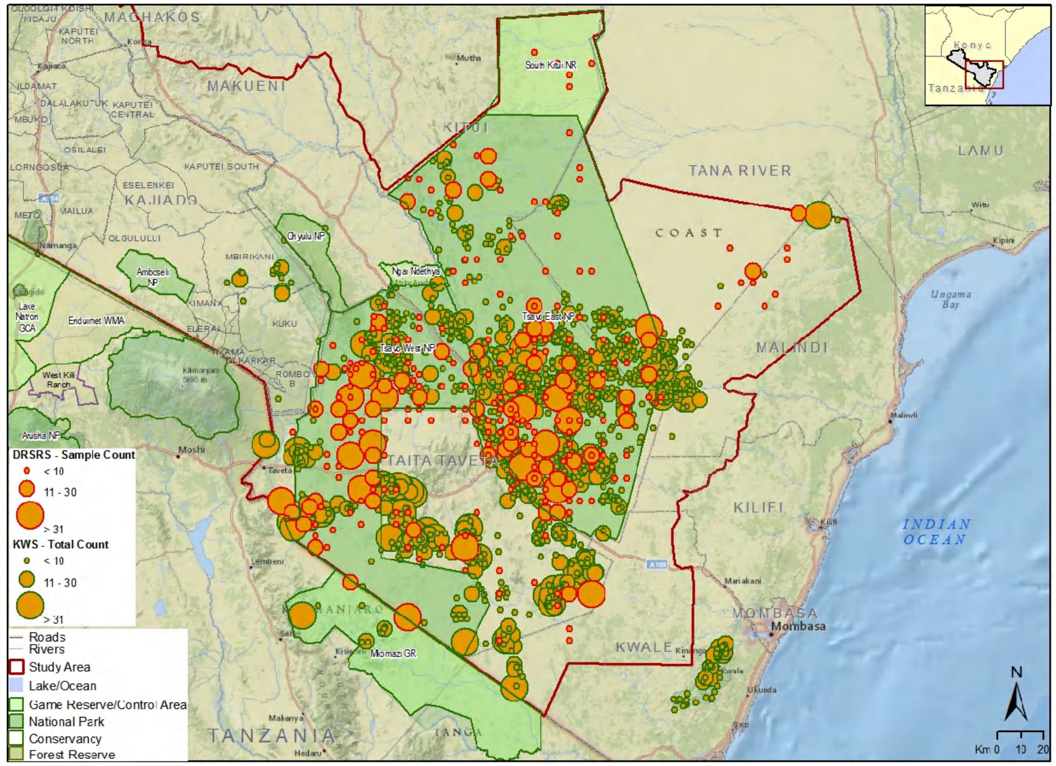
Map 5.2.13: Aggregated distribution of common zebra in Tsavo-Mkomazi Ecosystem in the period 1978-2011.

5.2.14. Distribution and Trends of Elephant in Tsavo Ecosystem

Tsavo ecosystem is the largest protected area in Kenya. It covers 4% of total landmass and home to the country's biggest elephant population (Blanc *et al.*, 2007). Tsavo National Parks and Reserves (Kenya) are connected to Mkomazi Game Reserve (Tanzania) to form a single large ecosystem (Tsavo-Mkomazi) with a total area of 46,000 Km^2. The elephant population in the ecosystem was over 35,000 animals by the end of 1974 (Cobb, 1976; Poole *et al*., 1992) and about 11,733 in 2008 (Omondi *et al.*, 2008). The drought in early 1970s killed about 6,000 elephants, with mortality largely confined to the eastern sector of Tsavo West (Leuthold and Sale 1973, Corfield, 1973; Cobb, 1976; Ottichilo 1981). Heavy poaching further reduced the elephant population to approximately 12,000 animals by 1980, and by 1988 the elephant numbers had declined to 6,399 animals (KWS, Douglas-Hamilton et al. 1995). However, elephant numbers has been on a recovery course since then with a steady increase, a trend observed upto date (Table5.2.14 and Figure 5.2.14) (KWS, Douglas-Hamilton *et al.*, 1994).

Although the Tsavo elephants still face a number of threats including the frequent and prolonged droughts, habitat encroachments and lack of adequate land use policies and legislations, the long-term trends show that they have recovered. This is due to the concerted security efforts to secure population from poaching and human-elephant conflicts. In the dry season counts of 2011, a total of 567 elephant carcasses were recorded, which represented 4.3% of the carcass ratio (Ngene *et al.*, 2011).

The Tsavo-Mkomazi elephants were 12,573 animals in 2011, which had increased by 2% up from the 2008 counts (Table 5.2.14). Most of these elephants (69%) were found inside the protected areas and 31% outside. Large herds of elephants were found in the southern sector of Tsavo East NP and within 45 km north and south of Galana River, with the Ndara plains being the mean centre of distribution. Large herds also occurred in the Taita ranches, south of Tsavo West NP (Njukini and Jipe area) and north of Mkomazi GR (Map 5.2.14). High densities were observed close to the wet water pans and low densities near the dry water pans.



Map 5.2.14: Aggregated distribution of elephant in the Tsavo-Mkomazi Ecosystem in the period 1978-2011.

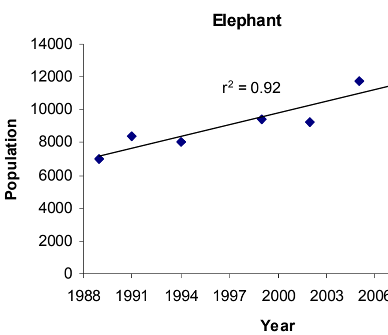


Figure 5.11.18: Trends of elephant in the Tsavo-Mkomazi Ecosystem.

Table 5.2.15: Elephants numbers in the Tsavo-Mkomazi Ecosystem from 1962 to 2011 based on aerial total and sample counts

Census Area	2011	2008	2005	2002	1999	1994	1991	1989	1988	1978*	1973	1972	1970*	1969*	1965*	1962
Tsavo East NP (North)	2094	4118	2499	4089	1337	399	450	134	770	220	9011	6435	0	6619	8056	4073
Tsavo East NP (South)	4120	3731	3896	2087	3221	2733	3436	3020	2283	2469	3955	6633	6008	5709	4744	1358
Tsavo West NP	2142	2161	2626	2168	2119	3132	1233	2106	1274	1938	9208	4328	6592	8134	2238	1394
Chyulu NP	135	131	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mkomazi NR	256	8	41	63	77	302	131	11	93	667		2067	-	-	-	-
Galana	398	308	11	14	27	46	50	74	90	1076	500	4379	-	2964		3540
Taita	2751	1108	1292	828	1245	287	1413	642	853	79		1235	-	500		
Rombo	0	0	31	2	12	446		193	-	-	-	-	-	-	-	-
Other Blocks	509	130	1	35	30	26	50	46	-	-	-	300	100	-	-	-
Outside	168	38	1376		1391	1107	1644	966	1036	-	-	-	-	-	-	-
Total (Parks)	8614	10149	9062	8344	6754	6566	5250	5271	4420	5294	22174	19463	12600	20462	15038	6825
Total (Non-parks)	3959	1584	2680	940	2693	1466	3157	1728	1979	1155	500	5914	100	3464		3540
Totals	**12573**	**11733**	**11742**	**9284**	**9447**	**8032**	**8407**	**6999**	**6399**	**6449**	**22674**	**25377**	**12700**	**23926**	**15038**	**10365**

The periods when no aerial census took place is represented by a hyphen (-), the star (*) represents data acquired using sample counts method. The rest of the datasets was collected using an aerial total count method. Data was collected in late January-early February (dry season) from 1999 to 2011, and in June, after wet season from 1962 to 1994. (*Source:* ***KWS, 2011;*** *Laws, 1969; Leuthold, 1973; Otichillo, 1983; Olindo et al., 1988; Douglas-Hamilton et al. , 1994; Kahumbu et al., 1999; Omondi and Bitok, 2008*).

5.2.15. Distribution and Trends of Giraffe in the Tsavo Ecosystem

The Tsavo-Mkomazi ecosystem supported a population of about 2,055 giraffes (Feb, 2011), which had increased from 1,148 giraffes in 1999 (Table 5.2.15). This represented an increase of 55% over a period of 12 years, however, a decline 19% was recorded in three years as compared to the population in 2008 (Ngene et al., 2011). The Tsavo East National Park (North) and Chyulu National Park recorded the highest declines of 60% and 45% respectively.

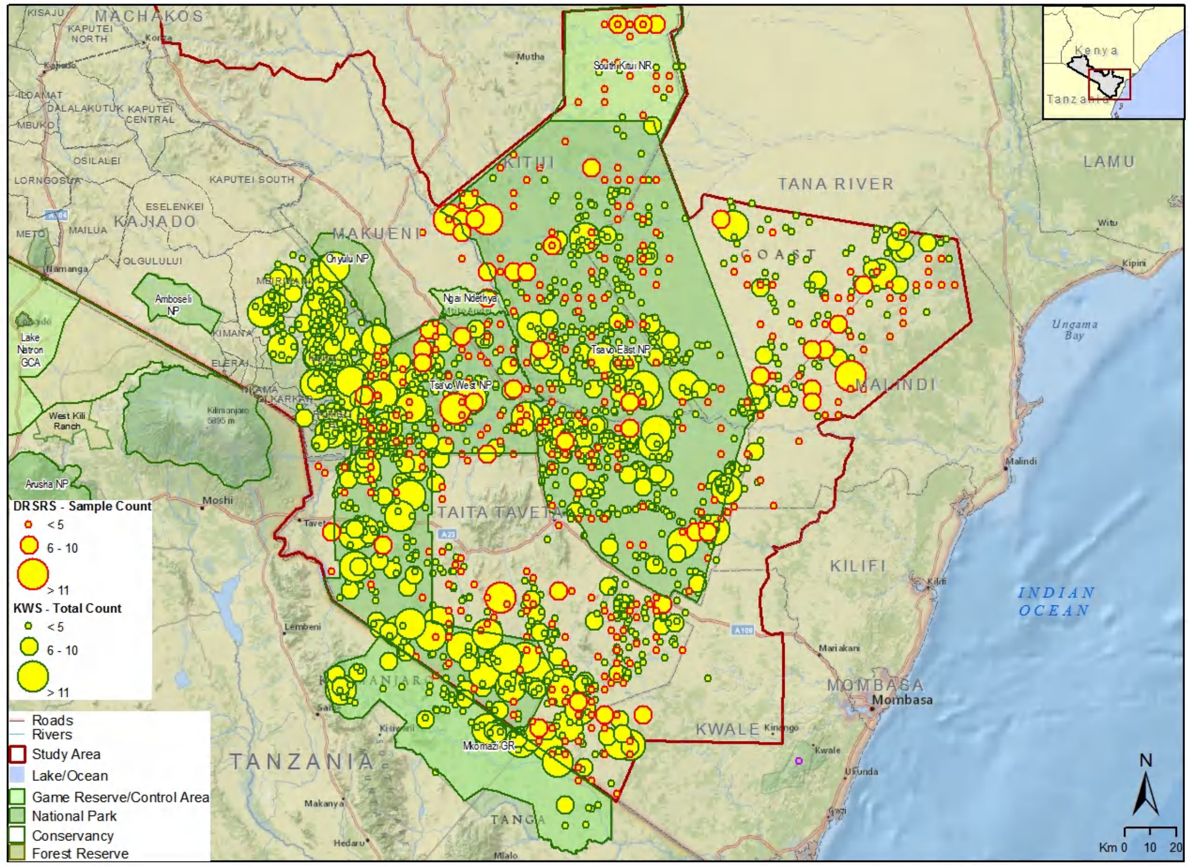
In the four census periods (1999-2011), the highest number of giraffes was observed in Tsavo West NP while South Kitui NR recorded the least. Large groups were observed in west Chyulu, south of Tsavo West NP and north of Mkomazi NR (Map 5.2.15).

Table 5.2.15: A comparison of population numbers of giraffe in the Tsavo-Mkomazi ecosystem between 1999 and 2011**.** ***Source: KWS Counts***

Census Area	2011	2008	2005	1999
Tsavo East National Park (north)	170	424	281	133
Tsavo East National Park (south)	222	257	261	222
Tsavo West National Park	691	678	568	272
Chyulu National Park	292	534	-	-
Mkomazi National Reserve	120	116	62	82
South Kitui National Reserve	6	3	-	-
Galana Ranches	93	95	153	171
Taita Ranches	282	193	148	147
Other Blocks	178	148	111	121
Outside	1	2	-	-
Total (Parks)	1501	2012	1172	709
Total (Non-parks)	554	438	412	439
Totals	**2055**	**2450**	**1584**	**1148**

Plate 5.2.15: Giraffe browsing on the leaves of Acacia tree while zebras graze on the undergrowth grasses and herbs in Chyulu NR. *Photo Courtesy: KWS/Joseph Mukeka*

SPECIES DISTRIBUTION AND TRENDS IN THE TSAVO-MKOMAZI ECOSYSTEM



Giraffe Distribution

Source: DRSRS, KWS,AWF,ESRI, Nat-Geo World Map

Map 5.2.15: Aggregated distribution of giraffe in Tsavo-Mkomazi Ecosystem in the period 1978-2011.

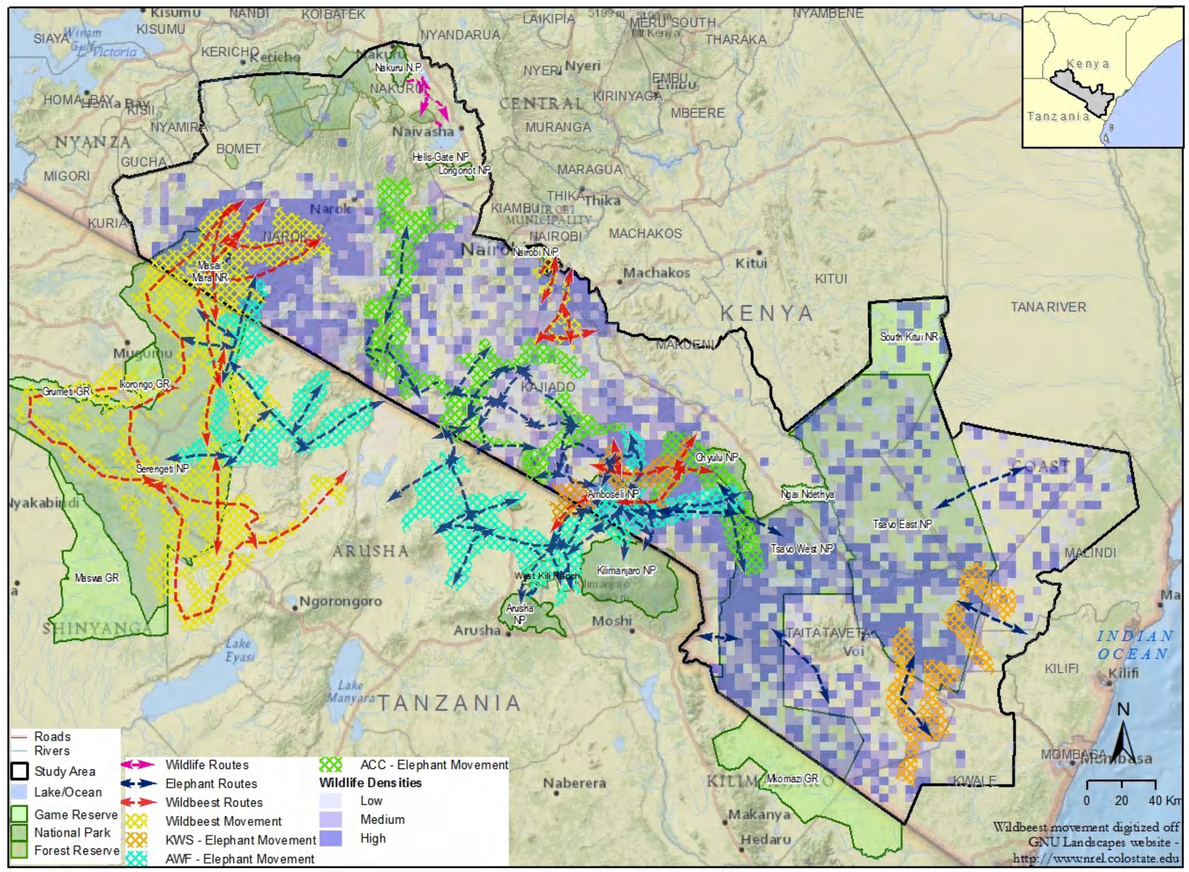
5.3. Wildlife Dispersal Areas, Migratory Routes/Corridors

The insularization of protected areas and habitat loss or fragmentation leads to extinction of species, and directly affects biodiversity by reducing species abundance and diversity. The isolation of habitats will reduce the effective area by limiting species movements and causing competition for resources. Isolation can be caused by various factors such as habitat encroachment by agriculture or high density settlements, roads that open up new ventures for the rural poor to sustain their livelihood such as charcoal burning, forest clearing for timber and construction materials, and fences to demarcate the subdivided lands as well as protect intrusions to land uses incompatible with wildlife conservation. Protected areas should have wide dispersal areas to enhance genetic drifts and avoid inbreeding. This may lead to population instability and local extinction as resulting from lack of adaptation to the fast changing environmental conditions.

As the protected areas increasingly become insularized by the growing anthropogenic activities such as crop cultivation, forest clearing and high density settlements, the loss of biodiversity is imminent with active elimination of wildlife populations around the parks and reserves. In the southern Kenya rangelands, the attributes associated with the rapid loss of biodiversity includes land use and tenure change, high rural poverty level and sedentarization. It is likely that the protected areas will lose a significant proportion of wildlife if they become completely isolated as large wildlife populations depend on vast areas outside the parks and reserves for their year round sustenance.

The intensity of human-wildlife conflicts around protected areas is correlated to the human density and incompatible land use. A high human density is an indicator and predictor of the local extinction of large mammals in many areas. An increase in human population and associated anthropogenic activities will reduce wildlife space and increase human-wildlife conflicts. These human-wildlife conflicts create frustration and animosity towards wildlife and mostly result in retaliatory wildlife killings in the absence of mitigation measures, interference of wildlife migratory routes and blockade of corridors through land subdivisions, wetlands drainage, fences, vegetation clearing for timber and construction materials, and high density human settlements.

WILDLIFE DISPERSAL AREAS, CONNECTIONS AND LINKAGES IN THE SOUTHERN KENYA RANGELAND ECOSYSTEMS



Wildlife Movement Routes

Source: DRSRS,AWF, ACC, ILRI, KWS, Colorado State University, ESRI, Nat-Geo World Map

Map 5.3.1: Spatial overlay of species densities (DRSRS long-term aerial counts on 5x5km grid) and wildlife telemetry showing elephant and wildebeest migration routes and corridors in the southern Kenya rangeland ecosystems.

5.4. Conservation Connectivity Threats

The exponential growth of human population, making humans the dominant species and their activities overriding in landscapes occupied by people, wildlife and livestock is having a grave impact on biodiversity conservation. This impact is taking place through several processes and primarily: habitat fragmentation or outright destruction, species over harvesting, pollution, climate change, introduction of alien species and lack of adequate policies and legislations among others.

1. *Land use changes:* land is one of the most important resources in Kenya as it is the base upon which activities like agriculture, wildlife conservation, urban development, human settlement and infrastructure are carried out. There have been remarkable land use and tenure changes over the years. Some of these land use and tenure changes, particularly agriculture and rural and urban development are incompatible with wildlife conservation and negatively affect dispersal areas, migratory routes/corridors across the landscape. Furthermore, these changes are exacerbated by inadequate land use policies to guide the planning and management of natural resources.

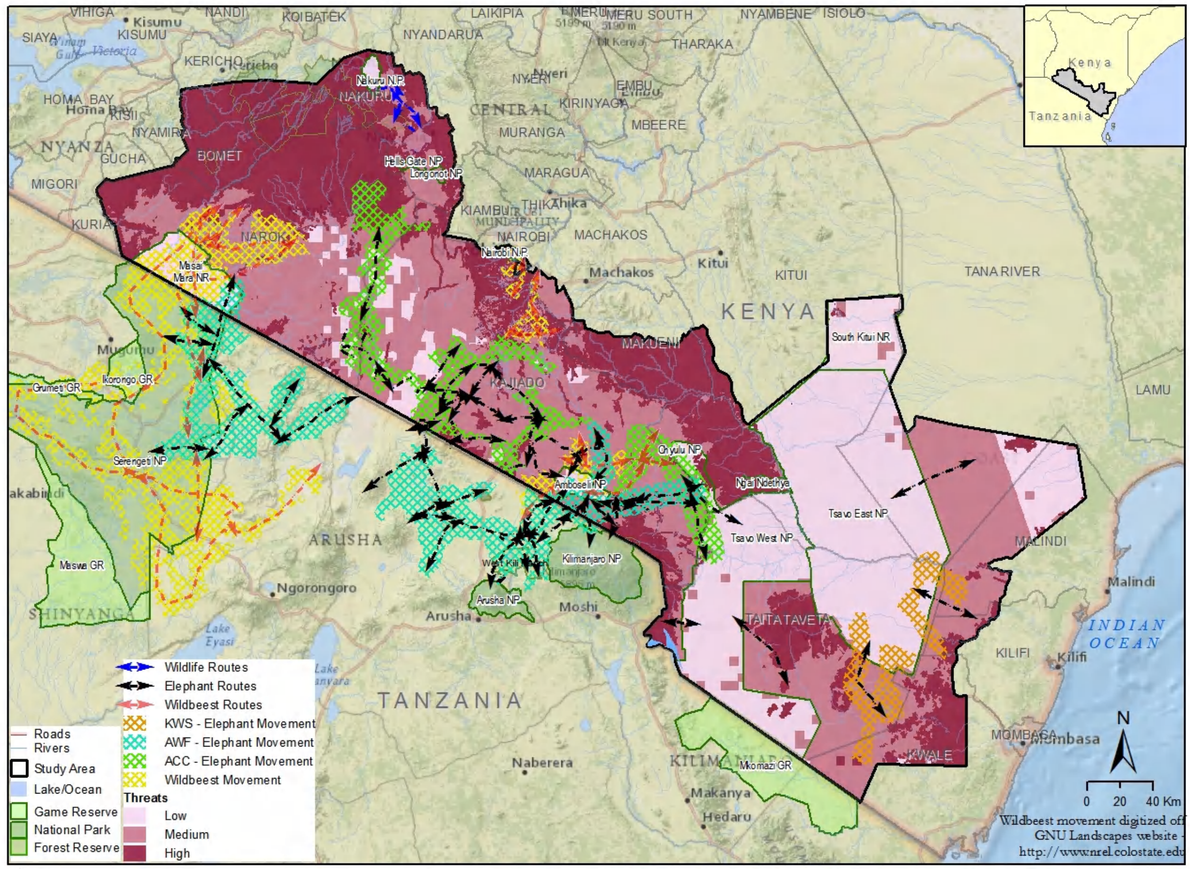
2. *Destruction of wildlife habitats*: wildlife habitats provide ecosystem goods and services for rural people's livelihoods. However, the rapidly increasing human population and other complex socio-economic factors have put enormous pressure on the limited productive land, and forcing the rural poor to resort to poor land use practices for subsistence. This has caused habitat loss and fragmentation in many areas.

   Although humans had earlier recognized that biodiversity can help support their endeavors, such as eco-tourism, agriculture and medical research, and attempted to preserve small "islands" of native habitat, these are now increasingly being isolated by oceans of human habitat. While noble in intent, this isolation of species has in many cases led to the demise of biodiversity. Usually the "islands" are too small to sustain the species and many species, being unable to migrate or renew their fragmented gene pool, may become extinct.

   Outright habitat destruction such as deforestation, wetland drainage, charcoal burning, and conversion of diverse woodland and grassland to endless mono-cropping agricultural area is the most destructive of human activities with regard to wildlife habitat and biodiversity loss. Thousand of plant species have been destroyed for agriculture, fuelwood, building/construction material, wood carving and traditional medicine. While the destruction of a forested land may only take a few days, regeneration, even if it were possible, might take several years.

3. *Insecurity:* insecurity in some of the wildlife areas is a serious challenge to biodiversity conservation and management. The security relates to protection of wildlife populations, local communities and visitors (tourists) in these areas. This situation has been exacerbated by proliferation of small arms from the neighbouring war torn states (Somalia and South Sudan) that fall into the hands of poachers, cattle rustlers and bandits.

CONSERVATION CONNECTIVITY THREATS IN THE SOUTHERN KENYA RANGELAND ECOSYSTEMS



Threats

Source: DRSRS,AWF, ACC, ILRI, KWS, Colorado State University, ESRI, Nat-Geo World Map

Map 5.4.1: Spatially model of conservation threats - GIS overlay of agriculture, human population density, protected areas and buffers, water bodies, roads with elephant and wildebeest routes to depict threat intensities.

4. *Insecure land tenure and illegal allocation*: in some of the wildlife areas, the insecure tenure has contributed to general apathy by the local community towards wildlife conservation. Increased subdivisions of large group ranches to individual parcels and animosity between the local communities and wildlife agencies can not be emphasized. In addition, the local authorities who hold huge parcels of land in trust for residents have often abused the trusteeship through illegal allocations and change of land use. These changes may have negative impacts on the original intent as the new landowner has the rights to practice any land use including those incompatible to wildlife conservation.

5. *Protected area management and partnerships:* most of the protected areas were established without due regard to surrounding landscapes. Consequently, the boundaries of protected areas and the wider landscapes are becoming distinct, being separated by fences and other barriers to deter wildlife movements outside these areas. In terms of wildlife and habitat management, the rigid boundaries have compromised the integration and effectiveness of many dispersal areas and migratory routes/corridors outside the protected areas. There is need to create more protected space and broadly redefine the protection status of the majority of wildlife populations existing outside the parks and reserves. This could be achieved by enhancing the partnerships between the local communities living adjacent to protected areas and park's management authorities.

6. *Management effectiveness assessment and prioritization:* biodiversity conservation and management receives fewer resources, given the enormous and compelling social challenges such as poverty, health care and education, yet it impacts on natural processes and human life, and affects development. The efficient and effective conservation of wildlife resources requires regular assessment and strategic actions aimed at addressing priority issues. Whereas protected areas are set aside for the purpose of wildlife conservation, it is equally important to realize that the areas outside these small seclusions are critical as dispersal areas and migratory routes/corridors in the wet and dry seasons, and that they are communally or privately owned. There are currently few initiative or programmes and inadequate incentives to motivate the local communities living in wildlife areas to support or practice land uses that are compatible with wildlife conservation.

7. *Inadequate accurate scientific data:* accurate scientific data on wildlife resources is critical for informed decision making by wildlife managers, other stakeholders and policy formulation. The investment in long-term studies of wildlife ecosystems and maintenance of similar datasets has been poor. This has prejudiced the understanding of ecosystem principles, ecological processes and rational decision making.

8. *Climate change:* the globally climate is changing and resulting in direct physiological impacts on individual species and communities - changes in abiotic factors, opportunities for reproduction and recruitment, and altered interactions among species. While there have always been climate change and periods of global warming throughout geological history, it is not the variability of precipitation and absolute temperatures that are important, but rather the frequency and severity of dry spells and rate at which the temperature increases locally. Many species are able to respond to changing climate condition by moving or migrating to more suitable habitats. This is a slow process, especially for plants, but rapid for large wildlife species, except for their lost or fragmented habitats combined with human barriers to movement such as agricultural areas, rural and urban developments, infrastructures and fences.

   Climate change may also produce more conducive condition for the establishment and spread of invasive species, as well as change suitability of microclimates for native species and the nature of interactions among communities. There is inadequate data on the impacts of climate change on biodiversity.

9. *Illegal and unsustainable off-take of wildlife and bush meat trade:* inadequate law enforcement, ineffective regulatory mechanisms, low penalties, lucrative markets for bush meat and rising poverty indices have contributed to escalating illegal taking of wildlife, illegal international wildlife trade and bush meat trade. In the 18th century a combination of scientific, technical and industrial innovations enabled humans to over harvest not only land mammals but any other species of their use. Like the technology of the spear and arrow did for the early humans, the technology of gunpowder and other tools (traps, snares, poison, etc) has allowed people to harvest species faster than they could replace themselves. It is the most obvious method of causing species declines and ultimate extinctions.

10. *Pollution:* the technology that enabled humans to control and eliminate other species is only obtained at a price. The price is in the form of pollution. The burning of fossil fuels, use of petrochemicals and heavy metals has led to the increase of "greenhouse gases" and contamination of water - the key to life on earth. Pollutants continue to cause drastic modifications to wildlife habitats. The introduction of solid wastes and other pollutants into water systems and land by intention or accident negatively affect wildlife and may impair, cause mutation or wipe out entire populations.

11. *Invasive alien species:* humans are the most mobile of species - they travel widely and often transport other species along, resulting in alien introductions. While the most drastic devastation may occur on small "islands", large land masses have also felt the impact of alien species that may not have local natural control. These alien species are major threats to the natives particularly in arid and semi arid areas and aquatic ecosystems. The invasive alien species can transform the structure and species' composition of ecosystems by repressing or excluding native species either directly (out competition) or indirectly (changing the nutrient cycled in systems).

    The control of invasive species is a major management challenge. In addition to direct economic costs of management, there are severe environmental consequences. For example, the introduction of Prosopis (*Prosopis juliflora)* is a major threat to conservation of natural vegetation in northern Kenya. The encroachments by agriculture into wildlife areas come with many invasive weeds that are alien to the ecosystems.

12. *Human-wildlife conflict and compensation:* increasing human-wildlife conflict is a major problem in wildlife areas. Acute water shortage and inadequate dry season pasture has severely affected wildlife, livestock and humans. As competition for the meager resources continues, the human wildlife conflict levels rises. In addition to the climate variability that is responsible for the low plant biomass productivity, the increased human-wildlife conflicts have been attributed to extension of human activities in wildlife areas.

    Currently, compensation for wildlife damage is paid by the government. The amounts payable, which relates to human injury or death, crop damage and livestock predation has been very low. Although the new proposed compensation bill has adjusted high payments, it is still not commensurate to the losses incurred by the communities living in wildlife areas. In addition, the bureaucratic process for compensation payment does not advantage the large majority of the rural poor.

13. *Conservation of shared wildlife resources:* habitat requirements for wildlife species are critical for their survival and reproduction. Most wildlife species have evolved and adapted to large home ranges, some of which straddle the boundaries of two or more countries. This affects their life cycle and migration, which raises the need to promote a harmonized approach to the conservation and management of shared wildlife resources. For instance, Serengeti-Mara Ecosystem is shared between Kenya and Tanzania and important for the annual wildebeest and zebra migration. Similarly the Amboseli-West Kilimanjaro cross border is a critical area for the elephants and other wildlife, but whereas Kenya imposes a burn on game hunting, the counter part Tanzania condones and created game controlled areas. It means, when the wildlife crosses the border from Kenya into Tanzania, they arrive into the hunting grounds.

14. *Size of Protected Areas:* the delineation of protected area boundaries did not take into consideration the entire requirement of most wildlife species. Most of the protected areas are too small to encompass ecosystem processes on which wildlife populations depend. The increase in wildlife populations within the narrow confines of parks and reserves can result in pressures that degrade the ecosystems integrity. Protected areas of limited size and confined wildlife populations are detrimental to the survival of species, especially at the edge of demarcations where fences separate incompatible land use with conservation.

15. *Management plans:* lack of a comprehensive integrated management plan and lethargy in implementation where they exist is a major challenge for wildlife conservation and management, and especially as concerns the wildlife that exists outside the protected areas. This can be attributed to (lack of local community involvement) the non-participatory manner in which these plans have been developed, lack of preparedness for their implementation (inadequate resources) and lack of a monitoring and evaluation framework for gauging the performance and outcomes.

5.5. Interventions and Opportunities

a. *Community Conservancies* - the post-privatization land reconsolidation for wildlife and livestock mobility is taking place in conservancies around many protected areas in Kenya to benefit local communities whose land is occupied by wildlife through community-private partnerships. In Narok County a total area of eight (8) conservancies (approximately 92,248 Ha), more than half (61%) of the park area (150,000 Ha) have been formed and offer bed-nights based rates and/or leases of U$36-43 per Ha.

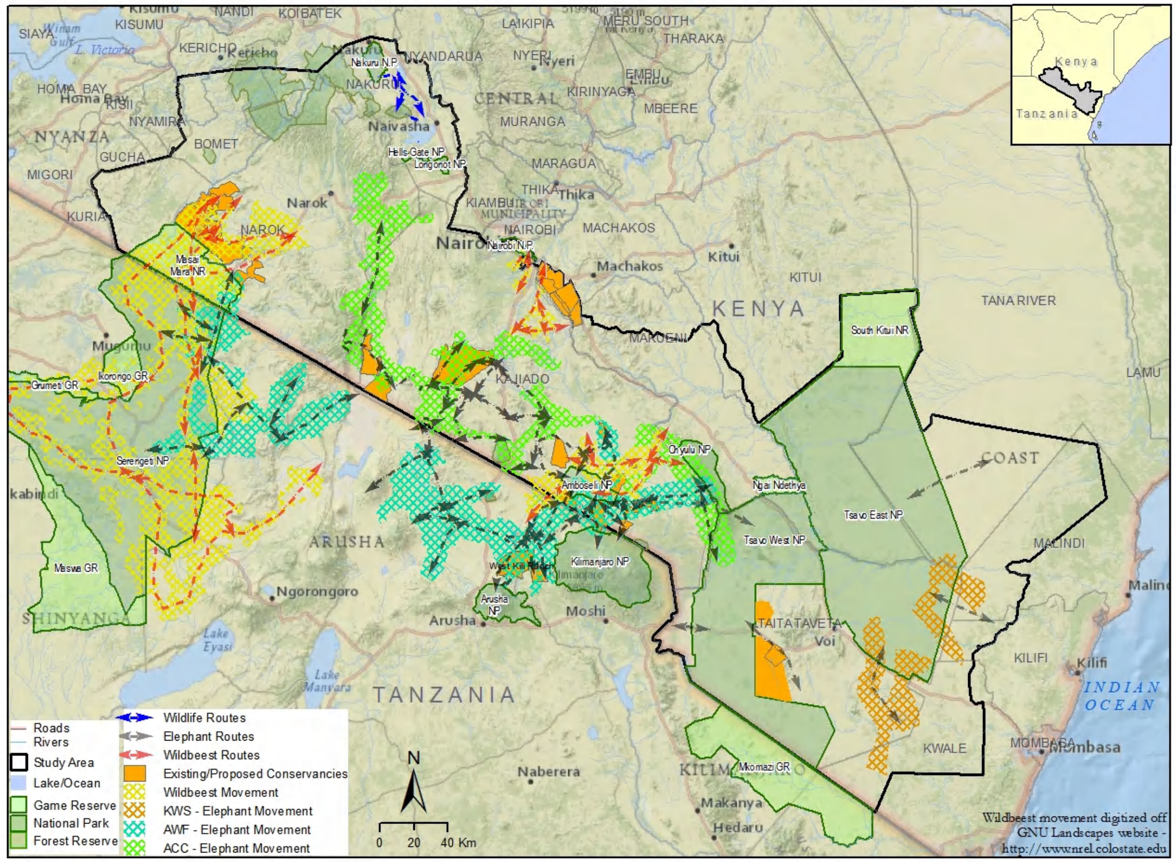
b. *Payments for Ecosystem Services* - biodiversity conservation among the pastoral communities could hold the key to helping the pastoralists deal with challenges of land use and climate change by enabling them to diversify their income. The use of payments for ecosystem services, mostly around Kenya's protected areas is providing a stable, reliable and predicable source of income to the pastoralists with double advantage of reducing poverty and protecting wildlife. In many areas where payments for ecosystem services have be piloted, the local-level institutions have played a significant role in enabling the communities to self-govern, supported by flexible land uses and governance systems that respect the traditional communal land ownership patterns.

   Payments to livestock herders for ecosystem services generated through the use of land are currently being made in areas adjacent to Kenya's famous Masai Mara National Reserve and the Kitengela wildlife dispersal area to the south of Nairobi National Park. In both areas, the Maasai people have formed "eco-conservancies" to protect the grazing areas for both their livestock and wildlife alike.

Plate 5.5.1: Maasai pastoral herders signing up to the Naboisho Conservancy in Mara area in 2010. Ecosystem conservation schemes are giving herders new sources of income (*Photo courtesy: ILRI/Bedelian*).

c. *REDD programmes* - carbon project on Reduction of Emission from Deforestation and Forest Degradation (REDD) is being implemented by many communities living in wildlife migratory routes and corridors to benefit from payment of ecosystem services. For instance the Kasigau corridor REDD project in the Taita communal and private ranches, which has set aside a total of 330,000 Hac with phase I of the project being implemented at the Rukinga Sanctuary covering 30,168.66 Hac (Map 6.8.11).

CONSERVATION OPPORTUNITIES IN THE SOUTHERN KENYA RANGELAND ECOSYSTEMS



Opportunities

Source: DRSRS,AWF, ACC, ILRI, KWS, Colorado State University, ESRI, Nat-Geo World Map

Map 5.5.1: Community conservancies in wildlife dispersal areas outside parks and reserves - key to the protection of wildlife migratory routes/corridors.

Photo Credit: David Huberman (IUCN)

CHAPTER 6

SYNTHESIS: MIGRATORY ROUTES AND CORRIDORS

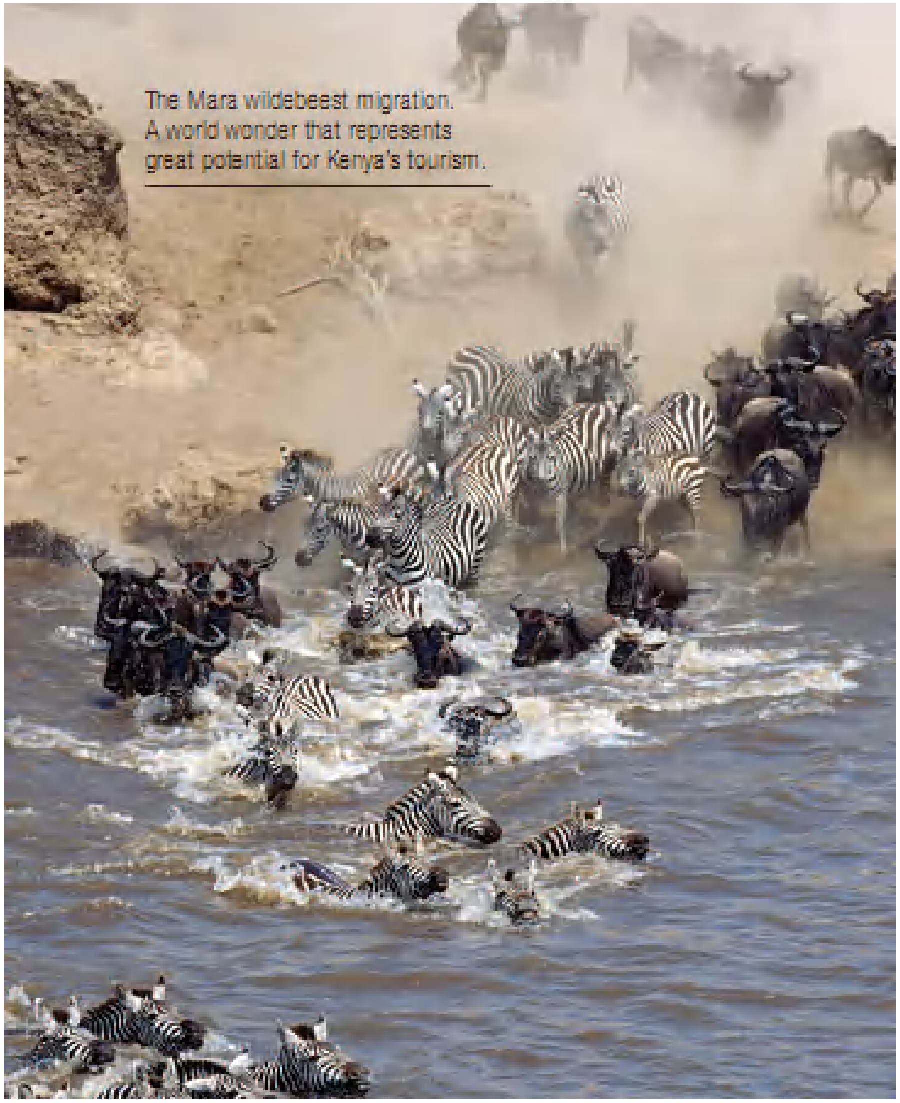


Plate 6.1.1: Wildebeests and zebras crossing the Mara River. *Source: Vision 2030 Abridged Version*

6.1. The DPSIR Framework Model

The DPSIR framework model approach, which structures the description of environmental problems in a logical way to show relationships between various sectors of human activities and the environment as causal chain of links (UNEP 1997) was adopted to investigate and prioritize wildlife dispersal areas and migratory routes/corridors identified in the mapping process. The DPSIR (Driving force, Pressure, State, Impact and Response) model (Fig. 6.1) which was originally developed for environmental reporting purposes is based on the understanding of basic principles of system dynamics as it relates to planning and decision making.

In the last few decades, most of Kenya's wildlife populations have declined and their distribution range diminished, mainly due to land use and tenure changes, impacts of recurrent droughts and poaching. The rapidly escalating human population associated with proportionately high demand on natural resources, especially land for agriculture and settlements, and land based products have led to the uncontrolled conversion of wildlife habitats and livestock dry season refuges. The loss or fragmentation of habitats (core areas, dispersal and connectivity) has negative impacts on wildlife populations.

As the protected areas increasingly become engulfed by incompatible land uses, human-wildlife conflicts also increases as the communities living adjacent to these areas continually interact with wildlife. In most of the dry seasons, a large number of wildlife species will endeavor to survive in unfamiliar territories as they roam widely in search of meager resources such as food and water. In addition to competition for resources with humans outside the protected areas, the wildlife also becomes easy targets to poaching. The biological significance of animal movements and importance of connectivity has been discussed in Chapter 3.

In this study, the historical and current states of wildlife dispersal areas and migratory routes/corridors, the driving forces, pressures, impacts and responses were investigated through literature review (reports and journal articles), expert opinion, fieldwork, personal communications and feedbacks from the local communities.

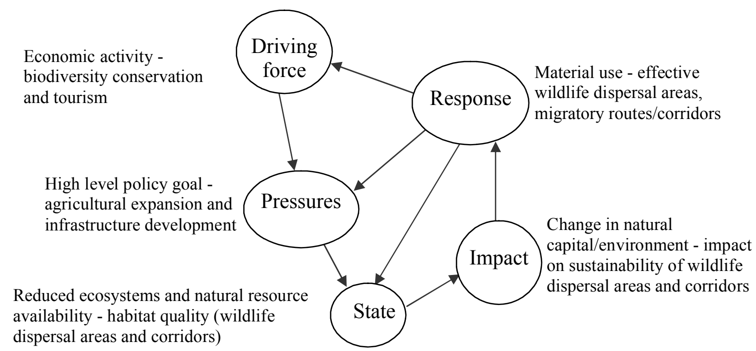


Figure 6.1.1: Diagrammatic presentation of the DPSIR model approach as it relates to conservation and decision-making process.

Based on the DPSIR analysis, we have derived a set of recommendations and actions including economic, legal and policy instruments for each of the wildlife dispersal areas and migratory routes/corridors investigated. These will help in guiding the various government institutions and ministries in the implementation and actualization of the proposed conservation connectivity framework in southern Kenya rangelands. Further research on the viability and sustainability of the migratory routes/corridors that have been interfered with by human activities would be critical, as well as the consultative engagement of all the stakeholders and local communities whose lands are perceived as wildlife areas.

6.2. Mara Ecosystem

Plate 6.2.1: Wildebeests in the vast plains of the Serengeti - Mara Ecosystem during the migration.

Plate 6.2.2: A mixed herd of plains zebra and other antelopes in the background. *Photo courtesy: Rob O'Meara, Sarah O'Meara*.

Plate 6.2.3: Large-scale mechanized wheat farming in the Ngorengore area is a major impediment to wildlife dry season dispersal area in Narok County. *Photo courtesy: Gordon Ojwang'*

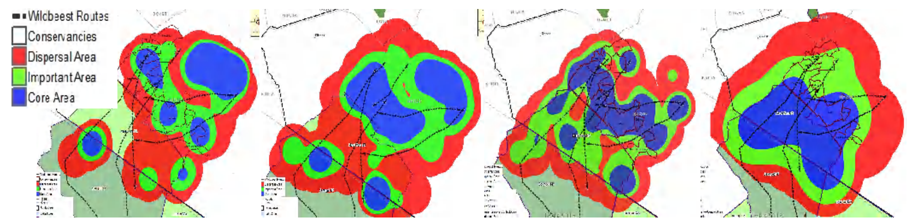
Introduction

Kenya is one of the world's foremost tourist destinations, which is primarily based on the country's stunning natural resource and landscape attraction including the magnificent wildlife in their native habitats, as well as some of Africa's finest beaches (WRI et al. 2007). This unique natural endowment has turned Kenya's tourism industry into a leading economic sector, generating revenues of about KSh. 49 billion (US$ 700 million) in 2005.

The Kenya Vision 2030 stipulates tourism as one of the economic pillars and encourages further development of tourism services targeting the country as prime tourist destination. This calls for proper management of wildlife resources and forward planning of the associated tourists facilities to realize the vision. This has been set back by the high declines of wildlife populations, the loss of key wildlife habitats and illegal wildlife harvesting.

The Maasai Mara National Reserve (MMNR) is one most visited park in the country, with more than 0.3 million visitors every year. The Maasai Mara Ecosystem (MME) is renowned for its abundant and diverse assemblage of wild ungulates and is connected to the southern part by the Serengeti National Park (Tanzania). The greater Serengeti-Mara Ecosystem (SME) is defined by the movements of its 1.6 million migratory wildebeests and 0.6 million zebras. The MME is one of highest density and species richness in the country.

Species kernel densities identify the core, dispersal areas and important wildlife habitats in the Mara Ecosystem (Map 6.2.1). Wildebeest's core area is largely outside the Mara NR and within the Ngorengore plains; zebras depict a similar pattern to the wildebeest but more widespread outside the park; giraffe is widespread and largely concentrated within the conservancies; and elephant is mainly confined to the park and the area around Talek.



Map 6.2.1: Kernel densities for wildebeest (left), zebra (left-centre), giraffe (right-centre) and elephant (right) in the Masai Mara Ecosystem and extended landscapes showing species core, important and dispersal areas. *Source: DRSRS/KWS.*

<u>The State of Conservation Connectivity</u>

Drivers

1. Human population - according to 2009 census, Narok County had 850,920 people with a density of 47 persons per km^2 and growth rate of 3.3% against the national rate of 2.2%. This has increased the pressure on wildlife and resources both in and outside the reserve.
2. Land tenure - the insecurity of land tenure has led many Maasai group ranch members to subdivide their land to individual titles. This privatization of the land has led to a land use transition with the emergence of large-scale mechanized cultivation (wheat, barley and maize) and the intensification of both agriculture and livestock production (e.g. in Lemek and Ngorengore areas) (see also Map 6.2.2 - left).
3. Climate change - there is expected a slight decrease in rainfall, the frequency of drought in the long rains seem to increase, with increase in maximum temperature of about 0.5ºC and minimum temperature of about 1ºC. This has resulted to unreliable rainfall leading to poor biomass production and water scarcity, which might have negative impact on water dependent species.

Pressures

1. Human population in the Mara has increased significantly with settlements increasing 5 fold around the park since 1940s. There is now more homesteads dispersed on the landscape than it were 60 years ago.
2. The rapid change in land tenure from group ranches to private ownership has left the majority of ranches subdivided to individual small parcels.

3. During the last 30 year, a rapid land use change has occurred in the Mara ecosystem. Since in 1975, about 40,000 hectares of wet season grazing land has been lost to agriculture.
4. Between 1977 and 2007 the population of resident wildebeest has declined from 150,000 to 40,000 animals. The overall cattle numbers have remained stable though it fluctuates through the mean based on yearly changes in rainfall pattern. But, the small stocks (sheep and goats) have increased.
5. The uncontrolled build up of tourism facilities in and outside the reserve will lead to habitat degradation.

State

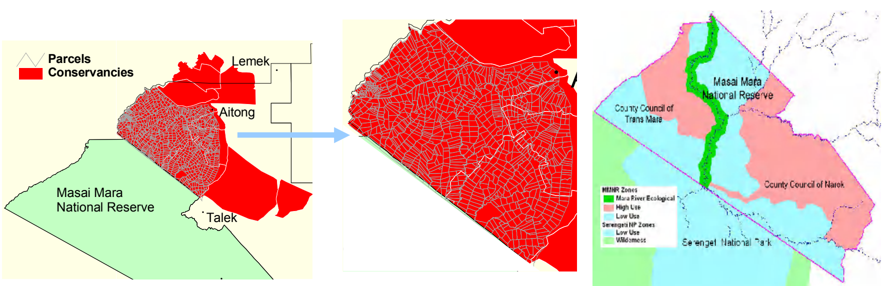
1. Wildlife movements outside the reserve are hampered by settlements, and competition from livestock and agricultural activities along the river banks.
2. The wildebeest movement to the Loita is curtailed by large-scale mechanized agriculture whilst the elephant movement to Transmara and Mau is hampered by agricultural fields and settlements (Map 6.2.3).

Impacts

1. The long-term trend shows a decline of more than 65% in the total wildlife density in the last 30 years. As the human population escalates and land use intensifies (through agriculture and land tenure change), the pressure on the remaining wildlife will be even greater.
2. The wildebeest's wet season grazing and calving areas in Loita and Ngorengore, as well as the Lolgorian forest for the elephant have been lost.
3. Resident wildebeest population declined from 150,000 to about 40,000 between 1977 and 2011. The zebra population has declined, but more worrying is the steep decline (85%) in giraffe population since 1977. However, the elephant is one of the few species in the Mara to record a population increase.
4. Loss of Mau forest will reduce water to the Mara, which will have direct impacts to wildlife and livestock.
5. Increasing tourists and development of new tourism facilities has put more pressure on wildlife habitats

Response

1. There is a proposed management plan for the Maasai Mara National Reserve. The plans are to moderate tourism development through enhanced the infrastructure and park zoning (Map 6.2.2 - right). The development of conservancies and management plan need to be coordinated for the efficient management.
2. Individual landowners have reconsolidated their parcels and together with private entrepreneurs formed a numbers of conservancies including Enonkishu, Ol Chorro Oiroua, Lemek, Ol Kinyei, Naboisho, Olare Orok, Motorogi and Mara Nark, while others are still being proposed for development e.g. Siana (Map 6.2.4).
3. With these arrangements the landowners leases the land to private companies who develop and run the tourism facilities. The contiguity of conservancies helps to ensure connectivity and increases the range for movement of large animals such as wildebeest, zebra, giraffe and elephant. Already there are 8 conservancies covering a total area of 92,248Ha, which were started in 2006 and facilitated through community-private partnership. On average a family owns between 60 and 100 Ha of land, which is leased out for payment of between US$25 to US$40 per Ha.



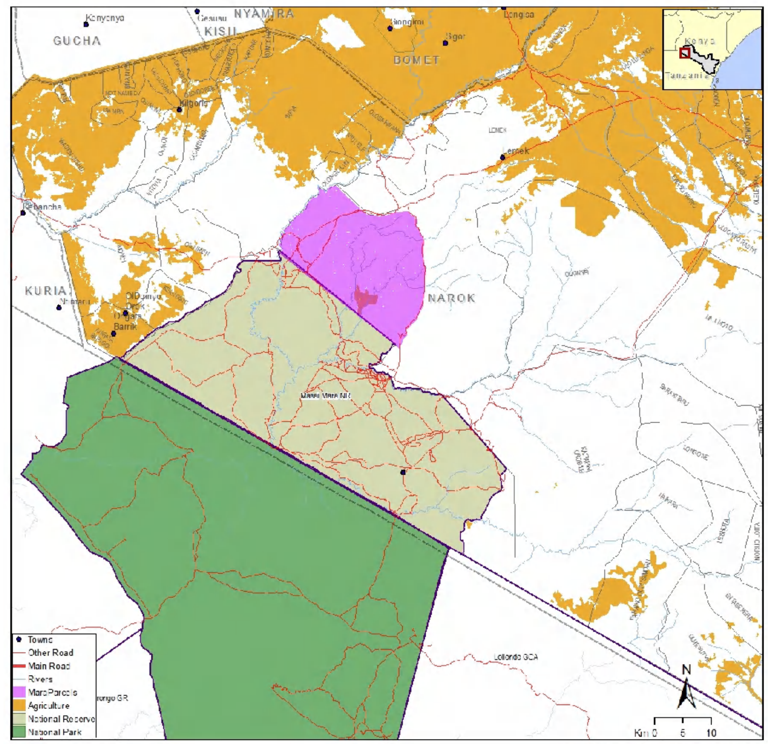
Map 6.2.2: Land subdivisions of Koyaki group ranch to family parcels was responsible for fragmentation and blockade of wildlife's dry season dispersal areas (left). The proposed Management Plan for MMNR (right). *Source: ILRI*

Threats to Conservation Connectivity

1. The key threats to biodiversity include land use change, insecure land tenure, conservation area management and partnership issues, fences, illegal off-take of wildlife and bush meat trade, human-wildlife conflicts, lack of comprehensive management plan and weak implementation of legislations, inadequate scientific data, and effects of adverse climatic condition.
2. Land subdivision, forest clearing and charcoal burning, high settlement densities and intensive agriculture is fast spreading throughout the Mara ecosystem. This practice threatens wildlife's wet season dispersal areas and dry season refuges for both livestock and wildlife.

Opportunities to Conservation Connectivity

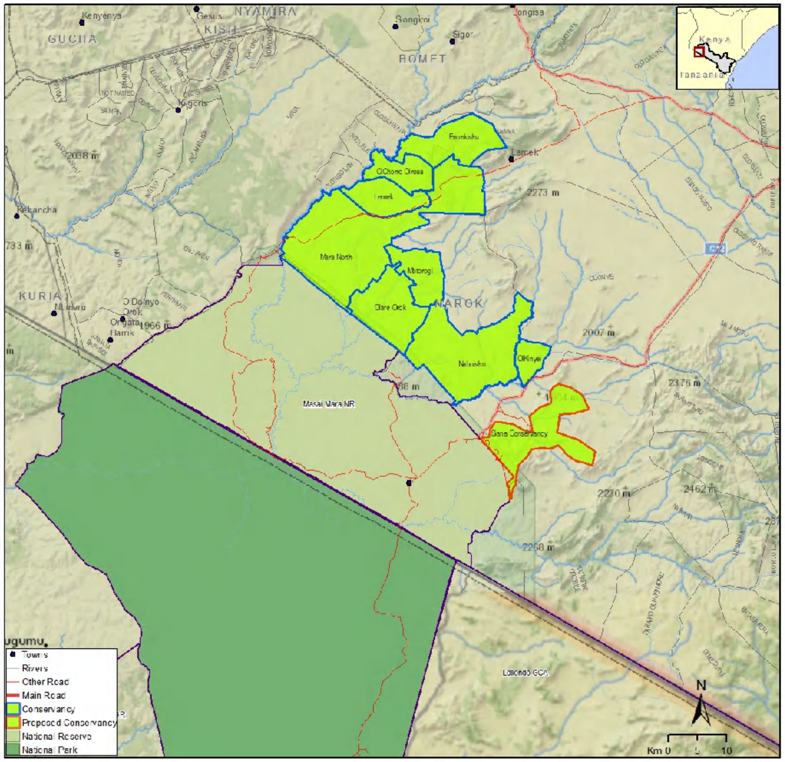
1. The area is currently experiencing an increase in eco-tourism related enterprise development as a result of pro-wildlife conservation initiatives. Many families are reconsolidating their subdivided parcels of land to form community conservancies. Conservancies form a crucial buffer for the MMNR and minimize the associated conservation threats as well as provide livelihood sustenance to the communities.
2. The potential economic development are livestock production and access to markets, sustainable eco-tourism, conservation off-sets through land leases and payment for ecosystem services.



Threats

Source: DRSRS, ILRI, ESRI, Nat-Geo World Map

Map 6.2.3: Threats to wildlife migratory routes/corridors in Masai Mara ecosystem - agriculture, land subdivision, settlements and infrastructure developments (tourism facilities and roads).



Conservancies Source: DRSRS, ILRI, ESRI, Nat-Geo World Map

Map 6.2.4: Existing and proposed community conservancies around the Masai Mara National Reserve.

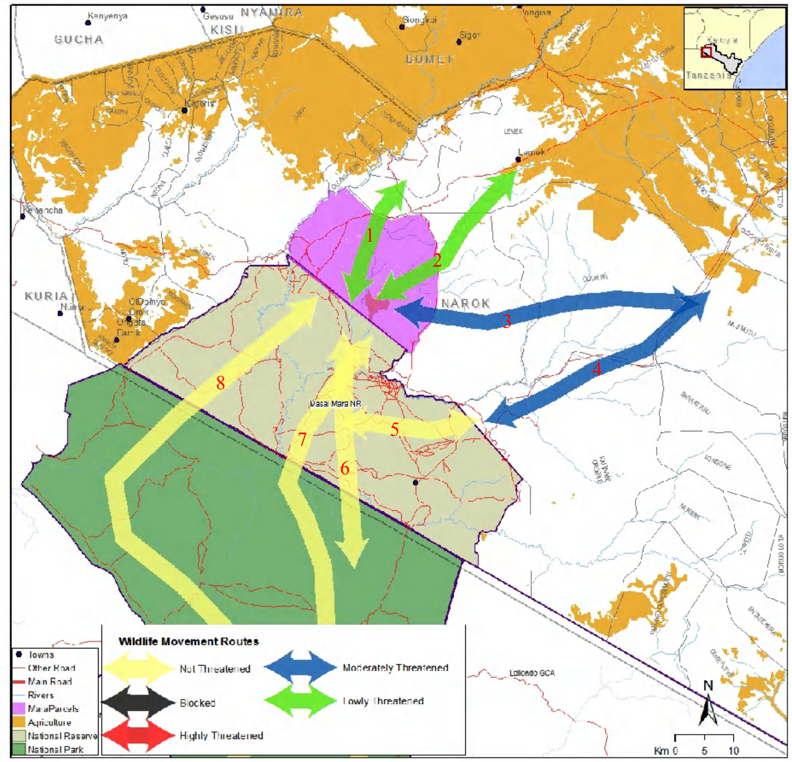
Wildlife Routes and Corridors

The following migratory routes/corridors were identified and assigned threat levels based on the DPSIR analysis and in consultation with a number of professionals and conservation stakeholders (Table 6.2.1 and Map 6.2.5).

Table 6.2.1: Connections and linkages, threat levels and required action in the Maasai Mara ecosystem

Ecosystem	Routes	Threats	State	Action
Mara Ecosystem	1 & 2	Low (green)	Low threats depending on the existence of conservancies	Immediate - need policy to support
	3 & 4	Moderate (blue)	Need compatible land use - low settlement and livestock numbers	Immediate - develop compatible land uses
	5, 6, 7, 8	Non (yellow)	No threats inside the park	Need s habitat monitoring and vegetation dynamics
Serengeti Ecosystem	6, 7 & 8	Non (yellow)	No threats inside the park	Low
			Intense poaching in Game Controlled Areas	High

Non Low Moderate High Blocked



Wildlife Movement Routes Source: DRSRS, ILRI, ESRI, Nat-Geo World Map

Map 6.2.5: Wildlife dispersal areas, migratory routes/corridors and threats in the Masai Mara ecosystem and surrounding areas (see Table 6.2.1)

Recommendations

1. *Creation of Conservancies* - the creation of more conservancies through public-private partnership should be encouraged in areas perceived to be corridors to ensure the contiguity of wildlife habitats. The policy governing the creation of conservancies is still lacking, the new Wildlife Bill is expected to address this and encourage the management of wildlife existing outside the protected areas. ***Responsible*** - Kenya Wildlife Services**,** Ministry of Forest, Wildlife, Ministry of Lands, conservation stakeholders and local community
2. *Payment for Environmental Service (PES) through Easements* - mechanisms to secure land under wildlife areas should be encouraged and pursued. Special funds or trust should be set up and legislation to run such fund to be developed. ***Responsible* -** Conservation Trust, Landowners and Private Entrepreneurs
3. *Watershed Management through Carbon Payments* - REDD and REDD+ mechanisms should be encouraged to rehabilitate the Mau catchments. It is crucial that Mau forest is restored if wildlife has to flourish in the Mara and Serengeti - both areas are depending much on the Mau for its water. ***Responsible*** - Ministry of Forest and Wildlife, NEMA
4. *Management Plans* - there a need to revisit the management plans and incorporate new programmes such as the development of conservancies outside protected areas. ***Responsible*** - Ministry of Tourism, Narok County Government and the Ewaso N'giro South Development Authority.

6.3. Greater Lake Nakuru, Elementaita, Naivasha and Eburu Forest Ecosystem

Plate 6.3.1: Eburu forest and the extended Mau forest complex in the far background – important water catchments and biodiversity conservation areas

Plate 6.3.2: Plains zebra in the thickets of Soysambu conservancy.

Plate 6.3.3: Herd of buffaloes near a water pool in Lake Nakuru National Park.

Introduction

The greater conservation area refers to land occupied by Lake Nakuru NP, alkaline Lake Elementaita and fringing acacia woodlands, the immediate riparian lands between the lake systems, and the shallow fresh waters of Lake Naivasha and fringing acacia woodland. In the north it is occupied by public land, forests, private wildlife sanctuaries and ranches which have a substantial wildlife presence including Marula, KARI, Loldia, Eburu forest reserve, Kekopey, Ututu and Soysambu conservancy. This area adjoins the larger Mau complex at the eastern tip of Eburu forest and has immense conservation value being a vital "water tower". The southern portion consists of Mt Longonot NP, Kedong ranch, Hell's Gate NP, Oserian, Crater Lake, Hippo Point and Mundui.

The rest of the area has mixed community small-scale holdings under varying uses. Historically, the land use was livestock ranching, but recently the land has been subdivided and converted to mix-ranching (livestock, wildlife and/or agriculture). The majority of small-holding land owners in the Kekopey area are absentees, mainly due to the harsh environment that does not support viable livestock production and/or sustain agriculture.

The lake system is a major source of water for an increasing human population and industries. A variety of critical habitats and associated wildlife also exists and the region is an important breeding site for the flamingo and numerous wildlife species including the recently reported critically endangered Eastern Mountain Bongo in Eburu forest. The area is a prime destination with increasing tourism enterprises, however uncontrolled and uncoordinated infrastructure growth is a major threat to sustainable development.

<u>The State of Conservation Connectivity</u>

Drivers

1. Human population of Nakuru County was 1,187,039 people with growth rate of 3.4% against national rate of 2.2% (2009 census). This has created a high quest for agriculture and settlements space especially maize and wheat farming, and residential houses.
2. Insecurity in land tenure has led the landowners with large tracts to subdivide and sale to small individual title holders. The quest for private land ownership, agricultural development especially horticulture industry, and soda ash mining has led to land fragmentation and increased fencing.
3. Infrastructure and industrial development have improved several towns along the main highway.
4. The climate change is expected to cause a slight decrease in rainfall (-100mm), increase in the frequency of droughts in the long rains, and increase in maximum temperature of about 1.1^{o}C and minimum temperature of about 0.5^{o}C. This will result to unpredicted rainfall with severe impacts to water resources and agricultural activities in the region.

Pressures

1. Increasing human population, urbanization, industrialization (thermal energy generation and salt mining), rainfed crop cultivation, irrigated horticulture and fences.
2. During the last two decades, the rapid land use changes have led to agricultural encroachments, deforestation, over grazing, logging and burning of charcoal.

State

1. Due to the nature of environment and limited access to fresh water (except in Lake Naivasha), large-scale agriculture is limited. The potential economic developments include livestock production, eco-tourism and conservation off-sets through land leases, game ranching and payment for ecosystem services (PES).
2. The local communities heavily rely on the Eburu forest reserve for dry season livestock grazing, as well as in the collection of medicinal plants, firewood extraction, charcoal burning, thatching materials and honey gathering. Accidental fires are common being caused by honey gatherers while the possibility of encroachment by agriculture constitutes a main threat to the forest.

Impacts

1. The wildlife populations have declined throughout the ecosystem due to land degradation, overgrazing and bush meat poaching;

2. Forests and woodlands is being eliminated by increasing logging for timbers and construction materials and charcoal burning,
3. Illegal water abstraction for horticulture irrigation and flower farming has adversely affected the hydrological functions of the lake systems;
4. The Rift Valley lake system and Eburu forest reserve are increasing being isolation and surrounded by agricultural activities and settlements.

Response

1. The area is experiencing an increase in development of eco-tourism enterprises as a result of pro-wildlife conservation initiatives, although traditional livestock ranching and facets of agriculture predominate.
2. The construction of Eburu forest reserve fence forms one part of the conservation initiative. Other components include initiatives to raise conservation awareness of local communities with a view to improving their livelihoods and reducing unsustainable dependence on forest products and resources.
3. Landowners and private enterprises are engaged in the establishment of conservancies e.g. Soysambu, Kigio, Kongoni and Marula and of game sanctuaries - Ututu and Soysambu or participatory land use planning through establishment of co-management strategies (e.g. ADC Dabibi and Eburu Forest Reserve);
4. Draft land use plan for the Eburu Forest Reserve to Reducing Emissions from Deforestation and Forest Degradation (REDD) is already developed.
5. Communities have increased the use of mechanisms to benefit from the presence of wildlife within their properties through Payment for Environmental Services (PES).

<u>Threats to Conservation Connectivity</u>

3. The key threats to biodiversity include land use change, insecure land tenure, lack of adequate incentives for conservation, conservation area management and partnership issues (construction of private electric fences/barriers), illegal off-take of wildlife and bush meat trade, human-wildlife conflicts, lack of a comprehensive management plan, weak implementation of legislations, inadequate scientific data and the effects of adverse climatic condition.
4. In the early 1990s, uncontrolled charcoal burning destroyed the original vegetation on the edge of Eburu forest leading to secondary invasion especially by weeds from surrounding farmlands, while the quest for charcoal had resulted in the loss of native Cedar trees from the Ututu area.
5. Land subdivision and expansion of agriculture is fast spreading throughout the area and threatens many wildlife corridors, particular in the Kedong ranch which lies between Mt. Longonot and Hell's Gate NPs.

<u>Opportunities to Conservation Connectivity</u>

3. The area is currently experiencing an increase in eco-tourism related enterprise development as a result of pro-wildlife conservation initiatives.
4. The potential economic development are livestock production and access to markets, sustainable eco-tourism, conservation off-sets through land leases, game ranching and payment for ecosystem services.

<u>Wildlife Routes and Corridors</u>

The land use in the Greater Lake Naivasha, Elementaita, Nakuru and Eburu Forest Ecosystem was mapped and wildlife routes and corridors identified based on recorded animal movements and consultation with experts and conservation stakeholders (Map 6.3.1). The Soysambu Conservancy plays a critical connection for animal movements between Lake Nakuru NP, Lake Elementaita, Eburu and Lake Naivasha while Hell's Gate NP links the upper sphere to the Kedong dispersal area in the south.

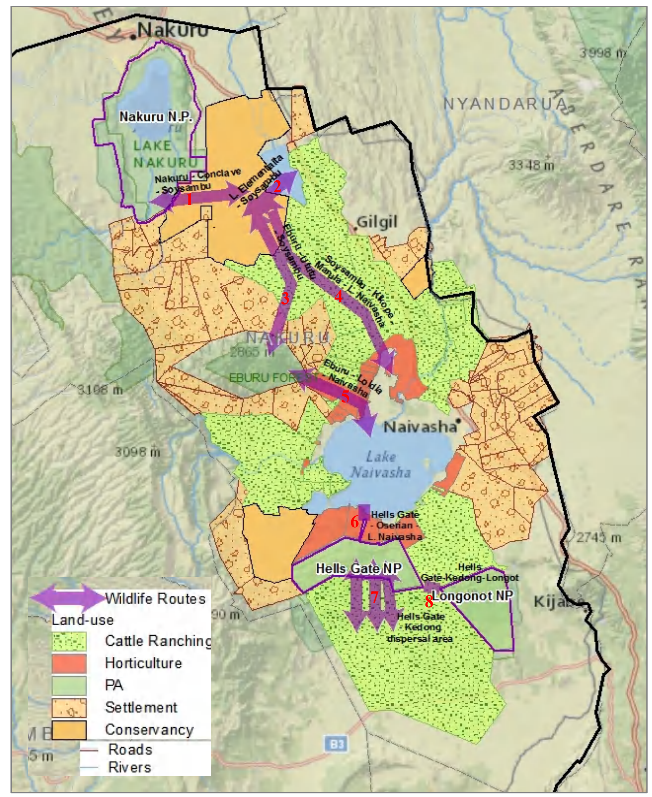
<u>Recommendations</u>

High Priority Action

1. Develop and implement the land-use master plans for specific areas i.e. large tracks of land unsuitable for crop production can be utilized for wildlife conservation and other compatible land uses.
2. Secure the corridor between Hell's Gate National Park - Oserian - Lake Naivasha through easement or land purchase from the landowners.
3. Gazettement of Lake Naivasha as a national reserve and the Gorge in Hell's Gate as a national monument (in public interest) to enhance tourism.
4. Secure Hell's Gate-Kedong-Mt. Longonot NP corridor through an easement with the Kedong ranch.
5. Encourage co-management arrangements in the Lake Nakuru National Park-Soysambu Wildlife Conservancy (Congreve) conservation area
6. Purchase private land for the extension of conservation areas (explore pilot areas in Kekopey)

Medium Priority Action

1. Develop and gazette participatory land use plans for the following focal areas: Eburru conservation area, Greater Lake Elementaita conservation area (Lake Elementaita wildlife sanctuary, Ututu conservation area and Soysambu wildlife sanctuary), Lake Naivasha riparian, Hells Gate-Longonot conservation area; Lake Nakuru National Park, Soysambu ranch.
2. Initiate a REDD project in the Eburru Forest Reserve
3. Promote the use of incentives (including consumptive uses and cropping of wildlife) in line with the new Wildlife Bill. This will also require regular and comprehensive monitoring of the targeted wildlife population.
4. Introduction of a Wildlife Trust Fund for specific areas / conservation efforts



Existing and Proposed Wildlife Routes and Corridors

Route 1: Lake Nakuru NP - Conclave - Soysambu

Route 2: Lake Elementaita - Soysambu

Route 3: Eburu - Ututu - Soysambu

Route 4: Soysambu - Kekopey - Marula - Lake Naivasha

Route 5: Eburu - Loldia - Lake Naivasha

Route 6: Hell's Gate NP - Oserian - Lake Naivasha

Route 7: Hell's Gate NP - Kedong Dispersal Area

Route 8: Hell's Gate NP - Kedong - Longonot NP

Map 6.3.1: Land use and existing/proposed wildlife routes and corridors in wider Lake Naivasha, Elementaita, Nakuru and Eburu Forest Ecosystem.

6.4. South Rift: Lake Natron - Magadi Area

Plate 6.4.1: Nguruman Escarpment (top) and Loita Hills (centre) in Kenya, and Lake Natron in Tanzania (bottom). *Photo Courtesy: Compdrw*

Introduction

The Natron - Magadi range extends across Lake Natron-Namanga-Lake Magadi areas-Nguruman escarpment and comprised of Lake Natron GCA, Magadi Concession, Shompole, Meto, Torosei, Mbuko, Elangata Wuas, Olkiramatian and Lorngosua ranches. Lake Magadi is the southernmost lake in the Kenyan Rift Valley, lying in a catchment of faulted volcanic rocks, north of Tanzania's Lake Natron. The southern Ewaso Ng'iro (Brown River) plays an important role in the ecology of Lake Natron-Magadi-Nguruman escarpment area. Changes to the land use in the river's headwaters or in the marshes before the river enters the Lake Natron could have a serious impact on these species.

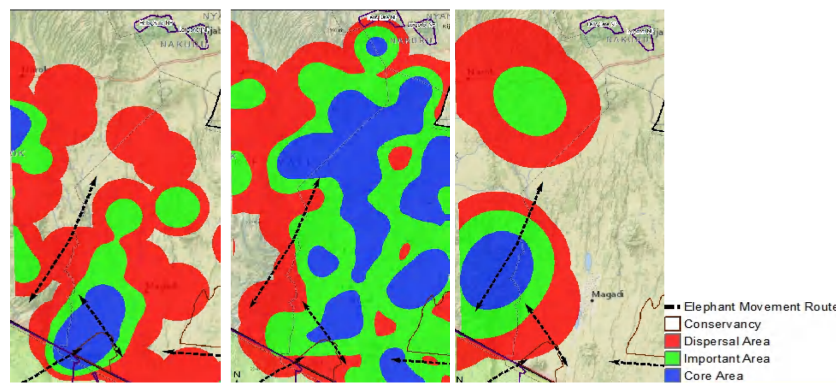
The Ewaso Ng'iro rises on the Mau escarpment and drains the south part of the Mau forest, which plays an important role in regulating and filtering its inflow, but forest is under threat from logging and land clearance for agriculture. The forest destruction would increase sediment loads in the river and cause greater seasonal variance in the water volume. The river which runs all year round flows south through the rift valley to the east of Nguruman escarpment, then crosses into Tanzania and empties into Lake Natron.

The southern Ewaso Ng'iro River has been dammed by a horst beside the Shompole volcano which causes the waters to spread out into the Engare Ng'iro swamp, where the river deposits its sediment. The sediment-free river water then seeps into the brine Lake Natron. This permanent swamp covers about 4,000 hectares and in the south of this is a seasonal floodplain of about double the size which stretches down to Lake Natron and along its eastern shore. The Engare Ng'iro swamp in Shompole is contiguous with the OlKiramatian conservation area and critical dispersal area for the wildebeest, zebra, elephant, giraffe and a host of other wildlife species.

Elephnnts are known to move to and from Kawuet-Lake Kapong to Engatreli forest through Noongumot, Lositeti, and Donyo Seleken. Although the Nguruman escarpment is a physical barrier to elephant movements across to the Loita Hills, they maneuver the escarpment at Olkiramatian and cross to Naimina Enkiyio forest and Kisinante.

Connections and Linkages

The kernel density of key species (zebra, wildebeest, elephant and giraffe) in the Greater Amboseli Ecosystem was mapped to identify the core wildlife habitats, important and dispersal areas during the wet and dry seasons (Map 6.6.1). The map shows core components and individual connections and routes in the Greater Amboseli Ecosystem. The essential wildlife areas and connections include the Amboseli NP, Chyulu NP, Tsavo West NP and transboundary (Mt. Kilimanjaro and Ngaserai areas) in Tanzania (see also Map 6.6.4).



Map 6.4.1: Kernel densities and migratory routes/corridors (black arrows) of wildebeest, giraffe and elephant in South Rift - core areas (blue), important areas (green) and dispersal areas (red). Source: DRSRS datasets

The State of Conservation Connectivity

Drivers

1. *Human Population* - increasing population, sedentarization and associated activities
2. *Land use and Land Tenure* - insecure tenure, privatization and increasing land subdivision in group ranches, land sales to speculators, agricultural expansion and declining livestock mobility.
3. *Infrastructure and Tourism* - increasing water resource development and unregulated tourism development around the Shompole concession area.
4. *Climate Change* - increasing climate variability and frequency of droughts.
5. *Policy* - lack of clear policy, coordination mechanisms and implementation across sectoral and cross borders

Pressures

1. *Human population* - increasing human population has lead to the increase of sedentarization. This is especially true in the key resource and wildlife dispersal areas.
2. *Land use and land tenure* - the pastoralists are increasing changing their lifestyle from nomadic to sedentarism, which has led to increase in livestock population. Land tenure change has caused massive subdivisions on group ranches to individual parcels, and in turn increase in human settlements and agricultural expansion especially around water sources, and increase in water extraction in the upstream. This is having a grave impact on the hydrological functions, whilst the rampant burning of charcoal and sand harvesting is having a great impact on environmental degradation.
3. *Climate change* – the inherent climate variability due to climate change has a major impact on the protected areas. The high loss of wildlife and livestock populations during the 2009 drought demonstrates this phenomenon while the increased human-wildlife conflicts highlight the vulnerability of the South-Rift area.

State

1. *Core Areas*
   a. *Land and habitat* - probably increased loss of key habitats and habitat resilience due to degradation and loss of productivity;
   b. *Biodiversity loss associated with habitat loss* - effective protection of certain key species e.g. elephant;
   c. *Wildlife populations* - reduced numbers of certain wildlife species as a result of 2009 drought; and the need for monitoring of key herbivore population dynamics such as the elephant, wildebeest and zebra.
2. *Dispersal Areas*
   a. *Land and habitat* - probably increased loss of key habitats and habitat resilience due to degradation and loss of productivity of the key dry season grazing areas.
   b. *Land use change* - high poverty levels, sedentarization and expansion of pastoral settlements, increasing land degradation and conflicting land use practices has led to habitat loss, fragmentation, homogenization and increased human-wildlife conflicts in the Shompole and Nguruman area;
   c. *Agricultural expansion and intensification* - leading to declining rangeland productivity, conflicts and associated reduced grazing and forage range;

Impact

1. *Core Areas*
   a. Land and habitat – increasing soil erosion, reduced land resilience, productivity loss and wildlife declines;
2. *Dispersal Areas*
   a. *Habitat fragmentation* - loss of dry season grazing areas, forests and wetlands, and increased soil erosion, encroachments by undesirable species and human-wildlife conflicts;
   b. *Biodiversity* - declining biodiversity and reducing wildlife numbers.
3. *Connections and Linkages*
   a. Ewaso Ng'iro River and Engare Ng'iro swamp in Shompole are critical to wildlife and livestock in the South Rift and increasing pressure from human settlements, land subdivision, agriculture, and water extraction threatens wildlife habitats and the development of sanctuaries and tourism.

Responses

1. *Core Areas, Dispersal Areas, Connections and Linkage :*
   a. Participatory land use planning mechanisms in group ranches is being used to engagement communities in addressing conservation issues and establishment of conservancies, re-afforestation initiatives and promotion of eco-tourism to open up the South Rift tourist circuit;
   b. The South Rift Landowners Association has brought together 14 group ranches to guide developments in the area and support conservation;
   c. Legal and economic instruments (leases, easements and agreements) are being encouraged in the subdivided group ranches and un-subdivided sections to expand wildlife areas and promote the development of viable conservation ventures;
   d. Enabling policies the Land Policy, Draft Wildlife Bill and Trans-boundary Ecosystem Management Bill are being pursued to guide the land use plans.
   e. Efforts to Reducing the Emissions from Deforestation and Forest Degradation (REDD) in Nguruman escarpment is being encouraged.

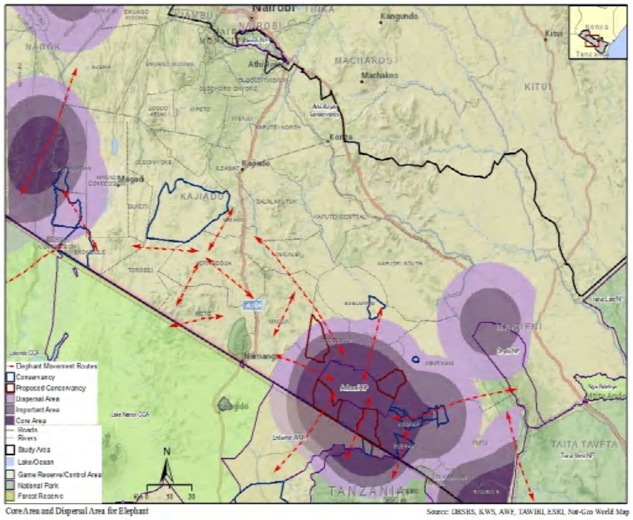
Threats to Conservation Connectivity

The South Rift spans a wide elevation gradient and all but one of Kenya's seven ecological zones. It links two of Kenya most important parks, Maasai Mara National Park and Amboseli National Park (Map 6.4.2). Unlike the parks, the South Rift is representative of the problems facing pastoral communities where wildlife and pastoral people share open rangelands.

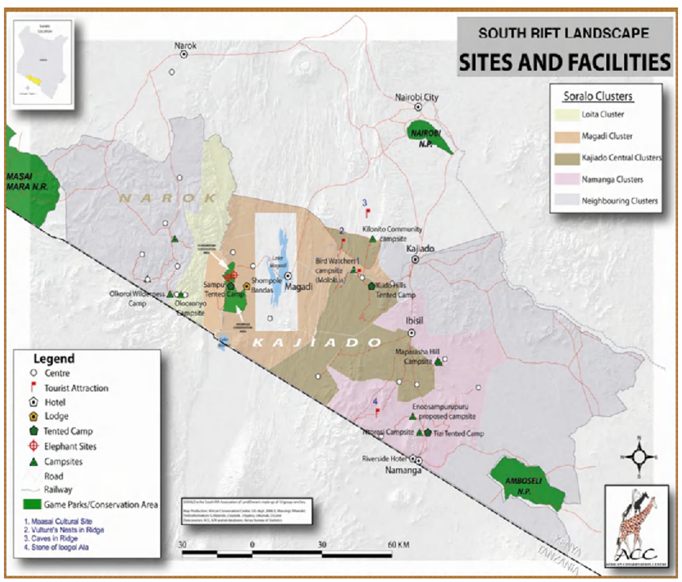
The growing conflict with wildlife over diminishing land and resources in the South Rift is typical of the rangelands. More and more of the pastoralists have been forced into a cash economy and transact their businesses. When their herd numbers are decreasing and livestock prices poor, they resort to unsustainable exploitation of the rangeland resources such as land fragmentation for sale to speculators, subsistence farming, woodland clearing for charcoal and timber, poaching and sand extraction from the dry river beds among others.

Insecure land tenure, lack of comprehensive management plan, weak implementation of legislations, inadequate scientific data, the effects of adverse climatic condition, lack of adequate incentives for conservation, increasing sedentarization/settlements, water extraction, overgrazing/degradation and human-wildlife conflicts are other main threats to conservation connectivity in the South Rift.

1. *Suswa-Mosiro-Olorgeseile route*: the recent increase in elephant poaching around Mosiro area is a major cause of alarm. Large-scale wheat farming is taking up much of this area and speculations for the Geothermal Power station would have another potential consequence for the wildlife. Land use planning should be undertaken to stem agricultural fields from spilling into wildlife areas. In addition, intersectoral consultations should consider effective conservation within the geothermal development plans.
2. *Nguruman-Loita elephants*: the main water catchments for the Shompole/Olkiramatian areas are being converted to crop cultivation, and associated with increased subdivisions and land disputes. This requires urgent monitoring and evaluation of the water catchments, water extractions and logging in the Nguruman escarpment.
3. *Namanga/Amboseli wildlife (lions and elephants as well as other species):* Namanga town is being developed into a major cross-border clearing house for trade. High land speculations and fences being put up by the wealthy developers have changed the situation in the areas and a threat to wildlife movements. The land use planning of the upcoming urbanization should incorporate compatibility with the conservation of Amboseli ecosystem.
4. *Magadi/Oldonyorok area*: currently a migratory corridor for wildlife but the on-going group ranch sub divisions in central Kajiado will lead to influx of settlements, habitat fragmentation and curtailing wildlife movements. Increased awareness creation is needed to avoid subdivisions that further degrade wildlife refuges and pastoral grazing lands. Policy and legal framework to should define compatible land use options to ensure wildlife dispersal areas and migratory routes/corridors are secure.
5. *Natron/Lengai wildebeests*: this area spans two countries with different policies i.e. game hunting in Tanzania while game hunting had been burned in Kenya. Land use planning should be coordinated and compatible across the international boundaries sharing common resources to avoid sectoral and cross-border policy conflicts.



Map 6.4.2: Core areas for all species (indigo shade) and wildlife routes (red arrows) in Amboseli, South Rift and Chyulu NR.



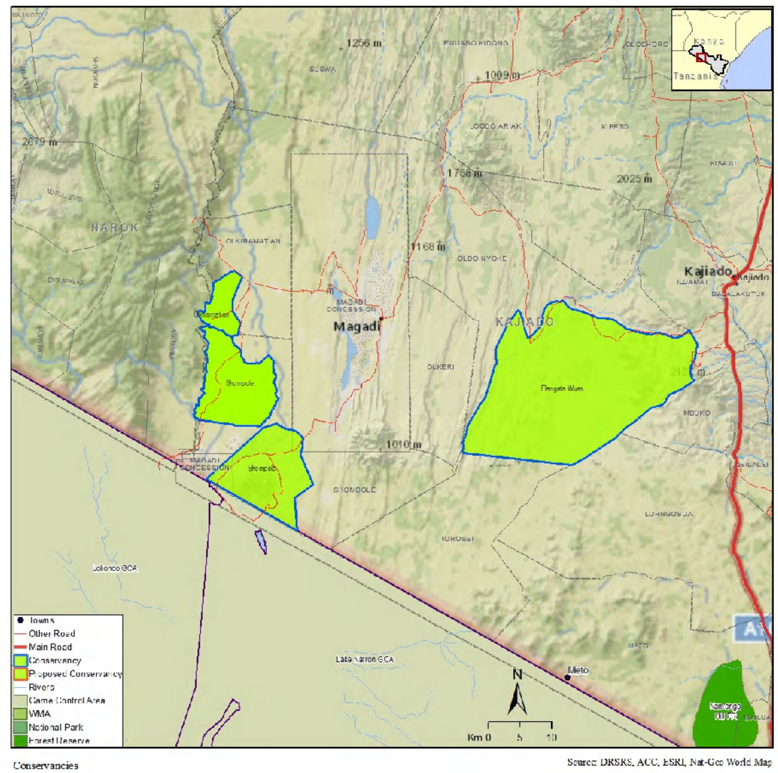
Map 6.4.3: SORALO Clusters (Loita, Magadi, Kajiado Central, Namanga and neighbouring areas), conservation areas and tourism facilities in the South Rift landscape. *Source: African Conservation Centre (ACC)*.

Opportunities to Conservation Connectivity

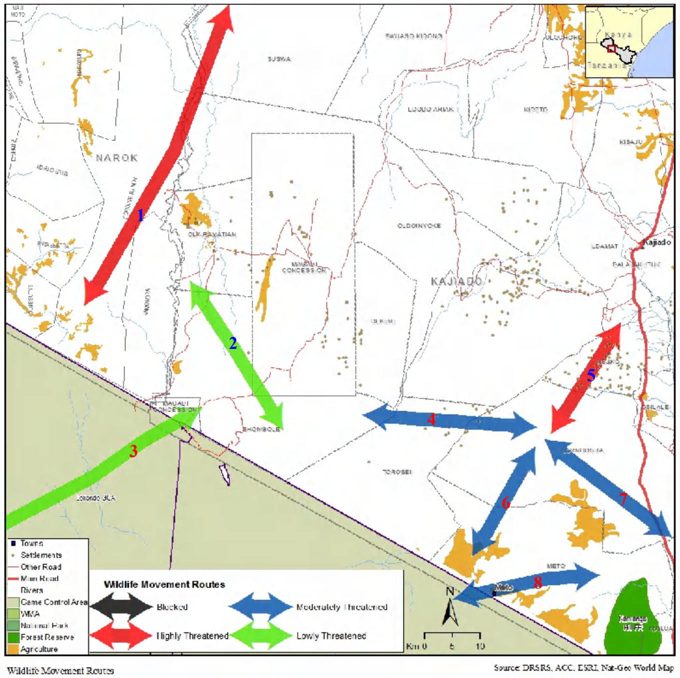
Community-based conservation initiatives in the South Rift began in 2002 by the establishment of conservation areas and ecotourism lodges in Shompole and Olkiramatian group ranches, as well as capacity and institutions needed to manage tourism enterprises and wildlife (African Conservation Centre (ACC). More than 15 group ranches under the South Rift Association of Landowners (SORALO) and over 8,000Km^2 of land linking up the Amboseli and Maasai Mara is involved and ACC is drawing in new partners to help SORALO develop and market the South Rift as a premier tourism destination (Map 6.4.3). The program aims at maximizing sustainable benefits from natural resources and ensures natural resilience to stress and change based on traditional and new mechanisms of land use such as drought refuges and drought insurance schemes to improve production and marketing skills.

Wildlife Routes and Corridors

The existing and proposed conservancies and wildlife migratory routes/corridors in the South Rift were identified and assigned threat levels based on the DPSIR analysis and in consultation with a number of professionals and conservation stakeholders (Maps 6.6.3 and 6.4.4). We have also forwarded some recommendations and responsibilities for each of the actions identified.



Map 6.4.3: The existing (Shompole, Olkiramatian and Bangata Wuas) and proposed (Shompole) conservancies in the South Rift landscape.



Map 6.4.4: Wildlife migratory routes/corridors in the South Rift (Table 6.4.1).

Table 6.4.1: Connections and linkages, and conservation threats and action needs in the South Rift

Routes	Threats	State	Action
1		Suswa-Nguruman-Loita: The main water catchments for Shompole-Olkiramatian being converted to agriculture; increased subdivision and land disputes	Immediate - monitor water catchments and logging in Nguruman; Land use plan to stem agricultural fields from spilling into wildlife corridors.
2		Shompole-Magadi-Olkiramatian:	
3		Loliondo GCA-Shompole	
4		Lorngosua-Shompole: sedentarization associated with high density settlements	
5		Lorngosua-Mbuko: high density settlements, subdivisions, and cultivation	
6		Lorngosua-Meto-Lake Natron GCA: Settlements and agriculture	
7		Lorngosua-Namanga -Amboseli: increased sedentarization, on-going subdivision and influx of settlements.	Awareness creation to avoid subdivision; Policy and legal framework to define the compatible land use options
8		Namanga Hills-Meto-Lake Natron GCA: high density settlements and agriculture	Immediate - land use plans and compatible cross-border policies

None Low Moderate High Blocked

Recommendations

High Priority Actions

1. Establish community conservancies in the main wildlife dispersal areas and migratory routes/corridors. The Lorngosua area is a critical converging zone for many wildlife species and a priority area suitable for establishment of a conservancy. This will form a contiguous area with the existing Bangata Wuas Conservancy. The Nguruman-Loita Hills is another critical area for the elephants and requires the establishment of a conservancy.
2. The cross-border corridors especially the Namanga-Longido-Lake Natron GCA and Shompole-Loliondo CGA should be secured.

Medium Priority Actions

1. The government should recognize community conservancies as legitimate protected areas with legal standing;
2. Concerted efforts should be made by public-private partnership initiatives to invest in tourism infrastructure development to open up the south Rift as a tourism circuit;
3. Economic potential of the rangelands (wildlife conservation and livestock production) should be identify and promoted as a mean of sustainable environmental management and community livelihoods
4. Encourage the participation of South Rift Landowners Association (SORILO) in wildlife conservation through engaging host communities in land use planning and decision making processes.
5. Encourage the local communities to initiate a REDD+ program in the forested and woodland areas such as the Nguruman escapment.

6.5. Athi-Kaputei Ecosystem (Nairobi NP - Kitengela Area)

Plate 6.5.1: Wildebeests with calves at the Sheep and Goat open land in the outskirts of Nairobi city - surrounded by the high density urban settlements in the background. *Photo Courtesy: Shem*

Plate 6.5.2: Large herds of cattle moved across residential estates in Nairobi during the drought periods. The Maasai cows usually have the right of way, and often cause traffic jams and destroy flower gardens. *Photo Courtesy: GOjwang'*

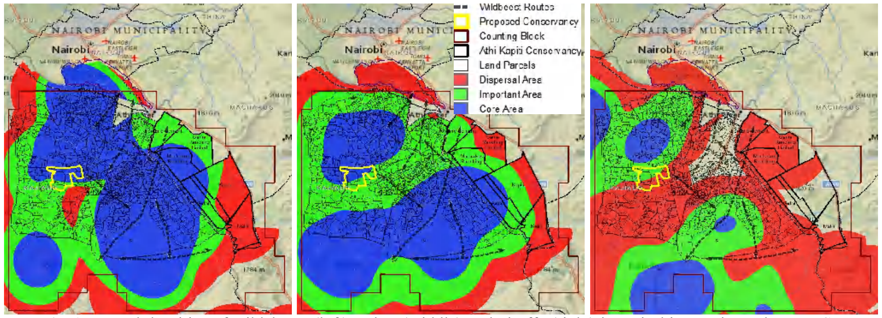
Plate 6.5.3: A large parcel of land .fenced to mark its boundarywith the adjacent parcel, as well as to deter wildlife from accessing into the property. Overgrazing can be noticed on the land parcel outside the fenced property. *Photo Courtesy: GOjwang'*

Introduction

The Athi-Kaputiei ecosystem (consisting of the Nairobi National Park and southern Maasai land) is next to Kenya's capital of Nairobi, a city of over 3 million people, but supports a large population of wildlife (more than 20 species) that includes long distance migratory species such as the wildebeest and zebra. The semi-arid plains south of Nairobi National Park have been the long-time home of the Kitengela Maasai community. These plains also host a rich wildlife population, which is vital to the health of the Nairobi National Park, since 70 to 80 percent of the park's animals roam outside the protected area boundary at any one time (Ogutu et al. submitted).

Connections and Linkages

The kernel density of key species (wildebeest, zebra and giraffe) in the Athi-Kaputei area and Nairobi NP was mapped to identify the core wildlife habitats, important and dispersal areas, and depict the species range (Map 6.5.1). The wildebeest's core area was around Olooloitikoishi, Kaputei North, Machakos ranches and park; which form almost similar pattern to the zebra except in the park utilized by the latter as dispersal area. Giraffes are widely dispersed with core areas around found around Olooloitikoishi and towards the south.



Map 6.5.1: Kernel densities of wildebeest (left), zebra (middle) and giraffe (right) in Nairobi NP-Kitengela area. *Source: DRSRS/ILRI*

The State of Conservation Connectivity

Drivers

1. *Human Population* – According to 2009 census, Kajiado County has 687312 people with density of 31.4 people per km^2 and growth rate of 4.51% against the national rate of 2.2%. The increasing population in Nairobi and it's environ has put a lot of pressure on the Athi-Kaputei ecosystem, especially the quest for space for building residential houses.
2. *Land Tenure* – Insecurity in land tenure lead many Maasai group ranches members to subdivide and get individual title. Privatization in Athi-Kaputei has land to severe land fragmentation, fencing of land and developments of agriculture, mining and flower farming.
3. *Infrastructure and Industrial Development* - The vicinity to Nairobi city and proposed Konza ICT city, and numerous upcoming towns (Machakos, Kitengela, Kajiado). Highways include the Nairobi-Mombasa, Kitengela-Namanga, Southern bypass (Mlolongo-Mbagathi), while major industrial activities are cement factory and Export Processing Zone (EPZ).
4. *Climate Change* - expected slight decrease in rainfall, frequency of droughts in the long rains seem to be increasing, there is increase in maximum temperature of about 0.5°C and minimum temperature of 1°C. This has resulted to unpredicted rainfall with negative impacts on the water in rivers and boreholes.

Pressure

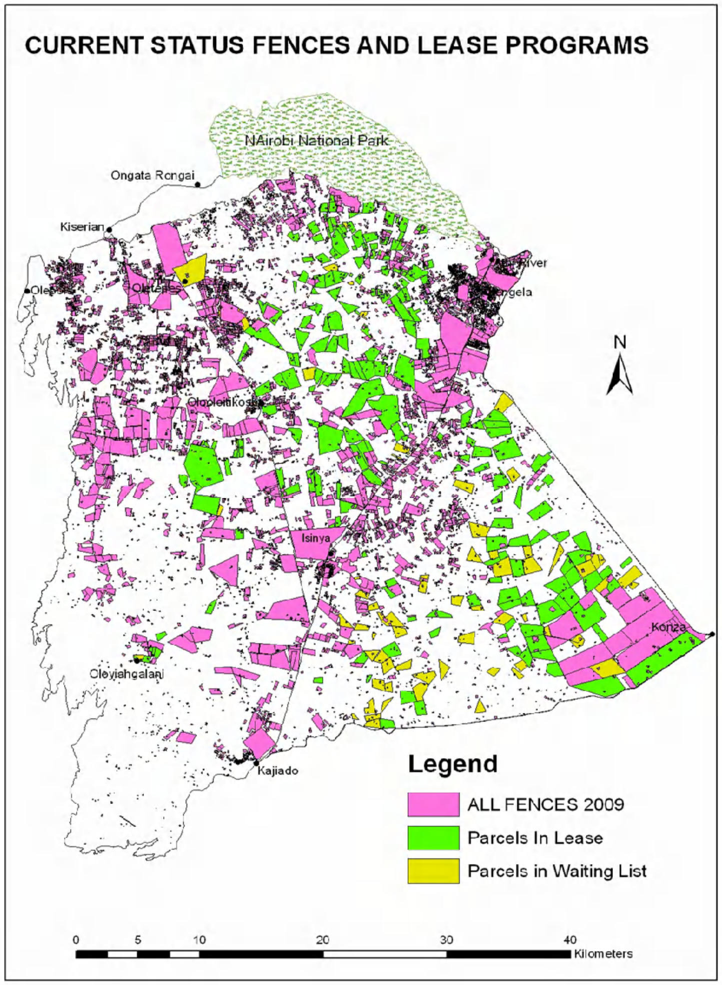
1. There is escalating human population, increasing livestock numbers, spread of urbanization and expanding industrialization (gypsum and quarry mining, EPZ, etc) and agriculture (flower farming and subsistence crop

cultivation), high density fences, and infrastructure developments (Southern bypass and improvement of other road network).

2. During the last 2 decades rapid land use changes have occurred. Most of the wetter parts of the ecosystem have been placed under crop cultivation. Real estate developments and residential houses have been built along the Nairobi-Namanga road, which is now dotted by nuclear shopping centre and markets.

State

1. More than 20% of the Kitengela area is under fences, and includes several upcoming shopping centres and residential estates, gypsum and quarry mining, while agriculture and other property development have increasingly squeezing out the wildlife and blocked migratory routes and corridors (Map 6.5.2).



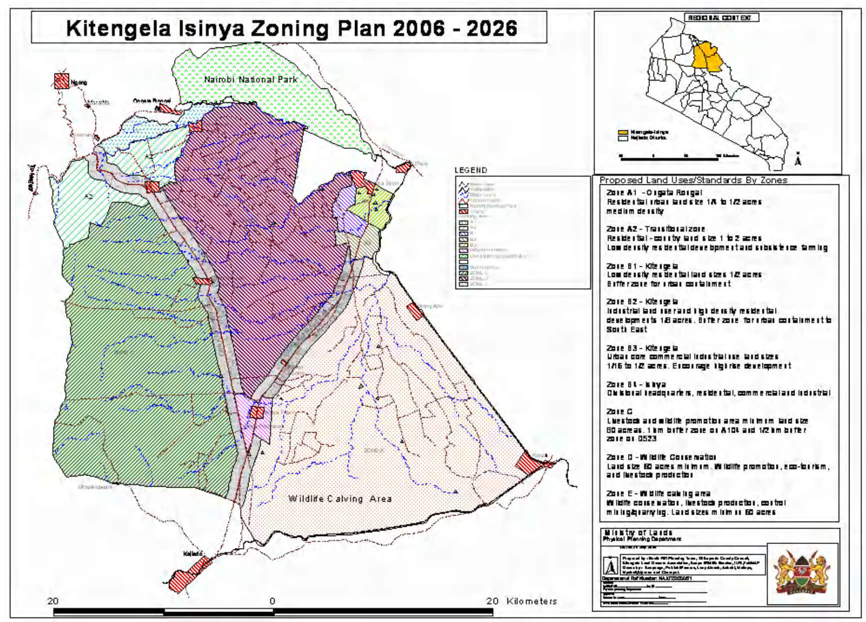
Map 6.5.2: Current status of fences and land lease program in Kitengela.

Impacts

1. *Infrastructure and urban developments* - uprising residential housing, highways (Nairobi-Mombasa, Kitengela-Namanga and proposed southern bypass (Mlolono-Mbangathi) has created physical barriers to wildlife movements, as well as reduced the wildlife range.
2. *Increasing isolation of the Nairobi National Park* - limited movements of wildlife into the Nairobi National Park, most of the animals e.g. wildebeest and zebra are blocked in the Machakos Ranches.
3. *Diminishing wildlife dispersal areas and pastoralist grazing areas* - most of the wildlife range have been blocked and pastoralists have moved away from the ecosystem with their livestock due to land tenure change (private properties associated with high density fences), land degradation and inaccessibility to watering points in the dry season grazing areas.
4. *Decline of wildlife populations* - wildebeest numbers declined in the Athi-Kaputei ecosystem from 40,000 in the late 1970s to less than 5,000 in 2011.
5. *Increase in livestock numbers* - high livestock densities near the Nairobi National Park and spillovers into Nairobi City especially during the droughts in search of water and pasture

Response

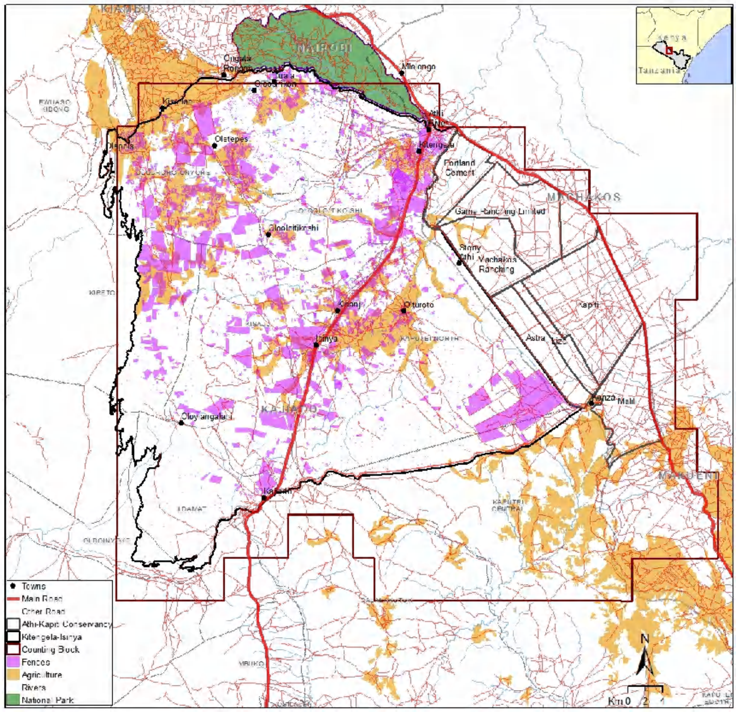
1. *Land lease and easement programmes* - the community and private entrepreneurs are engaged in community-private partnerships to develop more conservancies and wildlife resource management to enhance community livelihoods such as the development of Olerai conservancy in Kekonyokie and Kaputei plains. (Map 6.5.2).
2. *Master land use plan* - the community and conservation stakeholders have come up with plans to sustainably manage the resources within the Athi-Kaputei Ecosystem based on zoning areas (Map 6.5.3).
3. *Research and capacity building* - many development institutions are engaged in research and local capacity building to improve the livelihoods of pastoralists i.e. rainwater harvesting, farming diversification, market access, livestock sales and milk production.



Map 6.5.3: Proposed Isinya zoning plan (2006-2026).

Threats to Conservation Connectivity

The intensity of fenced small plots in the Kitengela area indicate that almost all the wildlife corridors are under threat (Map 6.5.2). The major threats to wildlife conservation in the Athi-Kaputei Ecosystem include land subdivision, urban development and upsurge of residential housing, expansion of agricultural activities (small-scale farming and horticulture), industrial developments (gypsum mining, quarrying and sand harvesting) and rivers pollution by industrial effluents. For instance, the expansion of Tuala-Oloosirikon, Empakasi, National Pipeline Cooperation (NPC) area, and growth of Olooloitikoshi town associated with subsequent land subdivision and erection of fences will further lead to the blockade of route 1 (Map 6.5.4).



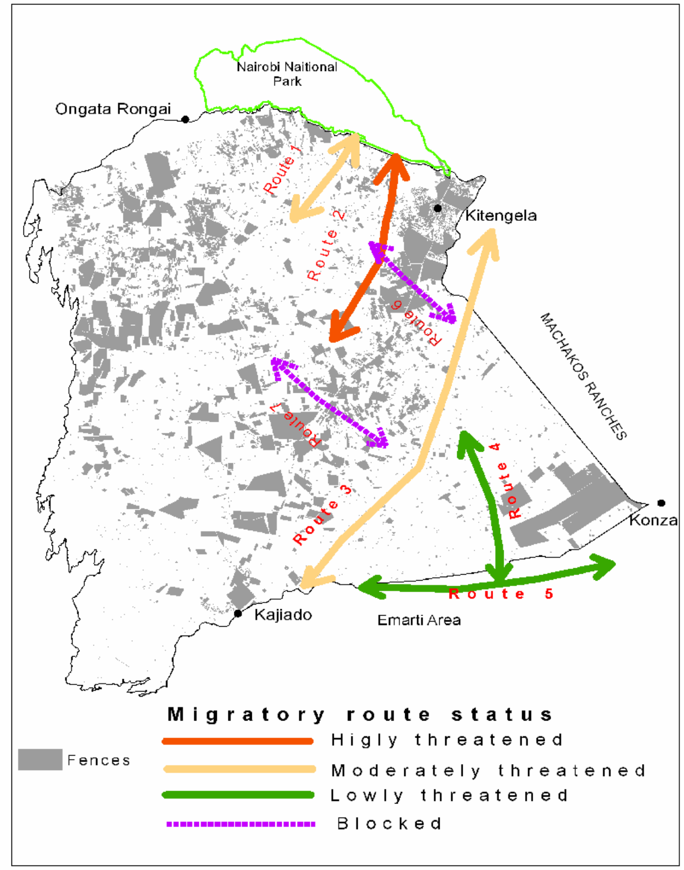
Map 6.5.4: Land subdivision, high density settlement, fences, expansion of agriculture and industrialization (gypsum mining and pollution) threatens conservation in Athi-Kaputei Ecosystem.

The Sheep and Goat land is one of the critical passage for wildebeests and zebras into the Nairobi National Park, however the two routes that passes through this area are now highly threatened by private land ownership, urban development and increasing land subdivision to plots, high density settlements in Empakasi, fences and expansion of the Mlolongo, Athi-River and Kitengela towns. It has also been blocked by the expansion of Kisaju and Isinya towns in the south.

High density settlements and agricultural activities around Olturoto area and gypsum mining in Enkirigirri threatens route 3. Although routes 4 and 5 have few threats, the increasing land subdivision between Ilasit and Olturoto and gypsum mining in the Ilopolasat and Enkirigirri area are responsible for land degradation and habitat fragmentation. Routes 6 and 7 are completely blocked by upsurge of property developments along the Kitengela-Namanga highway (Map 6.5.4).

Wildlife Migratory Routes and Corridors

The wildlife migratory routes/corridors in the Athi-Kaputei Ecosystem were identified and assigned threat levels based on the DPSIR analysis and in consultation with experts, the local community and conservation stakeholders (Map 6.5.5).



Map 6.5.5: Wildlife migratory routes/corridors and threat levels in the Athi-Kaputei Ecosystem (Nairobi National Park - Kitengela Area).

Table 6.5.1: Connections and linkages, and conservation threat le and action needs in the Athi-Kaputei Ecosystem.

Route	Threat	Description	State	Action
1		Runs to and from Nairobi NP through upper eastern part of Sheep and Goat open land, and towards Oloolotikosh-Kipeto open lands.	Privately owned but critical passage to the park. Also imminent blockade by the proposed Mlolongo - Mbagathi bypass.	Immediate - Negotiate for land lease; plan to construct animal subway bypasses across the highway.
2		Exits the park at Sheep and Goat open land and crosses Kitengela and Oloolotikishi Rivers to Enkasiti and Kisaju	The sheep and goat open land is a critical link to Nairobi National Park	Immediate - GoK land - reclaim
3		Runs from the upper Machakos ranches to east of Kitengela town, and crosses Ilasit and Olturoto in the south, and then to wildebeest calving zone in Enkirigirri (Kaputiei North).	Housing developments (shopping centres, residential estates) along the Kitengela-Namanga highway	Immediate - Need land use policy to support
4 & 5		4 - Runs to and from Ilasit in the east of Olturoto and crosses Olturoto River to Emarti in Kaputiei Central. 5 - Cross Emarti and connect calving zone in Enkirigirri to Machakos ranches	Land subdivisions between Ilasit and Olturoto, and gypsum mining at Ilopolasat and Enkirigirri	Immediate - Implement land use master plan; put restriction to the minimum size of land parcel.
6 & 7		Connects the 1st and 2nd triangle to ensure wildebeest and zebra movements to Nairobi NP	Blocked	Immediate - Secure the corridors; Develop compatible land use.

None Low Moderate High Blocked

__Recommendations__

High Priority Action

1. *Expansion of wildlife space* - the Sheep and Goat open land to the south of Nairobi National Park is a government property and should be reclaimed to increase the wildlife range as well as enable wildlife movements to and from the Nairobi National Park. This will ensure accessibility of wildebeest population from the 1st triangle to the 2nd triangle and the Machakos Ranches.
2. *Land lease or outright purchase* – The government to negotiate with the landowner (about 10,000 acres already identified as the only remaining passage in the south of Nairobi NP) to link Nairobi National Park with the core wildlife area in Oloolotikoishi plains.
3. *Establishment of conservancies* – the community and private enterprise should be encourage to engage in partnerships to explore opportunities for establishing more conservancies in areas perceived to be wildlife migratory routes/corridors, core species areas of Oloolotikoishi and wildebeest calving grounds in Kaputei North.
4. *Formation of conservation areas* - none agriculturally viable land already subdivide should be encouraged to reconsolidated their land and form conservation associations including those falling within core wildlife areas, dispersal areas and calving grounds. Already certain private properties holds abundant wildlife and are pro-wildlife conservation including Portland Cement, Machakos Ranching, Game Ranching (Hopcraft), Astra, Lisa Farm, Kaputiei and Malili.
5. *Proposed Wildlife Bill* – the bill should address policies governing the creation of conservancies and encourage sustainable wildlife management including those that exists outside the protected areas.
6. Government should implement and enforcement the Land use Master Plan. This will discourage uncontrolled land subdivision and promote conservation and other compatible land uses.

Medium Priority Action

7. Payment for Ecosystem Service (PES):
   a) Land lease programme should be expanded to include areas formerly used by wildlife for migration and dispersal especially during the dry seasons.
   b) Easements mechanisms should be encouraged and pursued to secure wildlife areas. Legislation should be developed to legalize the formation of a special fund to address the easement programme. Land lease programmes should also be expanded to include all areas used by wildlife as corridors. *Responsible* - Conservation Trust, local landowners, and private entrepreneurs.
8. Watershed Management:
   a. Carbon payments - REDD and REDD+ mechanisms should be encouraged to rehabilitate the the Ngong Hills which supplies water to the Athi-Kaputiei Ecosystem through carbon payments. It is crucial that Ngong forest is restored if the wildlife has to flourish in Nairobi NP and the Kitengela plains. *Responsible* - Ministry of Forest and Wildlife, KWS and NEMA
   b. Payment of Ecosystem Services (PES) - encouragement of upper stream water resource users associations (WRUAs) to benefit for forgoing use of water in uplands and compensation should be from populations in the lowlands and urban centres who use water for domestic purposes. *Responsible* – Ministry of Water, Ministry of Livestock Development, Ministry of Agriculture and County Government
9. Management Plans: There a need to revisit the management plans and incorporate new programmes such as development of conservancies. ***Responsible*** - Ministry of Tourism, County Government and Athi River Development Authority.

6.6. Amboseli Ecosystem

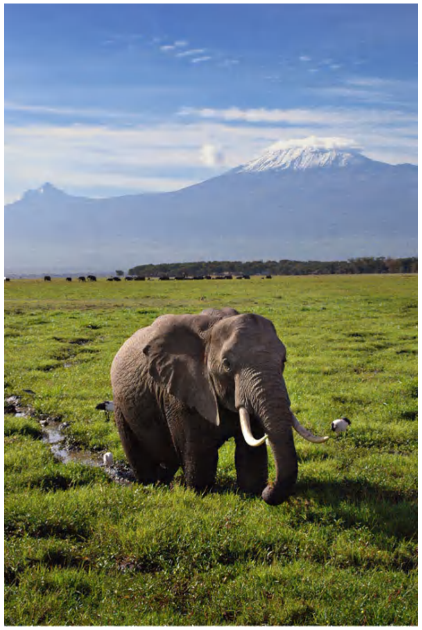


Plate 6.6.1: A lone elephant crosses the Amboseli swamp. A herd of elephants and a view of the ice capped summit of Mt. Kilimanjaro in the background. *Source: Philip.*

Plate 6.6.2: Frequent drought typifies the Amboseli region. An elephant and giraffe struggle over a patchy browse at peak of a dry spell. *Source: AATT.*

Introduction

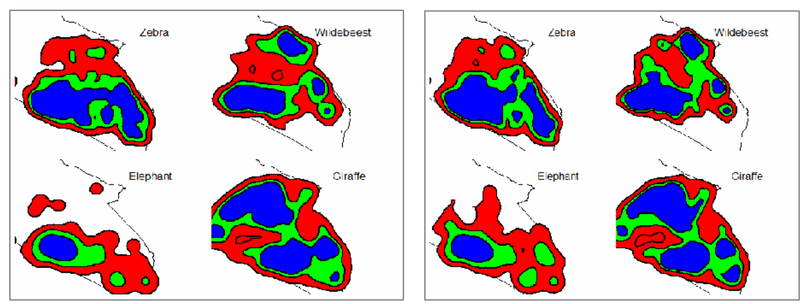
The Greater Amboseli Ecosystem is one of the leading tourist destinations in the country. High concentration of wildlife in the Amboseli basin at the foot of Mt. Kilimanjaro during the dry season is one of the quintessential images of conservation and tourism in Africa. Yet, this rich wildlife area is increasingly threatened by ongoing loss of critical wildlife habitats, migratory routes and corridors. The increasing human population and the associated activities (e.g. high settlement densities, agriculture and livestock numbers) in the ecosystem have put high pressures on the dwindling resources. In addition, the development activities around the park's edge resulting from land tenure changes and associated subdivisions, and including tourism infrastructures have to fragmented wildlife habitats, encroachments on the dispersal areas, disruption of free animal movements and blockade of their migratory routes/corridors.

The Greater Amboseli Ecosystem consists of the Amboseli NP (392 Km^2) and surrounding six group ranches namely Kimana/Tikondo, Olgulului/Lolarashi, Selengei, Mbirikani, Kuku and Rombo in Loitokitok District, all of which covers about 5063.3 Km^2. The greater Amboseli ecosystem also includes the former 48 individual ranches located at the foot slope of Mt. Kilimanjaro and now under rainfed agriculture. The community owned group ranches surrounding the Amboseli NP lies within the wet season wildlife dispersal areas and include the key and essential habitats. The park itself is the heart (core habitat) of the ecosystem, utilized by the majority wildlife during both the dry and wet season grazing. Swamps in the park are the productive engine that supports large populations and migrations of the greater Amboseli ecosystem, but it is the interaction of these productive wetlands and the high quality grasslands of community owned dispersal areas, and the essential linkages with neighbouring ecosystems that ensures the resilience of this unique landscape.

The Greater Amboseli Ecosystem faces as myriad of challenges which threaten the dispersal and movements of wild herbivores and the long-term resilience of the ecosystem. One of the biggest challenges to survival of the ecosystem is habitat loss and degradation. The vast community managed group ranches adjacent to the park are currently undergoing privatization and subdivision, a process which combined with the general increase in human population and sedentarization has been disruptive to the unique wildlife habitats and key resource areas such as riverine forests, swamps, wetlands and the highlands. In more general terms, the land tenure change has led to increased land sales and expansion of developments incompatible to wildlife conservation such as rainfed and irrigated agriculture, quarrying and unregulated tourist facilities.

Connections and Linkages

The kernel density of key species (zebra, wildebeest, elephant and giraffe) in the Greater Amboseli Ecosystem was mapped to identify their core habitats, important and dispersal areas during the wet and dry seasons (Map 6.6.1). The maps show core components and individual connections and routes. The essential wildlife areas and connections include the Amboseli NP, Chyulu NP, Tsavo West NP and transboundary (Mt. Kilimanjaro and Ngaserai areas) in Tanzania (see also Map 6.6.4).



Map 6.6.1: Kernel densities of zebra, wildebeest, elephant and giraffe in Amboseli ecosystem in wet season (left) and dry season (right). The Amboseli swamp remains the critical (core habitat) for all the species in all seasons except for the giraffe. *Source: ACC.*

The dispersal areas (mainly essential as dry season refuges) are Ol Kejuado flood plains and Olgulului rangelands, while the important linking corridors includes Olngosua connection, swamp stepping stones, Kitendeni corridor, Isinya extension and Rombo areas.

The State of Conservation Connectivity

Drivers

1. *Human Population* - increasing population, sedentarization and associated activities
2. *Land use and Land Tenure* - insecure tenure, privatization and increasing land subdivision, land sales and agricultural expansion especially in key wildlife areas, and declining livestock mobility.
3. *Infrastructure and Tourism* - increasing water resource development and peri-urbanization, completion of tarmac on Emali-Loitokitok road, unregulated tourism development around the Amboseli National Park
4. *Climate Change* - increasing climate variability and frequency of droughts
5. *Policy* - lack of clear policy, coordination mechanisms and implementation across sectoral and international boundaries

Pressure

1. *Human population* - increasing human population and provision of key services such as markets, schools, medical facilities, and water has lead to the increase of sedentarization. This is especially true in the key resource areas and on the periphery of the National Park.
2. *Land use and land tenure* - the Maasai pastoralists are increasing changing their lifestyle from nomadic to sedentarism, which has led to increase in livestock population. Land tenure change has caused massive subdivisions on group ranches to individual parcels, and in turn increase in human settlements and agricultural expansion especially around water sources, fencing of swamps and water extraction. This is having a grave impact on the hydrological functions, whilst the rampant burning of charcoal is having a great impact on environmental degradation.
3. *Infrastructure and tourism* - the completion of Emali-Loitokitok tarmac road marks the beginning of a new era of developments of the Amboseli ecosystem. The upgraded road not only bisects the key migration routes linking herbivores to essential wet season resources and neighboring ecosystem, but also increases the pressure for land subdivision and sales, as well as facilitates the extraction of natural resources (e.g. charcoal burning, sand harvesting, etc). Although the opening of the road has enhanced conservation through increased access to the national park and conservancies, but the gains associated with increased exposure and visitation are negated by the unregulated development of tourist facilities around the protected area.
4. *Climate change* – the inherent climate variability due to climate change has a major impact on the protected areas. The high loss of wildlife and livestock populations during the 2009 drought demonstrates this phenomenon while the continued habitat fragmentation and segregation effects in the ecosystem have heighten the isolation of the park. The near collapse of wildebeest population, the decline in buffalo numbers, and the increased human-carnivore conflicts highlight the vulnerability of Amboseli ecosystem. The gradual recovery of the ecosystem is a testament to the relatively compatible land use practiced by the pastoralists in the surrounding areas and the absolute necessity of wildlife corridors to neighboring ecosystems which enables populations to recover following such catastrophic die-offs.

State

1) *Core Areas*
   a) *Land and habitat* - intact, but probably increased loss of key habitats, habitat resilience and edge effects due to degradation and loss of productivity of the key dry season grazing areas
   b) *Biodiversity loss associated with habitat loss* - effective protection of certain key species e.g. elephants;
   c) *Wildlife populations* - the collapse of wildebeest and buffalo populations as a result of 2009 drought; gradual recovery of wildebeest populations as a result of existing connections to neighboring ecosystems e.g. Chyulu, Tsavo, West-Kilimanjaro; and the need for monitoring of key herbivore population dynamics such as the elephant, wildebeest and buffalo.

2) *Dispersal Areas*
   a) *Land use change* - sedentarization and expansion of pastoral settlements, increasing land degradation and conflicting land use practices which has led to habitat loss, fragmentation, homogenization and increased human-wildlife conflicts in the Amboseli-Olgulului North-Selengei and neighboring areas;
   b) *Agricultural expansion and intensification* - irrigated farming in the Amboseli-Kitenden-Mt. Kilimanjaro area, Amboseli-Olgulului North and Mbirikani-areas leading to declining rangeland productivity, conflicts and associated reduced grazing and forage range;
   c) *Fences* – fence lines along the Amboseli-Kimana-Kuku-Chyulu-Tsavo West NP edge is blocking wildlife movements.

Impacts

1. *Core Areas* - reduced land resilience, restricted wildlife movements, loss of productivity and declining wildlife numbers;

2. *Dispersal Areas*
   a. *Habitat fragmentation* - loss of dry season grazing areas, forests and wetlands, and increased soil erosion, encroachments by undesirable species and human-wildlife conflicts;
   b. *Biodiversity* - declining and wildlife numbers reducing.

3. *Connections and Linkages*
   a. The connection between the Tsavo West NP and Amboseli ecosystem through Kuku and Mbirikani group ranches as well as the access to Chyulu Hills has been curtailed;
   b. The last remaining link in the ecological gradient running down the northern face of Mt. Kilimanjaro to Amboseli NP as well as the corridor between the mountain forest and lowlands is being severed;
   c. Swamps such as Kimana and Lenker which are critical to wildlife and livestock in Kimana, Kuku and Mbirikani group ranches are increasing being eliminated, and threatens the development of sanctuaries and tourism.

Response

1. *Core Areas:*
   a. The Amboseli Ecosystem Plan is already in place and will soon to be gazetted. The Land Policy, Draft Wildlife Bill and Trans-boundary Ecosystem Management Bill should be fast tracked;
   b. The protected area management is being strengthened through the inclusion of wildlife extensions and diversification of incentive;

2. *Dispersal Areas*:
   a. Participatory land use planning mechanisms in group ranches is being used to engagement communities in addressing conservation issues and establishment of conservancies in all the Amboseli group ranches;
   b. Legal and economic instruments (leases, easements and agreements) are being encouraged in the subdivided group ranches and un-subdivided sections to expand wildlife areas and promote development of viable conservation ventures;
   c. Efforts to Reducing the Emissions from Deforestation and Forest Degradation (REDD) in Chyulu and Mbirikani areas is being encouraged.

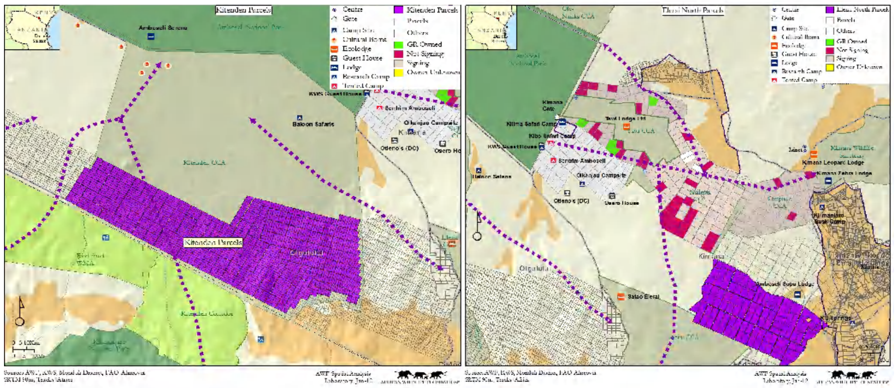
3. *Connections and Linkages*:
   a. Implementation of trans-boundary conservation initiatives is critical especially along the Amboseli-Kitenden-Kilimanjaro wildlife corridor.

Threats to Conservation Connectivity

The main threats to conservation connectivity in the Amboseli ecosystem are increasing human population, expansion of agriculture, land subdivision, overgrazing/degradation, sedentarization/settlements, fences, wetlands and forests destruction, water extraction, charcoal burning, bush meat and poaching, and human-wildlife conflicts. A report submitted to the taskforce for the development of the Amboseli Ecosystem Plan (Western, D. 2007) identified the following threats to migratory routes and corridors in the Amboseli ecosystem (see also Maps 6.6.2 and 6.6.4).

a. Farming, settlement and subdivision which threaten the dispersal areas south of the park and wildlife route to and from the Kilimanjaro forest.

b. Settlements along the Loitokitok Pipeline that threatens to severe migrations between Amboseli and Mbirikani dispersal areas as well as access to the Chyulus.
c. Subdivision, shambas and fences around Namelok and Kimana threatens continued wildlife and especially elephant movements to and from Amboseli.
d. Farming and irrigation of the Kimana and Lenker Swamps threaten to cut off access to these critical drought refuges on Kimana, Kuku and Mbirikani Group Ranches. The tourism facilities on the ranches are also threatened by the loss of swamps.
e. Farming along the Loleterish River and water extraction threatens to dry up the riverine habitat and Soit Pus Swamp, an important drought refuge connecting the Tsavo, Kuku and Mbirikani wildlife populations.
f. Land subdivision and settlement on Selengei threatens to severe the link between the Amboseli and Eastern Kaputei populations of migratory herbivores.



Map 6.6.2: Farming, settlement, subdivision and fences threaten the wildlife dispersal areas in the south of Amboseli National Park, Kitenden-Kilimanjaro and Kimana-Tsavo routes.

Opportunities to Conservation Connectivity

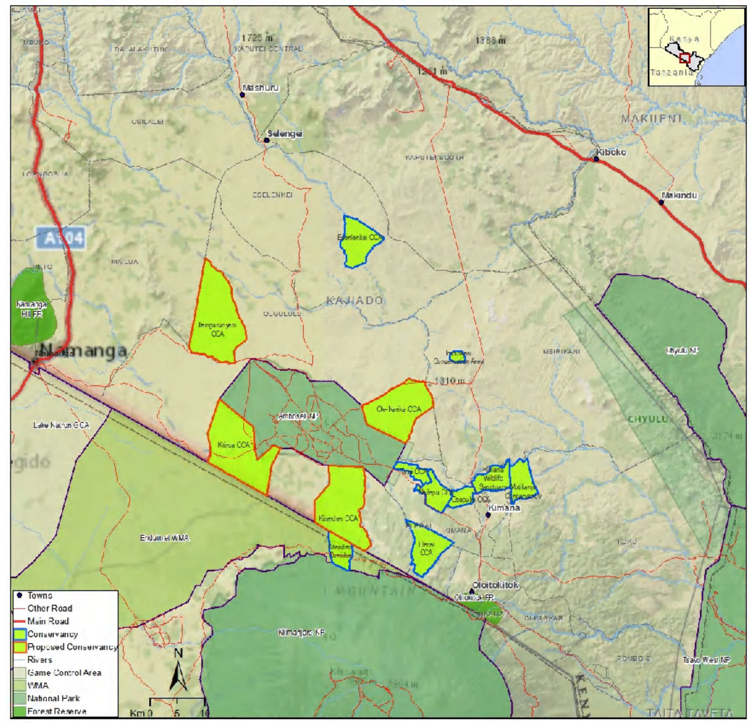
The Maasai pastoralists have increasing changed their lifestyle from nomadic to sedentarism, which has led to the increase in their livestock production as a means of livelihood sustenance. However, this paradigm shift associated with land tenure changes has caused the massive subdivision of formerly large group ranches to individual parcels. Upon the realization that these small parcels are not viable in the rangelands and that wildlife conservation provides a better alternative land use in addition to pastoralism, the pastoralists have reverted to the amalgamation of land parcels to form conservancies for conservation purposes.

Table 6.6.1: Proposed conservancies in the Greater Amboseli Ecosystem

Conservancy	Location
Ileng'arunyani	Partly in Olgulului/Olorarashi GR and Mailua GR
Selengei-Kinyei	Selengei conservation area and proposed Kinyei conservation area
Losikutok	Establishment of a Rhino Sanctuary in Mbirikani GR. (failed)
Chyulu West	Western footslope of Chyulu hills traversing both Mbirikani and KuKu group ranches.
Motikanju	Kimana extension at the north-western tip of Kuku GR.
Kilotome	In subdivided Kimana GR, borders Amboseli NP and Olgulului/Olorarashi GR
Osupuko	Subdivided Kimana GR borders Mbirikani ranch and Oloitokitok-Emali road
Elerai	Footslopes of Mt. Kilimanjaro in Entonet.
Rombo Emampuli	In Rombo GR along the Rombo-Tsavo West boundary.
Kitirua-Kitenden	Kitirua concession and Kitenden elephant corridor in Olgulului/Olorarashi GR.

Source: KWS, 2008. The Amboseli Ecosystem Management Plan (2008-2018)

The ownership and control of land is a significant issue in the establishment of Community Conservancies. Land not only offers empowerment in decision-making on resource management, but it also confers on a community pride of ownership and long-term security. The pastoralists who live with wildlife outside the protected areas historically practice an "open access" approach to land use, but these traditional use systems are struggling to keep pace with the rapidly changing socio-economic environment, and the long-term security over land tenure is becoming an increasing priority as pastoralists become more sedentary.



Conservancies

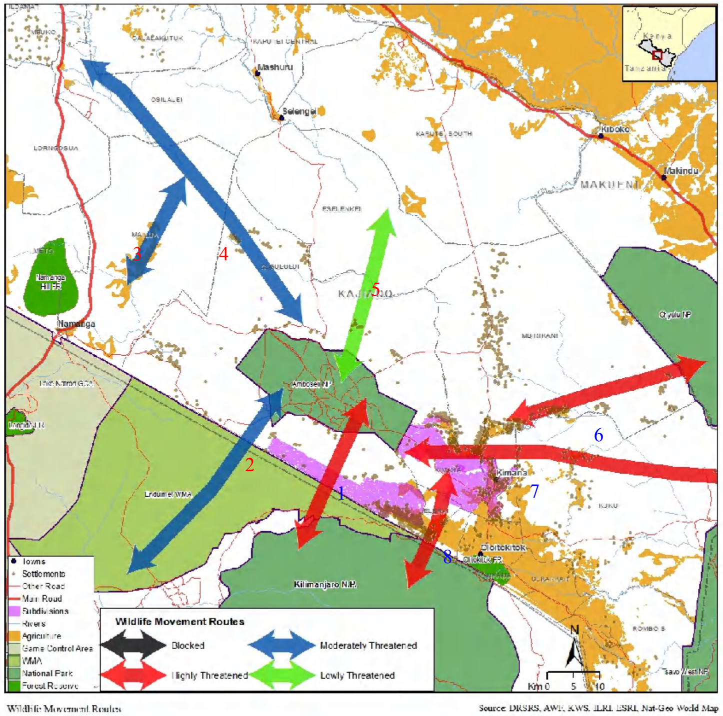
Source: DRSRS, AWF, KWS, ILRI, ESRI, Nat-Geo World Map

Map 6.6.3: Community conservation areas form important wildlife dispersal areas and migratory routes/corridor outside the Amboseli National Park.

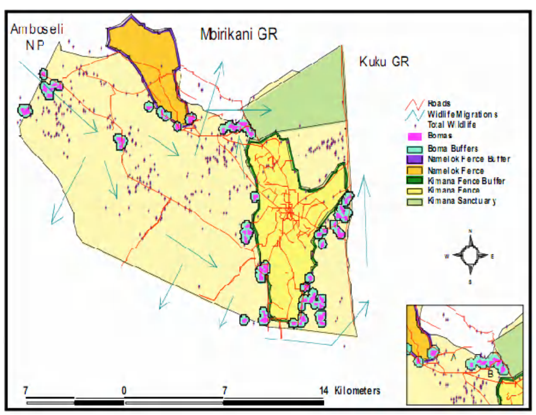
The establishment of conservancy reflects this need in tandem with the growing recognition of the value of wildlife as an alternative livelihood strategy and contributor to development for the community at large. This value is amply illustrated in the conversion of many group ranches to conservancies and demarcation of core conservation areas outside the parks and reserves for wildlife and tourism development, which are designated as livestock-free core areas (Map 6.6.3 and Table 6.6.1). These conservancies form important conservation areas that buffer the Amboseli NP, as well as effective migratory routes and corridors to the neighboring ecosystems.

Wildlife Migratory Routes and Corridors

The migratory routes/corridors in the Amboseli Ecosystem were identified and assigned threat levels based on the DPSIR analysis and in consultation with a number of professionals and conservation stakeholders (Map 6.6.4). We have also forwarded some recommendations and responsibilities for each of the actions identified.



Map 6.6.4: Wildlife migratory routes/corridors and threats (agricultural expansion, land subdivision, roads and settlement) in the Greater Amboseli Ecosystem.



Map 6.6.5: Present potential wildlife migration routes from Amboseli to Kimana Community Wildlife Sanctuaries (KCWS). Inset: Remaining wildlife corridors into KCWS (A=1.82 km, B=111.75m).. *Source: M.M. Okello (2009).*

Table 6.6.1: Connections and linkages, conservation threats and action needs in the greater Amboseli ecosystem

Routes	Threats	State	Action
1	(red)	Kitenden-Kilimanjaro - impinged by subdivision and irrigated agriculture	Immediate - needs legal and economic instruments to maintain connection
2	(blue)	Kitirua-West Kilimanjaro - challenged by sedentarization and fragmentation	Needs policy coordination across international boundaries
3	(blue)	Amboseli-Mailua-Namanga - challenged by sedentarization and degradation	
4	(blue)	Amboseli-Magadi-Shompole - challenged by sedentarization, fragmentation and degradation	
5	(green)	Amboseli-Eselenkei-Imbirikani - open, threatened by agriculture and the impacts of new Emali-Oloitokitok tarmac road	Protect the remaining key habitats "stepping-stones" - e.g. swamps and riverine areas
6	(red)	Amboseli-Chyulu-Tsavo - invaded by subdivision, agriculture and settlements	Immediate -
7	(red)	Amboseli-Kimana-Tsavo - encroached by subdivision, agriculture and settlements	Immediate -
8	(red)	Kimana-Elerai-Kilimanjaro - impinged by subdivision, agriculture and settlements	Immediate -

None Low Moderate High Blocked

Recommendations

1. Immediate Action

a. Gazette and implement the Amboseli Ecosystem Management Plan (2008-2018)
b. Establish conservancies in Kimana and Kuku Ranches to link Amboseli-Chyulu-Tsavo route.
c. Establish conservancies in Olgulului North and Mbirikani to connect Amboseli-Olgulului North-Mbirikani-Chyulu-Tsavo route, and encourage community conservation in Olgulului/Olorarashi ranches.
d. Establish a conservancy in Olgulului South to connect Amboseli-Olgulului-Loliondo-Longido route.
e. Establish a conservancy in Rombo to connect Chyulu-Rombo and Tsavo and enhance the security.
f. Secure the Amboseli-Kitenden-Kilimanjaro Corridor, and keep the areas south of Amboseli NP open (unfenced) along the Kilimanjaro corridor by establishing grazing associations and grassbanks that fosters wildlife and livestock mobility.
g. Maintain the Kimana-Namelog-Amboseli corridor delineated by elephant movements.
h. Draw cross border agreements in line with the EAC Ecosystem Bill.

2. Medium -Long Term

a. Establish mechanisms for ecological monitoring of the greater Amboseli ecosystem in collaboration with the Amboseli Conservation Programme (ACP), local communities and relevant stakeholders.
b. Establish water associations of down stream users aimed at legally enforcing river flows and wetland regulations to establish grassbanks and drought refuges for livestock and wildlife.
c. Monitor wildlife populations and curb poaching through community scouts linked to wildlife authorities on either sides of the border and Amboseli-Tsavo Community Scouts Association.
d. Link up the South Rift Landowners' Association with the Amboseli-Tsavo Association, aimed at exploring the prospects for a connecting tourist route between Magadi and Amboseli, establishing 'stepping-stone" grassbanks and wildlife refuges and coordination of community scout activities.
e. Develop species plans aimed at protecting and restoring threatened species and habitats, reduction of poaching and reduction of human-wildlife conflict. Species plans should be based on individual threats and integrated into the overall ecosystem management plans.
f. Reestablish elephant migrations and explore ways of keeping open space within the Amboseli ecosystem for livestock seasonal and drought movements using the landowner and grazing associations.

6.7. Tsavo-Mkomazi Ecosystem

Plate 6.7.1: Baboons roosts on a rocky outcrop overlooking the expansive Tsavo East NP in the background. *Photo Courtesy: Philip*

Plate 6.7.1: Elephants browsing on flush vegetation. *Photo Courtesy: KWS/Mukeka*

Introduction

Tsavo-Mkomazi Ecosystem is the largest protected area complex in Kenya and includes three national parks (Tsavo East NP, Tsavo West NP and Chyulu NP), three national reserves (South Kitui NR, Tsavo Roads and Railways NR and Ngai Ndeithya NR) and extends across the border into Tanzania to Mkomazi Game Reserve. It also includes the adjacent community and private ranches. Almost 45% of the ecosystem is protected area and 55% mainly outside the parks consist of nearly 40% extensive cattle ranches and small-scale crop cultivation, while 2% is large-scale sisal plantations.

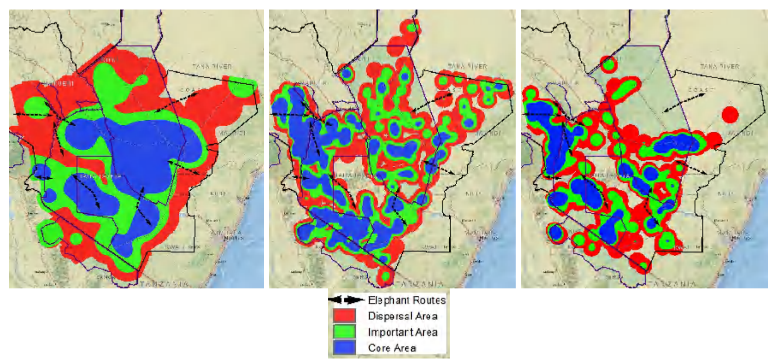
The Tsavo-Mkomazi ecosystem is particularly important for its migratory wildlife species, including the elephants that are known to migrate from Tsavo West NP to Mkomazi Game Reserve (Tanzania). Partly by virtue of its large size (44,000 km^2), the Tsavo-Mkomazi ecosystem contains a high number of endangered species. It has the largest population of elephants in the country and hosts a considerable number of black rhinos, wild dogs, Hirola (hunter's hartebeest) and Grevy's zebra, all of which are categorised a threatened. The latter two species (Hirola and Grevy's zebra) were translocated from their natural habitats to provide increased protection.

The ecosystem is also Kenya's vital catchments area for much of the southern part. Most of the Tsavo River (the only perennial water source in the area) and Mzima Springs that supplies several large towns including Mombasa with domestic and industrial water lies within the ecosystem. A substantial proportion of the Athi/Galana, the largest river in the country, also flows through Tsavo East NP and form a large part of the boundary.

<u>Connections and Linkages</u>

The kernel density of key species (elephant, giraffe and zebra) in the Tsavo Ecosystem was mapped to identify the core habitats, important and dispersal areas (Map 6.7.1). The maps show core components and individual connections and routes. The essential wildlife areas and connections include the Tsavo West NP, Chyulu NP, Tsavo East NP, Galana Ranches, dispersal areas in the Taita-Taveta County and transboundary (Mkomazi GR) in Tanzania

The elephant core area is largely to the southern half of Tsavo East NP, the expansive range outside the parks in the south west of Taita Hills and corridors linking Amboseli and Tsavo West NP. Their dispersal area extends widely in the entire Tsavo ecosystem and including important areas in the Galana Ranches and the Mkomazi Game Reserve in Tanzania. The core habitats for the giraffe are widespread in the entire ecosystem, but largely concentrated in Tsavo West NP, the overlapping area with Amboseli Ecosystem outside the Chyulu NR and transboundary into Mkomazi (Tanzania). The zebra have core areas in almost the entire Tsavo West NP and immediately outside the Chyulu NR overlapping with the Greater Amboseli Ecosystem, southern part of Tsavo East NP and into Mkomazi.



Map 6.7.1: Kernel densities of elephant (left), giraffe (middle) and zebra (right) in Tsavo Ecosystem showing the species core habitats, important and dispersal areas. *Source: DRSRS/KWS datasets*

The State of Conservation Connectivity

Drivers

1. *Human population* - increasing population and associated activities.
2. *Land use and land tenure* - insecure tenure, privatization and increasing land subdivision, land sales and agricultural expansion (small-scale cultivation, sisal plantations and livestock ranching) especially in key wildlife areas.
3. *Infrastructure and Tourism* - increasing water resource development and peri-urbanization.
4. *Climate change* - increasing climate variability and water scarcity as a result of increasing frequency of droughts.
5. *Policy* - lack of clear land use policy, coordination mechanisms and implementation across sectoral and international boundaries, lack of incentives to support wildlife conservation and development of conservancies.

Pressures

1. *Human population* - increasing human population has led to the conversion of key resource areas outside the parks and reserves to agriculture (small-scale crop cultivation and sisal plantations), livestock grazing leases and fences. This is true on the periphery of the protected areas and especially around the southeast of Taita Hills which is a critical wildlife dispersal area and link between Tsavo West NP and Tsavo East NP. In this area, the human-wildlife conflicts (crop damage, livestock predation, injury and/or death to humans) are rampant.
2. *Land use and land tenure* - land tenure change has caused massive subdivisions on ranches to individual parcels, and in turn increase in human settlements and agricultural expansion especially around water sources coupled with fencing and water extraction. This is having a grave impact on the hydrological functions, whilst the rampant charcoal burning, forest destruction, bush meat poaching, horny gathering associated wild fires and precious stone mining is having a great impact on environmental degradation.
3. *Infrastructure and tourism* - the Nairobi-Mombasa highway line bisects the key migration routes linking herbivores to essential wet and dry season resources, as well as facilitates the extraction of natural resources (e.g. poaching, charcoal burning, sand harvesting, etc). The highway has enhanced conservation through increased access to the national parks, but the gains associated with increased exposure and visitation are negated by the unregulated development of tourist facilities around the protected area and the animals knock down by the highway speeding vehicles.
4. *Climate change* - the inherent climate variability due to climate change has a major impact on the protected areas. The high loss of wildlife and livestock populations during the 2009 drought demonstrates this phenomenon. The variability of climatic conditions and frequency of droughts, and increasing human-wildlife conflicts highlights the vulnerability of the Tsavo ecosystem.

State

1) *Core Areas*
   a) *Land and habitat* - intact, but probably increased loss of key habitats, habitat resilience and edge effects due to degradation and loss of productivity in key dry season grazing areas
   b) *Biodiversity loss associated with habitat loss* - effective protection of certain endangered species e.g. elephant, Hirola (Hunters hartebeest), Grevy's zebra and wild dogs.
   c) *Wildlife populations* - decline in wildlife populations as a result of 2009 drought; the need for monitoring the vegetation and key herbivore population dynamics such as elephant, zebra and buffalo.

2) *Dispersal Areas*
   a) *Land use change* - expansion of settlements associated with high density habitation, increasing land degradation and conflicting land use practices which has led to habitat loss, fragmentation, homogenization and increased human-wildlife conflicts;
   b) *Agricultural expansion and intensification* - small-scale crop cultivation and sisal plantations leading to declining rangeland productivity, land use conflicts and associated reduced grazing and forage range;
   c) Fences – fence lines along the Amboseli-Kimana-Kuku-Chyulu-Tsavo West NP edge is blocking wildlife movements.

Impacts

1. *Core Areas*
   a. Reduced land resilience, loss of productivity and declining wildlife numbers (e.g. wild dogs) as a result of reduced range.

2. *Dispersal Areas*
   a. *Habitat fragmentation* - loss of dry season grazing areas, destruction of woodlands, increased soil erosion, encroachments by undesirable species and increased human-wildlife conflicts;
   b. *Biodiversity* - declining biodiversity and reducing wildlife numbers.

3. *Connections and Linkages*
   a. Connection between Tsavo East, Rukinga and Taita Hills - threatened by high density settlements, fences and small-scale farming;
   b. Connection between Maktau and Kasigau - threatened by high density settlements, fences and small-scale farming;
   c. Connection from Kamboyo to Chyulu - threatened by encroachments (small-scale farming and settlements);
   d. Link between Chyulu and Amboseli - threatened by land subdivision, irrigated and rainfed agriculture, fences and incompatible tourism developments;
   e. High density settlements and agriculture threatens the Tsavo West-Lake Jipe area;
   f. Corridors degraded by livestock over grazing are Tsavo East NP to Galana and Tsavo East NP to Kulalu

Responses

1. *Core Areas:*
   a. The Land Policy, Draft Wildlife Bill and Trans-boundary Ecosystem Management Bill should be fast tracked;
   b. The protected area management is being strengthened through the inclusion of wildlife extensions and diversification of incentive;

2. *Dispersal Areas*:
   a. Participatory land use planning mechanisms is being encouraged to strengthen the protected area management through inclusion of wildlife extension and diversification of incentives, as well as engagement of communities in addressing conservation issues and establishment of game sanctuaries and conservancies;
   b. Legal and economic instruments (leases, easements and agreements) are being encouraged in the subdivided ranches and un-subdivided sections to expand wildlife areas and promote the development of viable conservation ventures;
   c. Enhancing conservation through efforts aimed at Reducing the Emissions from Deforestation and Forest Degradation (REDD programme) in Chyulu Hills and Rukinga sanctuary.

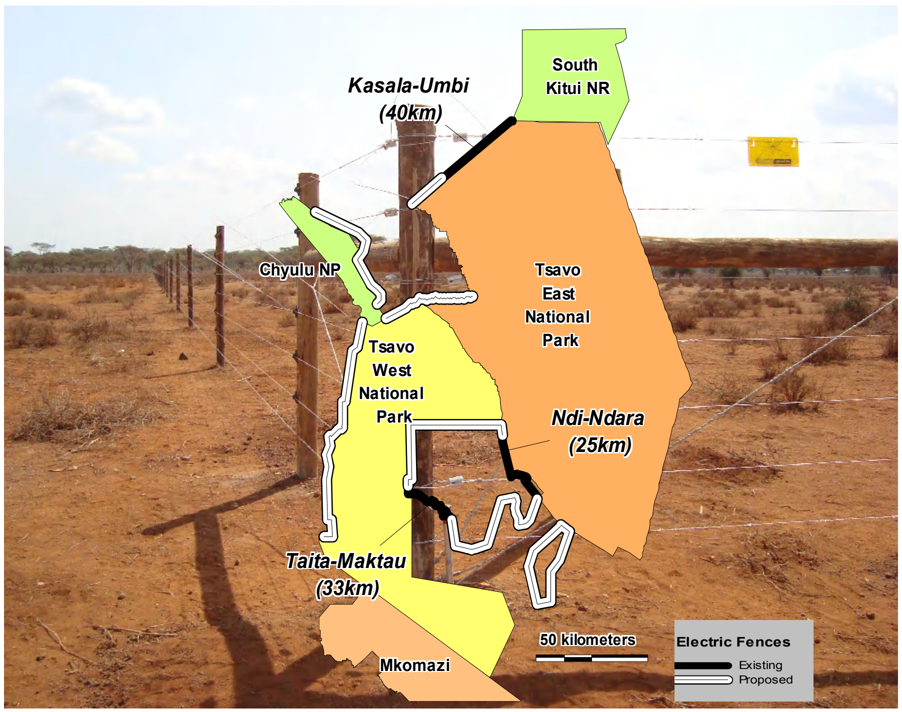
3. *Connections and Linkages*:
   a. Implementation of trans-boundary conservation initiatives is critical especially along the Tsavo West National Park and Mkomazi Game Reserve.

Threats to Conservation Connectivity

The increasing human population and associated activities in the protected-adjacent area system represents a major challenge to viability of the exceptional biodiversity and habitats essential in the maintenance of ecological processes. The main threats to conservation connectivity in the Tsavo-Mkomazi ecosystem include the increasing human population, settlements, expansion of agriculture, land subdivision, overgrazing/degradation, wetlands and forest destruction, fences, water extraction, charcoal burning, bush meat and poaching, and human-wildlife conflicts.

In the last 20 years, high density settlements and small-scale farming have increased around the Tsavo West National Park and Chyulu GR, which have threatened the blockade of traditional migratory routes between the two parks. Similarly, the intensive agricultural activities, high density settlements and fences around the Taita and Rukinga Hills have blocked the direct connection between Tsavo East and West National Parks and curtailed elephant movements (Map 6.7.4). Other examples include the loss of forest cover on the upper Chyulus, as well as farming and settlements on the lower slopes which threaten to severe the ecological link between the Tsavo West NP and the Amboseli ecosystem; and water off take from the rivers fed by the Chyulus which threatens the drought refuges and habitat diversity created in large part by gravitational water flows.

In the efforts to mitigate human-wildlife conflicts in the Tsavo-Mkomazi ecosystem, the Kenya Wildlife Service (KWS) has spearheaded the construction of a number of electric fence lines at conflict hotspots along the park's boundary (Chapter 3 - Maps 3.4.1 and Map 6.7.2). It is true that such fences have proved effective in many situations in containing the problem wildlife within the protected areas and minimizing the conflicts (crop damage, livestock predation, injury and even death to human, etc). However, the delineation of protected area boundaries in most cases, did not take into account the total wildlife habitat or species ecological needs i.e. the extended dispersal areas and migrations, while most of the large animals moves beyond these narrow confines (Lusigi 1981). In times of severe stress, mainly during the droughts, the animals and especially the elephant will often break up these fences to find water and forage.



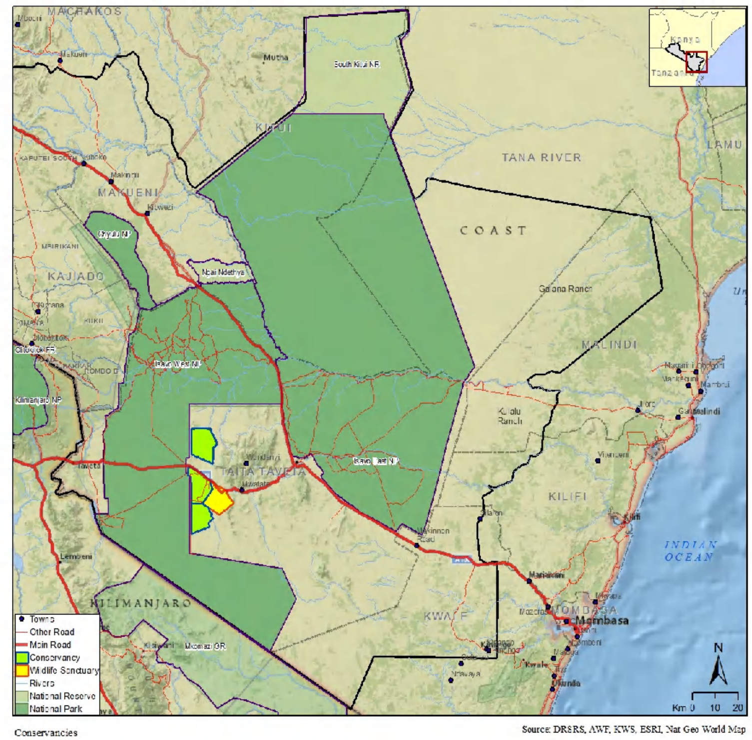
Map 6.7.2: Existing and proposed fences at 'hotspots' along Tsavo National Parks boundary. *Source: KWS*

Opportunities to Conservation Connectivity

The Tsavo East and West National Parks are second to Maasai Mara National Reserve (MMNR) with regard to visitation of protected areas in Kenya. The two parks attract over 200,000 visitors per annum, the majority of whom visit as part of a package holiday mainly based at the coast. Most visitors are attracted by the high concentration of wildlife which congregates around the few water points, making them easily visible.

The recent increase in the elephant population within the Tsavo ecosystem requires viable connectivity between its major components to enable natural migration to dispersal areas especially during the dry seasons. It is critical that these traditional migration routes remain open and accessible to minimize human-wildlife conflicts.

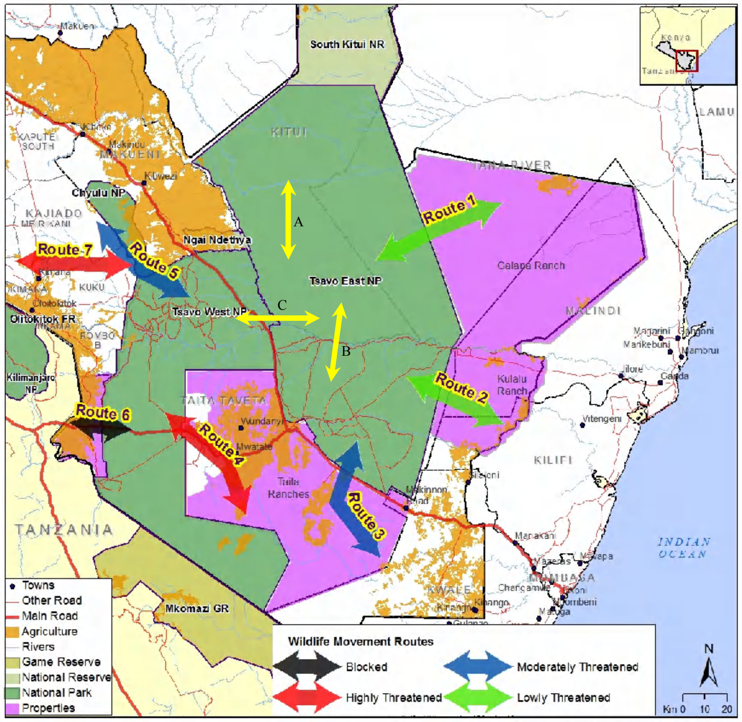
The establishment of new community conservancies and provision of support to the existing will ensure the availability of contiguous wildlife habitats outside the protected areas, while at the same time help in improving the livelihoods of communities through derived benefits (payments for ecosystem services, eco-tourism and related enterprises) (Maps 6.7.5 and 6.8.12).



Map 6.7.3: Existing and proposed conservancies that form part of the wildlife routes in Taita ranches.

Wildlife Migratory Routes and Corridors

Most of the large mammals and other large carnivores in the Tsavo-Mkomazi ecosystem often come under increasing human pressure as they depend on wide dispersal areas for their requirements. For instance, the Taita ranches (Map 6.7.5) forming a wide gap between Tsavo East and West National Parks, and critical elephant connection is facing increased agricultural activities, fences and high density settlements, which curtails animal movements and source of human-elephant conflicts. We have identified the existing routes, threats and actions action needs in the Tsavo-Mkomazi ecosystem (Map 6.7.4).



Wildlife Movement Routes

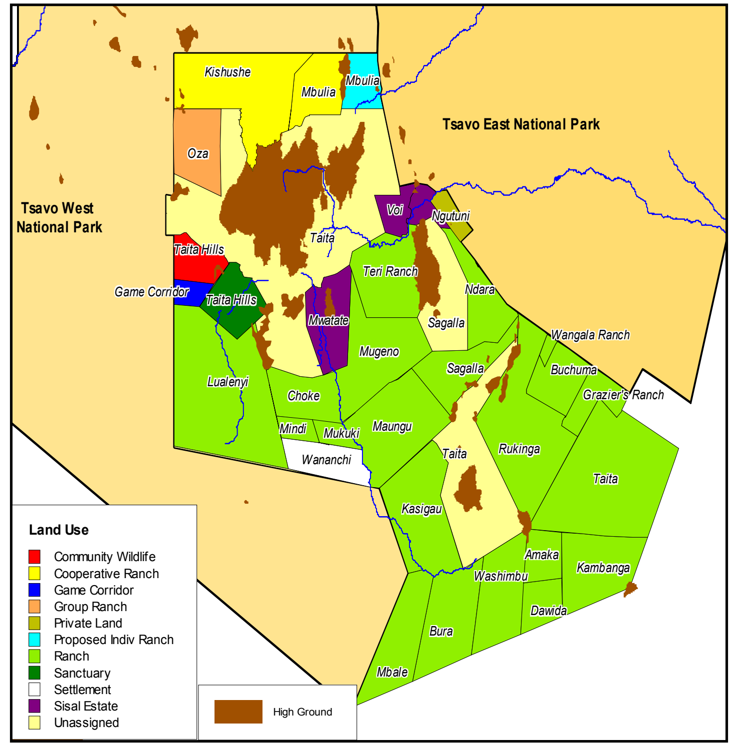
Source: DRSRS, AWF, KWS, ILRI, ESRI, Nat-Geo World Map

Map 6.7.4: Wildlife migratory routes/corridors in Tsavo-Mkomazi ecosystem (see also Table 6.7.1).

Table 6.7.1: Connections and linkages, threat levels and required action in the Tsavo-Mkomazi Ecosystem.

Routes	Threats	State	Action
A, B, C		Tiva River crossing, Gaps in Yatta and Nguli to Yatta - critical elephant corridors inside the park.	Monitor water resources and vegetation dynamics
1&2		Tsavo East to Galana and Kulalu Ranches - degraded through overgrazing by livestock	Immediate - landowners to adapt proper range management.
3		Southern part of Tsavo East NP to Rukinga and Taita hills - fences and small-scale farming;	Immediate - establish conservancies in ranches
4		Maktau to Kasigau - settlements, small-scale farming and fences blocking wildlife movement.	Immediate - establish conservancies and fences.
5		Kamboyo to Chyulu - heavily encroached by small-scale farming and settlements.	Immediate - construct and maintain fences to separate farms and settlements from wildlife areas.
6		Tsavo West NP to Lake Jipe - blocked by settlements, small-scale farming and fences.	
7		Chyulu to Amboseli - subdivision, irrigated agriculture, fences and tourism developments.	Immediate - establish conservancies; restore wetlands

None Low Moderate High Blocked



Map 6.7.5: Land use in the Taita ranches, some of the area is critical elephant dispersal and migratory routes/corridors.

Recommendations

High Priority Action

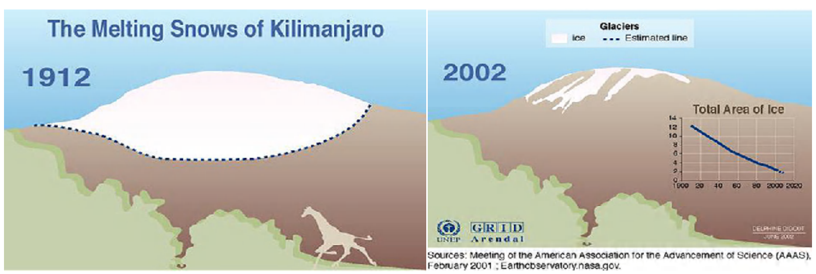
1. Kenya Wildlife Service, the local communities and stakeholders to support the establishment of new wildlife conservancies around the Tsavo-Mkomazi ecosystem, and specifically in the following areas: Taita Discovery Centre, Yatta II, Galana, Kulalu, Saghasika, Kishushe-Mburia, Rombo and Kasigau ranches to ensure contiguous habitats available for the wildlife.

Medium Priority Action

2. The government and relevant conservation stakeholders to support the implementation of Reducing Emissions from Deforestation and Forest Degradation (REDD+) programmes currently being undertaken in the Chyulu Hills and Rukinga Sanctuary in Taita ranches.
3. The government to support the development and gazettement of participatory land use plans for the conservancies in Galana, Kulalu, Saghasika, Kishushe-Mburia, Rombo and Kasigau ranches.
4. Kenya Wildlife Service (KWS) and ADC Galana ranch to develop a co-management arrangement strategy to ensure a proper range use for both livestock and wildlife, and avoid overgrazing/degradation.
5. Kenya Wildlife Service (KWS) and the counterpart Tanzania National Parks (TANAPA) to strengthen transboundary wildlife management in line with the East Africa Community Ecosystem Bill.

6.8. Climate Change – Impacts of Precipitation and Temperature on Biodiversity

Plate 6.8.1: Majestic walking giraffes in Amboseli National Park and magnificent snow capped Mt. Kilimanjaro in the background. *Photo Courtesy: AWF/Philip Muruthi*



The melting water security: graphics show the estimated extent of glacier on Mt. Kilimanjaro in 1912, extent in 2002, and decline in total area of ice (1900 - 2000), with projection to 2020. *Source: UNEP/GRID-Arendal (2005).*

The remaining 'snow' fields atop famed Mt. Kilimanjaro in Tanzania are melting so fast they could be gone within two decades, according to experts. Scientists believe the rise in global temperature (warming) rather than local weather (changes in cloudiness and precipitation) is chiefly responsible for the rapid loss of ice from Africa's highest peak (Thompson et al. 2009). The team, led by Professor Lonnie Thompson, from Ohio State University (US), pointed out that the snows had survived intact for 11,700 years. However, they found that the total area of the Kilimanjaro ice fields had shrunk by nearly 85% between 1912 and 2007, and more than a quarter of the ice present in 2000 has now gone. The first calculation of ice volume loss indicates that from 2000 to 2007, the loss by thinning is now roughly equal to that by shrinking (http://researchnews.osu.edu/archive/lonkilipnas.htm).

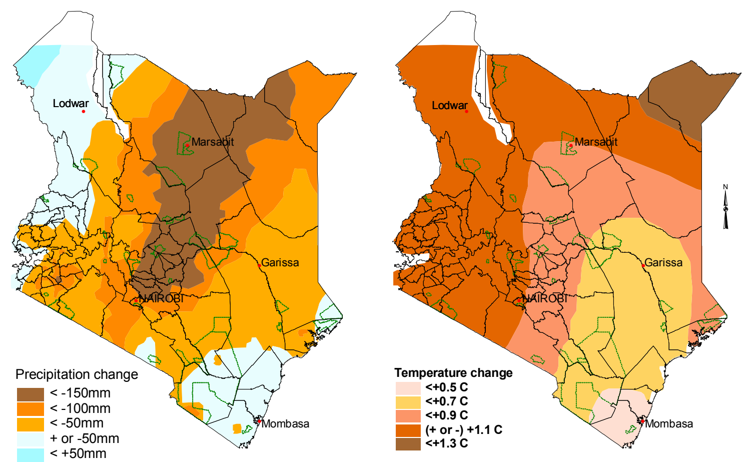
Introduction

Although Kenya has contributed little to the causes of global warming, it is one of the countries most affected by the climate change phenomena. The effects are likely to become more severe in future and could slow down the nation's projected economic growth, which is heavily dependant on climate-sensitive sectors such as agriculture and tourism. The changing climate condition is already to blame for the melting of glaciers on Mount Kilimanjaro and Mount Kenya. Mount Kenya, the highest peak in the country had 18 glaciers in 1900 but now only 7 remains, and explains the downstream decline in water levels of major rivers whose catchments is the mountain such as Tana and Ewaso Nyiro Rivers.

Rainfall and Temperature Changes

The observed link between Indian Ocean and Pacific Ocean warming and drought-inducing subsidence across Kenya may indicate that continued precipitation declines are likely over at least the next decade. The La Niña years tends to be drier with the Indian Ocean east - west wind bringing subsidizing drier air across the horn of Africa. Warming over Eastern Africa exacerbates evaporation and crop water deficit. This rising temperatures and declining rainfall may lead to progressive habitat desiccation and reduction in vegetation production in the southern Kenya rangeland ecosystems (Ogutu et al 2007, Analysis of this report).

On other hand it has been observed that the long rains in central Kenya have declined by more than 100 millimeters since the mid1970s in Central Kenya (FEWSNET 2010). This decline is probably linked to warming of the Indian Ocean, and seems likely to continue. A warming of more than 1°C may exacerbate drying impacts especially in the lowland areas. FEWSNET indicate critical surplus crop growing areas in Central Kenya are threatened, and the amount of prime arable land could diminish substantially. Similarly other agricultural potential areas also may face rainfall declines and push its population into the rangelands where wildlife abounds (Map 6.8.1). In the FEWSNET study, seventy rainfall gauges and seventeen air temperature stations were used to analyze the long rains period (March to June) between 1960 and 2009.



Map 6.8.1: Projected changes in precipitation (left) and temperatures (right) in Kenya from 1975 to 2025. *Source: FEWSNET 2010*

The observed and projected precipitation changes from 1975 to 2025 show substantial rainfall decline in the Mara, South Rift, and Kitengela. The Amboseli and Tsavo Ecosystems will have a mixed of less rainfall and in some places of more rains. Estimates of temperature change over the same period indicate a general warming represented by Mara - 1.1˚C (FEWSNET 2010, Ogutu et al. 2007), Amboseli by 0.9˚C (FEWSNET 2010), South Rift by 1.1˚C, Kitengela between 0.9 and 1.1˚C (FEWSNET 2010, Ogutu et al. submitted), and Tsavo by 0.7˚C.

Estimates of climate change in the long rains (Mar-Apr-May-Jun) over the same period in Mara, Amboseli, Athi-Kaputei, Tsavo and South Rift ecosystems indicate a general warming and reduced precipitation represented by Mara (-50mm), Amboseli (-50mm), Tsavo (±50mm), South Rift (-100mm) and Kitengela (-100mm), and temperature by Mara (1.1˚C), Amboseli (0.7-0.9˚C), Tsavo (0.5-0.7˚C), South Rift (1.1˚C) and Kitengela (0.9-1.1˚C) (FEWSNET 2010, Ogutu et al. 2007, Analysis from this study). This warming and diminishing rainfall is likely to blame for intensifying the impacts of observed changes in vegetation production and cover in these areas.

<u>The State of Conservation Connectivity</u>

Driving Force

Increasing human population and anthropogenic activities - Future prognosis suggests that on average the continent will be 2-6˚C warmer. This will accelerate desiccation and deterioration of the vegetation and engender phenological shifts including wildlife's breeding dates, plants flowering and bud burst, with the potential to disrupt existing faunal and floral associations and large-scale ungulate migrations (Ogutu et al 2007).

Pressures

The increasing demand on land for agriculture and settlements, timber and poles for building and construction, charcoal burning for fuelwood and other plant uses will lead to forests destruction and environmental degradation.

State

Evidence of the climate change is the general rise in temperature and increased variability of rainfall in most regions. Extreme minimum night time and maximum temperatures have been rising (warming trend). The minimum temperature has generally risen by 0.7-2.0˚C and maximum by 0.2-1.3˚C (Analysis from this study). Rainfall has also shown increased variability from year to year, and in the course of the year there is a general decline of amount in the main rainy season (Mar-Apr-May), droughts in the long rains is more frequent and prolonged. On the other hand a positive trend (more rains) is observed during the short rainy season (Sept - Feb).

Impacts

There is likelihood in projected global climate change, which will directly affect biodiversity through changes in temperature and precipitation, and indirectly by increased frequency of disturbances such as drought and storms. Anthropogenic activities will exert additional pressure on biodiversity and expected to exacerbate climate mediated biodiversity loss through land use change, forest land conversion to agriculture and settlements, logging, soil erosion, water pollution, water abstraction and diversion for irrigation and urban systems, fragmentation of wildlife habitats, spread of invasive species, etc. Land use and cover changes progressively reduce and precludes the potential for species to spread or disperse to future climatically suitable habitats (Ogutu et al. 2007).

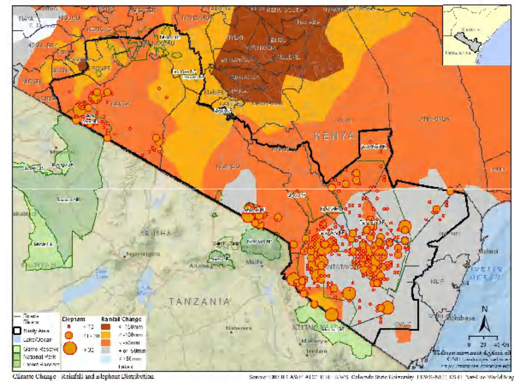
The impact of climate change is generally compounded by environmental degradation:

a. Increasing desertification and soil erosion especially in the arid and semi-arid lands (ASALs), dwindling natural resource base (loss of biodiversity, receding rangelands to support wildlife and pastoralists, animal displacement and increasing migrations).
b. Increased frequency, magnitude and severity of disasters especially the drought and floods will lead to loss of vegetation cover, increased scarcity of water resources, increased vector and water borne diseases, destruction of infrastructure, increased human-wildlife conflicts, loss of biodiversity and livelihoods among others.

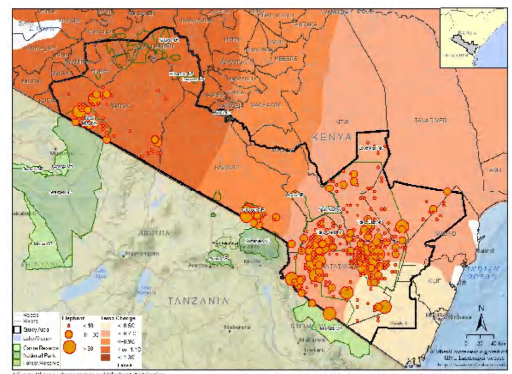
Recent studies on the impacts of climate (rainfall and temperature) on wildlife in the Nairobi National Park, Athi-Kaputei and the Mara ecosystem has shown that: rainfall exerts a pervasive influence on abundance and population of herbivore in the Kenya rangelands and different species respond contrastingly to rainfall variability. The population growth for kongoni and warthog in Nairobi NP was negatively correlated to wet season rainfall, but positively to wet season rainfall for the migratory wildebeest and zebra. The rising minimum temperature was associated with declining population growth rate for Grant's gazelle, waterbuck, wildebeest and zebra in Athi-Kapiti ecosystem (Ogutu et al. submitted), and high rainfall advanced onset and increased synchrony of calving and natality rates for topi and warthog in the Mara (Ogutu et al 2009).

Responses

1. Several institutions and stakeholders are increasing involved in climate change research, capacity building for coping and adaptation, and development of mitigation mechanisms. The communities are diversifying their livelihoods through sustainable resource use and conservation including benefiting from schemes such as payment for ecosystem service (PES), community conservancies, and REDD programmes.
2. Conservation stakeholders are increasingly developing climate change strategies such as green economy, protection of water catchments and re-afforestation and, green energy programs to reduce carbon emissions.



Map 6.8.2: Precipitation change zones and elephant distribution



Map 6.8.2: Temperature change zones and elephant distribution

<u>Recommendations</u>

1. Most wildlife species are generally adapted to natural habitats and slight change in the surrounding often invokes migration. There is need to develop a climate change strategy on wildlife adaptation and coping mechanisms, as well as undertake research to understand the climate change threats and impacts on wildlife, migratory routes and corridors.
2. The potential impacts of climate change should be assessed on a species basis. Tracking of animal's daily movement and seasonal migration, and habitat monitoring is essential as climate change is likely to alter migratory routes and breeding periods.

CHAPTER 7

RECOMMENDATION AND ROADMAP

Plate 7.1.1: A matriarch elephant (mother and two calves) crossing a track in barren land with scattered tress in the background. *Photo Courtesy: AWF/Philip Muruthi*

7.1. Reclaiming Wildlife Migratory Routes/Corridors

The results of this study indicate that human population and activities such as livestock husbandry, human settlements, fencing and arable agriculture have interfered with wildlife populations, their distribution and movements in various ecosystems. Most wildlife populations have declined in the last few decades due to these human activities and climate change related drought. The distribution range of most species has shrunk due mainly to these human activities. Also, human-wildlife conflicts have increased due competition for resources (water, forage) and space and wildlife habitats have been degraded or lost The corridors identified in various ecosystems , strategies and actions proposed should be include recommendations provided below..

This study has shown that most of the wildlife dispersal areas, migratory routes/corridors in southern Kenya rangelands have been interfered with by human activities to the extent that some are highly threatened or have been blocked; curtailing animal movements. The main threats to these habitat connections and linkages are expansion of incompatible land uses to wildlife conservation i.e. agriculture, high density settlements, fences, mining and quarrying, woodland clearing, wetland drainage, high livestock numbers, poaching and drought. These have been caused by increasing human population and poverty levels, change in land use, /insecure tenure, sedentarization, subdivisions, woodland clearing, poaching and droughts.

Although Kenya's wildlife has continued to decline in recent years both inside and outside protected areas, the continued existence of large wildlife populations and diversity pinpoints to the functional ecosystems that can be conserved and managed to maintain the ecological processes. The increase of human population and associated activities, especially the demand for land for agriculture and settlement, and extraction of natural products (water, timber, fuelwood, minerals, quarry and sand, etc) are the major impediment to wildlife conservation. These and other environmental factors such as climate variability especially droughts and floods have continued to interrupt the balance of ecological processes and affected ecosystems integrity.

The majority of wildlife in Kenya exists outside the protected areas and often come under intense pressure from human activities. The areas outside the parks and reserves have a full range of ecosystems, from those relatively undisturbed, such as the semi-arid and arid areas where wildlife is mostly found, to food producing landscapes with mixed patterns of human use, to ecosystems intensively modified and managed, such as agricultural land and urban areas. The issues that affect conservation outside protected areas include: space for wildlife, lack of security of tenure to land, user rights, security, human-wildlife conflicts, representation in wildlife management and governance structures, incentives and benefit sharing, technical and financial capacity to manage wildlife, limited wildlife education and research.

The land outside protected areas is largely under the control of communities and private landowners. Their cooperation is essential for the success of conservation activities, as the majority of these lands are subject to a multiplicity of uses - some of which conflict with wildlife conservation. Land use practices that are phasing out wildlife through habitat loss and fragmentation or curtailing movements by blocking migratory routes/corridors such as agriculture, settlement and fences can be minimized or confined to appropriate areas with proper incentives. The individual or corporate landowners in wildlife areas who adopt wildlife as a form of land use will require adequate incentives to induce or promote the establishment of conservancies and wildlife sanctuaries or to implement measures that promote sustainable wildlife conservation such as establishing REDD programmes and range management.

In recent years, prime land in Kenya has increasingly become expensive and highly political issue. Although there is urgent need to secure wildlife dispersal areas and migratory routes/corridors already interfered with or blocked by human activities to increase wildlife space, the demarcation of corridors will be harder than simply drawing lines on a map. It will involve wider consultation and concerted efforts by all the conservation stakeholders, county governments, local communities and private landowners whose lands are perceived to be wildlife areas. It will also require political goodwill and the immediate implementation of land use and biodiversity policies and pieces of legislation, and economic and legal instruments that are already in place.

7.1.1. Integrated Land use Planning and Management

The expanding human needs and economic activities is placing an ever increasing pressure on land resources, and creating competition and conflicts which results in suboptimal use of land and natural resources. To meet the future requirement of humans sustainably, it is essential that these competing uses and conflicts are resolved amicably by developing effective and efficient use of natural resources by integrating physical and land-use planning and management. When all the land uses are examined in an integrated manner, it makes it possible to minimize the land use conflicts through an informed decision making while crafting the most efficient trade-offs and linkages to socio-economic development and wildlife conservation. The essence of integrated approach to resource planning finds expression in the coordination of sectoral planning and management activities as it relates to various land use aspects.

In the process of addressing conservation issues, integrated land use planning and management is critical as relates to wildlife dispersal areas and migratory routes/corridors. The landscape approach defines a holistic manner in which land resources and systems are integrated to enable functions of ecological processes that underlies the integrity of ecosystems. The implementation of conservation plans should be coordinated with arrangements outside the protected areas, since majority of wildlife live with the communities and on private lands and across transboundary. Community participation in planning and decision making is therefore critical to ensure the survival of wildlife on their properties. On the other hand, transboundary ecosystems should be supported by respective governments sharing the resources in the establishment of safe refuges and connectivity to critical wildlife habitats. They should also promote compatible land uses on both sides of the border to reduce conflicts and poaching.

7.1.2. Policies and Legislation

Land and biodiversity policies and legislation including the national land policy and various land Acts, wildlife policy and Act, forest policy and Act and other economic instruments that ensures the payment for ecosystem services (PES) should be implemented immediately. To secure wildlife dispersal areas and migratory routes/corridors, legal and economic instruments for negotiation with communities and private landowners whose properties lies within these areas. Such would require community and private landowners assenting to conservation programmes that would create wildlife space such as easements, leases or direct land purchases.

Furthermore, the owners of land parcels identified as wildlife dispersal areas and migratory routes/corridors should be consulted with a view to negotiate the mechanisms for partnership in wildlife management. This could be in the form of concessions, payment for ecosystem services (grazing occupation and corridor fees), development of community projects (schools, health centres, infrastructure) and support to the formation of conservancies.

7.1.3. Community Participation in Biodiversity Conservation

Programmes and initiatives involving local communities in wildlife conservation have been recognized as a viable trade-off for sustainable wildlife conservation and management outside protected areas. The promotion of community conservancies and wildlife sanctuaries, wildlife scout associations and related eco-tourism ventures that directly benefit the rural poor will ensure protection of wildlife and their habitats. Standards and performance measures should be established and maintained to support the evaluate wildlife conservation areas' and sanctuaries' programmes to ensure that they achieve the broad national wildlife conservation and management goal.

Supporting conservation education, public awareness and capacity building will foster wildlife conservation and change attitudes amongst local communities, schools and other interested groups. The proliferation of conservation awareness will ensure well informed public to undertake adequate management of wildlife resources in their midst.

7.1.4. Resources for Conservation Connectivity Management

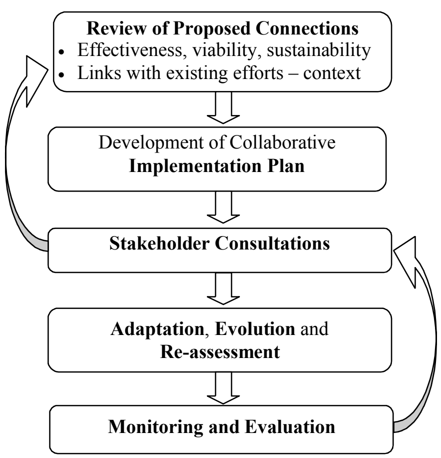
Adequate resources for management of wildlife corridors and migratory routes should be allocated to ensure the availability of human resource (multidisciplinary expertise) and sufficient financial backing to achieve management objectives in protecting these areas.

7.1.5. Research and Monitoring

The management of wildlife or maintenance of ecological processes and focused biodiversity targets require sensitivity and knowledge derived from long-term understanding of wildlife dynamics. A scientific basis for management actions will depend on collection of accurate data related to the wildlife sector. The understanding of species ecology, and ecosystems functions and processes through scientific studies and indigenous knowledge can be used to develop innovative approaches to address a range of conservation related problems. Monitoring of wildlife and their habitats is essential for effective conservation and management.

7.2. **Conservation Connectivity Implementation Framework**

This study proposes the framework outlined in Figure7.1 to operationalise the recommendation proposed in Chapter six.



7.2.1 Review of Proposed Connections

The connections proposed in this report will be reviewed to assess their effectiveness, viability and sustainability over time.

7.2.2. Development of Collaborative Implementation Plan

A participatory assessment of ongoing efforts towards acquisition, securing and management of wildlife dispersal areas and migratory routes/corridors should be conducted in order to align ongoing conservation efforts to the recommendations.

7.2.3 Institutional Framework

A multi-skilled taskforce to facilitate a collaborative implementation and actualization plan will be established. The team composed of wildlife managers, landscape and land use planners, scientists, land surveyors and legal experts, of the conservation connectivity acquisition and securing of wildlife dispersal areas and migratory routes hosted by the Ministry of Forestry and Wildlife.

7.2.4 Implementation and Actualization Plan

The committee or taskforce appointed to oversee the conservation connectivity strategy will draw up an implementation plan based on priority based on the level of threat. The taskforce will also estimate the required financial and human resources required for acquisition, securing, and management of the wildlife dispersal areas and migratory routes.

7.2.5 Stakeholder Consultation

The various relevant stakeholders (Ministry of Lands, MEMR, KWS, DRSRS, KFS, NEMA, ACC, AWF, ILRI) working in specific sites and the county government, local communities and private landowners in the targeted areas will be identified and engaged in an all inclusive consultation process.

7.2.6. Adaptation, Evolution and Re-assessment

The proposed recommendations for each ecosystem will be further devolved to specific sites or migratory routes/corridors, tagging on threat levels and unique conservation issues. The levels have been identified as high, medium and low and appropriate actions have been indicated.

7.2.7. Monitoring and Evaluation

The continuous monitoring and evaluation of the conservation connectivity implementation and actualization process is paramount to ensure the effectiveness and sustainability of the secured wildlife migratory routes/corridors.

REFERENCES

Afolayan, T.A. 1975. Effects of elephant activities on forest plantations in the Kilimanjaro. Forest-Game Reserve in northern Tanzania. Oikos 26:405-410.

African Elephant Specialist Group. 2004. *Loxodonta Africana*. In: IUCN. 2006. *IUCN Red List of Threatened species*.

African Wildlife Foundation. 1996. Studying Elephant, AWF handbook series 7, Published by African Wildlife Foundation, Nairobi, Kenya.

Anthony B. Anderson and Clinton N. Jenkins; Review of Applying Nature's Design: Corridors as a Strategy for Biodiversity Conservation.

Areendran, G., Krishna R., Sraboni, M.,Madhushree, M., Himanshu, and P.K. Sen.2011. Geospatial modeling to assess animal habitat suitability and corridors in Chhattisgarh, India. Tropical Ecology 52:275-283.

Archie, E.A., Morrison, T.A. and foley, A.H.2006. Dominance rank relationships among wild female African elephants (Loxodonta Africana). Journal of Animal Behaviour 71:117-127.

Burney, D.A. (1980). The Effect of Human Activities on Cheetah in the Mara Region of Kenya. MSc Thesis, University of Nairobi, Kenya.

Broten, M.D. & Said, M. (1995) Population trends of ungulates in and around Kenya's Masai Mara Reserve. In: Sinclair, A.R.E. & Arcese, P. (eds.) Serengeti II: Dynamics, management and conservation of an ecosystem. University of Chicago Press, Chicago, pp.169-193.

Bruner, A.G., Gullison, R.E., Rice, R.E. & da Fonseca, G.A.B. (2001) Effectiveness of parks in protecting tropical biodiversity. Science, 291, 125-128.

Bell, R.H.V., 1970. The use of herb layer by grazing ungulates in the Serengeti. In: Watson, A. (Ed.), Animal Populations in Relation to their Food Sources. Blackwell, Oxford, pp. 111-124.

Bell, R.H.V., 1971. A grazing ecosystem in the Serengeti. Scientific American 224, 86-93.

Bennett, A. F. (2003). Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation

Biru, Y and A. Bekele. 2011. Food habits of African elephant (*Loxodonta Africana*) in Babile Wildlife Sanctuary, Ethiopia. Tropical Ecology 53(1): 43-52.

Blanc, J. J., Thoules, C. R., Hart, J. A., Dublin, H. T., Douglas-Hamilton, I., Craig, C. G. and Barnes, R. F. W., (2003) *African Elephant Status Report 2002: An Update from the African Elephant Database.* IUCN/SSC African Elephant Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Blanc, J.J., Barnes, R.F.W.,Craig, G.C., Douglas-Hamilton, I., Dublin, H.T., Hart, J.A. and Thoules, C.R. 2005. Changes in elephant numbers in major savanna populations in eastern and southern Africa. *Pachyderm* **38**: 19-28.

Blanc,J.J.,Thouless,C.R.,Hart,J.A.,Dublin,H.T.,Douglas-Hamiliton,I.,Craig,G.C.and Barnes, R.F.W. (2007) *African elephant status report 2007: An update from the African Elephant Database.* Occasional paper of the IUCN Species Survival Commission No.33. Gland, Switzerland and Cambridge, UK: IUCN

Braat, L., ten Brink, P. et al. (eds.) (2008) The Cost of Policy Inaction: The Case of Not Meeting the 2010 Biodiversity Target, report for the European Commission. Wageningen/Brussels, May 2008.

Casebeer, R.L. and G.G. Koss. 1970. Food habits of wildebeest, zebra, hartebeest and cattle in Kenya. Masailand. E. African Wildlife Journal 8: 25-36.

Cobbs, S. (1976) The Distribution and Abundance of the Large Herbivore Community of Tsavo National Park. D.Phil. Thesis Univ. of Oxford.

Coe, M.J. 1972. Mammals of the northern slopes of Mt. Kenya. J.E. African N. Hist. Soc. Natl Mus. 131 (28) 1-18.

Corfield, T.F. (1973) Elephant mortality in Tsavo National Park, Kenya. *East African Wildlife Journal.* 11: 339-368

Douglas-Hamilton, I. and Hillman, A.K. (1981) Elephant carcasses and skeletons as indicators of population trends in Low-level aerial survey techniques. ILCA Monograph

Douglas-Hamilton, I. Gachago, S., Litoroh, M., Mirangi, J. (1994) Tsavo Elephant Count 1994. Kenya Wildlife Service

Douglas-Hamilton, I. (1996) Counting elephants from the air: total counts. In: Kangawana, K.F. (ed.), Studying Elephants. AWF Technical Handbook Series Vol. 7.pp.28-37. Nairobi: African Wildlife Foundation.

Economics of ecosystem and biodiversity, Interim Report, European Communities 2008. A Banson Production, Cambridge, UK.

Evan McKenzie & R.P.Bio (1995). Important Criteria and Parameters of Wildlife Movement Corridors - A Partial Literature Review

Field, C.R. & Ross, I.C. 1976. The savannah ecology of Kidepo NP II. Feeding ecology of elephant and giraffe. E. Afr. Wildl. J. 14: 1-15.

Feldhamer, G.A., Drickamer, L.C., Wassey, S.H., Merritt, J.F. and Krajewski, C. 2007.Mammalogy: Adaptation, Diversity, Ecology. 3rd Edn. The John Hopkins University Press, Maryland.

Galanti, V., Preaton, D., Martinoli, A., Wauter, A. and G. Tosi. 2006. Space and habitat use of African elephant in the Tarangira-Manyara ecosystem, Tanzania: Implications for conservation. Mamalian Biology 71:99-114.

Gichohi, H.W., 1996, *The Ecology of a Truncated Ecosystem – The Athi-Kapiti Plains.* Ph.D. University of Leicester, Leicester, UK.

Goodwin, H., Kent, I.J., Parker, K.T., & Walpole, M.J. (1998) Tourism, conservation and sustainable development; case studies from Asia and Africa. Wildlife and Development Series, No. 12. IIED, London.

Grubb, P. 1981. Eguus burchelli. Mammalian Species No. 157:1-9. American Society of Mammologists.

Gwynne, M.D. and R.H.V. Bell. 1968. Selection of vegetation components by grazing ungulates in the Serengeti National Park. Nature, 220: 390-393.

Hack, M. A., R. East & D. I. Rubenstein (2002). Status and action plan for the Plains zebra (*Equus burchelli*). Pp 43-57. In *Equids: Zebras, Asses, and Horses. Status Survey and Conservation Action Plan*. P. D. Moehlman (ed.). IUCN/SSC Equid Specialist Group. IUCN, Gland, Switzerland.

Hanski, I. Metapopulation Dynamics. 1998. Nature, 386: 41-49

Hanski, I and Gilpin, M. 1991.Metapopulation Dynamics: Brief History and Conceptual Domain. *Biological journal of Linnean Society: 42:3-16*

Hoare, R.E. and J.T. Du Toit.1999. Coexixtence between people and elephants in African savannas. Coservation Biology 13:633-639.Stephenson, P.J.2007. WWWF Species Action Plan: African Elephant, 2007. WWF. Gland.

Hoare, R. E., (1999) Determinants of human - elephant conflict in a land-use mosaic. *Journal of Applied Ecology* **36**(5): 1365-2664.

IUCN (2000) Red list of endangered species. IUCN, Gland.

ILRI Policy Brief 2007, Kitengela: Keeping land open for people, livestock and wildlife

Jackson, T. ad Erasmus, G., 2005. Assessment of the seasonal home range use by elephants across the southern Africa's seven elephant clusters. Conservation Ecology Research Unit, Univ. of Pretoria, SA.

Jolly, J.M.1969.Sampling methods for aerial censuses of wildlife populations. E. Afr. Agr. J. 34: 46–49.

Kahumbu, P., Omondi, P., Douglas-Hamilton, I., King, J. (1999) Total Aerial Count of Elephants in Tsavo National Park and Adjacent Areas. Kenya Wildlife Service.

Kasiki, S.M. (1998) Human elephant conflict in areas adjacent to the Tsavo national parks. Phd. Thesis, University of Kent at Canterbury.

Kifugo, S., Bedelian, C., Ng'ang'a, L., Makui, R., Nkedianye, D., Said, M.Y., Ogutu, J.O., Reid, R.S., Kimiti, J., and Turere, J. 2009. Atlas on counts of livestock, wildlife and People in Kitengela. ILRI.

Kioko J, Okello & P. Muruthi. (2006) Elephant numbers and distribution in the Tsavo-Amboseli ecosystem. Pachyderm, 40: 61-68.

Kristjanson, P., Radeny, M., Nkedianye, D., Kruska, R., Reid, R., Gichohi, H., Atieno, F., and Sanford, R., 2002, Valuing alternative land use options in the Kitengela wildlife dispersal area of Kenya. ILRI Impact Assessment Series No. 10. ILRI, Nairobi, Kenya, 61 pp.

Kok, O.B. & Opperman, D.P.J. 1980. Feeding behavior of giraffe *Giraffa camelopardalis* in Willem Pretoria Game Reserve, Orange Free State. S. Afr. J. Wildl. Res. 10:45-55.

Kenya Wildlife Service (KWS) 2010. Aerial Total Count. Amboseli-West Kilimanjaro-Magadi-Natron Cross, Wet Season, March 2010.

Kenya Wildlife Service (KWS), 2008. Amboseli Ecosystem Management Plan (2008-2018)

Kenya Wildlife Service (KWS), 1996a. Wildlife Policy, KWS, Nairobi.

Kenya Wildlife Service (KWS), 1996b. Wildlife-human conflicts in Kenya. A report of the five person review group, KWS, 36 pp.

Lamprey, H.F. 1963. Ecological separation of large mammal species in the Tarangire Game Reserve, Tanganyika. EAWJ., 1: 63-92.

Lamprey, R. H., and Reid, R. S. 2004 Expansion of human settlement in Kenya's Maasai Mara: What future for pastoralism and wildlife? *Journal of Biogeography* **31**:997-1032.

Leuthold, B.M. & Leuthold, W. 1972. Feeding behavior of giraffe in Tsavo National Park, Kenya. E.Afr. Wildl. J. 10: 129-141.

Leuthold, W., and Sale, J.B. 1973 Movements and patterns of habitat utilization of elephants in Tsavo National Park, Kenya. E.Afr. Wildl. J. 11:369-384.

Leuthold, W. (1973) Recent Elephant Counts in Tsavo National Park. Tsavo Research Project. Typescript.

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bull. Entomol. Soc. Am. 15, 237-240 (1969).

Litoroh, M., Omondi P., Kock R., and Amin R, (2012). Conservation and Management Strategy for Elephant in Kenya (2012-2021)

MacArthur, R. H. & Wilson, E. O. (1967) The Theory of Island Biogeography (Princeton University Press.

Maddock, L. 1979. The "migration" and grazing succession. Pp. 104–129 *in: Serengeti: Dynamics of an Ecosystem* (eds. A.R.E. Sinclair and M. Norton-Griffiths). Univ. of Chicago Press.

Maddock, L. (1979) The Migration and Grazing Succession. In: Sinclair, A.R.E, Norton-Grifths, M. (eds.), Serengeti: Dynamics of an Ecosystem. University of Chicago Press, Chicago, pp.104-129.

Mauny, R.A. 1956. Repartition do Ia grande faune thiopienne du nordouest africaine do palÈolithique ·nos jours *Proceedings of the 3rd Pan-African Congress Prehistory,* pp. 102-105.

McNeill, J. R. and McNeill, W. H. (2003). The Human Web: A Bird's-Eye View of World History. W. W. Norton & Company, NewYork.

MNP/OECD (2007) Background report to the OECD Environmental Outlook to 2030. Overviews, details and methodology of model based analysis. Netherlands and Organisation of Economic Cooperation and Development, Paris, France.

Muruthi, P. (2005). Human Wildlife Conflict: Lessons Learned from AWF's African Heartlands; AWF Working Papers.

National Environment Monitoring Agency (NEMA) (2011). Kenya Status of the Environment and Outlook 2010.

Ngene S., Ihwagi F., Njumbi S., Nzisa M., Mukeka J. and Omondi P. (2008). Total Aerial Census of Elephants and Other Large Mammals in the Tsavo-Mkomazi Ecosystem. Typescript, August 2008.

Nkedianye , D. , 2004 , Testing the attitudinal impact of a conservation tool outside a protected area: The Case for the Kitengela Wildlife Conservation Lease Programme for Nairobi National Park. M.Sc. Thesis, University of Nairobi, Kenya.

Norton-Griffiths (1978). Counting Animals. African Wildlife Foundation

Norton-Griffiths, M., Said, M.Y., Serneels, S., 2008 Land use economics in the Mara area of the Serengeti ecosystem. **In**: Sinclair, A.R.E., Packer, C., Mduma, S.A.R. & Fryxell, J.M. (eds) Serengeti III: Human Impacts on Ecosystem Dynamic, Univ. of Chicago, 379-416.

Ogutu, J.O., Said, M.Y., Kifugo, S.C., and Nkedianye, D. (in prep.) Wildlife population dynamics in Nairobi National Park.

Ogutu, J.O., Owen-Smith, N., Piepho, H.-P. Said, M.Y. 2011 Continuing wildlife population declines and range contraction in the Mara region Kenya during 1977-2009. *Journal of Zoology*.

Ogutu J. O., Piepho H.P., Dublin H. T., Bhola N. and R. S. Reid (2008). Rainfall influences on ungulate population abundance in the Mara-Serengeti ecosystem. *Journal of Animal Ecology*.

Ogutu, J.O., Piepho, H.P., Dublin, H.T., Bhola, N. and R.S. Reid. 2009. Dynamics of Mara-Serengeti ungulates in relation to land use changes. *Journ. of Zoology*, **278**:1-14. Zoological Society of London.

Ojwang' G.O., Wargute, P.W. and Njino, L.W. 2006. Trends and Spatial Distribution of Large Herbivores in Kajiado District (1978-2000). DRSRS Technical Report No. 161. Nairobi.

Okello M.M. (2009). Contraction of wildlife dispersal area and displacement by human activities in Kimana Group Ranch near Amboseli National Park, Kenya. School for Field Studies, Center for Wildlife Management Studies, Kenya. Open Conservation Biology Journal, **3**, 49-56 49

Omondi, P., Bitok E.K., Mukeka, J., Mayienda, R.M. & Litoroh, M. (2008) Total aerial count of elephants and other large mammal species of Tsavo/Mkomazi ecosystem. Kenya Wildlife Service.

Ottichilo, W. 1981 Population studies of elephant (Loxodonta Africana) in Tsavo Ecosystems, 1975-1980. MSc Thesis, Univ of Nairobi.

Ottichilo, W. K., De Leeuw, J., Skidmore, A. K., Prins, H. H. T. & Said, M. Y. 2000. Population trends of large non-migratory wild herbivores and livestock in the Maasai Mara ecosystem, Kenya, between 1977 and 1997. *Afr. J. Ecol.* **38**, 202-216.

Osborn, F.V.2005. Habitat selection by bull elephants in Central Zimbambwe. Pachyderm 39:63-66. Parker, D.M. & R.T.F. Bernard. 2005. The diet and ecological rrole of the giraffe (*Giraffa camelopardalis*) introduced to Eastern Cape, South africa, J.Zool., Lond. (2005) 267, 203-210. Zoological Society of London, UK.

Parker, D.M. & R.T.F. Bernard. 2005. The diet and ecological rrole of the giraffe (*Giraffa camelopardalis*) introduced to Eastern Cape, South Africa, J.Zool., Lond. (2005) 267, 203-210. Zoological Society of London, UK.

Pimm, S.L., Russell, G.J., Gittleman, J.L. & Brooks, T.M. (1995) The future of biodiversity. Science, 269, 347-350.

Poole, J., Aggarwal, N., Sinange, R., Nganga, S., Broten, M. and Douglas-Hamilton, I. (1992) The status of Kenya's elephants – 1992. KWS and DRSRS. Typescript 60pp

Prins, H.H.T., Olff, H., 1998. Species-richness of African grazer assemblages: towards a functional explanation. In: Newbery, D.M., Prins, H.H.T., Brown, N. (Eds.), Dynamics of Tropical Communities. Blackwell Science, Oxford.

Reid, R., Gichohi, H., Said, M.Y., Nkedianye, D., Ogutu, J., Kshatriya, M., Kristjanson, P., Kifugo, Sh., Agatsiva, J., Adanje, S., and Bagine, R., 2008 . *In* K.A. Galvin, N.T. Hobbs, R. Behnke, and R.S. Reid, editors. *Fragmentation in Arid and Semi-Arid Lands*. Kluwer Academic Press.

Reid, R.S., Rainy, M., Ogutu, J., Kruska, R.L., Kimani, K., Nyabenge, M., McCartney, M., Kshatriya, M., Worden, J., Ng'ang'a, L., Owuor, J.,Kinoti, J., Njuguna, E., Wilson, C.J., and Lamprey, R. (2003). People, Wildlife and Livestock in the Mara Ecosystem: the Mara Count 2002. International Livestock Research Institute, Nairobi.

Republic of Kenya (ROK). 2007. Kenya Vision 2030: A globally Competitive and Prosperous Kenya, Government Printer, Nairobi.

Republic of Kenya (ROK). 2012. Economic Survey Report . Kenya National Bureau of Statsistics. Government Printer, Nairobi

Richmond-Coggan, L. 2006. Assessing Wildlife Distribution and Population Trends in the Greater Mara Ecosystem, Kenya: the synergistic effects of landscapes and threats. MSc Conservation Biology. Durrell Institute of Conservation and Ecology. Un of Kent.

Rode, K.D., Chiyo, P.I., Chapman, C.A. and McDowill. 2006. Nutritional ecology of elephants in Kabale National Park, Uganda and its relationship with crop raiding behavior. Journal of Tropical Ecology 22:441-449.

Said, M.Y., Chunge, R.N., Craig, C.G., Thouless, C.R., Barnes, R.F., and Dublin, H.T. 1995 African Elephant Database 1995, p. 225 IUCN, Gland, Switzerland.

Serneels, S., Said, M.Y. and Lambin, E.F. 2001 Land cover changes around a major east African wildlife reserve: The Mara ecosystem, Kenya. *International Journal of Remote Sensing* 22(17):3397-3420.

Serneels, S. and Lambin, E.F. 2001. Impact of land use changes on the wildebeest migration in the northern part of the Serengeti-Mara ecosystem. Journal of Biogeography, **28**: 391-407, Blackwell Sc. Ltd

Sinclair, A.R.E. 1995 Serengeti past and present. In Serengeti II, dynamics, management and conservation of an ecosystem, edited by A.R.E. Sinclair and P. Arcese (Chicago, University of Chicago Press), pp. 3-30.

Simberloff, D., (1998) Flagships, umbrellas, and keystones: Is single-species management passé. In the landscape era? *Biological conservation* **83**(3): 247-257.

Talbot, L.M. & Talbot, M.H. 1963. Wildebeest in western Maasailand. *Wildlife Monographs. Chesterttown* **12**, p 88.

Thaxton, M. (2007). Integrating Population, Health and Environment in Kenya. Population Reference Bureau, Washington DC.

Thompson L. G., Brecher, H. H., Mosley-Thompson E., Hardy D. R. and Mark B. G. (2009). Glacier loss on Kilimanjaro continues unabated. Journal - *Proceedings of the National Academy of Sciences*, 2009, 106 (**47**).

Thirgood, S., Mosser, A., Tham, S., Hopcraft, G., Mwangomo, E., Mlengeya, T., Kilewo, M., Fryxell, J., A. R. E. Sinclair, A. R. E., and Borner, M., (2004) Can parks protect migratory ungulates? The case of the Serengeti wildebeest. *Animal Conservation* **7**: 113-120.

Western, D. 2010 "The Worst Drought: Tipping or Turning Point?" SWARA, 17-20.

Western, D. and Lindsay, W.K. 1984. Seasonal herd dynamics of a savanna elephant population. African J. of Ecology, 22: 229-244.

Western, D. (2007). The ecology and changes of the Amboseli Ecosystem. Recommendations for planning and conservation. A report to Task Force for developing the Amboseli Ecosystem Plan.

Whitehouse, A.M. and D.S. Schoeman. 2003. Ranging behavior of elephants within a small, fenced area in Addo Elephant National Park, South Africa. African Zoology 38:95-100.

Wittemyer, G., Getz, W.M., Vollrath, F. and Hamilton, I.D. 2007. Social dominance, seasonal movements and spatial segregation in African elephants: a contribution to the conservation behavior. Behavioural Ecology and Sociobiology 61:1919-1931.

World Resources Institute (WRI). 2005a. Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, World Resources Institute (WRI). 2005b. Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Biodiversity Synthesis*. Island Press, Washington, DC.

Woodroffe, R. & Ginsberg, J.R. (1998) Edge effects and the extinction of populations inside protected areas. Science, 280, 2126-2128.

Young, T. P. & Isbell, L. A. 1991: Sex differences in giraffe feeding ecology: energetic and social constraints. Ethology 87, 79-89.

ANNEX 1

1.1. Members of the RRI on Mapping Wildlife Migratory Routes/ Corridors Taskforce

This Rapid Results Initiative (RRI) report is submitted by a Taskforce comprising of ecologists, GIS Specialists, planners and meteorologists from various government institutions and NGOs. Specifically, these institutions have a wealth of databases extending over three decades on wildlife resources and environmental aspects in the southern Kenya rangelands.

The Kenya's Vision 2030 development plan accords environmental sustainability prominence under the economic and social pillars by undertaking this flagship project on "Securing of Wildlife Dispersal Areas and Migratory Routes/Corridors". The mapping of wildlife dispersal areas, migratory routes/corridors in Kenya project has been spearheaded by the Department of Resource Surveys and Remote Sensing (DRSRS). The Taskforce was appointed by the Permanent Secretary, Ministry of Environment and Mineral Resources (MEMR) Mr. Ali D. Mohamed, CBS on 3 October 2011 to conduct the work in 100 days. Members of the Taskforce are:

NAME	INSTITUTION
Jaspat L. Agatsiva	DRSRS
Patrick W. Wargute	DRSRS
Gordon O. Ojwang'	DRSRS
Charles Situma	DRSRS
Lucy W. Njino	DRSRS
Wilfred Nyaga	DRSRS
James Matundura	DRSRS
Joseph Gathua	DRSRS
Henry Roimen	DRSRS
Reuben Kibet	DRSRS
Mohammed Y. Said	ILRI
Shem Kifugo	ILRI
Philip Muruthi	AWF
Rose Mayienda	AWF
Erastus Kanga	KWS
Apollo Kariuki	KWS
Joseph Mukeka	KWS
Joycelyn Makena	KWS
Jeffrey Worden	ACC
Lucy Waruingi	ACC
Ezekiel Muigai	KMD
Barasa Shaban	KMD
Charles. M. Gachoki	MEMR

ANNEX 2

2.1. Wildlife Corridors Prioritization Criteria Matrix: Parameters for Defining

Ecological Importance - This is the overall ecological/environmental importance of the area. This could include rare, endemic, or threatened species, key habitats, or essential ecosystem processes. For example, a dispersal area that acts as a key breeding ground for a particular species would have a high ecological importance value. It is important to recognize that Importance values are often species or taxa specific and that balancing these different perspectives across an ecosystem can be challenging. One option would be to break this factor down further to include different sub-sections such as - rare and endemic species, drought refuge, large populations, key ecosystem processes, essential habitats, etc. Each of the sub-sections could then be scored and a composite score produced. This would provide a more transparent and repeatable process, and would have the added benefit of giving decision makers more information on which to base interventions. The added complexity may be a challenge, however. As always, a balance between complexity and simplicity is essential. Regardless, a clear description of the key ecological issues considered when giving and ecological importance score will be useful.

Threats – are widely understood, but like ecological components above, it might be worth breaking down into different subsections – agriculture, population, fragmentation, degradation, etc. As above, the idea is to rank areas based on the level of particular threats. This is of course species and taxa dependent so care and clarity must be used when considering a threat matrix and calculating the threat score.

Opportunities – represent the opposite of threats. They could include things like presence of a protected area or conservancy, existing land use plans which favor conservation, proactive and motivated communities or land lords, healthy core populations or potential for rehabilitation. Opportunities and threats will directly inform the types of interventions and actions recommended. These may be cross taxa, but likely to be taxa and species specific.

Viability – represents the general viability of the area given the threats and opportunities listed above. An area with lots of opportunity and low threats would have a high viability score. This is an attempt at representing the likelihood that any interventions in the area would be viable in the long term. For example, an area with relatively low threats in the short term, with a conservancy, may not be viable in the long term if there are national plans for compulsory acquisition, or changes in land use and tenure policies.

Priority – is an index that captures all the previous indices (importance, threats, opportunities, viability) in a single metric to highlight areas that need intervention. Priority scores should be weighted in favor of ecological importance, but also need to contain information about threats and opportunities as resources will always be limiting and difficult decisions will have to be made. We might consider breaking priority down into subsections based on time – e.g. short vs longer term priorities – which would essentially reflect the urgency of threats.

Partners – are all of the different individuals, agencies, organizations, and institutions that should be included in the assessment and implementation process.

Recommendations/Actions – are the key actions and interventions that are required at the site level and for each area in particular. The combination of priority scores, partners, and actions should give decision makers a useful starting point for further assessment, broad stakeholder agreement and engagement, and timely and effective intervention.

ANNEX 3

3.1. Glossary of Terms

Anthropogenic: resulting from or produced by human beings. Human impact on the environment or anthropogenic impact on the environment includes impacts on biophysical environments, biodiversity and other resources. The term anthropogenic designates an effect or object resulting from human activity. It also references to human influences but applies broadly to all major human impacts on the environment.

Adaptation: to reduce the vulnerability of people and ecosystems to climatic changes. Adjustments in response to actual or expected climate change or its effects (anticipatory' or proactive' adaptation is adaptation that takes place before impact of climate change are observed).

Benchmark: A standard by which something can be measured or judged.

Biodiversity: the variability (and relative abundance) of life, and encompasses diversity at all scales and levels of organization from genetic through populations, species, ecosystems (communities) and landscapes in a particular area. Biodiversity includes diversity within species, between species, and between ecosystems.

Biomass: the total mass or volume of living organisms in a given area, recently dead plant material is often included as dead biomass.

Biotechnology: Is the use of organisms by humans to make useful products in various fields such as agriculture, food production and medicine or use of living organisms and their products to modify human health and human environment.

Bioprospecting:Is searching fo, rcollecting and deriving genetic material from samples of biodiversity that can be used in various fields such as pharmaceutical and agricultural fields or search for organic compounds in living organisms (plants, animals, microorganisms) to make useful products

Clean Development Mechanism: the Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

Climate: the "average weather" in a narrow sense or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description of the 'climate system'.

Climate change: refers to a statistically significant variation in either the mean state of the *climate* or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or *external forcing* or to persistent *anthropogenic* changes in the composition of the *atmosphere* or in *land use*. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines "climate change" as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Connectivity: the degree to which the landscape facilitates or impedes movement among resource patches.

Corridor: a linear landscape features that serve as a linkage between historically connected habitat/natural areas that are means to facilitate movements i.e. connectivity between two important habitats.

Desertification: defined by the U.N Convention to Combat Desertification as "land degradation in arid, semiarid and dry sub-humid areas resulting from various factors, including climatic variations and human activities."

Disaster: a serious disruption of the functioning of a community or a society causing widespread human, materials, economic or environmental loss which exceed the ability of the affected community or society to cope using its own resources.

Dispersal: the widespread distribution of animal populations, and refers to wet season dispersal of large mammals and dry season concentration in their range.

Driver: a natural or human-induced factor that change ecosystems. There are indirect and direct drivers. Indirect drivers affect ecosystems by influencing the direct drivers. Habitat change and overexploitation, for instance, are direct drivers. These influence ecosystem processes explicitly. Examples of important indirect drivers are changes in human population, economic activity, and technology, as well as socio-political and cultural factors. Important direct drivers include habitat change, climate change, invasive species, overexploitation, and pollution.

Drought: phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems.

Early warning: The process of timely information enabling people to take steps to reduce the impact of hazards. Early warning is typically multi-hazards and requires genuine ownership of, and participation by, communities and other stakeholders, e.g., access to information by local people concerning an approaching typhoon storm.

Ecosystem: a natural unit of living things (animals, plants and micro-organisms) and their physical environment or a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit. An ecosystem is a collection of plants, animals, and micro-organisms interacting with each other and with their non-living environment

Ecosystem services: services provided by the natural environment that benefit people. Some of these ecosystem services are well known including food, fibre and fuel provision and the cultural services that provide benefits to people through recreation and cultural appreciation of nature. Other services provided by ecosystems are not so well known. These include the regulation of the climate, purification of air and water, flood protection, soil formation and nutrient cycling. The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept "ecosystem goods and services" is synonymous with ecosystem services. Ecosystem services are the benefits that people get from nature. Examples include fresh water, timber, climate regulation, recreation, and aesthetic value

Ecosystem processes: intrinsic processes and fluxes whereby an ecosystem maintains its integrity (such as primary productivity, trophic transfer from plants to animals, decomposition and nutrient cycling, evapo-transpiration, etc.). Ecosystem processes include decomposition, production, nutrient cycling, and fluxes of nutrients and energy.

Ecosystem approach: is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way…. It recognizes that humans are an integral component of many ecosystems.

Edge: contact zone between two different types of habitat and edge effect is the ecological result of increasing edge or ecological changes associated with the artificial abrupt margins of habitat fragments, e.g. increased numbers of animals at edge and increased diversity of animals at the edge

Environment: All living things and non-livings on earth.
Extinction: The complete disappearance of an entire species.

Endemic: restricted or peculiar to a locality or region. With regard to human health, endemic can refer to a disease or agent present or usually prevalent in a population or geographical area at all times.

Environmental Impact Assessment (EIA): is an assessment of the impact of a project on the environment

Geographic Information System (GIS): A Computer-based technique for organizing, analyzing, integrating, manipulating, storage, retrieving, and modeling spatially or geographically located phenomena or features

Habitat: The particular environment or place where an organism or species tend to live; a more locally circumscribed portion of the total environment or any place or type of place where an organism or community of organisms normally lives and thrives.

Hazard: a potentially dangerous or damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

Food Web: the complex patterns of energy flow in an ecosystem, summarized by the known feeding relationships in a biological community. A food web illustrates how each type of organism in a community is typically consumed by or consumes more than one other type of organism, and that different types of organisms compete for the same food sources.

Genes: a hereditary unit consisting of a sequence of DNA that occupies a specific location on a chromosome and determines a particular characteristic in an organism.

Innovation: a new way of doing something. It may refer to incremental, radical, and revolutionary change in thinking, products, processes or organizations.

Invasive species: an introduced species that invades natural habitats.

Land degradation: is in turn defined as the reduction or loss of the biological or economic productiv¬ity of drylands. This report evaluates the condition of desertification in drylands, including hyper-arid areas

Land use: the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The social and economic purposes for which land is managed (e.g. grazing, timber extraction, and conservation).

Nutrient cycling: process by which nutrients – such as phosphorus, sulfur and nitrogen – are extracted from their mineral, aquatic, or atmospheric sources or recycle from their organic forms and ultimately return to the atmosphere, water, or soil

Mitigation: an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases, to reduce the magnitude of climate change impact in the long term.

Metapopulation: often used for any spatially structured population or systems of local populations connected by dispersing populations. It is a set of discrete populations of the same species, in the same general geographical area, that may exchange individuals through migration, dispersal, or human-mediated movement (

Patch: -The area in which local population lives

Pollution: the presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects.

Primary production: formation of biological material through assimilation or accumulation of energy and nutrients by organisms

Risk: the probability or likelihood of a population suffering the disruption of a disaster. The risk is determined by a combination of the hazards that threaten the population and its vulnerability to those hazards. The probability of harmful consequences or expected losses (death, injuries, property, livelihoods, economic activity disrupted or environment damages). Resulting from interaction between natural or human-induced hazards and vulnerable conditions.

Rescue effect: high rates of immigration to protect a population from extinction

Resilience: Amount of change a system can undergo without changing state.

Sink: A sink is a population with deaths exceeding births and extinction only averted by immigrants exceeding emigrants.

Source: a source is populations with a net outflux of individuals. The identification of sources and sinks is complicated by temporal and spatial variability, and density dependence in demography and dispersal

Species: one of the basic units of biological classification and a taxonomic rank or The lowest taxonomic rank, and the most basic unit or category of biological classification. A species is defined as a group of organisms capable of mating or interbreeding and producing fertile offspring

Species diversity: biodiversity at the species level, often combining aspects of species richness, their relative abundance, and their dissimilarity.

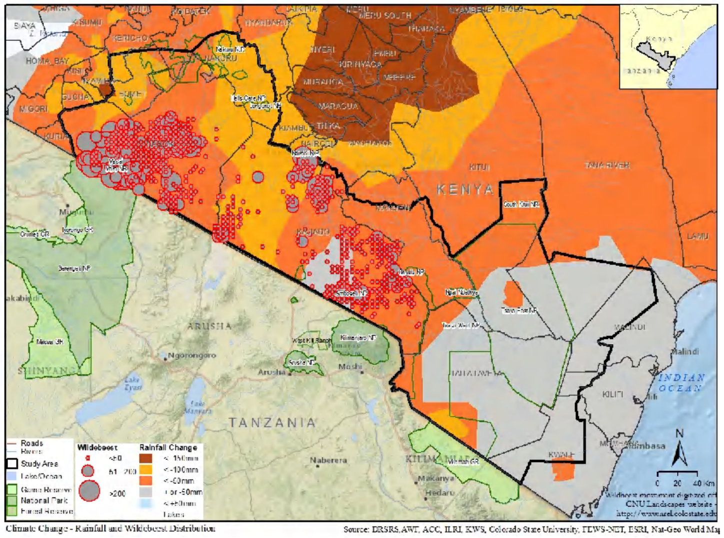
Species richness: the number of species within a given sample, community, or area.

Water catchments: an area drained by a river system. A drainage basin includes all areas that gather precipitation water and direct it to a particular stream, stream system, lake, or other body of standing water.

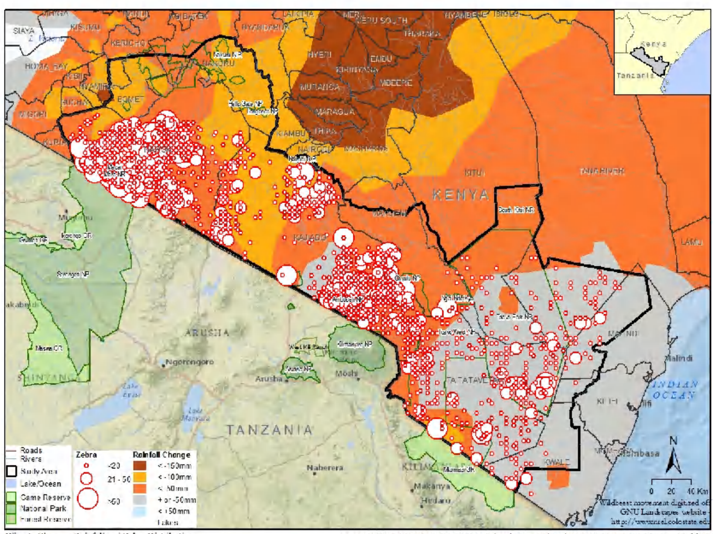
Wildlife Telemetry: the transmission of information from a transmitter on a free-ranging animal to a receiver. Advances in wildlife telemetry have made it possible to remotely acquire detailed fine-scale data on many aspects of wildlife ecology including habitat use, home ranges, ranging patterns, and migration timing and routes, with the use of Global Positioning System (GPS) - based research techniques. A GPS-enabled collar is attached to an animal, which records location data at pre-determined interval, then relays to a central data processing store. The wildlife locations are then plotted in near real-time against a map to analyze the animal movement tracks under a GIS platform.

APPENDIX 1

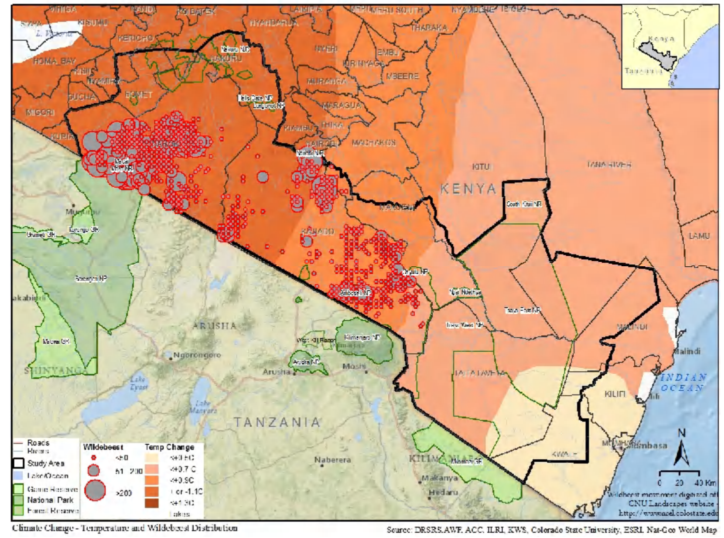
1.1. Wildlife Distribution in Relation to Rainfall and Temperature



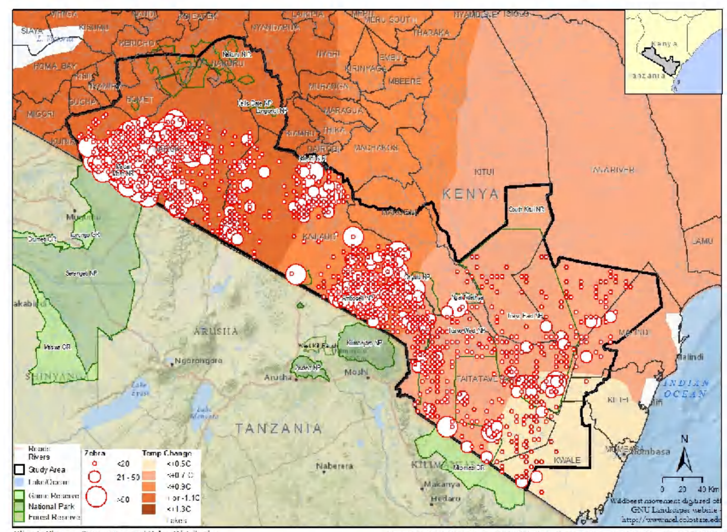
Map 6.8.3: Precipitation change zones and wildebeest distribution in southern Kenya.



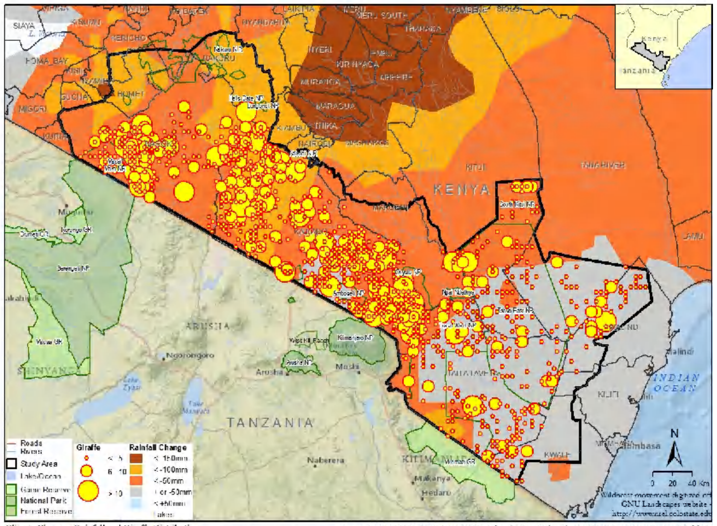
Map 6.8.4: Precipitation change zones and zebra distribution in southern Kenya.



Map 6.8.5: Temperature change zones and wildebeest distribution in southern Kenya.



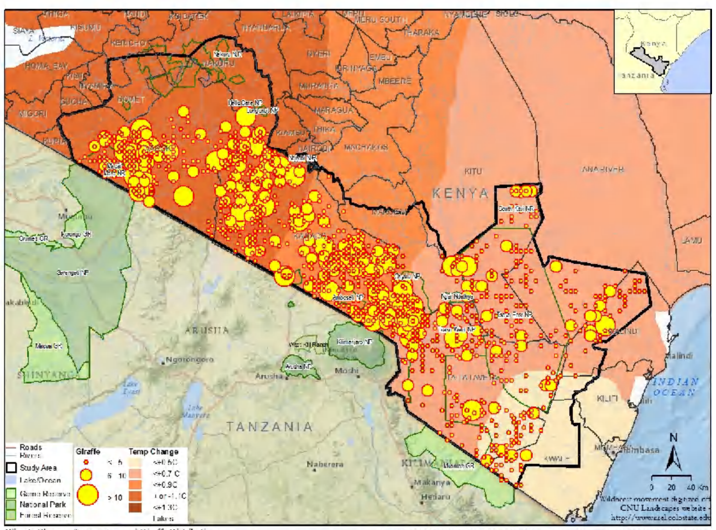
Map 6.8.6: Temperature change zones and zebra distribution in southern Kenya.



Climate Change - Rainfall and Giraffe Distribution

Source: DRSRS,AWF, ACC, ILRI, KWS, Colorado State University, FEWS-NET, ESRI, Nat-Geo World Map

Map 6.8.7: Precipitation change zones and giraffe distribution in southern Kenya.

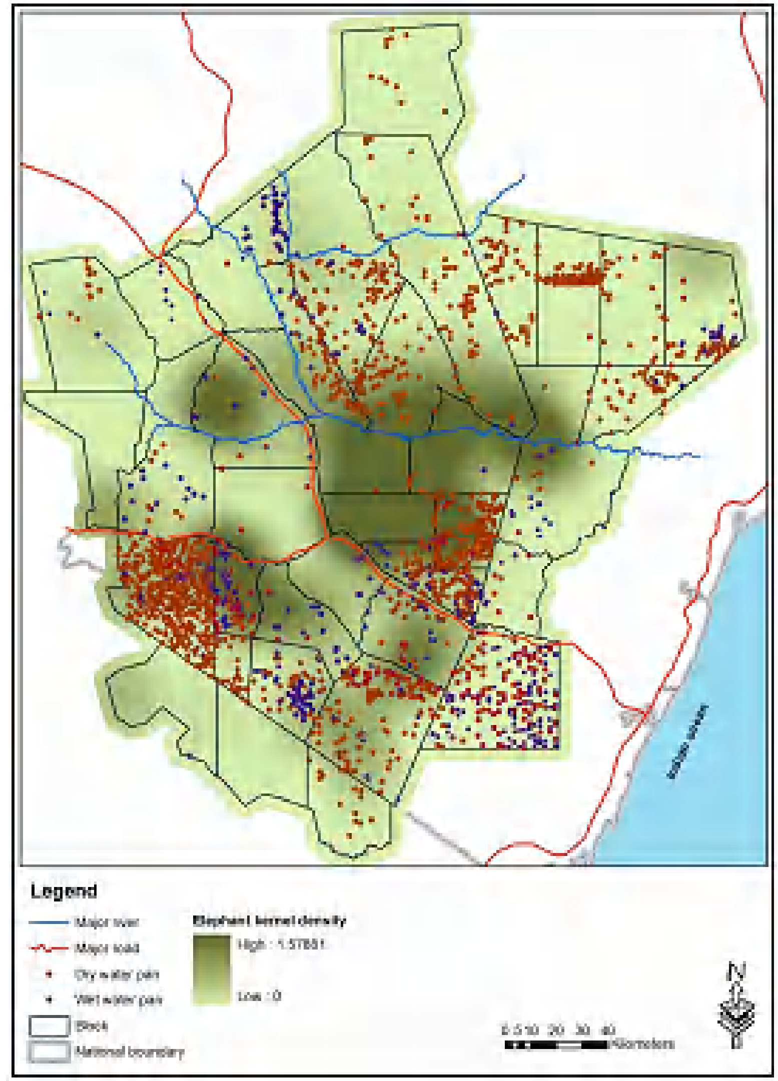


Climate Change - Temperature and Giraffe Distribution

Source: DRSRS,AWF, ACC, ILRI, KWS, Colorado State University, ESRI, Nat-Geo World Map

Map 6.8.8: Precipitation change zones and giraffe distribution in southern Kenya.

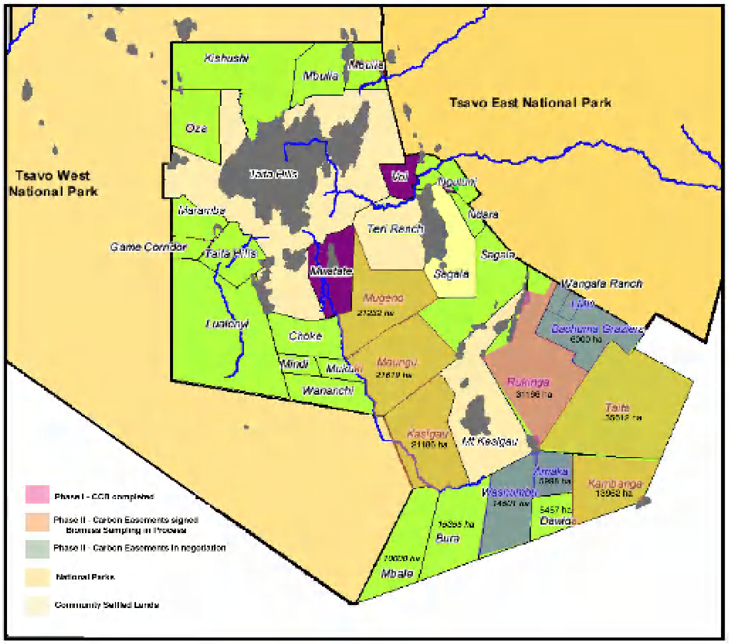
1.2. Kernel Density of Elephants in Relation to Water Resources in the Tsavo Ecosystem



Map 6.8.9: Elephant density distribution in relation to dry and wet water pans in Tsavo-Mkomazi ecosystem (February 2011). *Source: KWS.*

1.3. The Kasigau Corridor REDD Project in Taita Ranches

This carbon project on Reduction of Emission from Deforestation and Forest Degradation (REDD) established in the Taita communal and private ranches is being implemented by the community. The Kasigau corridor project covers 330,000 Hac. Phase I is being implemented at Rukinga Sanctuary covering 30,168.66 Hac (Map 6.8.11).



Map 6.8.10: Kasigau corridor REDD project phase status - established to secure wildlife connection and between Tsavo East and West National Parks through the Taita Ranches. *Source: KWS.*

1.4. Human-Wildlife Conflicts

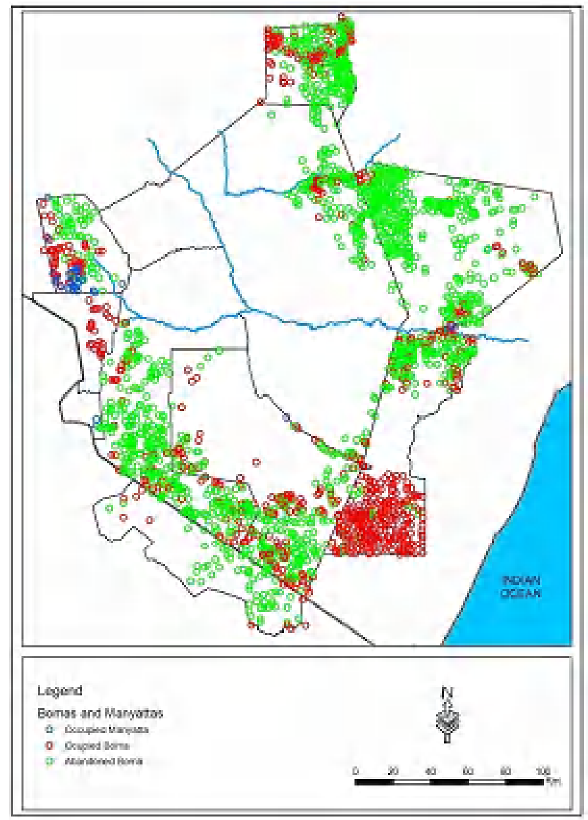
1.4.1. Carnivores speared to death after the predators killed livestock in Kitengela area.

Plate A - 1.4.1: Lions killed by villagers for predation on domestic goats. *Photo Courtesy: Rex Features*

Two adult lionesses, two younger lions and two cubs were speared to death on 20 June 2012 in the township of Kitengela, 30 Km outside Nairobi National Park by residents wielding spears angry at the predators for killing four goats at a small farmstead. The wild animals had gone in search of food outside the Nairobi NP, which is surrounded on three sides by the city. The killing was condemned by wildlife officials, who warn that country's lion population is under threat. Kenya has been losing 100 lions a year for the last seven years, and now there are only about 2,000 left. Some of the carnivores are dying because of habitat destruction, others have succumbed to disease. Conflicts caused by the encroaching human population have also contributed to the decline.

1.4.2. Protected areas attracts humans, but at a cost to biodiversity.

Some of the human related problems faced by wildlife managers do not originate from the areas adjacent to protected areas, but from within, such as encroachments by livestock and informal settlements. Rather than suppressing local communities, nature reserves attract human settlement. In the recent wildlife census (February 2011) by KWS in Tsavo-Mkomazi ecosystem, informal settlements dotted the entire landscape except the central and northeast of Tsavo East NP. Abandoned bomas were highly concentrated in Tsavo West NP, Mkomazi NP and western part of Tsavo East NP, while occupied bomas were scattered but more in Tsavo West NP and South Kitui NR (Map 6.8.11). Information settlements are temporary structures comprised of occupied manyatta (temporary), occupied and abandoned boma (livestock enclosure), and closely relates to livestock numbers. These have been known to increase with protected areas during drought periods. The negative impact of bomas and manyattas cannot be overemphasized - clearing of shrubs for the construction of cattle bomas and temporary manyattas create patches and leave behind fragmented habitats, while high livestock numbers will result in over grazing and competition with wildlife for the meager water resources.



Map 6.8.11: Temporary manyatta and occupied/abandoned boma in the Tsavo-Mkomazi ecosystem (February 2011). Manyatta - traditional pastoralist hut, Boma – livestock holding enclosure usually fenced with thorny branches to deter night predators. *Source: KWS*


AMBOSELI NATIONAL PARK
MESHANANI GATE