REPUBLIC OF KENYA

NATIONAL LAND COMMISSION
Our Land, Our Wealth, Our Heritage

EUROPEAN UNION

Food and Agriculture Organization of the United Nations

KENYA
NATURAL RESOURCES
ATLAS

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http://www.naturalrespirceatlasportal.co.ke

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ACRONYMS

ACZ	Agro-climatic zone
AEZ	Agro-ecological zone
ASALS	Arid and semi-arid lands
C	Carbon
CA	Calcium
CO^2	Carbon dioxide
ESM	Exploratory soil map
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO statistics
GDP	Gross domestic product
GIS	Geographic information systems
GoK	Government of Kenya
ISRIC	International Soil Reference and Information Centre
K	Potassium
KALRO	Kenya Agricultural and Livestock Research Organization
KENSOTER	Kenya soil and terrain database
KES	Kenya shillings
KNBS	Kenya National Bureau of Statistics
KSS	Kenya Soil Survey
KWS	Kenya Wildlife Services
Mg	Magnesium
MoALF	Ministry of Agriculture, Livestock and Fisheries
MLND	Maize Lethal Necrosis Disease
N	Nitrogen
NAAIAP	National Accelerated Agricultural Inputs Access Programme
NPP	Net primary production
P	Phosphorous
SDGs	Sustainable development goals
SOC	Soil organic carbon
SOM	Soil organic matter
TIMPs	Technologies, innovations and management practices
USD	United States Dollar
WRB	World Resource Base
LCPDP	Least Cost Power Development Plan
NuPEA	Nuclear Power and Energy Agency
MW	Megawatt
MJ/Kg	Megajoule per Kilogram
KenGen	Kenya Electricity Generation Company
IPPs	Independent Power Producers
MoE	Ministry of Energy
REP	Rural Electrification Programme
REA	Rural Electrification Authority
UNDP	United Nations Development Programme
kWh	Kilowatt hour
Mwh	Megawatt hour
We	Watt energy
REREC	Rural Electrification and Renewable Energy
SWERA	Solar and Wind Energy Resource Assessment
AGID	Africa Geothermal Inventory Database
AWF	African Wildlife Foundation
AWS	Africa Water and Sanitation
CAACs	Catchment Area Advisory Committees
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism

CITES	Convention on International Trade in Endangered Species of
	Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild
	Animals (Bonn Convention)
CSOs	Civil Society Organizations
DANIDA	Danish International Development Agency
DECs	District Environmental Committees
DRSRS	Department of Resource Surveys and Remote Sensing
EAC	East African Community
EMCA	Environmental Management and Coordination Act
ESFC	Environmentalistes San Frontier Consultants
ESP	Economic Stimulus Package
EWEs	Extreme Weather Events
GDP	Gross Domestic Product
GHG	Greenhouse gases
GIS	Geographic Information Systems
GoK	Government of Kenya
IBAs	Important Bird Areas
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
JF	January and February
JJA	June, July and August
JJAS	June, July, August and September
KEFRI	Kenya Forestry Research Institute
KenGen	Kenya Electricity Generating Company Limited
KEWI	Kenya Water Institute
KFS	Kenya Forest Service
KFWG	Kenya Forest Working Group
KMD	Kenya Meteorological Department
KMFRI	Kenya Marine and Fisheries Research Institute
KSh	Kenya Shilling
KWS	Kenya Wildlife Service
LVBC	Lake Victoria Basin Commission
LVEMP II	Lake Victoria Environmental Management Project Phase II
LVFO	Lake Victoria Fisheries Organization
MAM	March, April and May
MDGs	Millennium Development Goals
MEAs	Multilateral Environmental Agreements
MTPs	Medium-Term Plans
MEMR	Ministry of Environment and Mineral Resources
MPAs	Marine Protected Areas
NBCs	Nile Basin Countries
NBI	Nile Basin Initiative
NEMA	National Environment Management Authority
NEPAD	New Partnership for Africa's Development
NEWP	New England Wetland Plants
NIB	National Irrigation Board
NMK	National Museums of Kenya
NOAA	National Oceanic and Atmospheric Administration

NRCS	USDA Natural Resources Conservation Service
NTEAP	Nile Transboundary Environmental Action Project
NWCPC	National Water Conservation and Pipeline Corporation
OND	October, November and December
REDD+	Reducing Emissions from Deforestation and Forest Degradation, Forest Conservation, Sustainable Management of Forests and Carbon Stock Enhancement
SEI	Stockholm Environment Institute
SST	Sea-Surface Temperature
TDIP	Tana Delta Irrigation Project
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP DEWA	UNEP Division of Early Warning and Assessment
UNEP/WCMC	UNEP World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
URT	United Republic of Tanzania
USA	United States of America
USAID	United States Agency for International Development
USDA	US Department of Agriculture
USGS	United States Geological Survey
VIP	Ventilated Improved Pit latrine
WAB	Water Appeal Board
WASREB	Water Services Regulatory Board
WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WMO	World Meteorological Organization
WRB	World Resource Base
WRI	Water Resource Institute
WRMA	Water Resource Management Authority
WRUAs	Water Resources Users Associations
WSBs	Water Services Boards
WSPs	Water Service Providers
WSTF	Water Services Trust Fund
WWF	World Wildlife Fund
CMS	Convention for Migratory Species
CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora
RAMSAR	Convention on Wetlands
CBD	Convention of Biological Diversity.
CR	Critically Endangered
EN	Endangered
VU	Vulnerable
NT	Near Threatened
DD	Data Deficiaent
EX	Extinct

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Introduction

Kenya is endowed with vast and diverse natural resources including biodiversity, land and unique ecosystems, which underpin the main beacons for socio-economic development and resilience building. Land, the primary natural asset, is an enabler to socio-economic and ecological development. While this is an inelastic and finite resource, it has many competing uses. Balancing the main three-facets of land resource mainly social, political and ecological perspectives remain a major challenge due to complexity of varied premiums attached on land and land-based resources. Article 61 of the Constitution of Kenya classifies Land in Kenya as Public, Private and community respectively. Conversely, natural resources constitute public land and collectively belong to the people of Kenya.

As a country, we pride ourselves as strategically positioned in terms of natural wealth, which ranges from the hills, climate, soil, biodiversity, to water and wetlands as well as minerals and petroleum among others. Indeed, we are blessed with unique landscapes and ecosystems that supply important benefits to people's survival and well-being. Despite these endowments, Kenya's natural resource base, mainly forests, wetlands, dry land, aquatic and marine resources, are under severe stress stimulated by a myriad of forces. Population pressure, deforestation, coastal modification, ongoing degradation of eco-systems as well as unsustainable use and poor governance of these resources threaten vulnerable habitats and biodiversity and, for a large proportion of Kenyans, livelihoods and long-term food security. Article 69(1)(a) of the Constitution of Kenya mandates the State to ensure sustainable exploitation, utilization, management and conservation of the environment and its natural resources, and to ensure the equitable sharing of the accruing benefits.

Against this background, the National Land Commission (NLC), exercising its mandate as per Article 67 (2), in collaboration with Food and Agriculture Organization of the United Nations (FAO), embarked on a journey to inventorize all the natural resources in Kenya. The exercise utilizes modern technologies aimed at improving the management and the use of natural resources in Kenya through cross-sectoral planning policies.

Purpose and Objectives

The judicious management of natural resources is based on the premise that an equitable and sustainable relationship between human and natural capitals exist. This Atlas provides an inventory of all land-based resources in Kenya with a view to creating necessary data bases for information sharing, decision making, planning and sustainable management of these resources.
Specifically, the Atlas seeks to:

1. Identify, map and document all natural resources in Kenya.
2. Provide access to information to the general public and decision makers to support integrated and landscape-scale natural resource management in Kenya.
3. Provide a basis for review, updating and formulation of natural resource's strategies, policies, plans and programmes (PPPs).
4. Enhance the capacity of regulatory and enforcement agencies including ministries, departments, and agencies and County Governments (MDACs) on management of natural resources in Kenya.
5. Provide a framework for valuing (through monetization or otherwise) services derived from natural resources, and promote the use of incentive-based instruments that perpetuate the continued delivery of environmental services.
6. Foster trans- boundary natural resource management (TBNRM) in the interest of national, regional and international conservation and development goals.

Justification for the Atlas

Natural resource management is a concurrent jurisdiction of both national and county governments. This therefore calls for multi-sectoral coordination and cooperation. Further, access to information is one of the fundamental human rights in line with Article 35 of the Constitution of Kenya. Indeed, public agencies are obligated to provide information in a manner that is clear, easy to understand and comprehend in order to bolster people's meaningful participation in governance spheres. Information and data relating to natural resources are scattered and largely domiciled by the respective government agencies, and there is no single information portal that provides crucial information for decision-making, planning and sustainable management of the entire spectrum of Kenya's natural capital. This lacuna impedes investment decisions and compounds the intricacies around land and resources management and use. Yet, the Government's policy on ease of doing business requires that public agencies champion open and transparent information access to the public as well as ensure that information is in a format that is usable and understandable in line with the Rio Declaration on Environment and Development. This Declaration postulates that at the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities.

Equally, the current paradigm shift towards digital transformation and the emergence of a data-driven economy (DDE) in which data and data mining are critical factors of production and achievement of socio-economic development, has profound implications on the role of the state as both an economic agent and as regulator. Government decisions and actions must therefore be buttressed in credible and authentic data, properly and carefully analyzed and interpreted to meet information demand by the public and relevant stakeholders. In addition, Section 15 (3) of the Land Act 2012 empowers the National Land Commission to undertake an inventory of all land-based resources with a view to facilitate informed decision making on the distribution and use of natural resources in Kenya.

Indeed, the Third Medium Term Plan (2018-2022) prioritized the development of this atlas and creation of natural resources databases as flagship projects. In this regard, through the Inter-Agency Technical Committee (IATC), the Commission in partnership with FAO has consolidated all the available information and data on natural resources; culminating into an atlas comprising of both a hardcopy and an interactive geoportal. These visually paints the picture of where, how much, the threats and inter-linkages between these resources themselves and with the people. The atlas is therefore beneficial to the entire public including researchers and academia while supporting teaching and researching; investors, communities who are rights holders, Governments as duty bearers, private sector players, civil society for advocacy, media fraternity and development partners seeking to understand the natural resources landscape in Kenya. It provides a succinct and visually orienting information in form of maps, images and photos, summary tables and graphs, as well as policy statements for sound management, conservation and use of natural resources.

The atlas therefore promotes good governance and stewardship of Kenya's natural capital and will be critical in advancing the oversight responsibility of the Commission. This includes provision of statues reports, advisories, guidelines, rules and regulations, and ensuring effective management of what is known. The development of the country's natural resources atlas therefore not only meets the country's legal and policy obligations but also is in sync with the Sessional Paper No. 01 of 2017 on National Land Use Policy as well as the National Spatial Plan 2015-2045, which guides the long term spatial development of the country for a period of 30 years.

Approach & Methodology

This atlas is an amalgam of social, ecological, geospatial data; packaged in a practical and visually orienting fashion to provide the much needed visual effects as well as summaries of the status, changes and threats that quickly inform policy, decision making, planning and sustainable management of Kenya's resources. Through an Inter-Agency Technical Committee (IATC) comprising of representatives from relevant Government agencies and the County Governments, extensive data gathering and rigorous stakeholder consultations were undertaken to compile and analyze data and information from various institutional databases, reports and the internet.

Where applicable, historical and current satellite images of relevant places were selected and analyzed using Geographic Information Systems (GIS) and remote sensing technologies. GIS was also used to collect, manage, analyze and create maps used in this Atlas. A number of experts from different public institutions, research institutions and development partners were involved and working sessions were organized to seek input from these experts; the sessions largely consisted of write-shops and map-shops for drafting and map generation respectively. The draft atlas was then validated through regional and national workshops.

In terms of dissemination, a national dissemination strategy was developed through the multi-stakeholder approach in collaboration with other non-governmental actors directly involved in the development and management of natural resources. In this regard, the atlas and geoportal shall be launched in a national function and popular versions developed for the wanjiku which shall be disseminated through the 8 regional nodes/ economic blocs. The geoportal hosted by the National Land Commission will be linked to other relevant government agencies databases to leverage on public outreaches.

Target Users

The atlas targets the following users:

- General public
- Government Ministries, Departments, Agencies (MDAs)
- County Governments
- Professional practitioners and bodies
- Academic and Research institutions
- Non-Governmental, Community based Organizations and Civil Societies
- The Media

Structure & Contents of the Atlas

The atlas has been structured into the following chapters:

1. Introduction
2. Wetlands and water resources,
3. Biodiversity and genetic resources
4. Energy, minerals and petroleum resources
5. Agrobased and livestock resources
6. socio-economic linkages and emerging imperatives

CHAPTER

01

WATER AND WETLANDS

Introduction

Water and wetlands are essential natural resources vital for Kenya's socio-economic development. Constituting national asset, these resources integrates terrestrial and aquatic environments including water, soil and vegetation (Lathrop, 2011) providing a number of critical ecosystem services that are indispensable to human beings and biodiversity's very survival, health and welfare.

Kenya's Vision 2030 adopted in 2006 has 5-year plans that were aligned towards achieving the out-phased Millennium Development Goals (MDG) and now the Sustainable Development Goals (SDGs) set by the United Nations General Assembly in 2015. Among the 17 Goals is the attainment of clean water and sanitation (GOAL 6) which aims to ensure sustainable access to safe drinking water and sanitation for all by 2030. Water and wetlands resources management has been granted by the Constitution of Kenya in section 66 (1) declaring water resources and its catchments including wetlands as public land (Section 62 on public land (i) and (l) specified rivers, lakes and other water bodies and their riparian as public land). Similarly, in the spirit of devolution, their managment is a shared function in the National and County Governments Performed by the National Lands Commission on their behalf.

Different legislations govern the water and wetlands resources. In addition, the international conventions and in particular, the Ramsar Convention has been in force in Kenya since 1990 the sessional Paper No 13 of the National Wetlands and Conservation Policy 2013 aims at ensuring wise use and sustainable management of wetlands in order to enhance sustenance of their ecological and socio-economic functions for present and future generations in Kenya.

The water Act 2016 provides for the regulation, management and development of water resources, water and sewerage services and for other connected purposes and establishes the Water Resources Authority (WRA) to protect, conserve, control and regulate the use of water resources. The Environmental Management Coordination Act was enacted to provide an appropriate legal and institutional framework for the management of the environmental and for the matters connected therewith and incidental thereto. Wetland regulations (2009), provides for environmental management and coordination (wetlands, river banks, lake shores and sea show management).

Water Resources

Kenya is water Scarce County endowed with water resources mainly relying on little and fragile catchments covered by the montane forests in the country's highland areas with a humid climate. It has a number of lakes, rivers, aquifers and other water bodies considered as a unit. The country adopted integrated water resources management approach of managing water resources along drainage system.

The Kenya's Basins

The Kenya Basin is divided into six basins; Lake Victoria South (LVSBA), Lake Victoria North (LVNBA), Rift Valley (RVBA), Ewaso Nyiro North (ENNBA), Tana (TBA) and Athi (ATBA). The total land mass of the basin is 575, 451 km2, Fig, xxx)

These basins contribute differently to freshwater resources but they are not squarely dependent on land mass of the basin. Lake Victoria South Basins, though small in size (5.5%), contributes 23%, Lake Victoria North (3.2%) and significant portion (23%), and Ewaso Nyiro North has the biggest land mass of 36.5% but contributes 8% of the country's freshwater (Fig, xxx). Lake Victoria South and North basins are highly endowed rivers; including Lake Victoria itself. In contrasts with Ewaso Nyiro has few rivers and also it lies in arid and semi-arid climate zone. Rift Valley basin covers 22.7% of the country's land mass and contributes approximately 12% of fresh water resources. Notably, Rift Valley is home to many saline-alkaline lakes except for Lake Naivasha and Baringo.

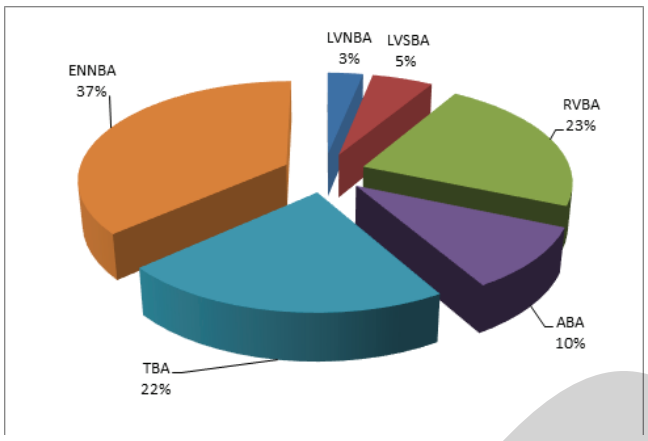


Figure 1: Proportion of Kenya land area (Sq km) by basin

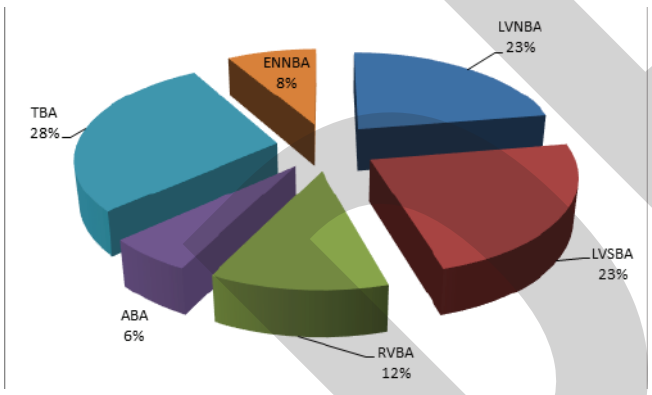


Figure 2: Contribution (%) of fresh water by basin

Kenya's renewable water resources

Kenya's renewable water resources are classified into two distinct types; surface and ground water resources. They are represented by lakes, reservoirs, rivers, swamps/wetlands, springs, dams, water pans and groundwater (NWMP, 2013). Kenya has total renewable freshwater resource estimated at 76.610 MCM/year, (NWMP 2030, 2013). Surface water accounts for 20.637 million m3/year while 55.973MCM/year is provided by ground water (NWMP, 2013 as shown in Table 1;

Table 1: *Kenya's renewable water resources*

Item	Year 2010 (MCM/ year)	Year 2030 (MCM/year)	Year 2050 (MCM/year)
Renewable water resources	76,610	80,747	83,583
Surface water	20,637	24,894	26,709
Ground water	55,973	55,580	56,874

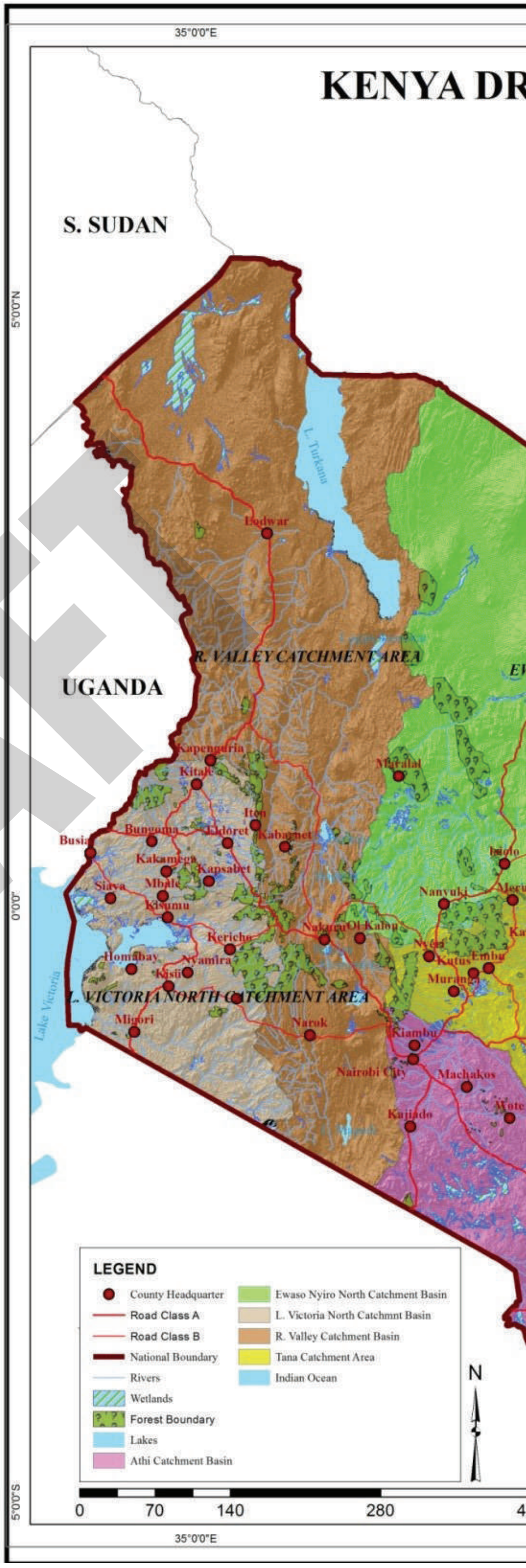
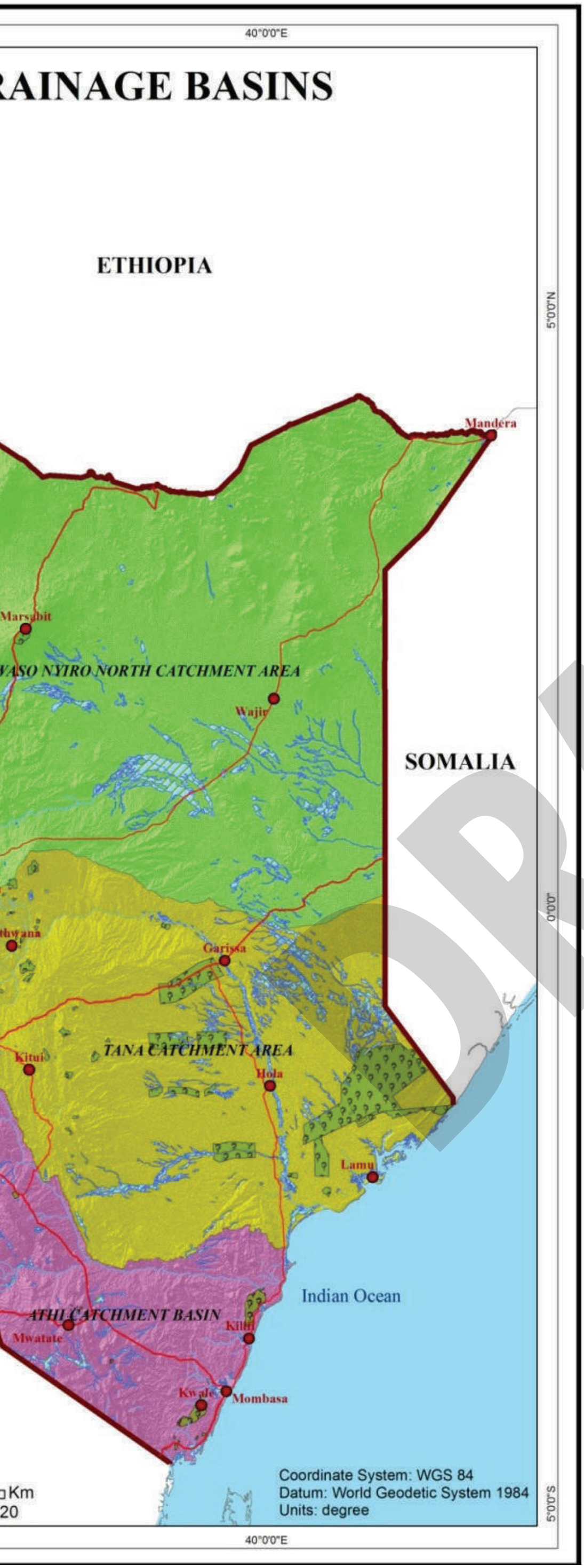


Figure 4: Map of Kenya drainage basins



Surface water resources

Kenya has a total of renewable surface water resources of 20.637 MCM/year, (NWMP, 2013) contributed by its permanent or seasonal inland waters; lakes, rivers & streams, reservoirs and wetlands in varying proportions. The surface water is distributed within the six drainage basins in Kenya and its contribution to the national freshwater resources is detailed in Figure 3.

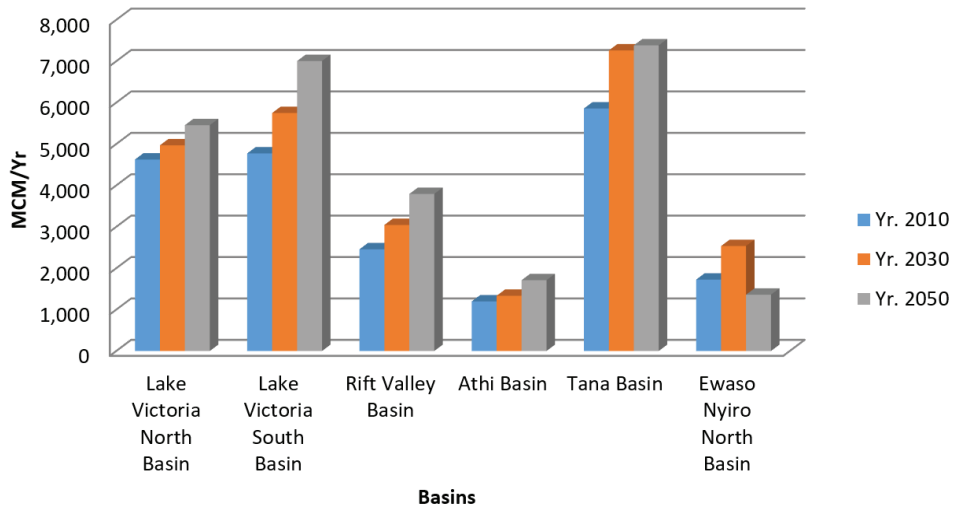


Figure 3: Trends of renewable water resources by Basin projected upto year 2050

Lakes and Reservoirs in Kenya

Lakes

Globally, lakes as are classified based on water quality as freshwater or saline -alkaline water. In Kenya, the lake water surface area is 12,973.43 km2. Salty lakes covers 65%, while freshwater lakes is 35% Table 2.

Table 2: *freshwater and Salty Lakes of Kenya*

		Water Quality			
Items	Catchment area (Km2)	Freshwater	Saline alkaline	% of freshwater against land mass	% of saline alkaline against land mass
Large lakes	12,840.30	4,481.30	8,359	34.5	64.4
Small Lakes	126.04	45.84	80.2	0.4	0.6
Smaller lakes	7.09	7.09		0.1	
Total	12,973.43	4,534.23	8,439	35	65

Classification of Lakes by Sizes

There are 8 lakes that are referred as the large lakes and they include Naivasha, Olbolosat, Baringo and Victoria; Turkana, Nakuru, Bogoria, Elementaita, Magadi, and Natron (Table 3).

Large lakes

Table 3: *Largest lakes in kenya*

Basin	S/n	Lakes	County	Surface area (Km^2)	Water Quality
L. Victoria South	1.	Victoria	Siaya, Busia, Kisumu, Homa-Bay, Migori	68,800	Freshwater
Rift Valley	2.	Turkana	Marsabit & Turkana	6750	Saline
	3.	Nakuru	Nakuru	40	Saline
	4.	Naivasha	Nakuru	139	Freshwater
	5.	Baringo	Baringo	100	Fresh water
	6.	Magadi	Kajiado	100	Saline
	7.	Lake Natron	Kajiado	600	Alkaline-Saline
Athi	8.	Olbolosat	Nyandarua	43.3	Freshwater
		Total	76,572		

Plate 1: Lake Victoria (Anita Ritenour/Flickr0

Small lakes

There are 13 small lakes shown in Table 4.

Table 4: *Smaller lakes in kenya*

Basin	S/n	Lakes	County	Surface area (Km²)	Water Quality
Lake Victoria South	1.	Simbi Nyaima	Homabay	3	Saline
Lake Victoria North	2.	Kanyaboli	Siaya	15	Freshwater
	3.	Lake Bob	Siaya	2	
	4.	Sare	Siaya	5	Freshwater
Rift Valley	5.	Solai	Nakuru	10	Saline
	6.	Lake Lokipi	Turkana	18	saline-alkaline
	7.	Lake Alabla	Turkana		
	8.	Elementaita	Nakuru	20	Saline
	9.	Lake Oloiden	Nakuru	5	freshwater
	10.	Lake Kamnarok	Baringo	1	Freshwater
Tana	11.	Lake Challa	Taita-Taveta	4.2	saline
	12.	Jipe	Taita- Taveta	25	saline
Athi	13.	Kenyatta	Lamu	3.7	Fresh water
		Total		111.9	

Smallest lakes

There are 17 smaller lakes that fall below 1 km2, thus can be classified as the smallest lakes Table 5.

Table 5: *Smallest lakes in kenya*

Basin	S/ No	Lakes	County	Surface area (Km²)
Lake Victoria North	1.	Namboyo	Siaya	
Rift Valley	2.	Lake 94	Nakuru	0.25
	3.	Lake Sonachi	Nakuru	
	4.			
TANA [Ox bow lakes especially in the Tana Delta]	5.	Chalbi	Marsabit	
	6.	Sokorte Dika	Marsabit	
	7.	Amboseli	Kajiado	
	8.	Shaka babo	Tana River	
	9.	Moa	lamu	
	10.	Lake Alice	Meru	0.2
	11.	Lake Michaelson	Meru	0.1
Athi	12.	Lake Ellis	Meru	0.1
	13.	Lake Rutundu	Meru	0.1
	14.	Lake Nkunga (Sacred Heart)	Meru	0.39
	15.	Lake Narasha (Timboroa)	Uasin Gishu	
	16.	Lake Paradise	Marsabit	
	17.	Lake Hotinel	Meru	0.08
	18.	Lake Carr	Meru	0.08
	19.	Lake Enchanted	Meru	0.04
		Total		1.34

Lake Victoria

Specific lake profiles is provided below

Lake Victoria

Lake Victoria is the largest tropical lake and second largest freshwater lake in the world with an area of 68,000km^2. Formed in the late Pleistocene (ca. 400,000 yr ago but dried before refilling again 15,000 years ago (Johnson et al., 2000, Talbot & Laerdal 2000), the lake stretching 412 km from north to south and 355 km from west to east the lake is shared by three countries, Kenya, Uganda and Tanzania.

The over 193,000 km^2 catchment covers Rwanda and Burundi. Plate 1 presents the aerial view of Lake Victoria

The lake depression is 1,134 m asl, between the west and east African rifts and it water balance is maintained by rainfall and evaporation rather than the inflows and outflows, (Spigel & Coulter 1996).

The lakes residence time is 23 years (Cohen et al. 1996; Spigel & Coulter 1996). More than 30 million livelihoods depend on the lake Basin ecosystem for their livelihoods that include landed fish of about $400 million in value every year, extensive irrigated agriculture and tourism, cottage industry from papyrus as well as sand and clay harvesting. The Lake, its tributaries and related wetlands comprise and ecosystem with extraordinary biodiversity and ecosystem service values.

Lake Baringo

Lake Baringo is named after the local word "Mparingo", meaning lake. The lake is located in the Eastern Rift Valley in Kenya and is one of the seven inland drainage lakes within the Rift Valley drainage basin. The lake has a surface area of about 100km2 and drains a total area of 6,820 km2. Plate 2presents an aerial view of Lake Baringo

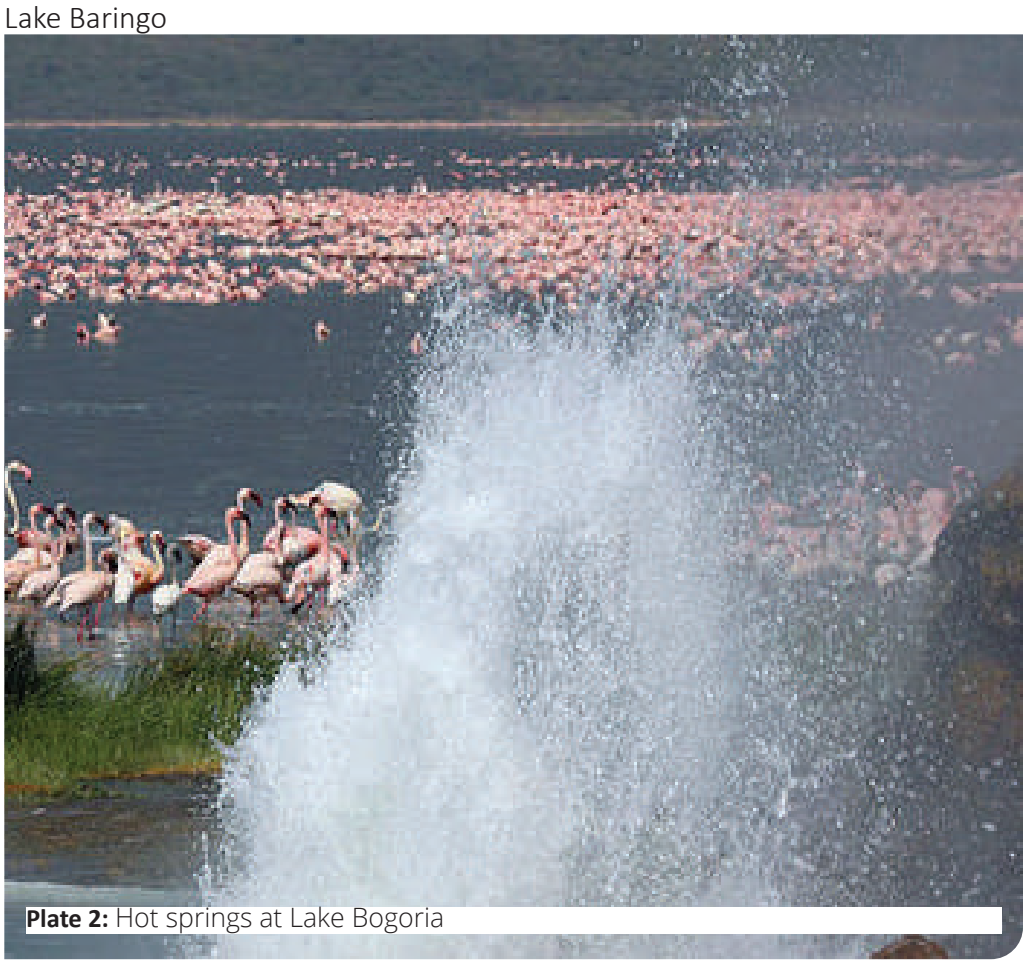


Plate 2: Hot springs at Lake Bogoria

Lake Nakuru

The Lake Nakuru, a closed hydrologic basin system, is a shallow alkaline-saline lake lying in Eastern African Rift Valley (Livingstone & Melack 1984). The lake surface area fluctuates from approximately 40-60km2, mean depth of 2.5 meters and a maximum depth of 7 meters. The panoramic view of Lake Nakuru is shown in Plate 5.

The lake volume has average of 92 x 106m3. The average water loss via lake evaporation is estimated at 4, 158, 59 m3/mo, average rainfall input is 2,908.597 m3/mo and ground water inflow is 464,013 m3/mo. The lake has a pH of >9.0 and high salinity (Electrical conductivity 8.5-165mS/cm). The lake's mean surface water temperature ranges between 25-28oC.

Plate 5: Lake Nakuru panoramic from Baboon Cliff

Lake Magadi

Lake Magadi has very shallow water, being a solid Salt Lake during the dry season, and it has the largest deposits of soda ash in the world.

Lake Turkana

Plate 3: Lake Turkana (courtesy of Wikipedia Creative Commons)

Lake Paradise

Plate 4: Lake Paradise Crater Lake in Marsabit National Park. Photo courtesy of F. King Tours and Safaris - Day Tours

Reservoirs and Dams

A dam refers to the structural barrier that is constructed across a river or a valley with the aim of ensuring that water is prevented from flowing causing water to accumulate behind the wall after which it is allowed to overflow after reaching a certain height of the dam whereas a reservoir is the large water body that forms behind a wall constructed across a river or a large valley.

Reservoirs in Kenya

There are over 170 reservoirs in Kenya with estimated water storage capacity of 9,600 MCM. The 9 major reservoirs with storage capacity above 16MCM providing the bulk 82% (7,847MCM) of the stored water. These major reservoirs are located in Tana basin within catchment area.

They include Gitaru, Kiambere, Kiamburu, Kindaruma, Masinga, Mutonga, Thika/Ndakaini and Moiben and Luanda within Lake Victoria North Basin. The rest 161 reservoirs are categorized either as medium (17) or small sized (144) which stores a combined 18% (1,753MCM) of water in the reservoirs.

Normally, people find it difficult to distinguish between a dam and a reservoir. A dam refers to the structural barrier that is constructed across a river or a valley with the aim of ensuring that water is prevented from flowing causing water to accumulate behind the wall after which it is allowed to overflow after reaching a certain height of the dam whereas a reservoir is the large water body that forms behind a wall constructed across a river or a large valley. In some instances, the reservoir accumulates large amounts to form a human-made lake.

Distribution of reservoirs by basin

Athi basin has 58% of the reservoirs with Rift Valley 13% while the rest Ewaso Nyiro North 11%, Lake Victoria South 8% , Tana 6% and lake Victoria North 4%. Interestingly, Tana basin with only 6% of the reservoirs has the highest reservoir storage capacity of 7,820MCM while 58% of the Athi basin reservoirs only stores 42MCM. The distribution of reservoirs by basin (Figure 5)

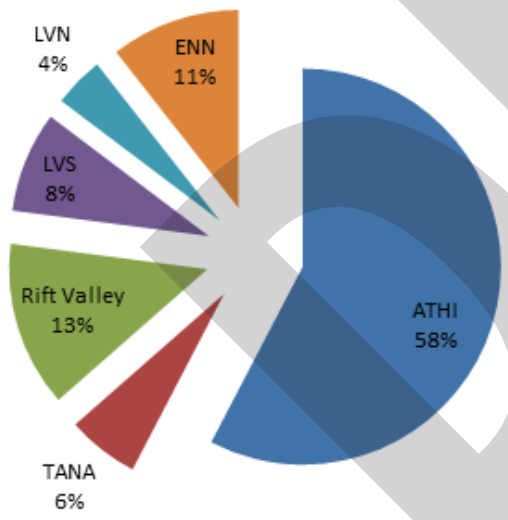


Figure 5: distribution of reservoirs by basins in Kenya

The storage capacity attributes of the reservoirs by basins is illustrated in Table 6.

Table 6: *Storage capacity of the reservoirs by Basins*

Reservoir storage	ATHI (MCM)	TANA (MCM)	Rift Valley (MCM)	LVS (MCM)	LVN (MCM)	ENN (MCM)	Total
Major reservoirs	0	7801	0.67	0	44	1.1	7846.77
Medium	31.3	16.5	30.2	4	8	5	95
Small reservoirs	10.33	2.96	1645	0.28	0	0	1658.57
Total	41.63	7820.46	1675.87	4.28	680.1	6.1	9600.34

The Purpose of the Reservoirs

Reservoirs are vital water resources complementing surface and ground water on major socio-economic and environmental fronts. The Hydro and Non-Hydro Reservoirs are used for Domestic, fishing, Hydropower. Conservation, flood control, Wildlife Tourism and Irrigation or several combinations of usage (Figure 6).

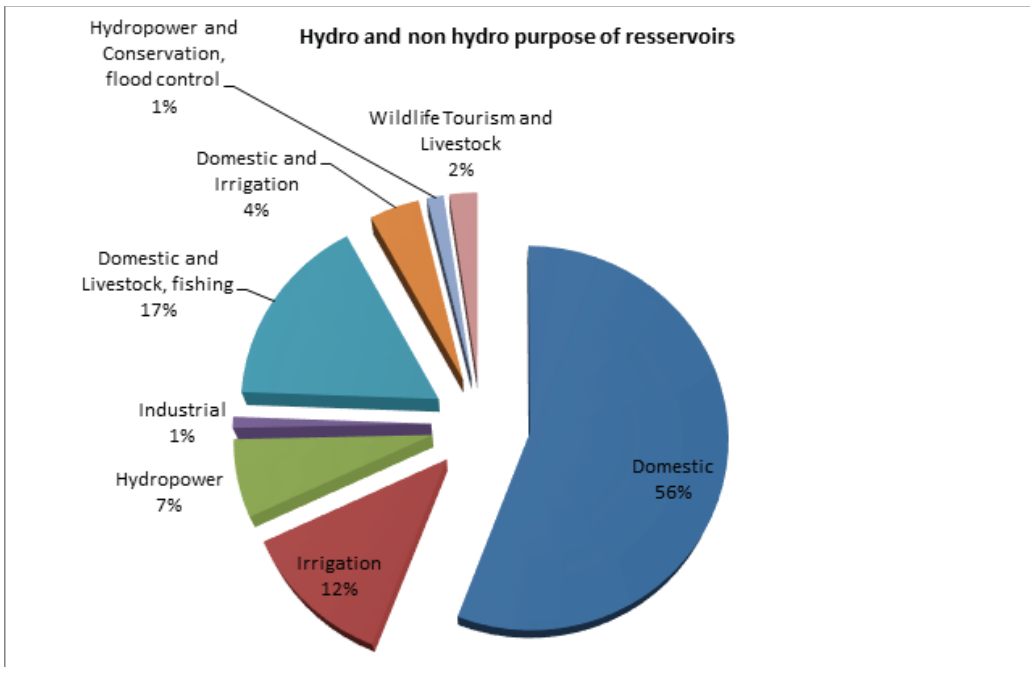


Figure 6: Hydro and Non-hydro power uses of reservoirs

KEY MESSAGE

The reservoirs provide key source of water for various use among other hydropower generation, domestic water for urban and rural use, irrigation and livestock, wildlife and fishing hence is imperative in the support of agenda four and other socio- economic development as anticipated in the Kenya's economic blue print vision 2030. However, due to population increase and impact of climate change the demand of water is likely to increase exponentially in order to meet the various demands. Thus, there is need to conserve the existing reservoirs through catchment conservation measures to control soil erosion hence increasing the life of the infrastructure and reducing the risk of associated with their development and use.

Kenya's Rivers

Kenya is bestowed with numerous rivers and watercourses, majority of which are seasonal. Large perennial rivers are few and most rivers originate from the major water towers and highlan ds areas. The Kenya river system is arranged by drainage basins. The map below shows the distribution of rivers in Kenya.

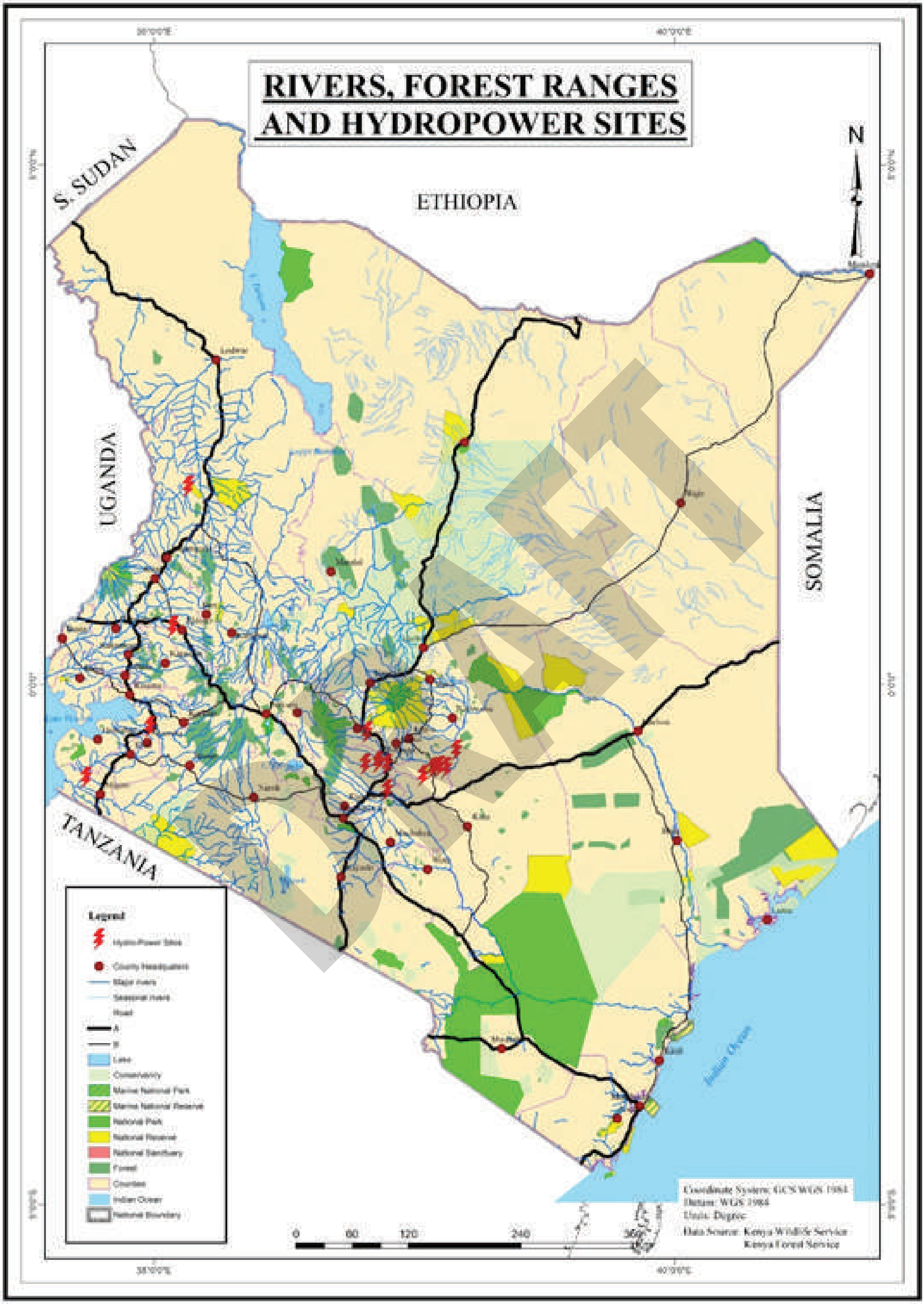


Figure 7: Kenya's rivers, Forest ranges and Hydropower sites

Rivers of Lake Victoria South Basin

The Lake Victoria South basin has four main rivers that drain into Lake Victoria. These are Nyando, Sondu, Gucha and Mara Rivers. Other rivers include the Southern shoreline and northern shoreline rivers Table 7. The Mara River is the longest with a flow of about 395km (part of its 295km being in Kenya) before draining into Lake Victoria.

Table 7: *Rivers of Lake Victoria South Basin*

Basin	Rivers	County	Surface area (Km)	Perennial/ Seasonal
Nyando	Nyando	Kisumu	148	Perennial
Northern Shoreline rivers	Mbogo	Nandi/Kisumu	111	Perennial
	Ainapngetung	Nandi	131	Perennial
	Nyamasaria [Kibos]	Kisumu	133	Perennial
	Asao	Kisumu	475	Seasonal
	Ainapisiwa	Nandi	143	Perennial
	Awach Seme	Kisumu	150	Perennial
	Awach Kano	Kisumu	370	Seasonal
Sondu	Kipsonoi	Kericho	1,043	Perennial
	Yurith	Kericho	263	Perennial
	Itare	Kericho	247	Perennial
	Sondu	Kisumu	271	Perennial
Kuja-Migori	Gucha	Kisii	Data not available	Perennial
	Migori	Migori	414	Perennial
	Kiabonyoru	Kisii	Data not available	Seasonal
Mara	Mara	Narok	1,167	Perennial
	Nyangores	Narok ,/Bomet/	978	Perennial
	Amala	Bomet/Nakuru/ Narok	393	Perennial
	Talek	Narok	223	Seasonal
	Longaianiet	Narok	619	Seasonal
	Ololorok	Narok	Data not available	Seasonal
	Sise	Narok	351	Perennial
	Sand	Narok	169	Seasonal
	Kanunda	Narok	Data not available	Seasonal
Southern shoreline rivers	Mogusi	Kisii	Data not available	Perennial
	Awach Kibuon	Homabay	158	Perennial
	Awach Tende	Homabay	144	Perennial
	Riana	Homabay	253	Perennial
	Awach Kabondo	Homabay	203	Perennial
	Awach Kasipul	Homabay	162	Perennial

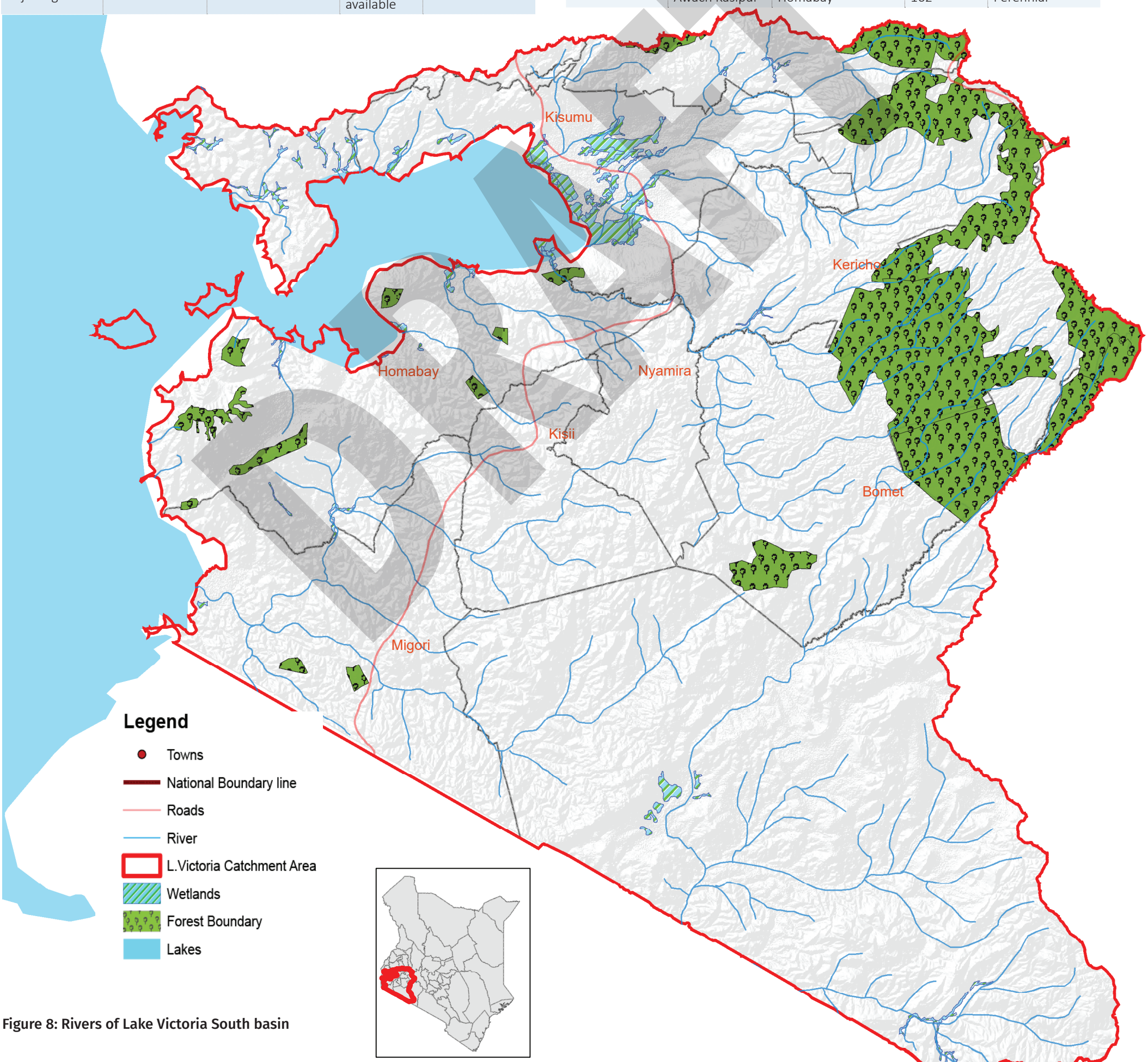


Figure 8: Rivers of Lake Victoria South basin

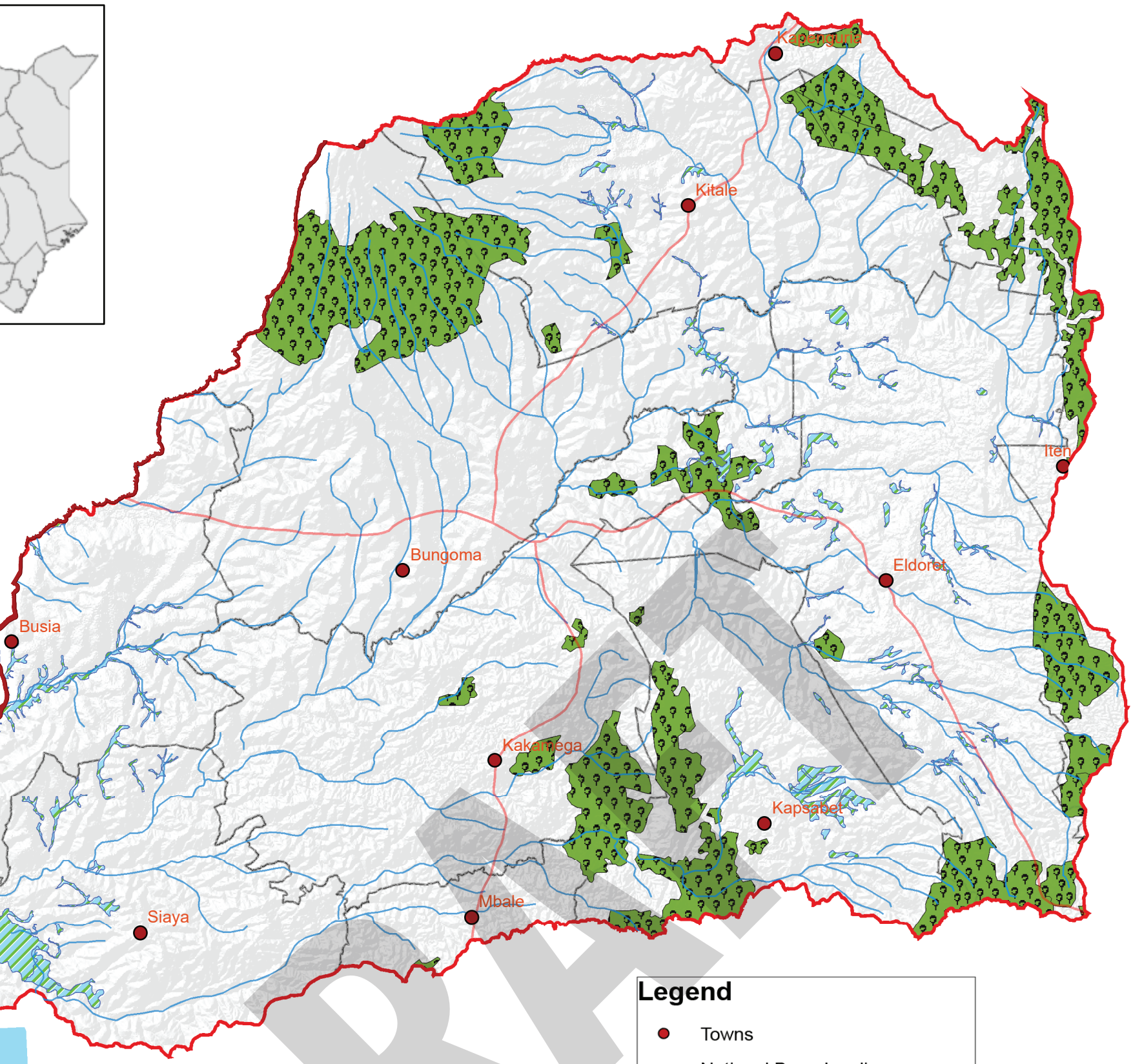


Figure 9: Rivers of Lake Vitoria North

Table 8: *Rivers of Lake Victoria North*

Rivers	County	Perennial/ Seasonal	Rivers	County	Perennial/ Seasonal
Cherangany Hills,			Kamokoiywo		
Mt. Elgon,			Kipyoiywan		
Mau complex			Kasawal		
River Nzoia	Trans Nzoia	Perennial	Kaibei	Trans Nzoia	Perennial
Nandi escarpments			Mubere		
Yala			Suam	West Pokot	Perennial
Lwakhakha	Bungoma	Perennial	Sasur		
Malakisi	Bungoma	Perennial	Emia		
Malaba	Busia	Perennial	Kapkateny	Bungoma	Perennial
Rokook			Kitaban		Perennial
Siit			Kibuk	Bungoma	Perennial
Terem			Nguresai		
Kibisi	Bungoma	Perennial	Labb		
Kimelill			Chepsoikei		
Sosio	Bungoma	Perennial	Chepirirbei		
			Chemkenge		

Rivers of Lake Victoria North Basin

Lake Victoria North basin has six major rivers originating from Cherengani Hills, Mt. Elgon, Mau Complex and Nandi Escarpment. Rivers Nzoia and Yala drains into Lake Victoria while the other four rivers are transboundary rivers; Sio, Lwakhakha, Malakisi, Malaba flowing across the border into Uganda and other smaller rivers originating from the peak of Mount Elgon Table 8and

The rest such as Sasur, Emia, Kapkateny, Kitaban, Kibuk, Nguresai, Labb, Chepsoikei, Chepirirbei, Chemkenge originate in the forest hill before moorland.

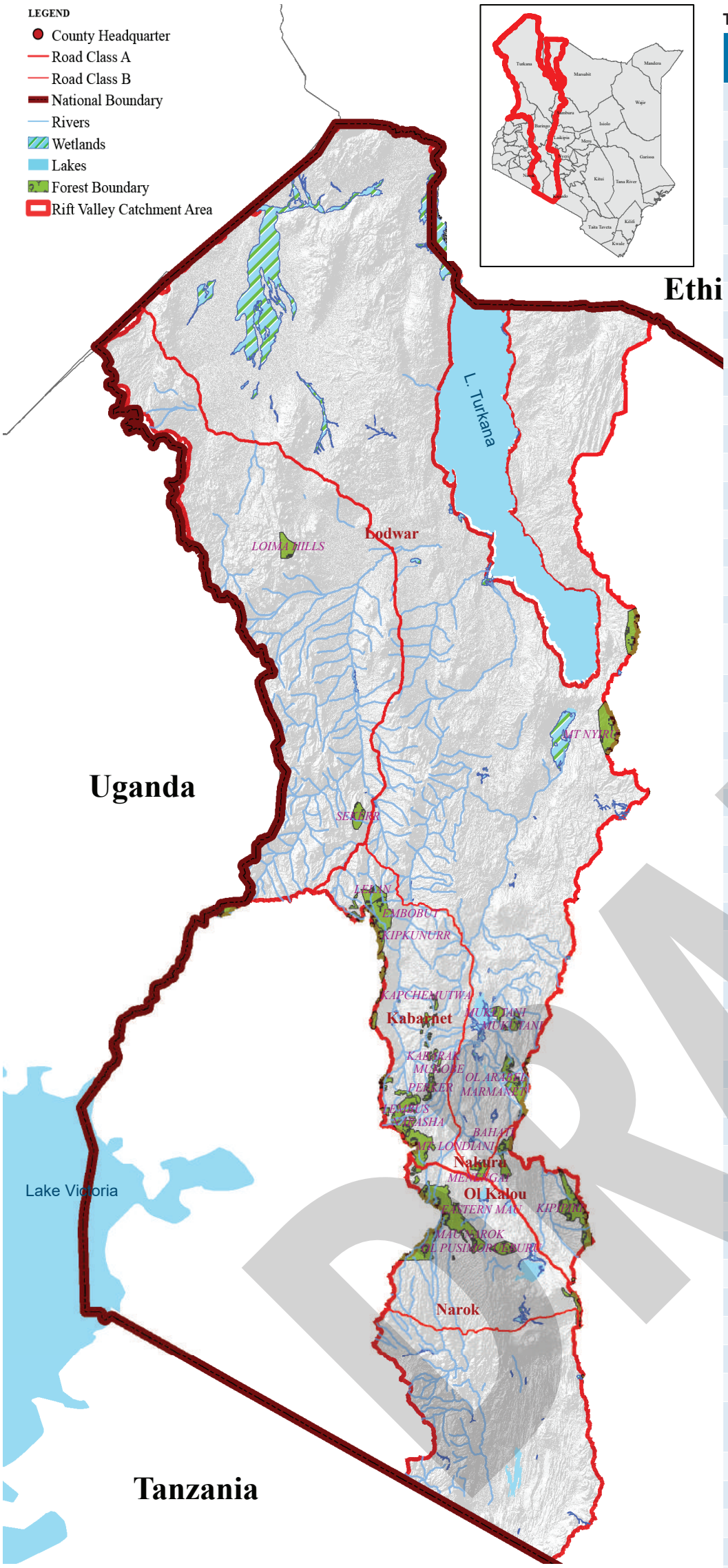


Figure 10: Rivers of rift valley basin

Rivers of Rift Valley Basin

The major rivers in the Rift Valley Basin flow into six lake drainages namely; Lake Turkana, Baringo, Bogoria, Naivasha, Magadi, Elementaita and Solai. For example, Suguta, Kerio, Turkwel [Suam, Wei-Wei, Muruny, Sebit], Kalapata, Lokichar flows into Lake Turkana. The aerial view of River Turkwel is presented in Plate 6.

The other rivers Olarabel, Rongai, Molo, Waseges, Perkera flows into Lake Baringo while Njoro, Ngosur, Nderit, Makalia, Mbaruk, Mereroni flows into Lake Nakuru. Two main river flows downwards into Lake Naivasha are Gilgil, Malewa. Rivers Siyabei, Ewaso Nyiro South flows into Lake Natron. Rivers Maji Matamu, flows into Lake Solai. A few seasonal rivers originate from southern highlands of Ethiopia extending into Kenya along the mutual boundary, e.g. River Daua, which flows during the rainy season.

Table 9: *Rivers of Rift Valley Basin*

Main River	Rivers	County	Catchment area (Km2)	Perennial/Seasonal
Lake Turkana	Suguta	Turkana		Seasonal
Kerio	Kerio	Turkana		Seasonal
	Kochodin	Turkana		Seasonal
	Kalapata	Turkana		Seasonal
Turkwel	Turkwel	Turkana		Perennial
	Malimalite	Turkana		Perennial
	Lokanam	Turkana	810	Seasonal
	Kawalathe	Turkana	1647	Seasonal
	Tarach	Turkana		Seasonal
	Araweet	West Pokot		Perennial
	Bendera	West Pokot	248	Perennial
	Kamasian	West Pokot	388	Perennial
	Kameris	West Pokot	226	Perennial
	Kapoghogh	West Pokot		Perennial
	Kasoughigh	West Pokot		Perennial
	Mosion	West Pokot	143	Perennial
	Sarmach	West Pokot	1269	Perennial
	Lelan	West Pokot		Perennial
	Kwenu	West Pokot		Perennial
	Arror	Baringo, Keiyo-Marakwet	288	Perennial
	Embobut	Keiyo Marakwet	160	Perennial
	Kimwarer	Keiyo Marakwet		Perennial
	Murunyi	West Pokot		Perennial
Lake Baringo	Olarabel	Baringo		Perennial
	Rongai	Nakuru		Perennial
	Endao	Baringo	469	Perennial
	Kongasis	Baringo		Perennial
	Olbanita	Nakuru	263	Perennial
Molo	Molo	Nakuru		Perennial
	BeregeiAnob Kimotoi	Baringo	323	Perennial
	Chemususu	Baringo	594	Perennial
	Eldama Ravine Lelgel	Baringo		Perennial
	Waseges	Baringo		Perennial
	Loboi	Baringo	263	
	Mbara Kaptich	Baringo		
	Narosura	Baringo		
	Olarabel	Baringo, Laikipia	510	
	Perkera	Baringo	293	
	Rongai	Baringo	1162	
	Turukwei	Baringo	106	
Lake Nakuru	Njoro	Nakuru	438	Perennial
	Ngosur	Nakuru		Perennial
	Nderit	Nakuru		Perennial
	Makalia	Nakuru		Perennial
Lake Elementatita	Mbaruk	Nakuru		Perennial
	Mereroni	Nakuru		Perennial
	Kariandusi	Nakuru	272	Perennial
Lake Naivasha	Gilgil	Nakuru	171+	Perennial
	Malewa	Nakuru	179+	Perennial
	Mkungi Kitiri	Nakuru		Perennial
	River Makalia	Nakuru		Perennial
	Upper Tarasha Kinja	Nakuru	291	Perennial
	Wanjohi	Nakuru	182	Perennial
	Karate Longonot	Nakuru		Perennial
	Marmanet River Basin	Nakuru	472	Perennial
Lake Solai	Maji Matamu			Perennial
Ewaso Nyiro South	Ewaso Nyiro South		2024	Perennial
	Enoosopukia	Narok		Perennial
	Naroosura	Narok	667	Perennial
	Enkare Narok	Narok	963	Perennial
	Kijabe Ewaso Kedong	Nakuru, Kajiado, Narok	2883	Perennial
	Siyabei	Narok		Perennial
	Enosagami	Narok		Perennial

Plate 6: River Turkwel flowing up to Lake Turkana [photo courtesy of WRA, 2016]

Rivers of Athi Basin

TThe basin is drained mainly by Athi-Galana-Sabaki River and other semi-permanent rivers. These rivers drain into the Indian Ocean. The River Umba is trans-boundary emanating from Usambara Mountains in Tanzania Table 10 Figure 11.

Table 10: *Rivers of Athi Basin*

Rivers	County	Perennial/Seasonal
Athi-Galana-Sabaki	Machakos	Perennial
Mwache	Kwale	Perennial
Kombeni	Kilifi	Perennial
Tsalu		
Nzovuni		
Mwachema	Kwale	Perennial
Voi	Taita Taveta	Perennial
Ramisi	Kwale	Perennial
Umba	Makueni	Perennial
Mkurumuji		
Kidogoweni		Perennial
Kathita	Meru	Perennial
Mutonga	Tharaka-Niithi	Perennial
Kiama		Perennial
Ragati	Nyeri	Perennial
Kururu		Perennial
Muhuhi	Nyeri	Perennial

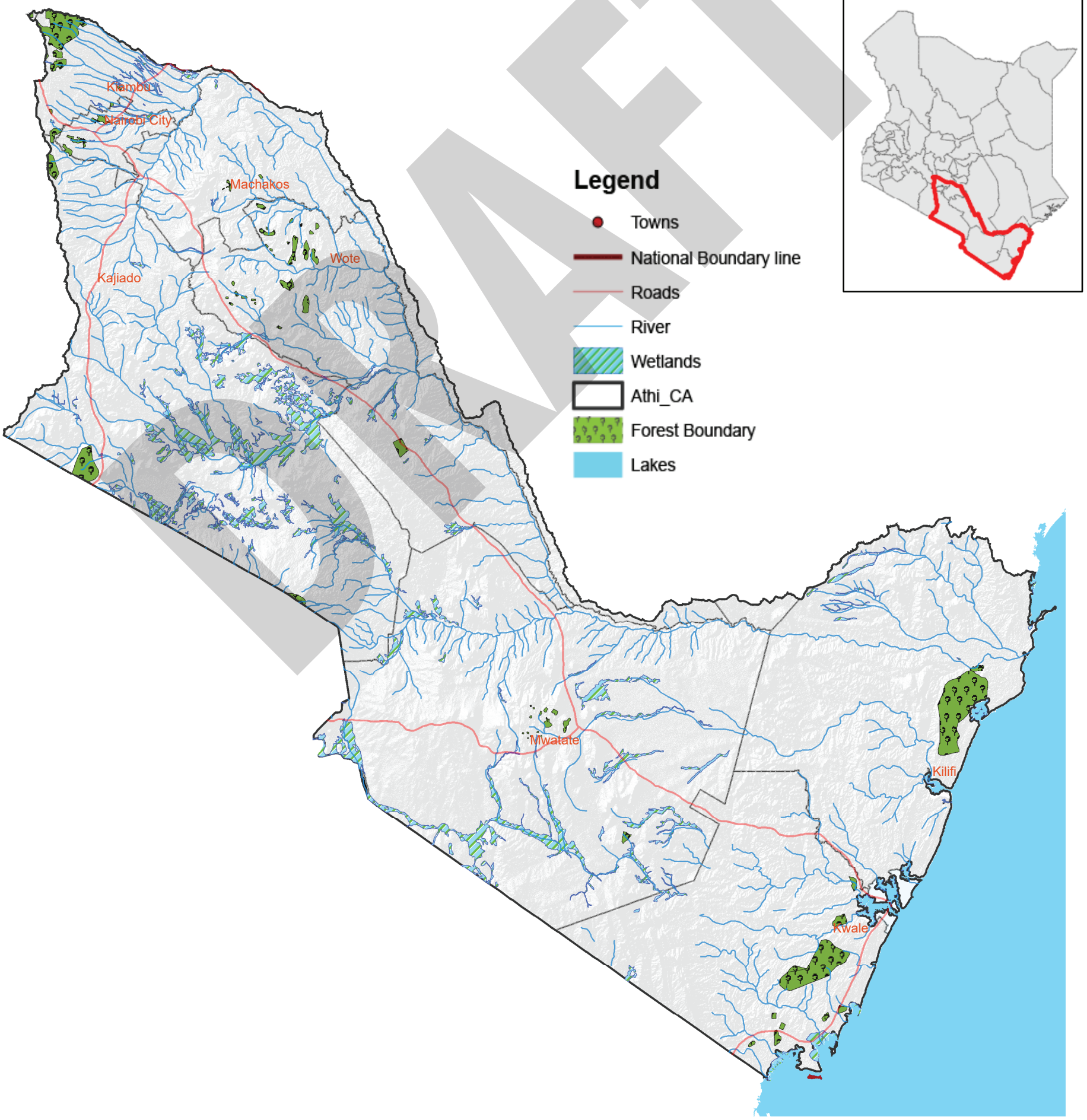


Figure 11: River of Athi basin

Rivers of Tana Basin

The Tana River is the main river in the basin originating on the slopes of aberdare ranges and Mount Kenya. Smaller rivers in the north-eastern part of the basin drain to Somalia and the Indian Ocean forming the Tana Delta. Table 11, Figure 12.

Table 11: *Rivers of Tana Basin*

Rivers	County		
Tana	Nyndarua, Nyeri, Tana River, Garisa	127,000	Perennial
Chania	Kiambu		Perennial
Thiba	Kirinyaga		Perennial
Maragwa	Murang'a		Perennial
Thika	Kiambu		Perennial
Nihunguthu,	Muranya		Perennial
Maua,	Meru		Perennial
Komoli,	Tana River		Perennial
Galole	Tana River		Perennial
Kokani	Tana River		Perennial

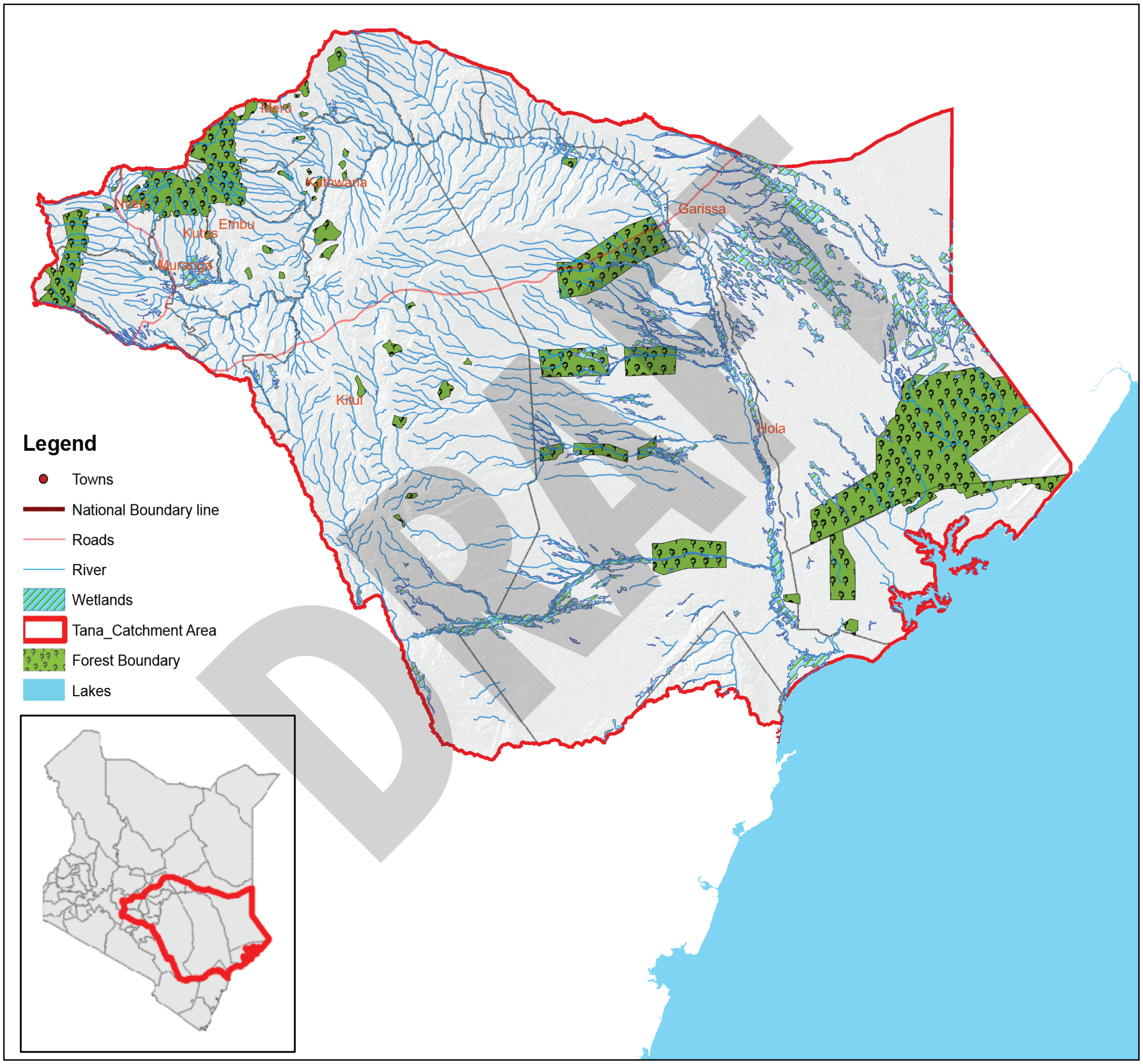


Figure 12: Rivers of Tana basin

Rivers of Ewaso Nyiro North Basin

The basin has several rivers the main one being Ewaso Nyiro North river. Its source waters in Mount Kenya, it flows for 435 miles eastewards underground before entering the Lorian Swamp and eventually joins the Jubba River in Somalia. The Daua River drains the north-eastern tip of the basin, and originates in the Ethiopian highlands Table 12 and Figure 13.

Table 12: *Table xxx Rivers of Ewaso Nyiro North Basin*

Main Rivers	Rivers	County	Catchment Area (Km2)	Perennial/ Seasonal
Ewaso Nyiro North	Ewaso Nyiro North	Nyandarua, Nyeri, Meru, Laikipia, Isiolo, Garisa, Wajir	15,200	Perennial
	Naro Moru	Nyeri,	83	Perennial
	Burguret	Laikipia, Meru and Nyeri	209	Perennial
	Nanyuki	Laikipia		
	Likii	Laikipia and Meru		
	Thegu	Laikipia and Meru		
	Sirimon	Nyeri, Laikipia		
	Timau	Meru, Laikipia		
	Ontulili	Meru, Laikipia		
Daua River	Daua	Mandera		Perennial
	Bor	Garisa		Seasonal
	Katula	Garisa		
	Sartumal	Garisa		Seasonal
	Dima	Garisa		Seasonal

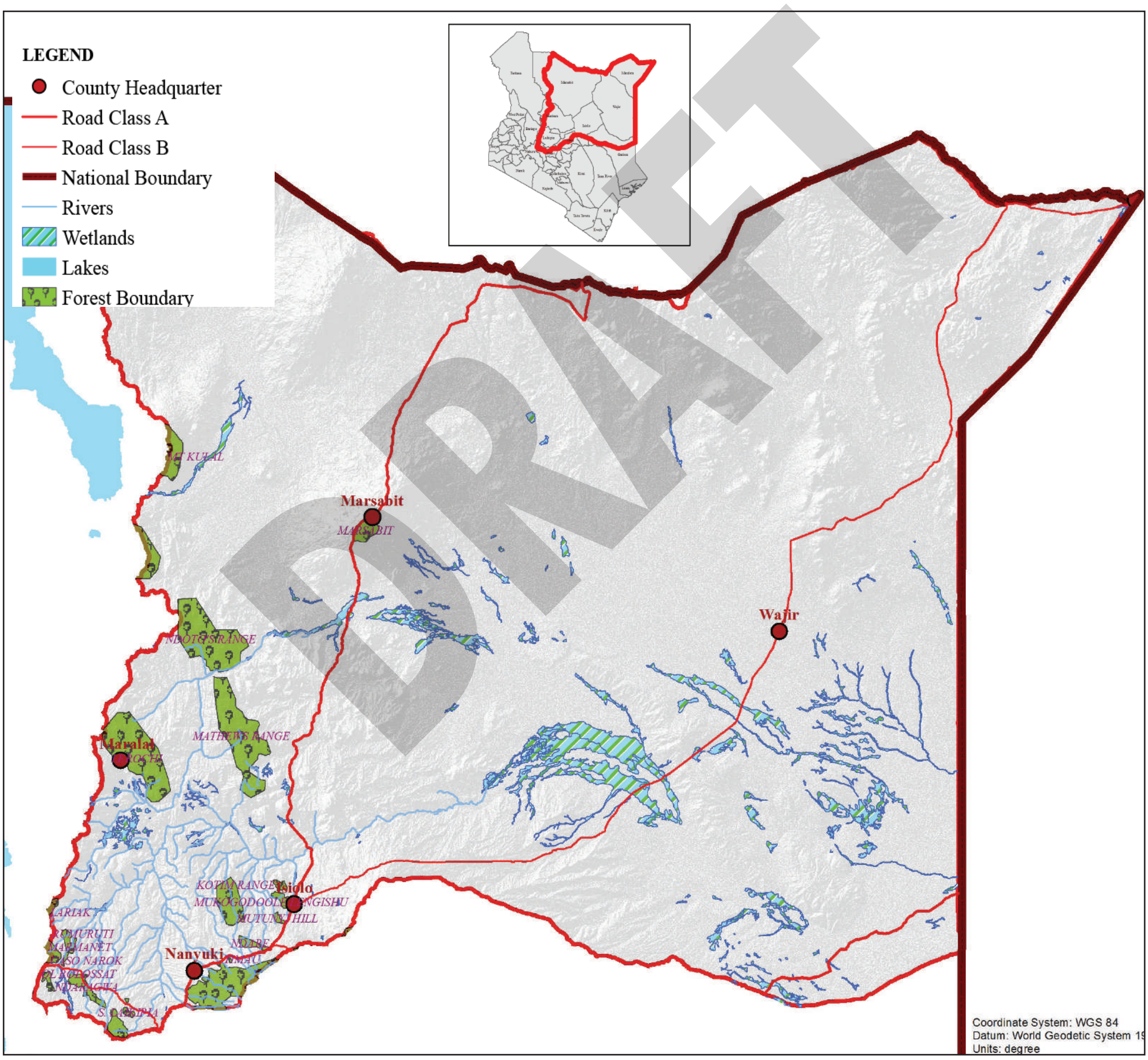


Figure 13: Rivers of Ewaso Nyiro north basin

Ground Water Resources

The Kenya's total renewable ground water resources are estimated at 55,973 MCM/year, (NWMP, 2013, MoENR, 2015). However, ground water resources are projected to decline over the 2010-2050 year trajectory decreasing to 55,580 MCM/year by 2030 while marginally increasing to 56,874 MCM/year by 2050 (NWMP, 2013). Although, it appears more compared with 20,637MCM/year renewable surface water resources the ground water available for use is 10% of ground water recharge estimated at 1,927 MCM/year in 2010, while the future ground water resources projections estimates for 2030 and 2050 at 1740 MCM/year and 1728 MCM/year respectively (NWMP, 2013).

a. Classification of Kenya's ground water aquifers

There are six major rock systems; igneous volcanic rocks; Precambrian Achaean, Precambrian protenzoil, sedimentary palaeazoic-mesozaic, and sedimentary tertiary- quaternary largely unconsolidated.

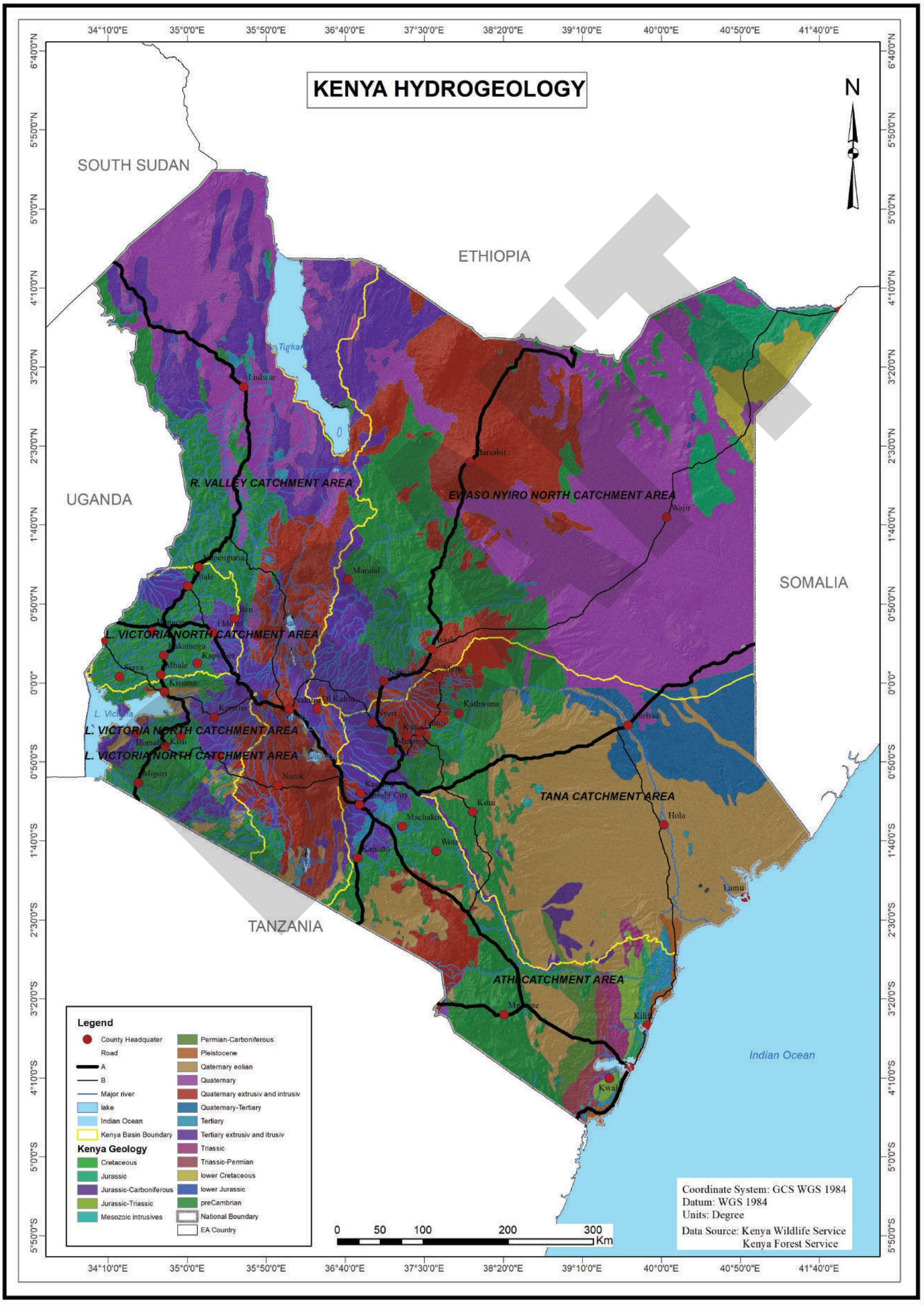


Figure 14: Kenya hydrogeology map

Table 13: *Description of sedimentary Aquifers in Kenya*

Name of Aquifer	Description
Lotikipi and Lodwar aquifers	Alluvials and sand sediments, ranging up to 80m deep. They can have high groundwater potential where dominated by coarse grained sediments (sand and gravel), but elsewhere, groundwater potential is typically limited.
Tiwi Aquifer	
	Small outcrop, but strategically important in the Kwale area. Also called Kilindini sands. The lithology is alluvial and lacustrine sand and clay and is typically not more than 70 m deep. High borehole yields can be obtained, and boreholes are typically 40–80 m deep. Transmissivity values range from 120 to 600 m^2/d, and storage coefficients from 9.3 x 10^{-3} to 8.0 x 10^{-2}.
Gongoni/ Msambweni Aquifer	The Gongoni/Msambweni Aquifer occurs in the Kwale area. High yields can be obtained. Boreholes are typically 40–100 m deep.
Baricho Aquifer	The Baricho aquifer is small but strategic in the coastal zone and comprises approximately 20 m of alluvial sand and gravel overlying around 40m of Jurassic Mazeras Sands to n and Kambe Limestone. Boreholes are typically drilled to25–60m depth. transmissivities of 3,750 to 25,000m2/d for a saturated thickness of 50m
Merti Aquifer	The Merti Aquifer occurs in Wajir County and comprises semi-consolidated clays, sands, sandstones and limestones. Groundwater is usually confined and water levels lie at 90 to120m below ground level. Found at fairly uniform depths of between110 and180m below ground level. The aquifer is thought to be between 80 and 280m thick. Successful boreholes are commonly between 105m to150m bgl (GIBB Africa Ltd 2004).Transmissivity ranges from 0.2 to 840m^2/d depending on the facies, with higher transmissivities in coarse grained materials. Specific yield ranges from 0.15 to 0.285 (Mumma et al. 2011).
Nairobi Aquifer	It comprises Plio-leistocene volcanic interbedded with old land surface and inter volcanic sediments, and underlies much of the Nairobi metropolitan area. It is a complex multi-layered aquifer system, recharged along the eastern edge of the Rift Valley with groundwater moving toward the east. The main aquifer layer, the Upper Athi series, is confined and typically found at depths of 120 to 300 mbgl. Transmissivity values range from 0.1 to 160m^2/d.
Kabatini Aquifer	The Kabatini aquifer occurs within the volcanic rocks of the Nakuru area. Boreholes are typically drilled to about150m depth.
Turkana Aquifer	
	Turkana Aquifer in the Rift System, as marked by major boundary faults, is characterized by well-defined aquifer systems whose location corresponds to the location of the Rift Lakes, that is, the Turkana aquifer. The aquifer roughly has a rectangular shape and occupies both the western and eastern part of the Rift Lakes.
Baringo-Bogoria Aquifer	The Baringo–Bogoria aquifer stretches from the area south of Lake Logipi and terminates weakly at the area south of Lake Bogoria. The Baringo–Bogoria aquifer has very high groundwater potential zones.

Water Resources Authority (WRA), however, classifies the aquifers based five classes relative to their yields and national importance; Strategic, Major, minor, poor and special aquifers. Table 14 presents the descriptions of the WRA classification of aquifers and examples in each class.

Table 14: *Water Resources Authority classification of Kenya's Aquifers*

Class	Description	Examples
Strategic aquifer	Aquifer used to supply significant amounts or proportions of water in a given area and for which there are no available alternative resources, or where such resources would take time and money to develop; significant transboundary aquifers.	Tiwi, Nairobi, central, Merti, Sabaki, Nakuru, Kabatini, Lake Naivasha, Lamu Island
Major aquifer	High-yield aquifer systems with good quality water	Daua in northern Kenya and Elgon volcanic in lake Victoria North
Minor aquifer	Moderate-yield aquifer systems with variable water quality.	Mandera Jurassics
Poor aquifer	Low- to negligible-yield aquifer systems with moderate to poor water quality.	Basement System such as the one where?
Special aquifer	Aquifer systems designated as such by WRA	Isinya (Kajiado)

b. Availability of ground water

The sustainable safe yield of ground water estimated at 1,927 by 2010 MCM/ year is distributed by the six basins as shown in Figure 15.

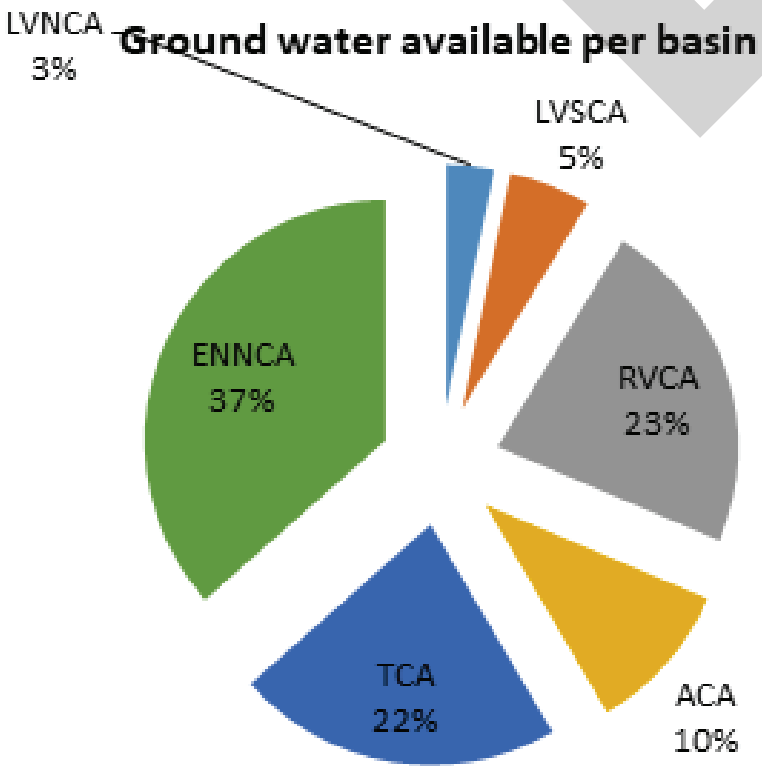


Figure 15: Ground water available per basin

Plate 7: Water from borehole

i. Lake Victoria North

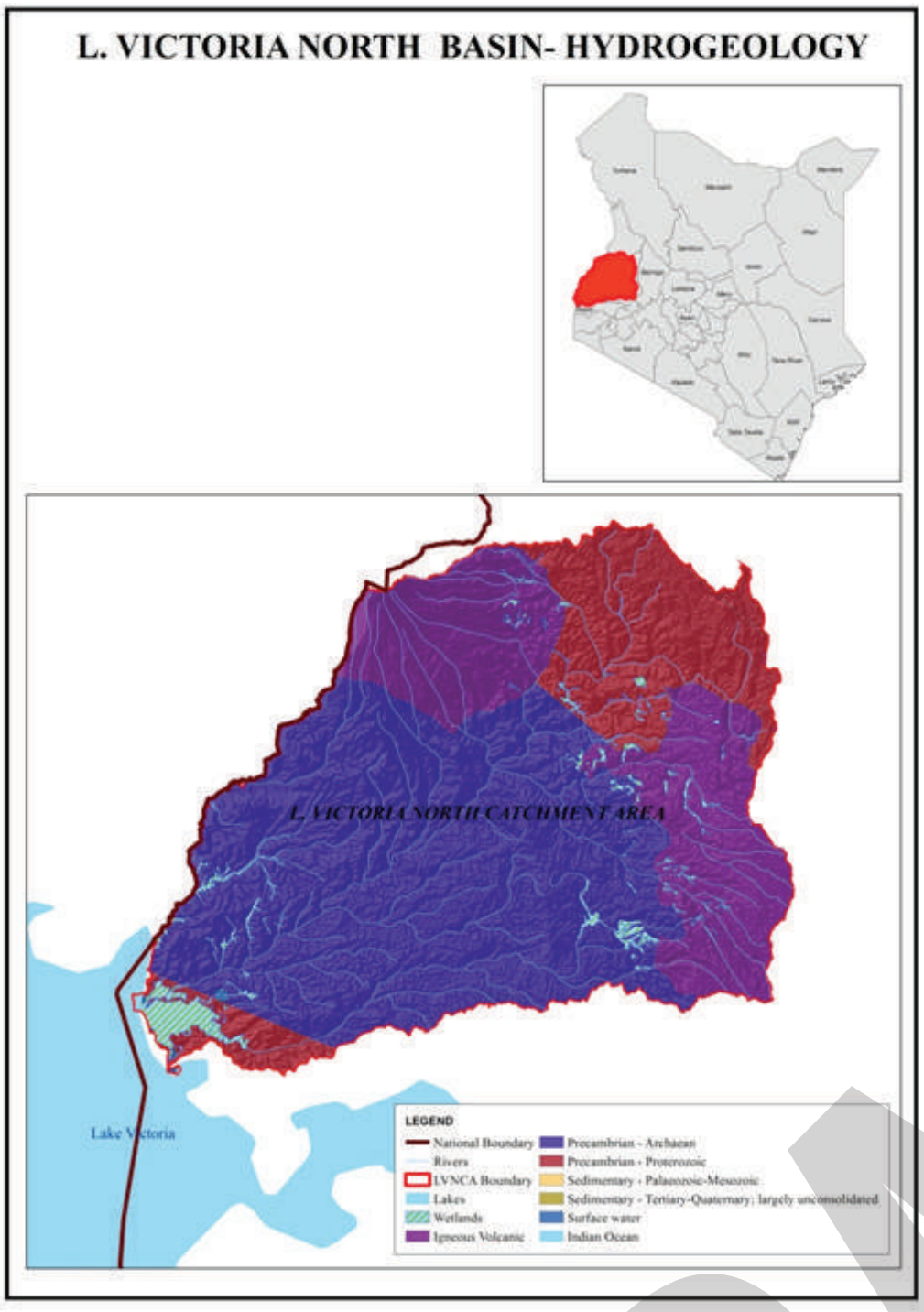


Figure 17: Ground water distribution areas for Lake Victoria North catchment Area

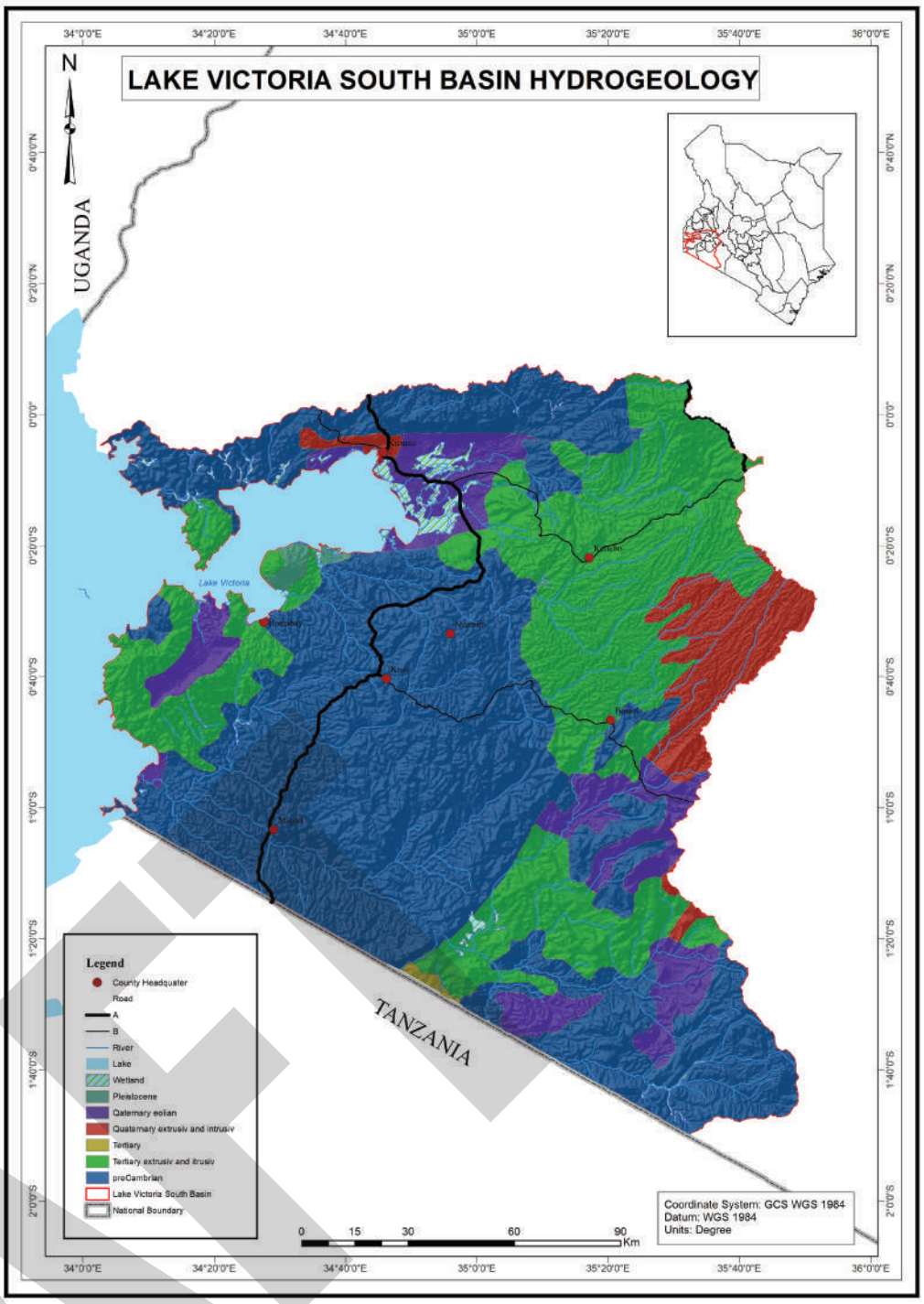


Figure 16: Ground water distribution areas for Lake Victoria South Basin

ii. Lake Victoria South Basin

Lake Victoria South groundwater distribution is presented in Figure 7.5. It provides an estimated 203 MCM/year (NWMP, 2013)

iii. Rift Valley Basin

The Rift Valley basin is characterized by several aquifers namely; Kerio Valley aquifer, Turkana Aquifer, Turkwel aquifer and Uasin Gishu Phonolite aquifer. The yield is estimated at 102 MCM/year (NWMP, 2013). The ground water distribution for Rift Valley basin is presented in Figure 18.

iv. Athi Basin

Athi Basin aquifer is diverse (WRA 2018). Comprisng three aquifer zones; the alluvial deposit aquifer, the Nairobi Aquifers and sansezone aquifer. Although, the actual contribution of 230 MCM/year abstraction volumes from 5,351 boreholesindicates a far less abstracted voulumes againts the estimated safe yield of 305 MCM/Year (NWMP,2013), Figure 19.

v. Ewaso Nyiro Basin

Ewaso Nyiro Basin travesed with several aquifers; Ashabito, Basement system, Mandera, Chalbi/Hedad basin aquifer, logologo aquifer, Wajir and Olobolosat plain aquifer presented in Figure 20. The basin is estimated to contribute 526 MCM/year of ground water

vi. The Tana Basin Aquifer

The TANA basin aquifer has three zones ranges from 1,300 amsl to 500amsl; The upper TANA comprised of the volcanic eastern slopes of Mt Kenya, Aberdares and Nyambane Hills is located 1,300m amsl, the middle Tana; Tharaka, Mithui, Mwingi and parts of Machakos (800-1,300m amsl) and Lower TANA area which is 500 amsl including coastal zone with complex and semi refined aquifer systems. The Aquifer contributes approximately 35% (675 MCM/year) of the national sustainable ground water resources (NWMP, 2013) of Ground water resources in Kenya Figure 21.

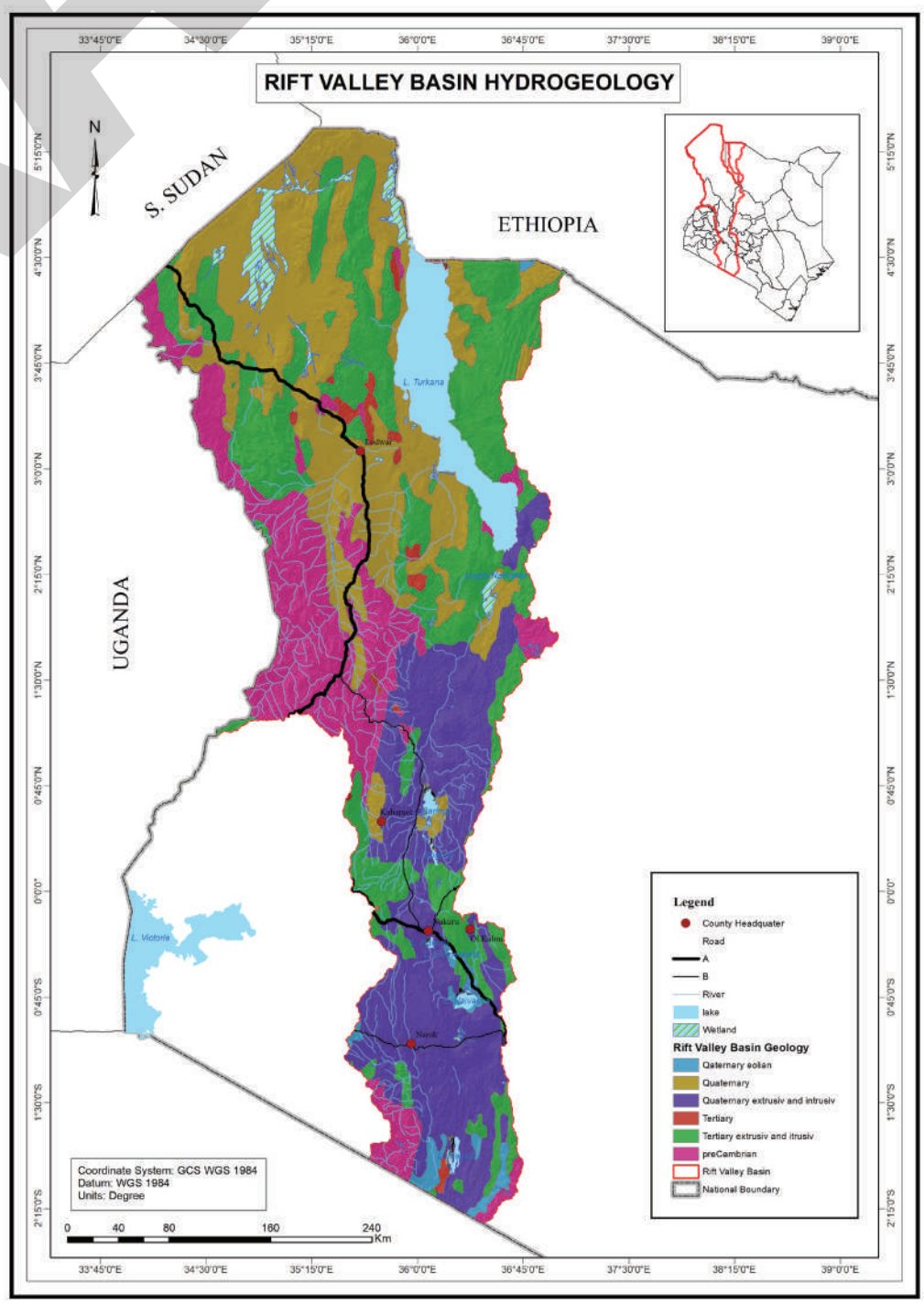


Figure 18: Ground water distribution areas for Rift Valley Basin

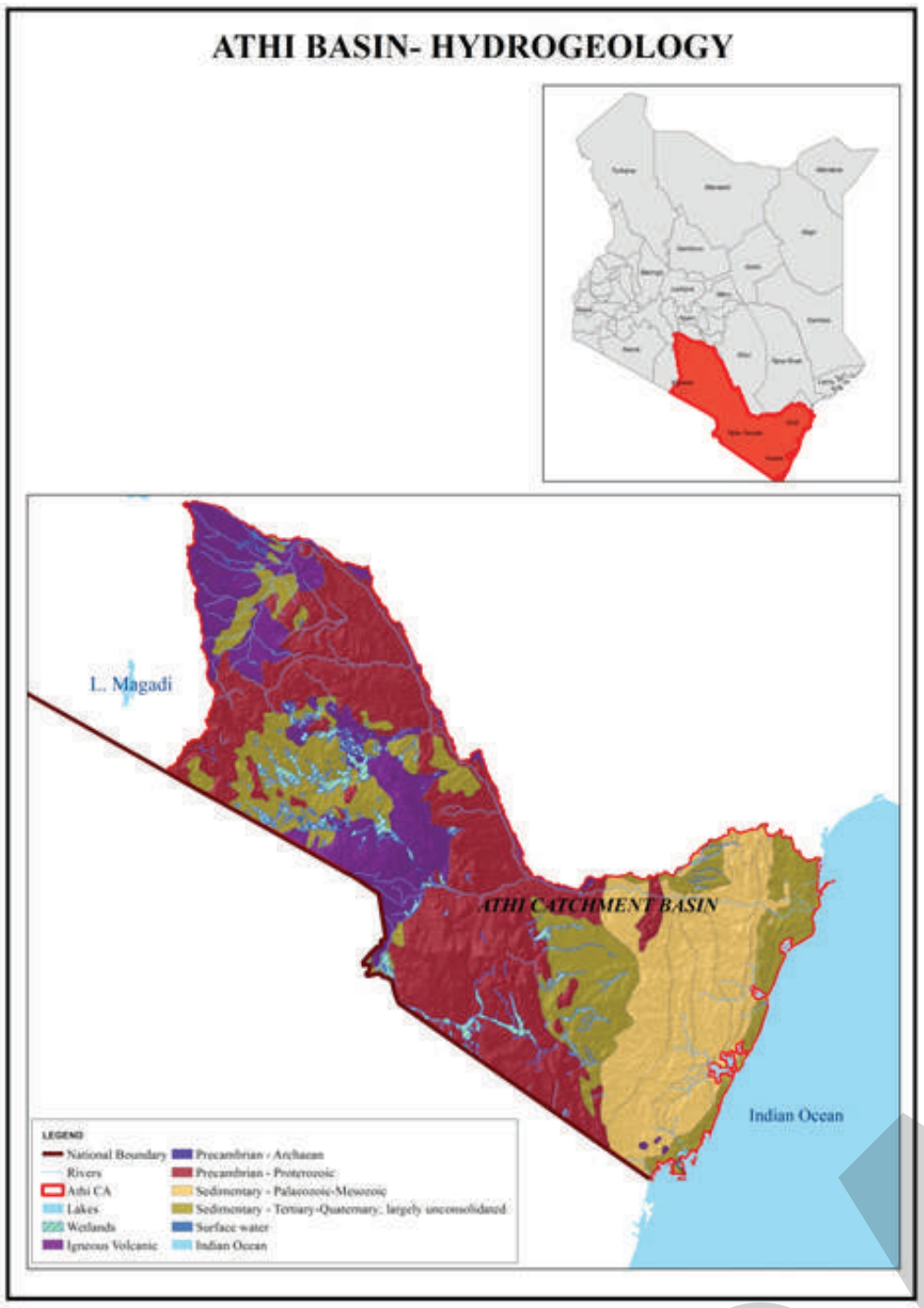


Figure 19: Ground water distribution areas for Athi River basin

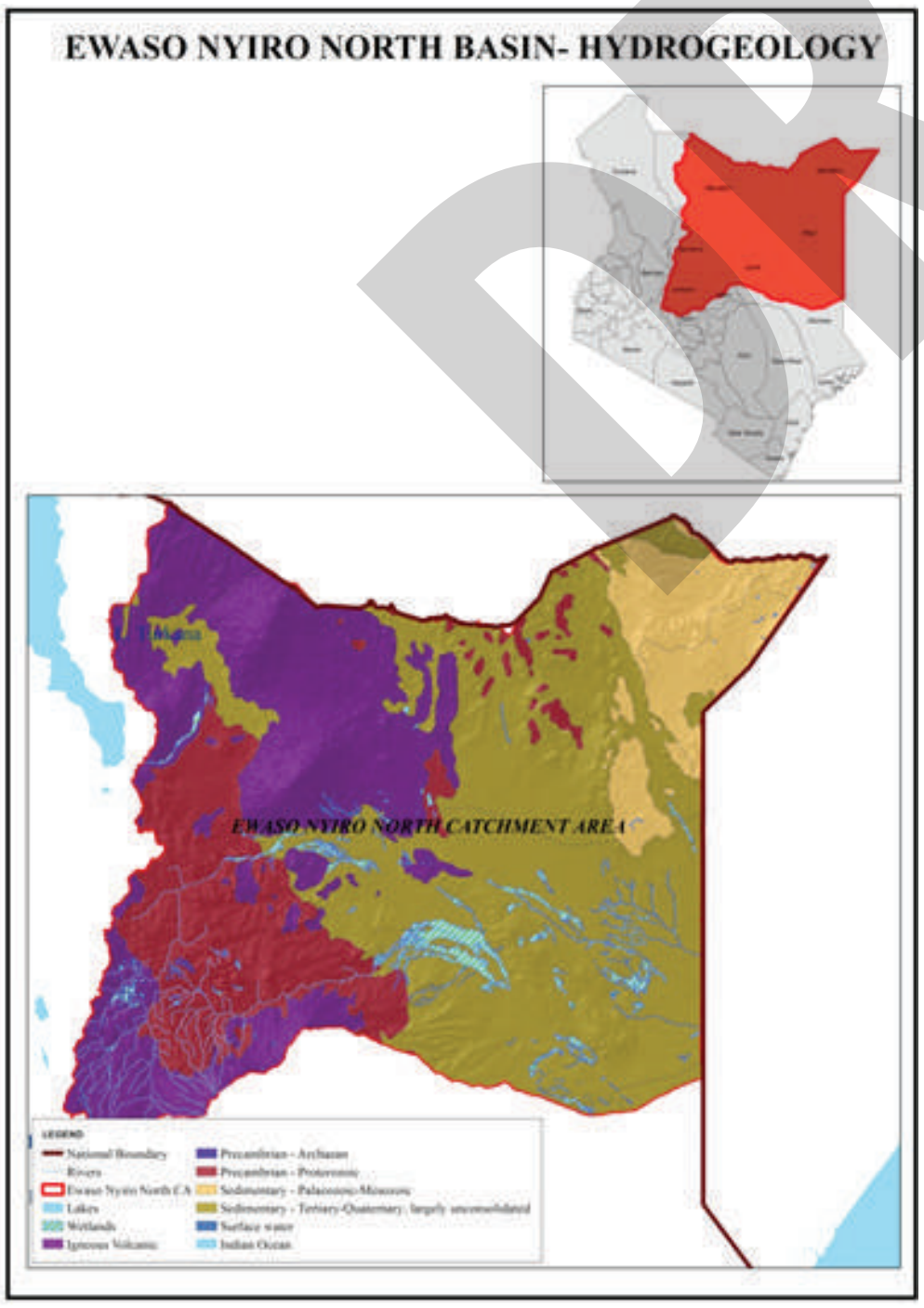


Figure 20: Ground water distribution areas for Ewaso Nyiro North Basin

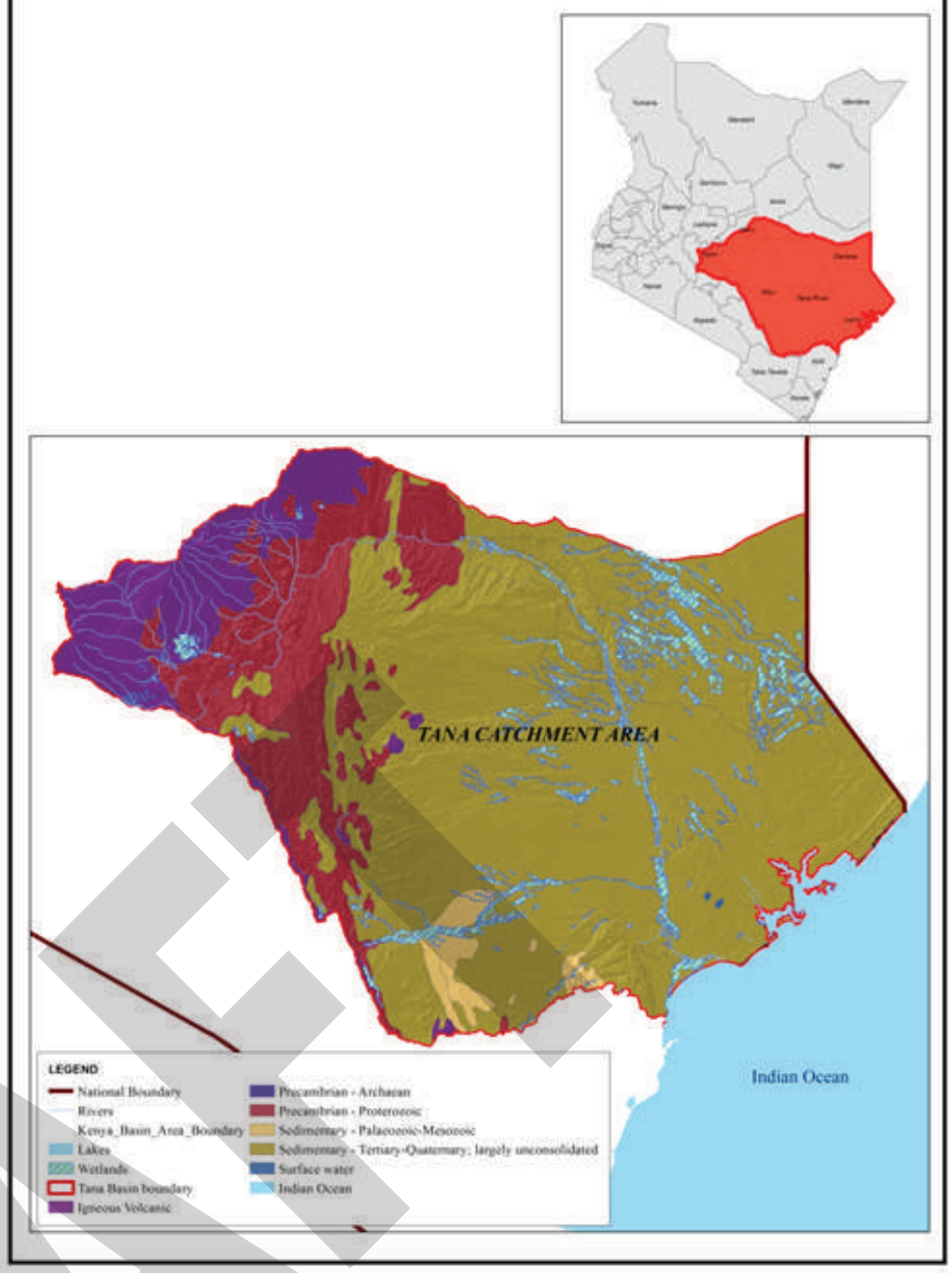


Figure 21: Ground water distribution areas for Tana North Basin

d. Transboundary aquifers

A total of 476,464 Km^2 of transboundary aquifers is shared with neighbouring countries ((IWMI, 2014). Table 15 provides a summary of the transboundary aquifers.

Table 15: *Transboundary aquifers*

Aquifer	Shared Country	Area (Km^2)
Merti Aquifer	Kenya, Somalia	13,623
Coastal / Karoo sedimentary aquifer	Kenya, Tanzania	17,067
Sudd Basin	Kenya, Ethiopia and South Sudan	370,648
Dauwa	Kenya, Ethiopia and Somalia	34,007
Kilimanjaro Aquifer	Kenya, Tanzania	14,576
Mount Elgon Aquifer	Kenya, Uganda	5,398
Rift Aquifer	Kenya, Tanzania	21,145
Precambrian basement aquifer	Kenya, Ethiopia	

e. Groundwater Quality

The groundwater acquifers are intimately linked with surface water resources such as rivers. Ground water quality is influenced by recharge from fresh water rivers. For example, the Lodwar Aquifer is recharged by the River Turkwel; the Merti Aquifer recharged by the River Ewaso; the Gongoni Aquifer recharged by the Mkurumudzi River and the Baricho Aquifer recharged by the River Galana.

Ground water quality is highly compromised by geology, there is high fluoride in the rift systems (Olago et al. 2009, Olaka et al. 2016), and Nairobi aquifer. Further, saline water intrusion at the coast within the Momabsa island Pleistocene sands and limestones and mumias granites and the Lotikipi aquifer in Turkana are affected by salinization.

Water demand

The total water demand in 2018 was estimated at xxxx compared with available water of MCM/a. Table 16.

Table 16: *Water demands in 2018*

Catchment Area	Area (Km²)	2010	2018	2030	2050
LVNBA	18,374	228	286	1,337	1,573
LVSBA	31,734	385	633	2,953	3,251
RVBA	130,452	357	481	1,494	1,689
ABA	58,639	1,145		4,586	5,202
TBA	126,026	891	1867	8,241	8,476
ENNCA	210,226	212	273	2,857	2,950
Total	575,451	3218		21,468	23,141

Source: NWMP, 2013 and Basi Plans 2020

Wetland Resources

Kenya is endowed with a variety of wetland types that range from riverine; lacustrine; palustrine; estuarine; marine; to human-made. About 3-4% (14,000 km²) is wetlands out of Kenya's total land mass of 583,000 km² (Ramsar Convention Secretariat 2006). In Kenya, wetland is defined as an area of land saturated with water either permanently or seasonally, where plants and animals have become adapted and include deltas, estuaries, mangroves and mudflats, swamps, marshes, flood plains, shallow lakes, rivers and the edges of deep lakes and rivers. According to the Environmental Management and Coordination Act (Wetlands, Riverbanks, Lakeshores and Seashores Management) Regulations 2009, wetlands are: 'areas permanently or seasonally flooded by water where plants and animals have become adapted; and include swamps, areas of marsh, peat land, mountain bogs, banks. A wetland is an area of land that is saturated with water either permanently or seasonally. Wetlands can be freshwater, brackish (partly salty), or saline (very salty).

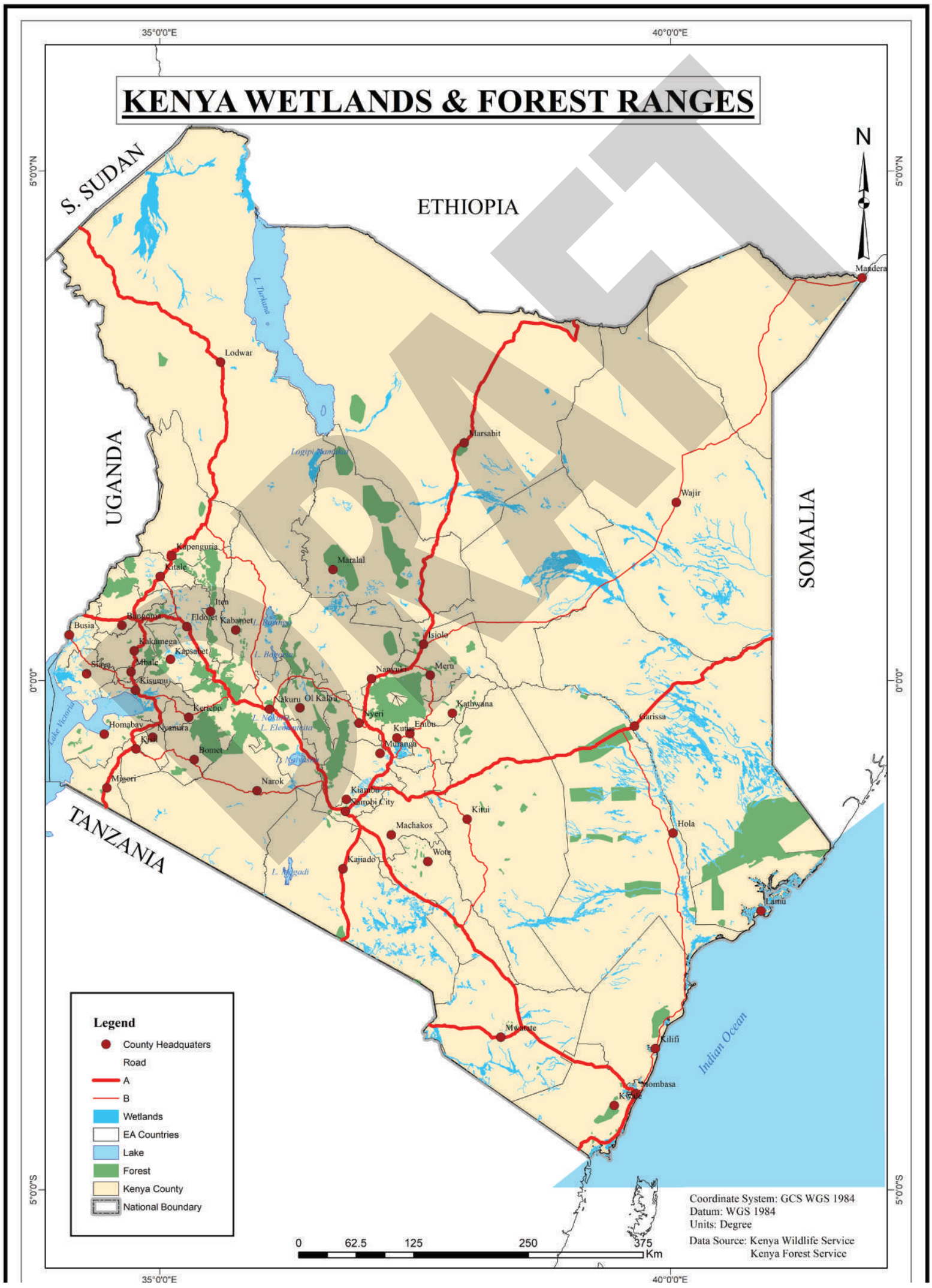


Figure 22: Map of wetlands and forest ranges of Kenya

Legislation framework

The international convention and in particular, the Ramsar Convention has been in force in Kenya since 1990. The constitution of Kenya 2010 and the Environmental Management and Coordination Act and related by-laws provide adequate legislative frameworks and the national wetland policy although a sector-specific wetlands law poses a challenge in general. The wetland ecosystem integrates terrestrial and aquatic environments including water, soil and vegetation (Lathrop, 2011). Hence, they provide a number of critical ecosystem services that are indispensable to human beings and biodiversity's very survival, health and welfare, These are provisioning, supporting, regulating, and cultural services (Millennium Ecosystem Assessment 2005), along with the wetlands' ecological and national development roles for instance SDGs and the Vision 2030 goals.

Categories of Wetlands

Wetlands are classified into three broad categories: inland; marine and coastal; and human-made (Ramsar, 2012). The inland and marine and coastal wetlands are described in the Kenya wetland Atlas (year).

Human-made wetlands include the disparate artificial structures such as water impoundment for irrigation such as Mwea, Ahero and Bunyala irrigation schemes or hydroelectric power generation with major dams besides salt pans, sewage farms as well as fish and shrimp ponds (Kenyan Atlas 2012).

Types of Wetlands

There are six wetlands types in Kenya that are dependent on diverse climate and topography, (Kenya Wetland Atlas, 2012). These are;: riverine; lacustrine; palustrine; estuarine; marine; and constructed wetlands. The riverine wetlands occur along rivers and streams and are common along the country's main watercourses. Lacustrine wetlands occur in and around lakes and are predominantly influenced by these water bodies, whether these are fresh or saline (source). Palustrine wetlands are stagnant water and non tidal including marshes, swamps, bogs and floodplains. Estuarine wetlands occur where fresh and salty water mix and include deltas, tidal marshes, and mangrove swamps. Marine wetlands are those that are exposed to the waves and currents of the open ocean and as such display a high level of salinity that typically exceeds 3 per cent (USGS n.d.).

Kenya's marine wetlands consist of lagoons, shingle beaches, mangroves, rocky shorelines, salt marshes, mudflats, sea beds and coral reefs (Nyamweru 1992; Kenya Wetlands Forum 2011) with each of these exhibiting unique hydrological and topographical attributes. For example, while the country's sea grass beds predominantly occur in shallow reef slopes and sandy beaches are associated with coastal areas that are dominated by terrigenous sediment but without fringing reefs (Mocha 2011), coral reefs occur farther seaward, around the Marine Protected Areas (MPAs) such as the Mombasa Marine National Park and the Watumu Marine National Reserve.

Distribution of Wetlands

Lake Victoria North Basin

Three types of wetlands are recognized in the lake Victoria North Basin as natural wetlands: riverine, lacustrine and Palustrine including human made wetlands are evident in the agricultural, aquaculture and sewerage works. as presented in Table 17.
Some of these wetlands in Lake Victoria North Catchment Area includes; Kingwal, Sergoit, Saiwa, Yala, Nzoia, Sio-Siteko [Trans-boundary [Kenya and Uganda and Lake Kanyaboli].

However, Yala Swamp is the biggest. The Yala Swamp is located at the Yala River mouth and covers an area of 175 km2. Although the Yala Swamp is not a designated protected area, the ecosystem provides major ecological and hydrological functions and is a major source of livelihood for the surrounding communities. Table xxx shows the attributes of LVNCA wetlands.

Table 17: *Attributes of Lake Victoria North Catchment Area wetlands*

Formation	System	Sub System	Description/Names of Wetland	Catchment Area
Natural	Inland	Palustrine	Kingwal swamp	2.73 Km^2
			Marura/Sergoit swamp	
			Saiwa Swamp	2.9 Km^2
			Leseru swamp	
			Chepckwony Swamp	
		Riverine	Yala and its tributaries [Kajuok Swamp and Yala Swamp and its related swamps such as Gomro, Wathding, Daraja, and Aram	175Km^2
			Nzoia river and its tributaries [Chepkoilel, Soin, Kiptoror, Kaplogoi, Sosiot, Kaptule, Kapkis, Sergoit, Ziwa-Sirikwa, Maji Mazuri, Kipsaina, Saiwa, Kerita, Kholera, Saf, Anyiko, Ukwala, Budalangi, Bunyala Swamp]	
			Sio river and its tributaries [Sio-Siteko swamp [Trans-boundary [Kenya and Uganda], Namaloko, Kiwa, Kimwaga dam, and Namasanda dam	400ha
			Mokong, Kundos,	
			Singilai Swamp [Kasese river]	
			Ainopngetuny , Olare Onyonkie	
		Lacustrine	satellite lakes Namboyo, Sare and Kanyaboli	15Km^2
Human Made		Aquiculture	Fish ponds	
		Agriculture	Irrigated rice fields –	
		Urban and Industrial	Sewerage and treatment works	
			Reservoirs	

Specific Wetlands

Sio Siteko Wetland

The figure below presents Sio-Siteko wetland in Lake Victorian north basin. It's a transboundary wetland shared between Kenya and Uganda and provides valuable ecosystem services.

Plate 8: Sio Siteko wetland Source: Wetland without border team, 2019

Ewaso Nyiro North Basin

Ewaso Nyiro North Catchment Area has several natural and human made formations ranging from the lacustrine and Palustrine inland wetlands systems. Lake Ol-bolosab is a high altitude lake in Nyandarua County, and is home to a variety of birdlife, aquatic animals and wildlife. The lake is the source of the Ewaso Narok River which supplies water to Nyahururu and recharges the Ol-bolosat aquifer. Other wetlands in the catchment include Ewaso-Narok and Suguta Marmar swamps. Table 18 shows the attributes of ENNCA wetlands.

The Lorian Swamp is a large wetland that is home to many large mammals and other wildlife. This wetland area is an important source for groundwater recharge of the Merti aquifer

Table 18: *Attributes of Ewaso Nyiro North Catchment Area wetlands*

Basin	Formation	System	Sub-System	Description/Names of Wetland	Catchment Area
Ewaso Nyiro North	Natural	Inland	Lacustrine	Lake Ol-bolosat	43km^2
			Palustrine	Permanent Swamps [The Lorian Swamp]	231,000 ha
				[Ewaso-Narok and Suguta Marmar swamps].	
	Human Made		Aquiculture	Fish ponds	
			Agriculture	Irrigated fields –	
			Urban and Industrial	Sewerage and treatment works	
				Reservoirs	

Tana Basin

The Tana Delta is the largest wetland area in the catchment. The 163,600-hectare Tana Delta becomes East Africa's second most important river mouth wetland after the Rufiji Delta in neighboring Tanzania. The delta supports a variety of ecosystems. This area provides a habitat for many endangered and protected plant and animal species, and is also a source of livelihood for surrounding communities. Table 19shows the attributes of TANA wetlands.

Table 19: *Attributes of TANA wetlands*

Basin	Formation	System	Sub System	Description/Names of Wetland	Catchment Area
TANA	Natural	Marine and Coastal	Estuarine	Estuarine waters-Tana river Delta	163,600 Ha
				Mangrove/tidal forests-	
			Lacustrine	Lake Alice, Michaelson on Mt Kenya	
				Tyndall Tarn, Hut Tarn and Hanging	
			Marine	Coral reefs	
				Sand beaches	
				Lagoons, shingle beaches, mangroves, rocky shorelines,	
				Salt marshes, mudflats, sea beds	
	Human Made		Aquiculture	Fish ponds	
			Agriculture	Irrigated fields –	
			Urban and Industrial	Sewerage and treatment works	
				Reservoirs	

Lacustrine wetlands includes the mountain wetlands are presented in below

Plate 9: Lake Alice on Mount Kenya

Plate 10: Lake Paradise on mount Marsabit

Rift Valley Basin

There are seven major wetlands around lakes in the RVCA, namely Lakes Turkana, Baringo, Bogoria, Nakuru, Elementaita, Naivasha and Magadi. Table 7.10 shows the attributes of RVCA wetlands

Table 20: *Attributes of RVCA wetlands*

Basin	Formation	System	Sub-System	Description/Names of Wetland	Catchment Area
RVCA	Natural	Inland	Lacustrine	Lake Turkana,	6105km^2
				Baringo,	130km^2
				Bogoria,	42.5km^2
				Nakuru,	49km^2
				Elementaita,	18,km^2
				Naivasha	156km^2
				Magadi	105km^2
				Lake Kamnarok	1km^2
			Riverine	Turkwel	20,283
				Kerio	14,172
				Ewaso Nyiro South	8,534
			Palustrine	Shompole, Lotikipi Swamp	
			Geothermal	Geothermal Wetlands Olkaria geothermal	
	Human-Made		Aquiculture	Fish ponds	
			Agriculture	Irrigated fields –	
				Perkrra Irrigation scheme	890 ha
				Wei Wei	570 ha
				Turkwel	1080 ha
			Urban and Industrial	Sewerage and treatment works	
				Reservoirs	

Athi Basin

Athi catchment has an area of 58,639Km^2 making it the third largest catchment area according to WRA catchment areas. Table 21 shows the attributes of Athi catchment wetlands Lake Amboseli and its associated wetland areas (Enkongo Narok and Loginye swamps) are located near the base of Mt Kilimanjaro. The wetlands are seasonal and are an important source of water for the Amboseli National Park. There are two international lakes located partly in the ACA, namely Lake Jipe and Lake Chala. (Plates or satellite images). Lake Jipe is of global importance as it is the habitat of the only remaining Oreochromis jipe, and this fish species is on the verge of extinction.

Table 21: *attributes of Athi wetlands*

Basin	Formation	System	Sub system	Description/Names of Wetland	Catchment Area
ATHI	Natural	Marine and Coastal	Lacustrine/ Palustrine	Lake Amboseli and its associated wetland areas (Enkongo Narok and Loginye swamps)	
			Lacustrine	Lake Jipe	25km^2
				Lake Chala.	6km^2
			Riverine	Lumi	
	Human made		Aquiculture	Fish ponds	
			Agriculture	Irrigated fields –	
			Urban and Industrial	Sewerage and treatment works	
				Reservoirs	

Lake Victoria South Basin

Lake Victoria South catchment area covering approximately 31,734 Km^2 is associated with Lake Victoria. The main wetlands in the catchment are associated with the Migori, Nyando and Sondu Miriu Rivers. Most of these rivers originate from the Mau Forest Complex. Other smaller wetlands in the basin include Ombeyi, Sironga, Daraja Sita-Kapkatet, Riyabu in Kenyanya Division and Bendere area in Kenyanya. Table 22 shows the attributes of LVSCA wetlands.

Table 22: *attributes of LVSCA wetlands*

Basin	Formation	Sub system	Name of Wetland	Catchment Area
LVSCA	Natural	Riverine/ Palustrine	Nyando [Kepseon swamp, Ombeyi Swamp, Koyo Swamp, Okana wetland, Awach swamp and Oroba swamp, Nyando Delta Wetlands, Nyando (Kusa) Swamp, (Nyangande, Singida, Kabondo, Okonyo-Muofu and Wasare Nam)]	
			Sondu Miriu and its tributaries [Kapsoit, Kabianga, Kapkatet, Serwer, Kapgot, Motata, Chagware, Chemawoi, Bargiro, Kororet, Daraja Mbili, Chepkolon, Biribei, Kapsewa and Osodo]	
			On Gucha Migori and Its tributaries [Sironga, Etora, Marani, Nyabioto, Kemera, Rianyatundo, Riambase in the upper reaches; Ondago, Kimira, River Kuja Delta wetlands (Sere, Nyora, Kabuto, Anyugo, Modi, Nyamfua, Mariwa, Manywanda, Kabodho, Kudisa, Wang' Migori, Kombuor Oiro, Kudbo and Kagua), Nyamanga, Samanyalo, Kadhiambo]	
			Dunga Swamp	1.036 km^2
			On Mara River and its tributaries Napuyapui Swamp (source of Mara River), Ngusero Swamp, Kugini Swamp Olenyapi Swamp, Tinet Swamp, Sotiki Swamp, Nyanyawet Swamp and Mara River Swamp (Mosirori wetland)	9,574 km^2
		Lacustrine	Lake Victoria Shoreline [Kusa, Dunga, Nduru, Kibos and the many river mouth wetlands, Oluch-Kimira, Bunyala, Kuja, Osodo, Nyando Wetland, Ngegu (south Nyanza) and Mara Swamp (Mosirori wetland]	68,800km^2
			Lake Simbi Nyaima	
	Human Made	Aquiculture	Fish ponds	
		Agriculture	Irrigated fields – Kobura Irrigation scheme,	
			Ahero Rice irrigation scheme	
		Urban and Industrial	Sewerage and treatment works	
			Reservoirs	

The Nyando (Kusa) Swamp, located at the mouth of the Nyando River, is covered with dense papyrus beds and is home to many rare bird species. The Swamp provides filtration to sediments and pollutants which are carried down the rivers towards Lake Victoria, and the papyrus is the source of livelihood for the local communities.

Plate 11: Lake Simbi Nyaima (Source Daily Nation, June 14, 2019 courtesy of Barack Oduor, Nation Media group)

Threats and Challenges of Wetlands

Kenya's water and wetlands resources face myriad and complex threats in many fronts in view of the complex disparities in global economies coupled with rapidly growing population, climate variability, urban growth, landscape changes and destructive anthropogenic activities. These include Catchment degradation, pollution, inadequate monitoring networks, limited integrated basin planning and management, water availability and supply issues, inadequate institutional capacity, uneven spatial and temporal distribution of water resources, anthropogenic encroachment on environmentally sensitive areas, inadequate flood and drought management. In addition, water and wetland resource experience specific threats.

Rising water levels

Most lakes in Kenya's Rift Valley and Lake Victoria basins have risen since 2011 to levels not seen in the last 50 years as a result of the impact of climate change. These include Nakuru, Bogoria, Baringo, Naivasha and Turkana. Others that are not in the main Rift Valley include Lake Victoria and Simbi Nyaima in (Lake Victoria basin). Figure 23.

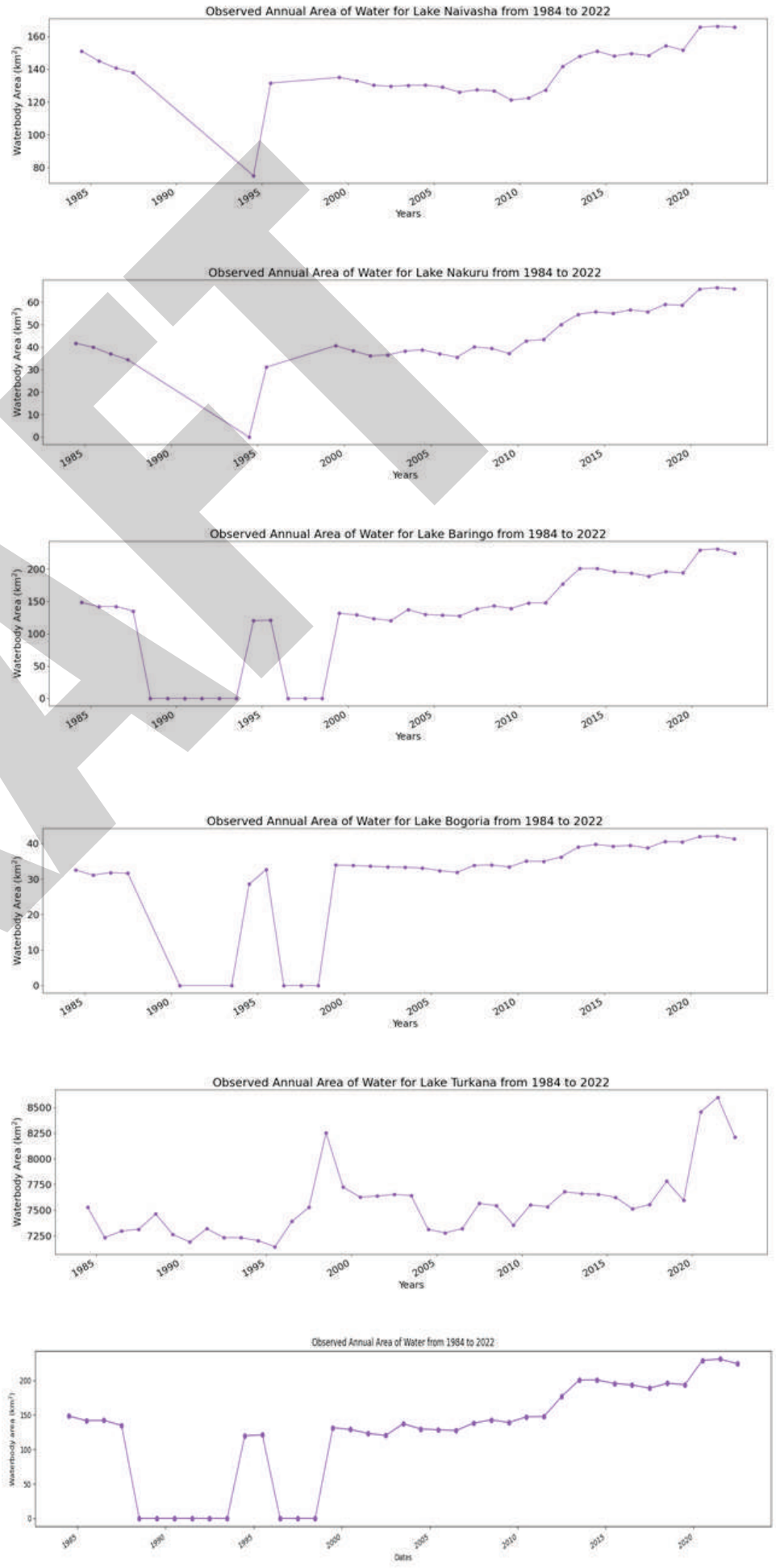


Figure 23: Rise of water levels in lakes

Plate 14: Lake Nakuru submerging the Nakuru national park main gate

Encroachment on water resources and wetlands

Plate 12: Encroached area

Plate 13: Encroached wetland

Pollution due to Surface water-groundwater interaction

Various contamination problems arise due to the hydraulic continuity between surface water and shallow groundwater systems in Kenya, for instance the poor sewerage and drainage systems are major contributors to groundwater contamination. This is an increasing problem in Nairobi and its environs; open cast mining of stones pose a threat to groundwater as a result of contaminated water infiltrating into the ground. For instance the Kiserian reservoir has suffered contamination problems due to inadequate sewage systems in nearby towns; this contaminated water may find its way into groundwater. Equally, groundwater may be becoming directly contaminated as a result of reliance on pit latrines and soakaway pits and river pollution by industrial wastes and sewage pose a great risk for groundwater protection.

CHAPTER

02

FISHERIES AND BLUE ECONOMY

Fisheries and Blue Economy

Introduction

The concept of the Blue Economy has been rising steadily in recent years. At the macro level, many nations have championed the development of the Blue Economy to protect aquatic resources at the same time as driving factor to various levels of socioeconomic development and countering the challenges of climate change. The potential linkages between the blue economy, sustainable development and economic growth is recognized in the 2030 Agenda for Sustainable Development, United Nations Sustainable Development Goals (SDGs), Agenda 2063 and EAC Vision 2050. The Kenya Vision 2030, a long-term development blueprint launched in 2008, aims to transform Kenya into a "newly-industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment". The Vision is being implemented through successive five-year medium-term plans. The Third Medium Term Plan (MTP III) 2018–2022 of the Vision 2030 as well as the United Nations Economic Commission for Africa (2016) refer to the Blue Economy as the sustainable use of aquatic and marine spaces including oceans, seas, coasts, lakes, rivers, and underground water. It encompasses a range of productive sectors, including fisheries, aquaculture, tourism, transport, shipbuilding, energy, bioprospecting and underwater mining and related activities (Kimani et al., 2018). Fisheries is increasingly being recognized among the most important renewable natural resources that contribute to the food and nutritional security as well as livelihoods of millions of Kenyans (Kimani et al., 2018). Harnessing the economic potential of Kenya's aquatic resources is among the key interventions towards combating rural poverty, enhancing food security, and strengthening the national economy.

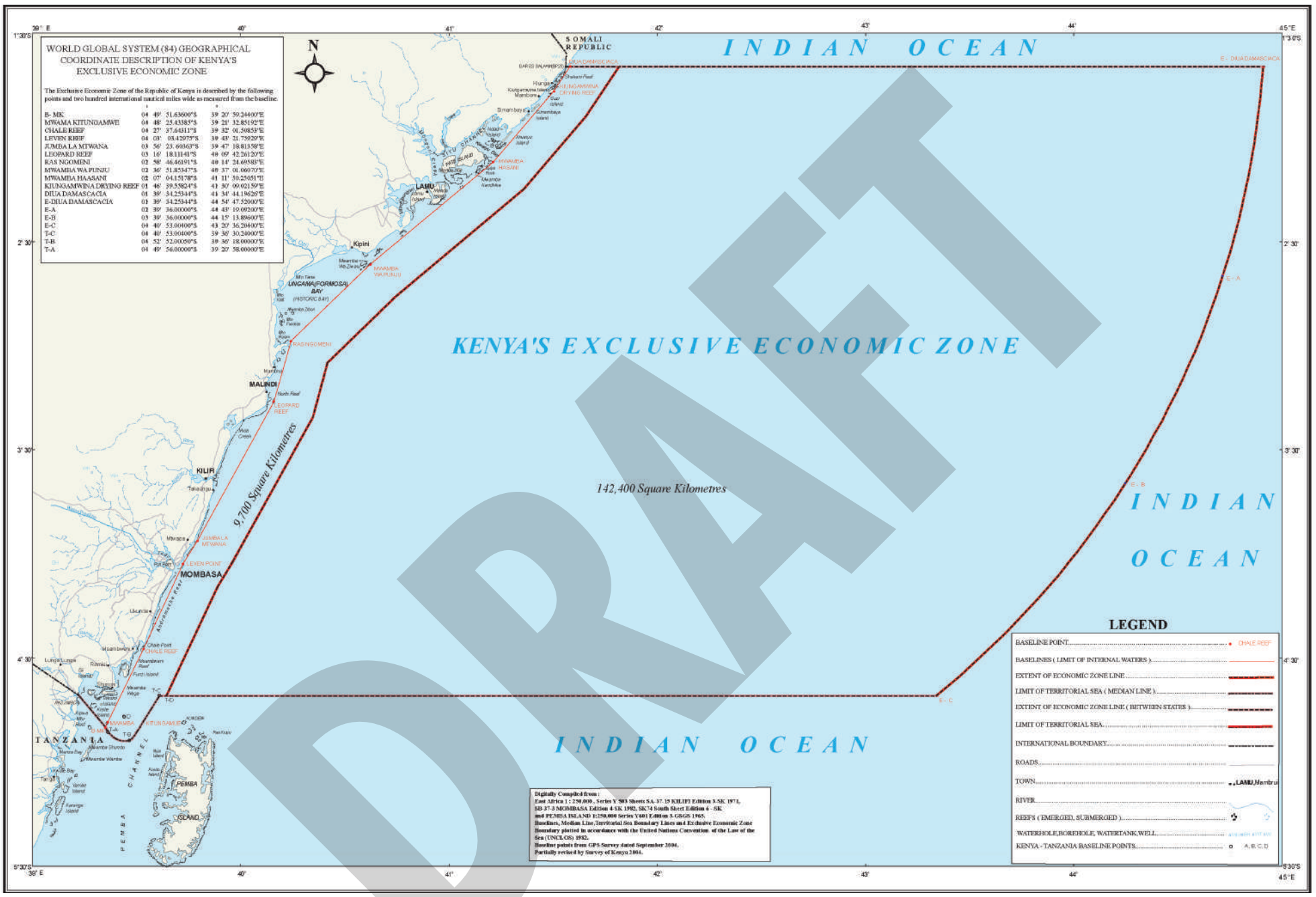


Figure 25: Kenya's oceanic exclusive economic zone

Blue economy components

According to the World Bank (2017), to qualify as components of the blue economy, activities need to:

1. Provide social and economic benefits for current and future generations;
2. Restore, protect, and maintain the diversity, productivity, resilience, core functions, and intrinsic value of marine ecosystems; and
3. Be based on clean technologies, renewable energy, and circular material flows that will reduce waste and promote recycling of materials. The components of the Blue Economy are highlighted in Table 23.

Table 23: *Components of the Blue economy*

Activity	Service	Industry	Drivers of Growth
Harvesting of living resources	Food	Fisheries	Food security
		Aquaculture	Demand for protein
	Biotechnology	Pharmaceuticals, chemicals	Research and Development for healthcare and industry
Extraction of nonliving resources, generation of new resources	Minerals	Rocked mining	Demand for minerals
	Energy	Oil and gas/ Renewables	Demand for alternative energy sources
	Fresh water	Water abstraction	Demand for fresh water
Commerce and trade	Transport and trade	Shipping	Growth in trade; international regulations
		Port infrastructure and services	
	Tourism and recreation	Tourism	Growth of global tourism
		Coastal Development	Urbanization Domestic regulations
Response to aquatic health challenges	Monitoring and surveillance	Technology and R&D	R&D in aquatic technologies
	Carbon Sequestration	Blue Carbon	Growth in coastal and aquatic protection and conservation activities
	Coastal Protection	Habitat protection and restoration	
	Waste Disposal	Assimilation of nutrients and wastes	

Source: (World Bank, 2017)

Based on the World Bank (2017) categorization of Blue Economy, the Kenyan Blue resources can be divided further into various categories that include riparian land use activities, water abstraction, invasive species, maritime transport, infrastructure development, tourism and wildlife, islands and cultural sports, energy and minerals (e.g., oil and gas from substrate deposits), production, trade and investment; that are affected by incidence and climate change. These resources can be extractively compared to fisheries in terms of quantity and quality, distribution, and occurrence for governance and decision making. Future prospects of the aforementioned classification could trigger Marine Spatial Planning (MSP) and their possible carrying capacities to establish their potential and space. This chapter will put emphasis on fisheries and its linkages to blue economic resources. For example, fishing boats (maritime transport, Plate 15) facilitate extraction of fisheries resources to landing sites.

Plate 15: Sindo landing site in Homa Bay county, Kenya; Photo credits: Fonda Jane Awuor

Kenya's Fisheries Sector

Kenya is endowed with both marine and inland water resources. The inland water resources include lakes, dams and rivers of varying sizes. Some of the major lakes include: Lake Turkana (6,405 km^2), Lake Victoria-Kenyan side (6% of the whole lake- 4,128 km^2), Naivasha (210 km^2), Baringo (129 km^2) and Lake Jipe (39 km^2). Major rivers include Tana (700 km), Athi/Galana/Sabaki (530 km), Ewaso-Nyiro North (520 km), Kerio (350 km), Suam-Turkwel (350 km^2), Mara (280 km), Nzoia (240 km), Voi (200 km), Yala (170 km), Ewaso-Nyiro-south (140 km), Sondu (105 km), Malewa (105 km) and Kuja (80 km). Across the country, there are also dams stocked with fish in areas like Uasin Gishu, Narok and Laikipia, where fish production is quite substantial (KeFS Bulletin, 2022).

Further to these inland water resources, Kenya also enjoys a vast coastline of 640 km on the Western Indian Ocean and a further 200 nautical miles Exclusive Economic Zone (EEZ) under Kenyan jurisdiction. The total area of the territorial waters is 9,700 km^2 while the Kenyan EEZ is 142,400 km^2. Kenya also lays claim to extended EEZ, reaching 350 km with an extra area of approximately 103,320 km^2. The total area for exploitation by the country is a massive 255,420 km^2 which is about half of the Kenyan land cover area.

The Kenyan fishery is mainly artisanal with very few commercial/industrial vessels targeting mainly shallow water shrimps, deep water shrimps and lobsters. The country has been developing the industrial fleet and is currently having four longliners and six purse seiners mainly targeting Tuna and Tuna like species in the Economic Exclusive Zone (EEZ). The artisanal fishery accounts for most of the inland and marine water catches and consequently it is the most important fishery in the country, even though EEZ which is predominately for commercial fishing is under exploited with an estimated potential of between 150,000 to 300,000 metric tonnes (Kimani et al., 2018).

The fisheries sector also plays a significant role in employment and income generation. During the year 2021 the sector supported a total of 65,000 people directly as fishermen and 70,000 fish farmers with 149,000 stocked fish ponds. The sector supports about 1.2 million people directly and indirectly, working as fishers, traders, processors, suppliers and merchants of fishing accessories and employees and their dependents. Besides being a rich source of protein especially for riparian communities, the sector is also important for the preservation of culture, national heritage, and recreational purposes. In 2021, the total fish production was 163,702 metric tons worth 30.38 billion Kenya shillings (KNBS, 2022). This was an 8.2% increase in production compared to 151,289 tons worth 26.25 billion Kenya shillings landed in 2020. The increase in the value was mainly due to the catches from industrial vessels and the increase in prices for areas with less production based on the demand and supply impacts on the fish prices. As has been the trend in the past, most of the production was from inland capture fisheries amounting to 115,353 metric tons with an ex-vessel value of Ksh. 17.4 billion. The fish production from marine and aquaculture was 27,306 and 21,076 metric tons worth Ksh. 6.2 and 6.7 billion shillings respectively (KeFS, 2022).

Considering the informal nature of the sub-sectors, many non-monetary activities and employment generated may not be fully captured, hence the sector's contribution to Gross Domestic Product (GDP) could be much higher than reported (Onyango et al., 2021). Demand for fish is increasing rapidly in Kenya driven by population and income growth, increased awareness of the health benefits of fish consumption and changes in lifestyles and consumer preferences (Obiero et al., 2019). Table 24 summarizes the key institutional and financial aspects of Kenya's fisheries sub- sector. A country analysis that set out the important features of the fisheries sector relating to the size, the constraints that it faces, and the existing institutional and financing mechanisms is presented.

Table 24: *Kenya's fisheries sub-sector at a glance*

Key indicators	Description
Production (2021)	Total fish output 163.6 thousand tonnes Total revenue generated KSh 30.4 billion
Fisheries' contribution to the GDP (2021)	0.7%
Average household size (2019)	3.9
Overall Poverty headcount rate (2015/16)	36.1
Size of the fisheries sector (2021)	Direct livelihood to at least 65,250 fishermen, and further support to about 1.2 million people working as fishers, traders, processors, suppliers and merchants of fishing accessories.
Institutional structures	National government (Institutions under the state department for Blue economy and Fisheries) State Department for the Blue Economy and Fisheries Kenya Marine and Fisheries Research Institute (Science, Technology and Innovation Act, 2012) Kenya Fisheries Service (Fisheries Management and Development Act, 2016) Fish Marketing Authority (Fisheries Management and Development Act, 2016) Kenya Fishing Industry Corporation County Government Local/community level Beach Management Units
Financing mechanisms	Domestic-Budgetary allocations Development partner assistance
Private sector interest	Domestic operators and; Substantial interest of international funds

Source: (KNBS, 2022; KeFS Statistical Bulletin, 2021)

Quantity and Value of Fish Landed

Inland capture fisheries contributed 71% of Kenya's total fish production, with the principal catches coming from Lake Victoria (Figure 26). The lake accounted for 94,349 metric tons (mt) which was a 7% increase in catch compared to 88,223 mt caught the previous year (KNBS, 2022; KeFS Bulletin, 2022).

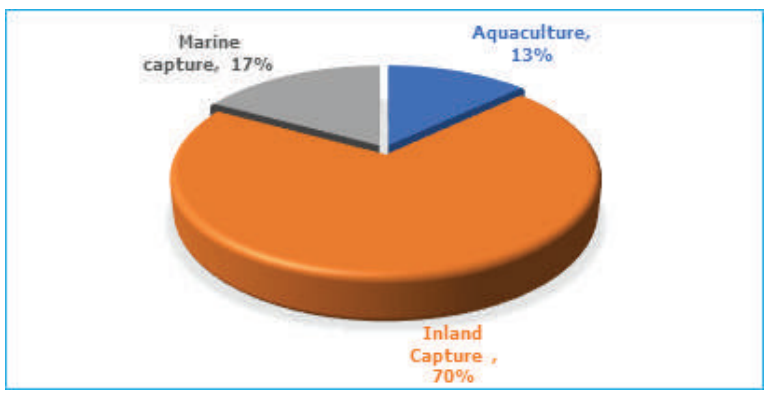


Figure 26: Pie chart showing the proportions of the major types of Fishery in the country

The increase was attributed to relaxed Covid-19 pandemic restriction and

resumption of normal fishing hours. Lake Turkana, the world's largest desert lake, produced 15,644 mt of fish during the year under review. This amounted to a 19% increase compared to 13,190 mt caught in 2020. This increase is mainly as a result improved recruitment due to raised water level and flooding of Ferguson Gulf and other critical fish habitats in the year 2020. Other freshwater-bodies of commercial importance whose catches increased in 2021 were lakes Baringo, Jipe and Kanyaboli. The catches from the lakes in 2021 were 406 mt, 218 mt and 1652 mt respectively compared to 162 mt, 197 mt and 264 mt in 2020. The increase was 526% for Kanyaboli, 151% for Lake Baringo and 11% for Lake Jipe. Lake Naivasha registered a 19% decline in production 1804 mt in comparison with 2216 mt landed in 2020. Other water bodies that recorded a decline catch were Lake Kenyatta (77), Tana River dams (197), Turkwel (98) and riverine (393) which 54%, 30%, 8% and 4% respectively. Tana River Delta and contribution from small dams across the country improved 114% and 6% respectively (KeFS, 2022).

Marine artisanal production increased from 23,646 mt worth 4.84 billion in 2020 to 25,380 mt worth 5.49 billion in 2021 (KNBS, 2022). Marine industrial fishing increased for the shallow prawn trawling, deep water trawling and deep-water crab pottery but decreased for deep sea longlining. Deep water trawling is undertaken from November to March while shallow water trawling commences from April to October. Deep water trawl catches increased from 943 mt to 1026 mt while deep water crab catches increased from 86 mt to 137 mt. Shallow water trawling catches increased to 330 mt from 273 mt while longline catches declined to 432.6 mt from 670 mt. The quantity and value of fish landed are shown in Table 25.

Table 25: *Quantity and Value of Fish Landed in marine, larger and smaller lakes, small water bodies, riverine, and aquaculture systems (2017 – 2021). Quantities in terms of exports and imports for the same period is also shown.*

	2017		2018		2019		2020		2021	
Fresh Water	M. Tons	Value '000 Kshs.	M. Tons	Value '000 Kshs.	M. Tons	Value '000 Kshs.	M. Tons	Value '000 Kshs.	M. Tons	Value '000 Kshs.
Lake Victoria	92,727	13,976,586	98,150	14,487,650	90,743	11,640,537	88,223	12,687,298	94,349	14,082,375
Lake Turkana	4,021	486,540	7,587	564,739	7,031	645,107	13,190	1,177,193	15,644	1,478,953
Lake Naivasha	1,689	222,579	2,287	287,194	3,087	391,719	2,216	238,638	1,804	216,974
Lake Baringo	155	46,606	145	43,442	203	49,499	162	39,502	406	118,590
Lake Jipe	112	21,756	131	38,260	157	45,957	197	57,549	227	66,051
Lake Kanyaboli	127	26,346	203	29,656	300	43,826	264	60,201	286	70,074
Lake Kenyatta	45	3,473	14	1,330	32	2,725	72	7,295	68	6,816
Tana River Dams	422	84,500	297	37,373	394	60,571	283	50,960	197	28,563
Tana River Delta	115	9,296	46	5,069	202	17,595	158	20,360	135	13,048
Aquaculture	12,356	3,691,046	15,120	4,480,875	18,542	5,581,142	19,945	6,303,617	20,973	6,711,360
Turkwel	35	9,905	34	9,822	50	12,850	107	16,112	98	14,750
Riverine	10	2,368	320	86,400	380	106,371	411	115,049	393	109,454
Small Dams	300	75,120	339	42,015	459	126,455	358	95,022	380	83,465
Total Fresh Water	112,114	18,656,121	124,673	20,113,825	121,580	18,724,354	125,586	20,868,796	136,326	23,335,961
Marine (Artisanal)	23,286	4,375,822	23,145	4,246,962	25,670	4,477,577	23,684	4,831,948	25,380	5,491,800
Mariculture	51	1,530	64	1,920	76	1,895	85	2,119	103	2,568
Industrial (Marine)										
Shallow prawn trawl fishery	346	115,486	520	189,605	535	185,900	273	177,446	330	115,231
Deep water trawl fishery	41	9,102	10	42,341	626	170,089	943	518,385	1,026	350,933
Deep water crab pottery	-	-	1	251	38	19,072	86	71,295	137	119,680
Deep sea longlining	62	1,788	508	20,362	795	30,759	670	26,855	432.6	170,965
Total Industrial	449	126,376	1,039	252,559	1,994	405,820	1,972	793,981	1,926	756,809
Marine Aquarium		28,701		42,414		38,575		34,516		809,219
Total Marine	23,786	4,532,429	24,248	4,543,855	27,740	4,923,867	25,741	5,662,564	27,409	7,060,396
Grand Total	135,900	23,188,550	148,921	24,657,680	149,320	23,648,221	151,327	26,531,360	163,735	30,396,357
EXPORTS										
Fish and fish products	3,554	2,253,644	7,250	2,974,980	8,821	3,407,548	8,387	2,740,678	10,782	3,412,116
Aquarium fish (Numbers)	323,691	22,866	366,776	34,241	297,367	31,219	272,696	27,583	498,908	609,668
Aquarium invertebrates (Numbers)	176,130	5,835	191,672	8,173	133,844	7,356	124,856	6,933	350,309	199,551
TOTAL		2,282,345		3,017,394		3,446,123		2,775,194		4,221,335
Imports	19,127	1,568,565	26,383	2,974,678	22,813	2,798,951	19,892	2,251,861	19,601	2,478,751
Balance of Trade		713,780		42,716		647,172		523,333		1,742,584

(Source: KNBS, 2022; KeFS, 2022)

Inland Freshwater Fisheries of Kenya

Lake Victoria Fishery

Selected attributes of Lake Victoria fishery for the period 2000-2020 are indicated in Table 4. The total number of landing sites decreased from 338 in 2016 to 329 in 2020. The number of fishers was 47,976 in 2020 as compared to 43,799 in 2016, showing an increase in the current year. There was also an increase in the number of fishing crafts for the period under review.

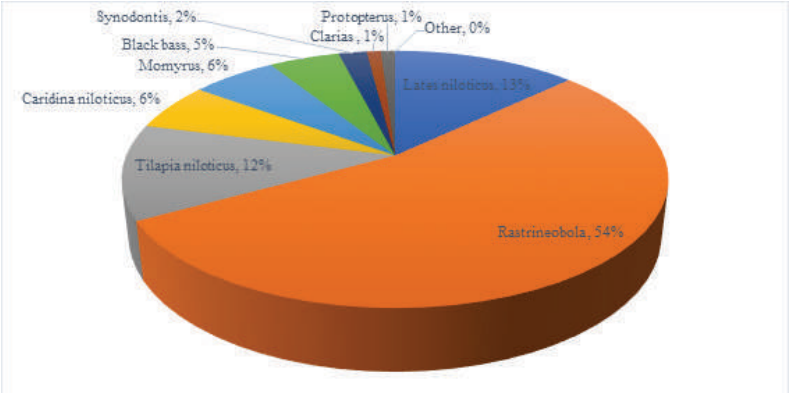


Figure 28: Lake Victoria fish landings by species 2021

Table 26: *Selected attributes of Lake Victoria fishery*

	2000	2002	2004	2006	2008	2010	2012	2014	2016	2020
No Landing sites	297	306	304	316	307	331	324	321	338	329
No. of Fishers	38,431	54,163	37,348	44,263	42,307	41,912	40,078	40,113	43,799	47,976
Fisher density No. Km^2	9.2	13.0	8.9	10.6	10.1	10.0	9.6	9.6	10.5	11.45
No. of Fishing crafts	11,515	12,209	12,284	15,280	14,257	14,251	13,717	13,402	14,365	15,463
No. of gillnets <5	33,544	28,527	28,996	30,876	43,467	47,629	54,085	75,205	76,731	49,522
No. of gillnets >5	99,820	101,981	161,760	185,807	170,312	165,246	153,865	113,779	116,256	131,599
No. of Gillnets	1,039,893	130,708	190,756	217,358	213,779	212,875	207,950	188,984	192,987	181,121
No. LL hooks	133,364	2,562,066	2,045,605	2,623,553	2,501,944	2,710,395	2,478,976	2,573,736	2,507,893	2,959,726
Beach seines	5,803	1,157	869	553	762	991	1,063	856	906	1,347
Cast net	4,548	102	78	114	131	143	85	128	75	50
Monofilament nets			58	469	4,190	1,468	12.161	1,432	20,842	13,770
Total Small seines	12,387	2,097	3,048	3,181	2,700	3,029	3,859	4,137	13,156	3,173

(Source: Frame survey, 2020)

Lake Victoria's Fishery accounted for 94,349 mt (Table 3) which was a 7% increase in catch compared to 88,223 mt recorded in the year 2020 (KNBS, 2022). The increase was attributed to relaxed Covid-19 pandemic restriction and resumption of normal fishing hours. Capture fisheries of Lake Victoria are a source of livelihood to many people employed directly as boat owners, fishermen, fish traders, fish processors, etc., and indirectly to fishing gear manufacturers, boat builders, and ice producers among others (KeFS, 2022). Lake Victoria is a multi-species fishery with many of known species, but only ***Rastrineobola argentea*** (Omena), ***Lates niloticus*** (Nile perch) and ***Oreochromis niloticus*** (Nile tilapia) are of major economic significance. The catch from the major species was recorded as; ***Rastrineobola argentea*** at 51,305 mt, ***Lates niloticus*** at 12,349 mt and ***Oreochromis niloticus*** at 11,173 mt (Figure 27).

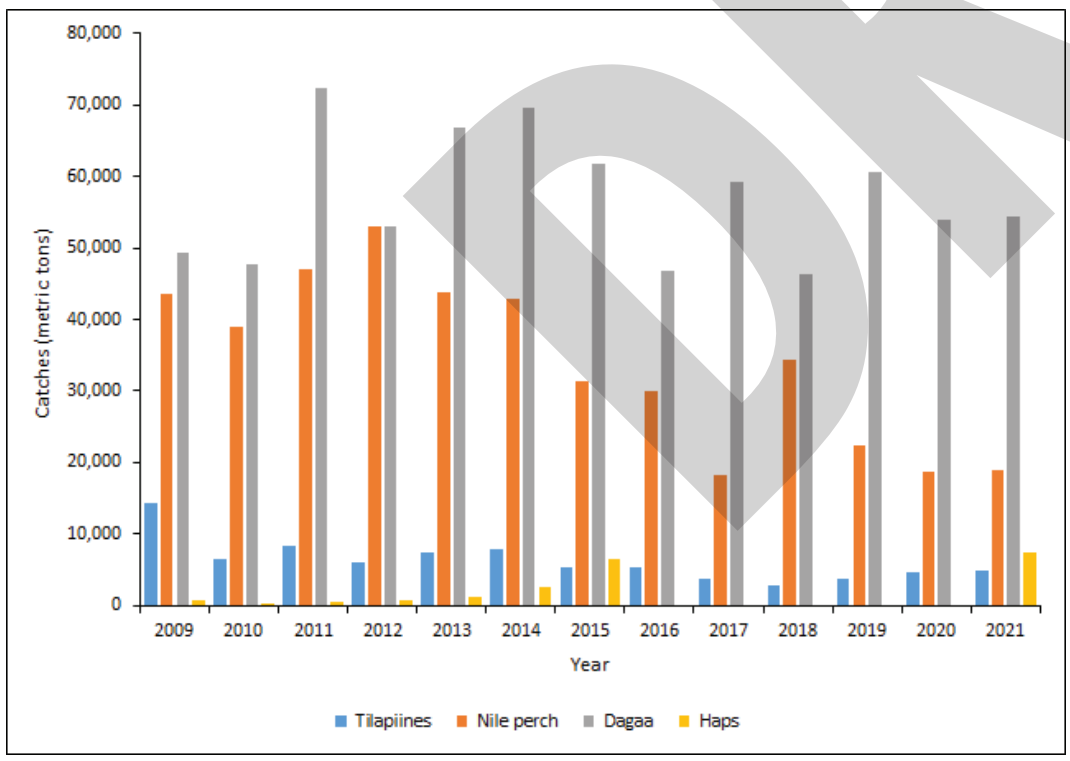


Figure 27: Fish landing in Lake Victoria, Kenya 2009-2021 (KeFS)

The species contribution to the total catch of fish landed from Lake Victoria in 2021, ***Rastrineobola argentea*** constitute the highest proportion with 54%, with ***Lates Niloticus*** 13%, ***Tilapia niloticus*** 12%, ***Caridina niloticus*** and ***Momyrus*** at 6%, ***black bass*** 5% and ***Clarias*** 1%. Haplochromines constitute less than 1% of the fish landed. (Figure 4).

Perceived Resource-Use Conflicts in Lake Victoria, Kenya

Prominent conflicts in Lake Victoria, Kenya are presented in Figure 5. Due to multiple users and the open-access nature of the lake, opportunities for resource competition arise hence causing conflicts amongst the users. Fishermen are centrally placed within the network because fishing is the dominant activity utilizing almost 90% of the lake space (Obiero et al., 2015). As a result, most of the conflicts are reported to arise between the fishermen and other lake users. Conflicts over fishing grounds were rampant probably due to many different types of fisheries and the increased number of fishers in the lake. For instance, in 2020 the number of fishers was 47,976 compared to 43,653 in 2016, showing an increase of 3323 fishers (8%) (Frame Survey, 2020) and this is expected to have increased in this current year. Anthropogenic pollution was reported as one of the leading causes of conflicts in the lake as many users do not adhere to the environmental regulations for managing the lake. Small-scale (households) and large-scale water abstractors are the main victims of such conflicts due to their high dependence on the lake and limited area of lake use which put them at a disadvantaged position. Poor water quality due to oil spills from transport and fishing boats, use of fertilizers for crop farming, discharge of untreated and inefficiently treated sewage, and siltation during port development have increased the vulnerabilities of the lake users who are wholly dependent on the lake. Other conflicts arise between conservationists and fishermen, cage farmers, and sand harvesters due to interference with fish breeding grounds and encroachment into wildlife (hippopotamus) corridors.

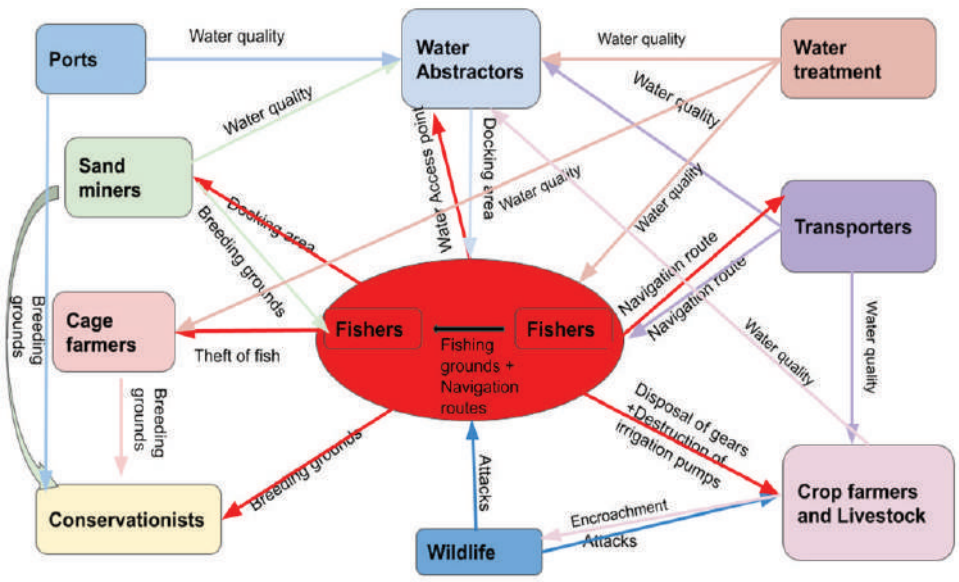


Figure 29: Resource-Use Conflicts in Lake Victoria, Kenya. Red = Dominant Lake user conflicting with many other lake users. Arrows point to the lake user being affected with the different colors representing who is affecting the other. (Adapted from Awuor et al., 2022).

Lake Turkana Fishery

Lake Turkana is Africa's fourth largest lake by volume and Kenya's largest inland lake with surface area of 6,405 km^2, about 249 km long by 48 km at its widest part, with a delta extending into Ethiopia. It lies in a closed basin 365 meters above sea level (Ojwang et al., 2016). The lake has about 48 species of fish with a dozen supporting a commercial fishery. The species exploited commercially include, Nile perch (***Lates niloticus***), Tilapia (***Oreochromis niloticus***), Catfish (***Clarias gariepinus), synodontis schall, Hydrocynus forskalii, Labeo horie, Bagrus spp***, ***Distichodus niloticus, Citharinus spp, Barbus spp*** and ***Alestes spp***. The fishery is characterized by bust cycles in fish landings associated with fluctuations in lake levels due to the dynamics of the climatic conditions especially precipitation leading to filling and drying up of the Ferguson's gulf (Ojwang et al., 2016). The filling up of the Ferguson's gulf is associated with an increase in fish catches especially tilapias. In 2021, 15,644 mt of fish landed with an ex-vessel value of 1.478 billion Kshs. from both sides (Turkana and Marsabit counties) of the lake (Table 3). The production in 2021 was an increase of 14.6% in quantity and a 47.7% increase in value compared to 2020 production of 13,664 mt with an ex-vessel value of Kshs.1.001 billion (Figure 30). The trends in annual fish catches from Lake Turkana are determined by the lakes' water level and as a result, the catches have been unpredictable for a long time (KeFS, 2022).

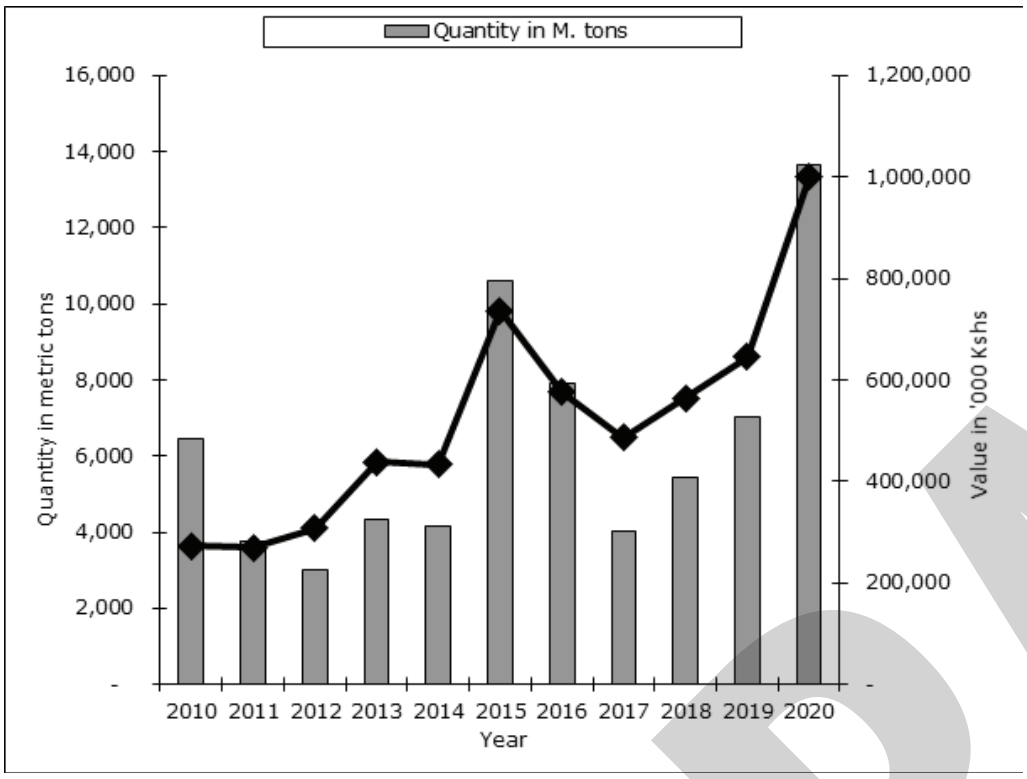


Figure 30: Trends in annual fish landings from Lake Turkana fishery 2010-2020; (Source: KeFS, 2021)

Lake Naivasha

Lake Naivasha is a freshwater lake with surface area ranging from 110 to 180 km^2 during the wet and dry spells respectively. Excluding two smaller and shallow lakes (Lake Oloiden and Lake Sonachi), the main lake covers an average area of 145 km^2, with mean depth of 6m. Its catchment area extends to the Aberdare ranges and the Kinangop plateau, from which three rivers (Malewa, Gilgil and Karati) recharge the lake. River Malewa contributes the largest volume (90%) of the lake water, and rest come from other ephemeral streams and surface runoffs. The lake lies in a closed basin without any physical outlet, but its freshness is maintained through a balance between the recharging and underground seepage systems.

The lake supports a host of fish community comprising 9 introduced species of which 6 are exploited commercially in present fishery. The species exploited commercially include, the large-mouth black bass (*Micropterus salmoides*), blue-spotted tilapia (*Oreochromis leucostictus)* red-belly tilapia (*Coptodon zillii),* common carp *(Cyprinus carpio),* nile tilapia *(Oreochromis niloticus) and* African catfish *(Clarias gariepinus).* In the past, a freshwater prawn species *(Procambarus clarkii*) and riverine straight-fin barb *(Barbus spp)* also formed important components of the fishery, but the two are no longer reported in the present catch statistics, implying their declined stocks in the lake. The fishery of Lake Naivasha is annotated with shifts in fish species composition of commercial landing where *O. leucostictus, C. carpio and O. niloticus* contribute the bulk of the catches landed over the year. The latter species was re-introduced into the lake in 2011, after a first attempt made in 1967 had failed due to unknown reasons. Common carp was reported in the lake in 2002 after the fishery had collapsed, due to overfishing, and one-year long fishing ban imposed to help fish stock recovery.

Fish production trend analysis for Lake Naivasha, between 1974 and 2021, reveals that until 2014, annual landings were less than 700 tonnes. However, following various management measures taken during the subsequent period, including fish stock enhancement and protection of fish breeding areas, fish production steadily increased in 2015 (1185 tonnes) and a maximum of 3087 tonnes reported in 2019. The increased landings correspond to the increased number of licensed fishing boats from 50 boats, in 2013, to 186 boats by 2021 (Figure 31). This excessive fishing effort has had consequent impact on the fishery with decline in catches in two consecutive years (2020 and 2021).

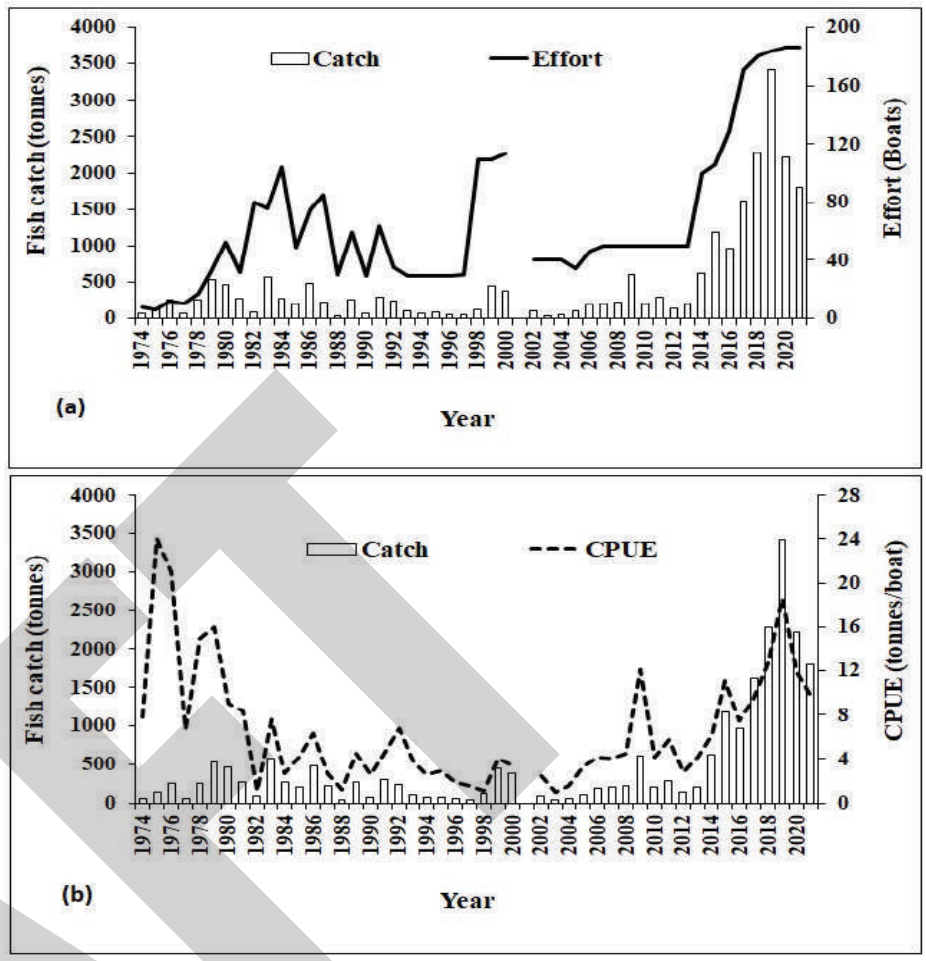


Figure 31: Trends in annual fish landings from Lake Naivasha fishery (1974-2020) in relation to: (a) fishing effort and (b) catch per unit effort (CPUE).

Before the establishment of Nile tilapia population in Lake Naivasha, the value of fish landed from the fishery was less than Kshs 100 million (Figure 32). However, between 2015 and 2021, the increasing trends in annual fish production parallels the rising value of fish during the period, with a minimum of Kshs 129.3 million and a maximum Kshs 409.5 million recorded during the period. These results reflect the importance and impacts of various management interventions made on the lake's fishery aimed at achieving the national objectives of blue economy.

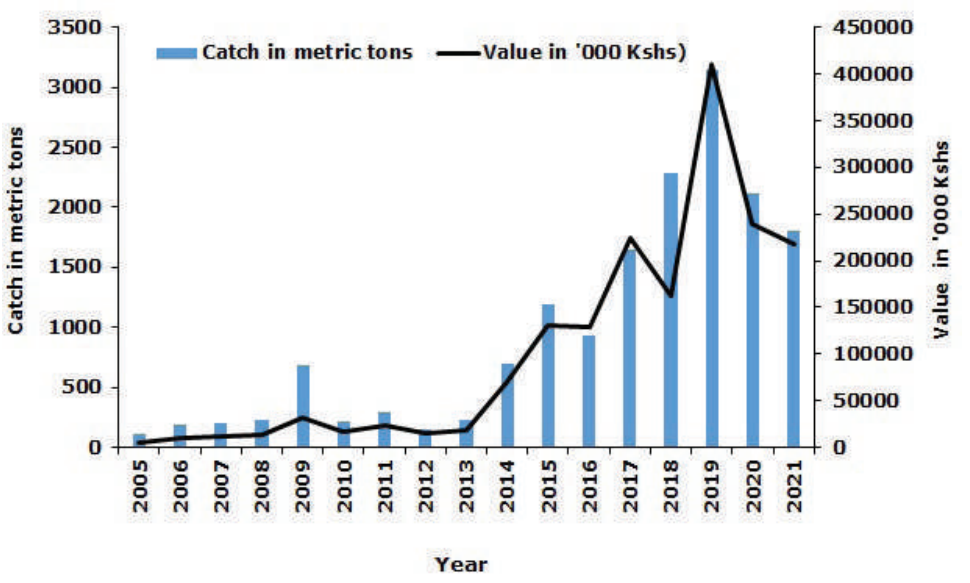


Figure 32: Trends in annual fish landings from Lake Naivasha fishery and value (2005-2021).

Aquaculture production in Kenya

Kenya is a regional player in the growth of aquaculture, as the fourth largest producer of farmed fish in Africa, having experienced a significant growth from 4,895 mt in 2009 to 20,973 mt in 2021 (Munguti et al., 2021; KNBS 2022) (Figure 33). Aquaculture is practiced in fresh, brackish and marine waters, with production limited to a smaller number of fish species compared to capture fisheries.

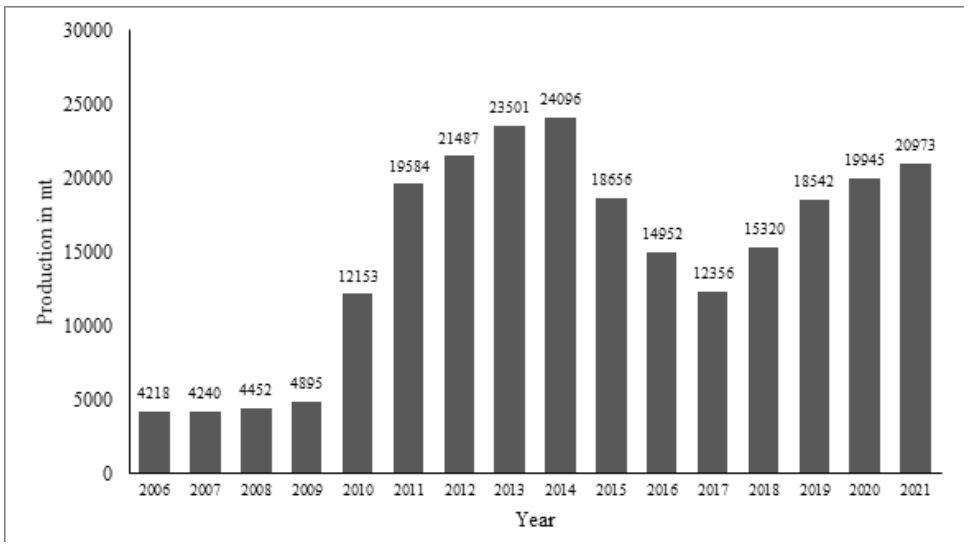


Figure 33: Trends in aquaculture production in Kenya 2006 – 2021; Source: (KNBS, 2022)

Production trends of main culture species

The supply chain is focused on two species, Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) accounting for over 93% of Kenya's aquaculture production (Opiyo et al., 2018) (Table 27). These species are found in virtually all aquatic systems and have high demand in the local and regional markets. Polyculture of Nile tilapia and African catfish is often done to control the prolific breeding of the former. Other cultured species include Common carp (*Cyprinus carpio*) and, Rainbow trout (*Oncorhynchus mykiss*), and Tilapia jipe (*Oreochromis jipe*). Trout is temperature restricted thus it is only cultured at temperatures below 19°C mainly in the Mt. Kenya region (Opiyo et al., 2018). A variety of freshwater species have been farmed on pilot scale including Nile perch (*Lates niloticus*), Largemouth bass African carp (*Labeo victorianus*), and Lung fish (*Protopterus aethiopicus*).

Table 27: *Cultured fish species production (in MT) in Kenya from 2010-2019*

Year/ Species	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Nile Tilapia	9115	16602	16115	17626	18072	13991	11962	9885	12356	15100
African Catfish	2188	3984	3869	4230	4337	3358	1944	1606	1960	2400
Common Carp	729	1328	1289	1410	1446	1120	299	247	300	300
Rainbow Trout	122	221	215	235	241	187	748	618	700	745
Total	12154	22135	21488	23501	24096	18656	14953	12356	15316	18545

(Source: FAO, 2021)

Cage culture in Kenya

Cage culture was pioneered in Kenya by the Lake Basin Development Authority (LBDA) with trials around Dunga Beach in 1988. In 2005, the Dominion Group of Companies harvested successfully from cages at its Yala wetland farm (Orina et al., 2018). Between 2008 and 2013, "BOMOSA," an EU-sponsored project, conducted trials on caging within small water bodies within the Lake Victoria basin. Cage culture techniques have grown in popularity on the beaches of Obenge and Dunga in Siaya and Kisumu counties, respectively, thanks to the efforts of the Fisheries Cooperative Society and Beach Management Units (BMU) (Aura et al., 2018). Despite early setbacks, cage culture approach was subsequently selected in 2010 at Dunga Beach in Kisumu County through collaborative work between KMFRI and Dunga Beach Management Unit.

Cage culture has emerged in recent years as a new livelihood in Lake Victoria, in addition to safeguarding diminishing wild fish species. The practice has since spread to Lake Victoria's five riparian counties, namely Busia, Siaya, Kisumu, Homa Bay, and Migori. For example, the total number of cages in the Kenyan section of Lake Victoria increased from 1663 to more than 4537 between 2016 and 2019, with further growth projected (Hamilton et al., 2020). Currently, there is an estimated 5,242 cages installed on the Kenya portion of the lake (6% of total surface area). The highest number of cages reported are in Siaya county (KMFRI-ABDP-CAGES, 2022).

Cage culture has presented itself as a new socioeconomic frontier with good prospects for income from Lake Victoria, besides conserving declining wild fish stocks, especially for low-density high-volume cages (LDHVC, Figure 10). The exponential growth in cage fish farming has been inspired by the dramatic decline in natural fish stocks, caused by overfishing and other ecosystem stressors and potentiated by increasing demand for fish protein because of rapid human population growth and awareness of benefits of eating fish (FAO, 2022).

Plate 16: Cages at Rasira Landing site; Photo credits: Fonda Jane Awuor

Cage installations have spread across the five riparian counties but its development varies from county to county (Aura et al., 2018). Figure 11 shows the distribution of cages in Lake Victoria Kenya (KMFRI-ABDP-CAGES, 2022). With increasing number of cages in the lake, KMFRI is developing a spatial plan and carrying capacity for Lake Victoria to guide its investment to ensure environmental sustainability and economic performance. This is based on the premise that the desired expansion of this industry will require sustainable management and utilization relying on guidance from sound science. The current rise in cage culture investments and the haphazard installation of cages, could spell doom for the lake ecosystem unless development is controlled more effectively. When sustainably managed, cage technology has the potential to provide significant contribution to national fish production, increased job opportunities, enhanced food security and incomes for both rural and urban dwellers considering the blue economy (Aura et al., 2021).

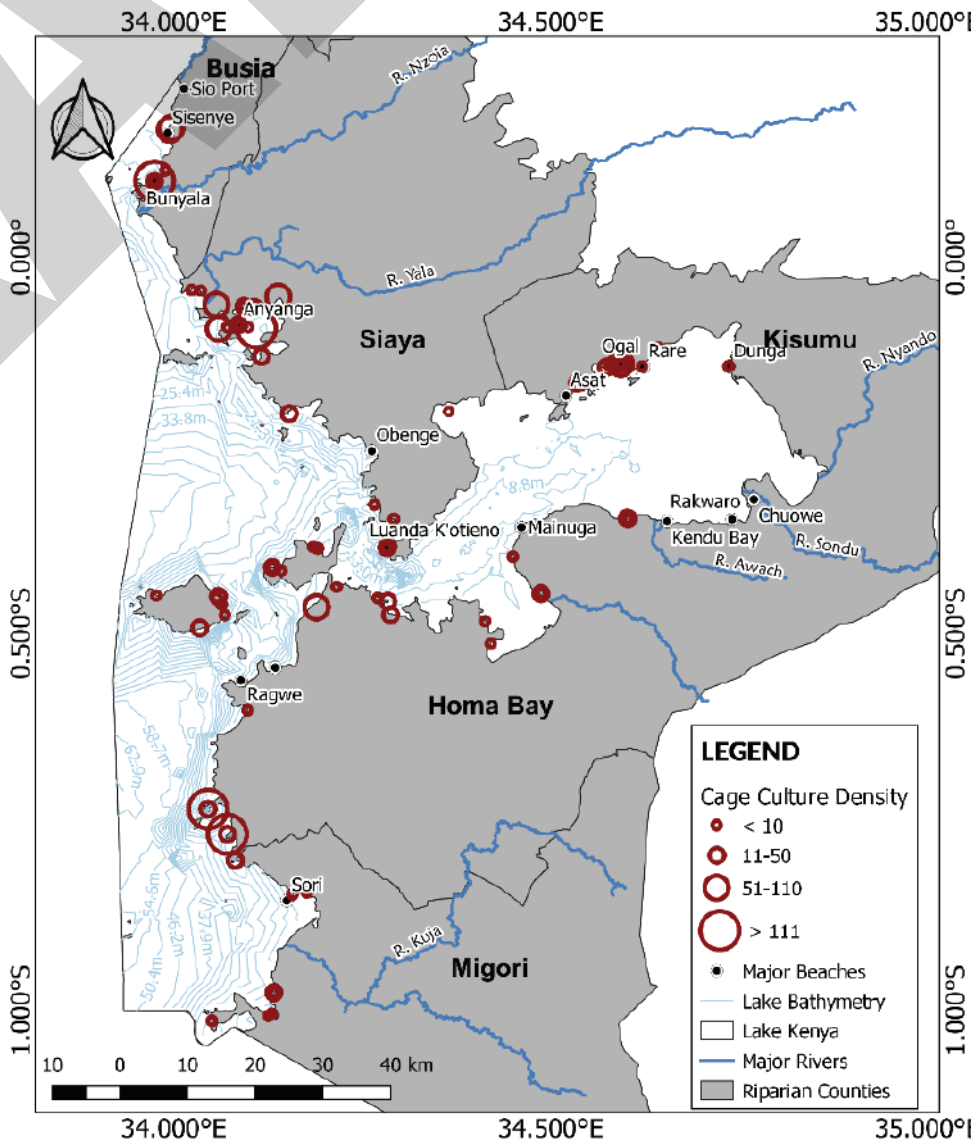


Figure 34: Distribution of cages in Lake Victoria, Kenya as per March 2022

In recent years, production from the rapidly increasing cage aquaculture has reached about 963mt estimated at Kshs. 279,838,000 in 2018 (KeFS, 2022). This suggests that cage culture is now an emerging and viable economic investment that could support the development of a "Blue Economy" in Kenya. Therefore, cage culture industry has experienced various changes overtime due to various morphoedaphic characteristics of the lake and socioeconomic status of the investors which seem to be time dependent (Table 26).

Table 28: *A summary of cage culture attributes, their changes and possible influencing factors in Lake Victoria, Kenya from 2016 to 2022.*

Attributes	Oct-Dec. 2016 findings Number (%)	May-Jul 2020 findings Number (%)	March 2022 findings Number (%)	Interpretations
Number of cages	1,663	5,357	5242	Cages increasing
Number of establishments	39	71	127	Cages increasing
Ownership: Individual	24 (62%)	47 (67%	87 (73%)	Increasing cage installation that are male dominated
Group	15 (38%)	24 (33%)	18 (15%)	
Men	55 (94%)	56 (79%)	113 (94%)	
Women	4 (6%)	15 (21%)	7 (6%)	
Age (years) ≤25	25%	11%	34%	Middle age (36-45 years) dominated the ownership
26-35	25%	25%		
36-45	32%	44%	48%	
46-55	11%	11%		
≥56	7%	8%	18%	
Education level Primary	36%	33%	26%	Dominant education level is secondary school that is indicative of literate farmers
Secondary	46%	47%	40%	
Diploma/ certificate	10%	14%	34%	
Degree	5%	3%		
Postgraduate	3%	3%		
Mean household monthly income	2,800 USD	2,000 USD	250 USD	Vital for blue economy
Dominant dimension	2.0 m x 2.0 m x 2.0 m (62%)	2.0 m x 2.0 m x 2.0 m (65%)	6.0 m x 6.0 m x 4.0 m	Because it cheap and in shallow areas
Highest county – Siaya	(51%), a total of 1,343 cages	(71.8%), a total of 3,847 cages.	(73.2%), a total of 3,838 cages.	Lower water hyacinth coverage & history of cages
Location of cages at > 4 m	76% of total cages	78% of cages	74% of cages	Because it cheap and in shallow areas
Average stocking density	359 fingerlings m-3	350 fingerlings m-3	350 fingerlings m-3	High stocking levels
Not sure of feed type used	12%	10%	21.3%	Detrimental to water quality
Mention of disease occurrence	51% of establishments	49% of establishments	79% of establishments	About half affected
Common disease type occurrence	Fin rot with 28% of farmers	Fin rot with 36% of the farmers	Injuries 20% of the farmers	Fungal infection dominant
Dissolved oxygen levels	3- 5 mg L-1	4.8- 8.9 mg L-1	3.35- 7.7 mg L-1	Varying levels
Total ammonia	63.0 to 327.7 µg L-1	60.0 to 315.7 µg L-1	65.0 to 335.9 µg L-1	Not lethal
Nutrients	High in inshore than offshore	High in inshore than offshore	High in inshore than offshore	Perhaps effect of feeding
Mean primary productivity	Chlorophyll-a 32.8 µg L-1	Chlorophyll-a 39.2 µg L-1	Chlorophyll-a 42.2 µg L-	Very productive

Source: (Aura et al., 2022)

Suitability of cage culture in Lake Victoria Kenya

Inshore Aquaculture

Figure 12a shows the inshore suitable areas that mainly ranges at a depth of about 6 – 10 m for cage culture alongside constraints like navigation routes, water hyacinth hot spots and breeding areas. Such cage culture installations are small in size and located in such areas to minimize farms economic constraints of logistics such as feeding and fuel consumption.

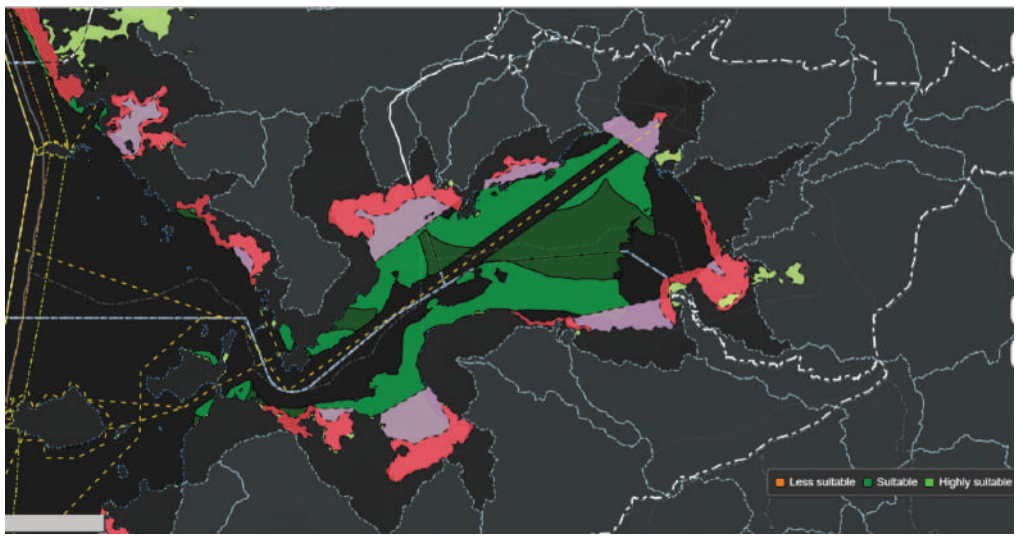


Figure 35: Inshore maximum area for aquaculture in Lake Victoria, Kenya

Figure 12b shows the offshore suitable areas that mainly ranges at a depth of about 10 – 40 m for cage culture alongside constraints like navigation routes, water hyacinth hot spots and breeding areas. Such installations require firm anchorage to withstand strong currents and could be mainly for capital intensive farms.

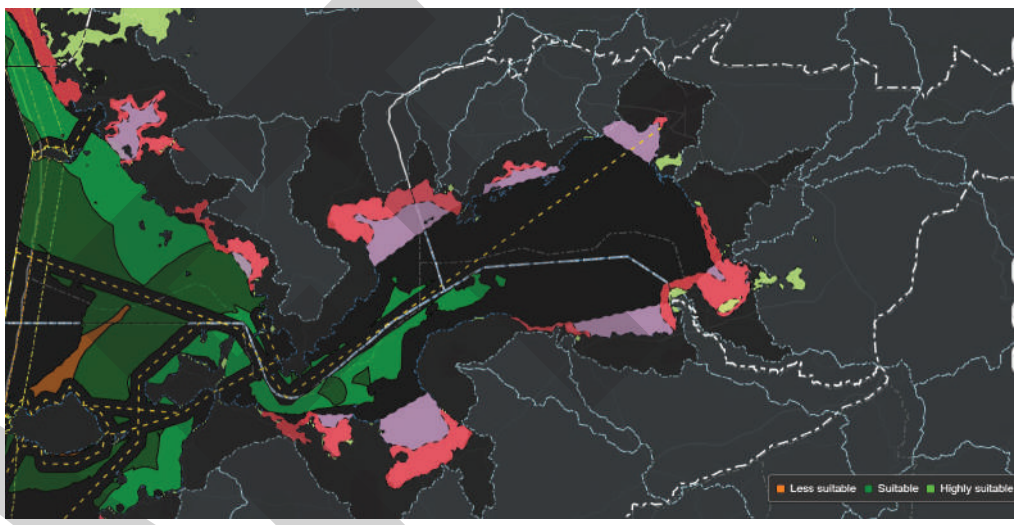


Figure 36: Offshore maximum area for aquaculture in Lake Victoria, Kenya

Aquaculture in Small Water Bodies (SWBs)

Understanding the potential of small water bodies (SWBs) will open greater opportunities in investment towards increased food and energy production. Recent studies on restocking and aquaculture expansion in SWBs have shown their potential in promoting fisheries and aquaculture in Kenya (Aura et al., 2023). For example, 37 SWBs in central region have shown a potential of about 72,447 mt while that of the western region had only 447 mt in a similar number of sampled sites that forms part of the total national aquaculture potential (Figure 36). The higher potential in the central region is attributed to the relatively larger hydro-electric dams located in the area. To boost production in SWBs with low carrying capacities, restocking with native endemic fish species which require limited, or no supplementary feeding, is recommended. However, in SWBs where depths reach 3.0 m or more, which optimizes on intensive feeding and good water circulation; cage culture reared fish coupled with a strong local community association would be recommended. The indexing holistic approach herein forms an integrative management tool for fisheries production (Aura et al., 2022).

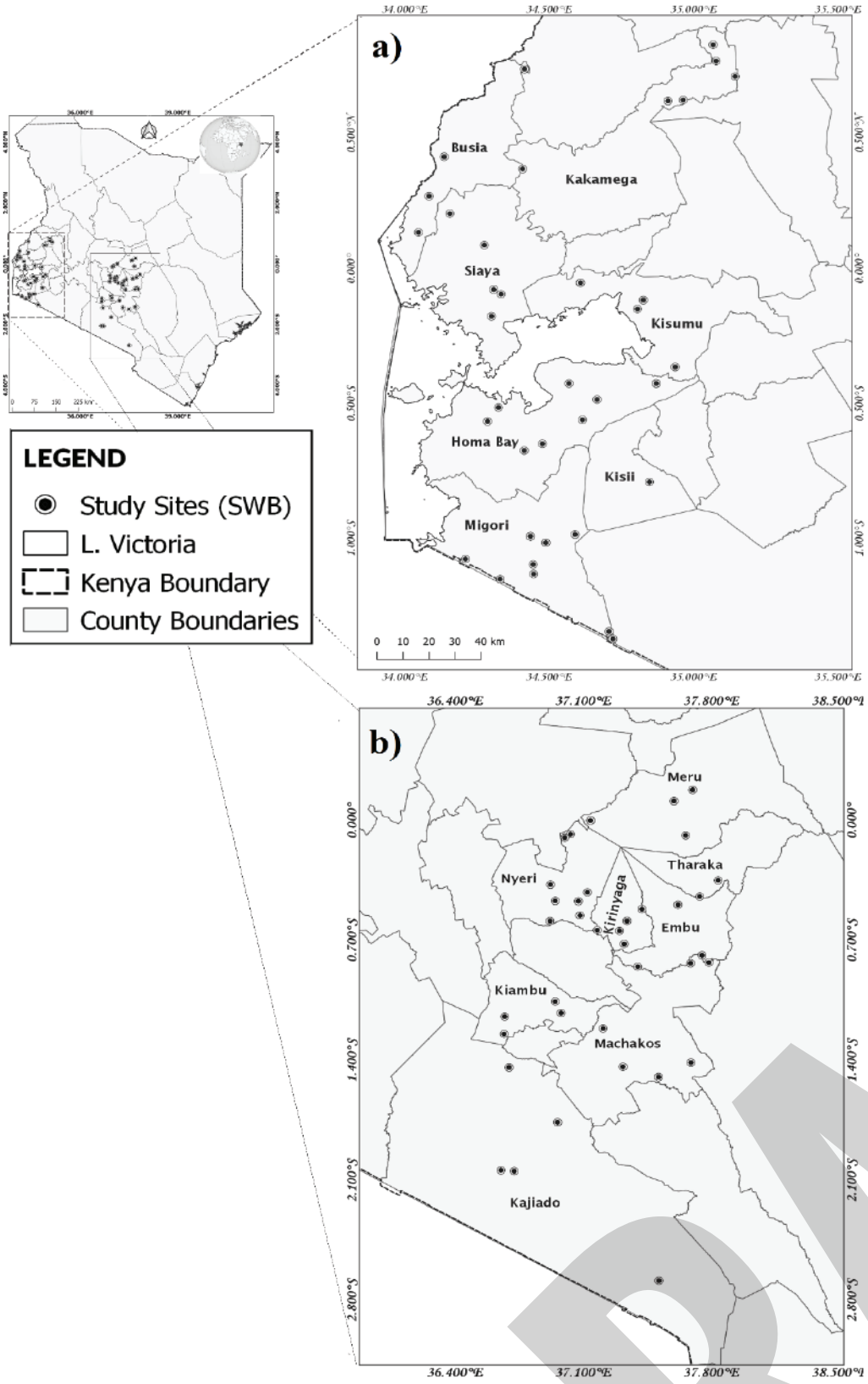


Figure 37: About 74 SWBs in a) western, and b) central regions of Kenya whose aquaculture and restocking potential has been identified (Source: Aura et al., 2022)

Coastal and Marine Fisheries of Kenya

Marine Capture fisheries

The marine capture fishery is composed of coastal and near shore artisanal, semi-industrial and offshore industrial fisheries. Artisanal and semi-industrial fisheries are exploited by the coastal local communities while the industrial fisheries are exploited by foreign fishing. Great potential exists in the exploitation of the Kenyan EEZ (Figure 37) where estimates done in 1975-1980 indicate potential of 100,000 to 150,000 metric tonnes annually and more recent estimates indicate potential of 300,000 metric tonnes (Kimani et al., 2018).

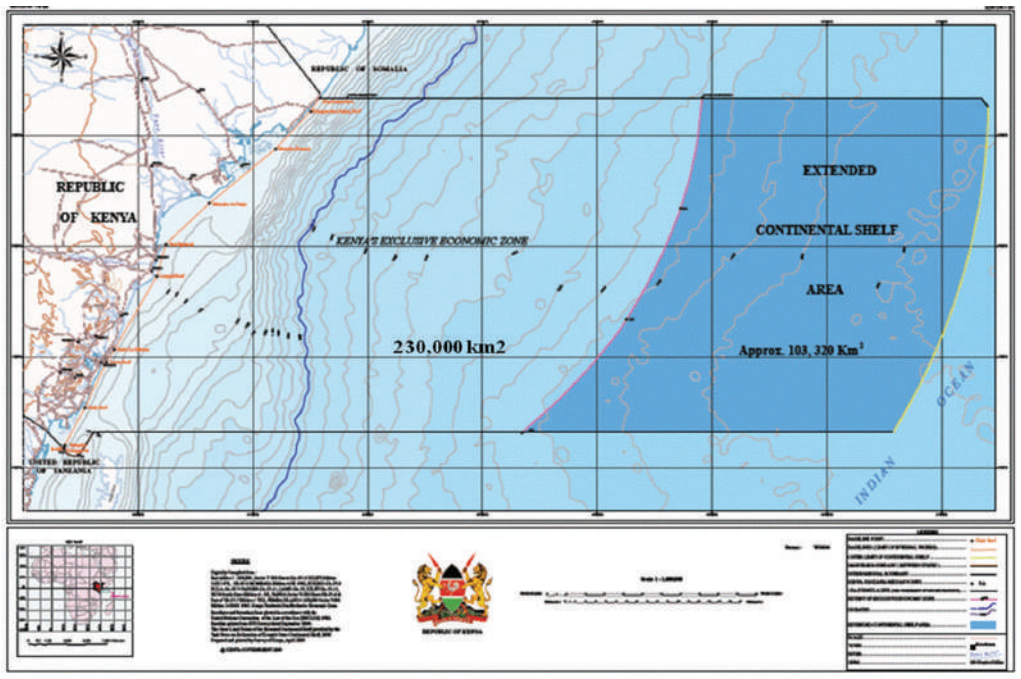


Figure 38: Kenya's oceanic exclusive economic zone

During the year 2021, the total production of marine landings was 27,306 metric tons with an ex-vessel value of 6,248 million Kenya shillings (KNBS, 2022). This was an increase of 6% in quantity and 10% increase in value compared to 2020 figures of 25,741 metric tons with an ex-vessel value of 5,662 million Kenya shillings (Table 3). In 2021, Demersals dominated artisanal marine fisheries catch accounting for 48% (12,264 mt) of the total landings. Pelagics contributed 20% (5059 mt), miscellaneous catch accounted for 10% (2,565 mt), Crustaceans contributed 8% (1,945 mt), and Sharks and Rays and sardines accounted for 14% (3,547 mt) (Figure 15).

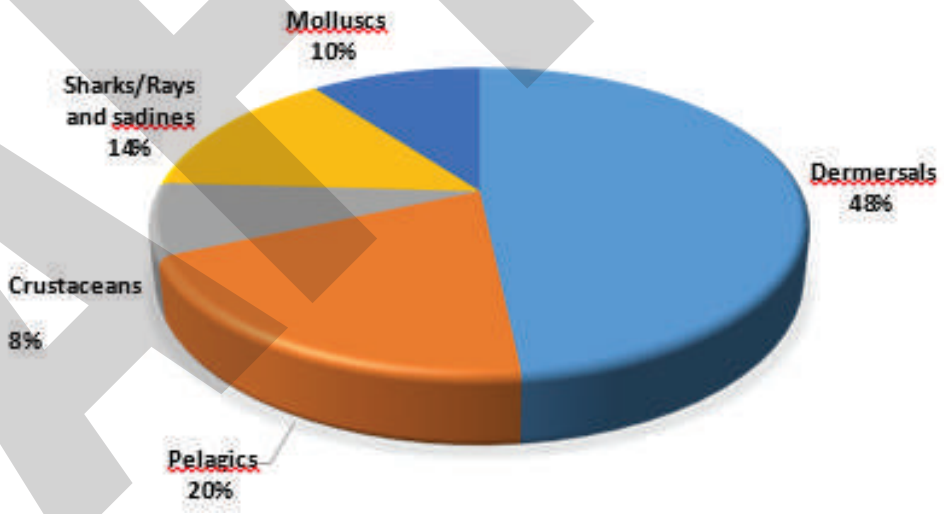


Figure 39: Percentage contribution of marine fish species groups by 2021

In 2021, Kwale county contributed the highest quantity of marine artisanal landing (10,106 mt - 39.8% of the total landings) with an ex-vessel value of Ksh.1725 million. Lamu county contributed 6,089 mt (24%) with ex- vessel value of Ksh1,048 million. Kilifi County with 4592 mt (18.1%) with ex- vessel value of Ksh.1,096 million (Figure 40). Mombasa contributed 2,966 mt (11.7%) with ex-vessel value of Ksh.1,356 million with Tana River County contributing the least (1626 mt- 6.4%) with ex-vessel value of Ksh.264 million (KeFS, 2022).

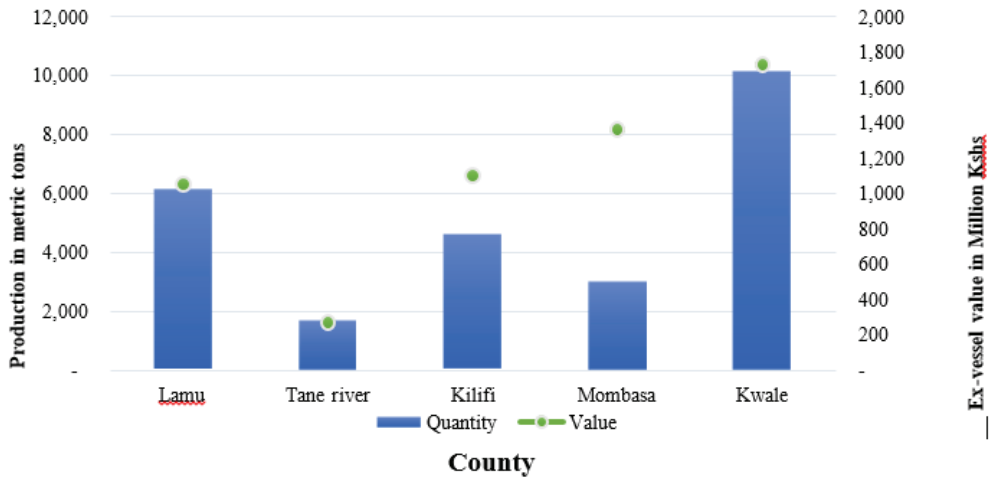


Figure 40: Marine fish production by Quantity, and Value by Counties by 2021

Industrial Fishing Grounds

Fishing areas for the industrial fishery is monitored through the Vessel Monitoring System and the logbook data. From the available data, most industrial vessels preferred the rich inshore marine fishing grounds around Lamu Archipelago, Ungwana Bay and Malindi Bank (Figure 17). This area is where the south flowing Somali Current meets the north flowing East African Current during

the Northeast Monsoon season (November to March) causing up welling and enrichment. The area is also where two major Kenyan rivers Tana and Sabaki/ Athi/Galana empty into the sea bringing enrichment from the land. It is in these areas that prawn trawling is majorly undertaken and where trawling surveys in the past have yielded reasonable catches of demersal fish. It was however noted that not much fishing was done in the North Kenya Bank which has been rich in fish in the past (KeFS, 2022).

Longline fishing is mainly observed in the Kenyan EEZ, Tanzanian EEZ and to some extent in the high seas. There was no activity observed in the area next to the Somali EEZ. The situation is similar to last year's situation. Pot fishing was also mainly undertaken off Kilifi and mainly on the southern waters off Kilifi. The spatial extent of fishing was mainly below 30 nm (KeFS, 2022).

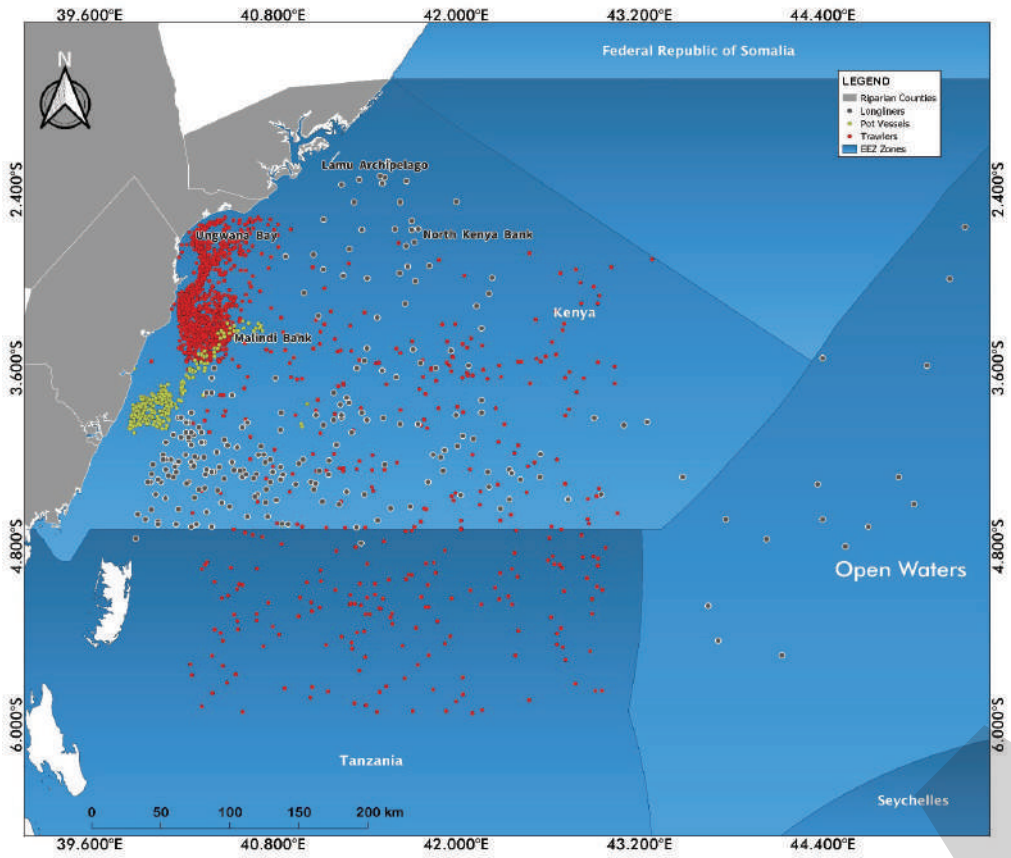


Figure 41: Map showing the Kenyan coastline, riparian counties and fishing ground data for the year 2021

Marine cage culture suitability

Cage culture suitability and exploitation in the ocean as of recent not picked up despite thriving and continuing trials of other culture systems such as seaweed and crab farming. However, the best scientific evidence available point to the need to assess the hydological nature of the ocean in relation to the potential of cage culture farms. This is because oceans have strong currents that require firm infrastructure to sustain their longevity. Preliminary suitability mapping indicates the suitability of cage culture to occur at depth of 10 – 16 m but with best management and engineering practices (Figure 42).

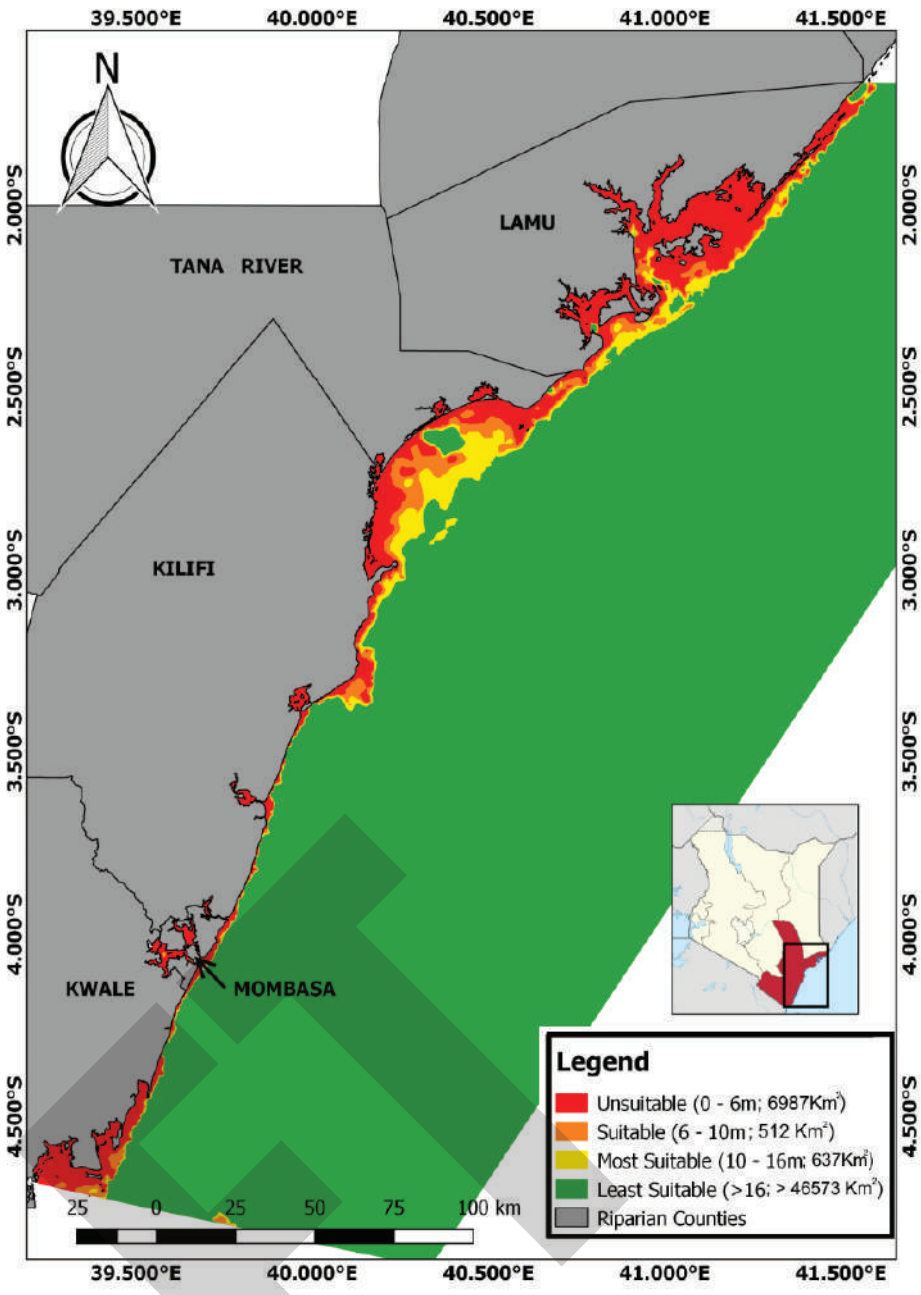


Figure 42: Proposed preliminary potential of cage culture suitability in Kenyan marine waters.

Threats and challenges in Fisheries and Blue Economy development

Kenya's Fisheries and Blue Economy sector development faces several threats and challenges that require appropriate action. These challenges include but not limited to the following:

Declining fish stocks

Fish stocks in Kenyan inland water bodies and shallow inshore waters of the Indian Ocean have been declining over time as stated earlier due to overexploitation owing to excessive increase in fishing effort, destructive fishing practices, pollution, inadequate enforcement of regulations and environmental degradation.

Limited domestic capacity for deep sea fishing

The artisanal fishers in the marine waters have concentrated their fishing activities in the near shore areas using simple gears and vessels due to limited skills and financial resources. This hinders them from venturing into semi-industrial and industrial fisheries in the deep waters. Scientific data indicates that there is a huge potential for investment in deep sea exploitation and investments. However, there is inadequate domestic investment in deep sea fishing.

Low aquaculture development

Kenya enjoys a competitive advantage for aquaculture in terms of access to diverse fresh and marine water resources that include ocean waters, springs, wetlands, rivers, water reservoirs and other temporary water bodies. The country's vast water system and diverse climatic conditions favours the farming of a wide variety of cultured fish species and can be used for large scale production. Yet, increased production has been hampered with inadequate supply of certified quality fish seeds (fingerlings) and low cost-high quality feeds as well as exorbitant transport cost of inputs for the smallholder fish farmers. Apart from these, poor aquaculture extension service delivery due to inadequate funding has led to poor information dissemination and slow adoption of appropriate aquaculture technologies. Other impediments include inadequate management skills, technical know-how and access to reliable and timely information despite the recent dramatic growth in the telecommunication

and mass media. The above challenges have resulted in continued stagnation of aquaculture development in Kenya despite the existence of potential and favourable macro–economic and environmental conditions for growth.

Pollution of the aquatic environment

The aquatic environments in Kenya face serious threats from agricultural, industrial, and municipal pollution arising from the developments around the basins. Pollution limits the productivity of the aquatic ecosystems and is also a threat to food security, human health, and environmental safety.

Threat to biodiversity

There are several threats to biodiversity facing aquatic ecosystems in Kenya such as invasive species, trophic imbalances, loss of habitat and fragmentation, anthropogenic forces, and climate change. Such threats have led to decline in species diversity and ecosystem functionalities which lead to declined yields and increased economic loss.

Inadequate marketing and value-chain infrastructure

The Blue Economy stakeholders are compelled to sell their products at prices dictated by the buyers as they fear losses. Lack of well-developed marketing facilities, un-functioning supply chains and market information systems both in rural and urban areas have caused distortions. In addition, inadequate marketing, and value-chain infrastructure particularly an undefined cold and dry chains are an impediment to fisheries and aquaculture development and growth in the country.

Low value addition

Value chains in the Blue Economy sector have not been properly mapped and explored. Thus, the bulk of Kenya's fish and fishery products are marketed without much value addition due to low investments in micro-processing. This is occasioned by among other factors, limited access to capital, and electricity, especially in the rural areas and limited adoption of appropriate technologies for new product development and uptake of the new fisheries products and profitability.

Limited access to affordable credit and insurance

Access to credit in the Blue Economy sector has not been actualized. Affordable credit is critical in ensuring increased production and productivity from capture fisheries and aquaculture enterprises. Major constraints to small-scale fish farmers and fishers are access to credit to finance procurement of inputs and capital investment such as pond construction, fishing gear and value addition technologies. Furthermore, there are inadequate insurance packages to cushion the fishers and fish farmers' investments against losses in addition to regularizing credit requirements.

Fragmented legal and policy framework

The Blue Economy sector cuts across many sectors with overlapping mandates and policies such as fisheries, mining, tourism, maritime, forestry and environment. Therefore, Blue Economy has brought together players from different institutions with diverse policies that have not been harmonized. For example, in the Fisheries sub-sector, we have the Fisheries Management and Development Act, 2016 which needs more specific Blue Economy and fishery specific sub-policies for clarity in the management and development of the sector. Other fragmented policy frameworks exist such as aquaculture guidelines, regulations and freshwater policies which may require enforcement for sustainability of such systems.

Maritime Security

Research and maritime activities have been hampered by insecurity in the Kenyan water bodies. This has come up because of conflicts in resource use in the Blue Economy sector occasioned by improper planning.

Cross cutting issues

The high incidence of HIV and AIDS and non-communicable diseases (NCD) among the Blue Economy stakeholders exerts pressure on the different Blue Economy resources due to its open access nature. This leads to reduced productivity, inability to venture into aquaculture, deep waters thus concentrating fishing effort in the near shores. It also affects the co-management structures already in place in addition to loss of acquired skills passed on through apprenticeship.
Alcohol, drug, and substance abuse affects the health of people thereby reducing their productivity and outputs from the Blue Economy sector. This may also lead to illegalities in utilization of resources in the Blue Economy sector to support the addiction. Therefore, the eminent challenge of a poor saving culture with limited re-investment along the value chain within the Blue Economy sector is perpetuated.
Natural calamities and pandemics have been documented to disrupt Blue Economy activities and functionalities, thereby reducing production and productivity in the sector. A case in point is the occurrence of COVID - 19 which led to restriction of movements that minimized trade of Blue Economy commodities. Other natural calamities that have been known to affect the sector include flooding, and drought and famine.

Climate Change

Owing to the high global population, there are huge carbon emissions to the environment that triggers climate change associated impacts (IPCC, 2022). Thus, climate change is a big threat to sustainable economic development across the globe due to its manifestation in increased water temperatures, flooding, upwelling, fish kills, shrinking of critical habitats, ocean acidification, loss of biodiversity and productivity. All this compounded significantly impact food security production systems.

Policy Statement

The following policy recommendations are made for action:

- Need to carry out re-valuation of fisheries production under blue economy for socio-economic development – to get true worth of the Blue economy resources.
- Having Blue Economy Satellite Account to allow for the economic measurement of the potential and real impact of Blue Economy activities and thereby assist with implementing sustainable strategies.
- The huge underutilized production potential of small fish could be realized with proper policy attention as well as public and private investments. There is room for diversification of production systems and improved value chains through investments in commercial, technologically advanced and professionally managed chains focused on scale, next to and including a shift to nutrition-sensitive fisheries policies aimed at improving the existing, thriving, African small fish chains.
- Implementation of the Ecosystem Approach to Aquaculture (EAA) to facilitate sustainable utilization of water resources.
- Need for a stock rebuilding policy for the fisheries resources that is economically efficient, socially responsible and environmentally beneficent.
- The Kenya Government may explore ways to optimize economic benefits from underexploited stocks. For example, Lake Turkana fisheries which has an estimated potential of 30,000 mt and the Exclusive Economic Zone (EEZ) which has an estimated potential of between 150,000 and 300,000 mt.
- It is important to take cognisance of the key role that indigenous knowledge play in developing innovations that will be socio-culturally acceptable and within the economic context of local fishers and farmers.
- Investments in the sustainable exploitation of non-extractive ecosystem services such as the aquarium trade, recreational fisheries, eco-tourism, and the development of nutritional or medical bioactive compounds and industrial materials should be adopted to boost the Blue Economy agenda.
- There is need to facilitate access to appropriate funding to support strategic funding to support vital initiatives that catalyze the delivery of national outcome and impacts of the blue economy.
- There is need for harnessing the demographic dividend to ensure substantive categories of the population participate in blue growth.
- There is need to undertake prioritization of fish safety, quality, post-harvest interventions and trade.
- There is need to catalyze research in renewable energy and deep ocean water applications.
- There is need to have deliberate inclusive conservation efforts to curb plastic pollution/ marine litter and to convert the plastic waste into valuable products for socioeconomic development.
- Further research could focus on oceanic studies to be strengthened through stronger integration of science, and greater investment in Technology and Innovations (STI) to transform lives

Caption to be updated here

CHAPTER

03

BIODIVERSITY RESOURCES

FOREST RESOURCES

Introduction

Forests are defined as land spanning more than 0.5 hectares with trees of at least 2 meters and a minimum canopy cover of 15%, and include natural and planted plantation forests on state, community and private land. Perennial tree crops like coffee and tea are not considered as forests under this definition irrespective of whether they meet the definition of forests. The National Forest Resource Assessment that was undertaken in 2021 indicate that Kenya has a forest cover of 8.83%. The country however has a tree cover of 12.13% which is slightly above the constitutional obligation of attaining and maintaining a minimum of 10% tree cover. Under the Special Presidential Forestry and Rangeland Restoration Programme duped "KAZI MAZINGIRA", The Ministry of Environment Climate Change and forestry has developed a National Strategy for achieving and maintaining a minimum 305% tree cover by 2032 as directed by His Excellency the President.

Kenya's forests are broadly categorized as natural forests and intensively managed plantation forests. These are further categorized by forest type and subtype. Trees planted on farms or agricultural land, although not forests per se, are also considered in the wood supply analysis, as they currently provide a substantial amount of wood and are projected to be a key source of wood in the future in rural communities. Forests are further classified into three groups based on their ownership and management characteristics as public forests, community forests, and trees on farmlands (Ministry of Environment, Water and Natural Resources [MEWNR] 2013). Public forests are government owned and are managed to provide goods and services such as water from natural forests and commercial and subsistence requirements of wood products from plantations. Because of an increased demand of environmental benefits, management of natural forests on government lands does not include production of wood—this takes place only on plantations

Forest management framework in Kenya

Kenya Forest Service (KFS) is a corporate body established under the Forest Conservation and Management Act no 34 of 2016 (henceforth referred to as the Act). The Act which was operationalized on 31st March 2017, gave the Service's mandate as "to provide for the development and sustainable management, including conservation and rational utilization of all forest resources for the socioeconomic development of the country and for connected purposes." For ease of administration and management, KFS' operations are devolved. The Service has its presence both at the National, Regional Forest Conservation areas, County Forest Conservation areas and the forest stations.

The Forests Conservation and Management Act 2016 recognizes the role of communities in the management of the country's forest resources and encourages their involvement as either co-managers or contract managers of the forests. According to FCMA, 2016, communities that are the users of particular forests can be involved in the management of such forests only by forming community forest associations (CFAs). CFAs are considered as second-level community-based organizations (CBOs) formed by several CBOs with stakes in particular converging forests. The CFAs are also expected to converge and form what is referred to in the country as third-level or national organizations that can also grow to become nongovernment organizations (NGOs), capable of raising funds either locally or even outside the country.

The Contributions of Forests to National Development

Kenya's economy is strongly dependent on natural resources including forestry. The Forest sector is the backbone of Kenya's Tourism since forests provide habitats for wild animals, offer dry season grazing grounds and protect catchments that provide water downstream. Forests maintain water catchments (defined as water towers) which support agriculture, industry, horticulture, energy sectors and contribute more than 3.6 per cent of GDP. In some rural areas, forests contribute over 75% of the cash income and provide virtually all of household's energy requirements (Cheboiwo et al., 2018). It is estimated that economic benefits of forest ecosystem services exceed the short-term gains of deforestation and forest degradation and therefore justify the need to conserve the forests.

Types of forests

The FCMA, 2016 places forest into three classes based on land tenure. These are:

Public Forests

These include public forests classified under Article 62(1)(g) of the Constitution; and forests on land between the high and low water marks classified under Article 62(1)(1) of the Constitution.

Community Forests

Community forests include; forests on land lawfully registered in the name of group representatives, forests on land lawfully transferred to a specific community, forests on any other land declared to be community land by an Act of Parliament, forests on land that is lawfully held, managed or used by specific communities as community forests, forests on ancestral lands and lands traditionally occupied by hunter-gatherer communities; and forests lawfully held as trust land by the county governments, but not including any public land held in trust by the county governments under Article 62(2) of the Constitution.

Private Forests

Private forests include; forests on registered land held by any person under any freehold tenure, forests on land held by any person under leasehold tenure, any forest owned privately by an individual, institution or body corporate for commercial or non-commercial purposes, and forests on any other land declared private land under an Act of Parliament.

Whether Public, Private or community forest, forests are categorized based on whether they exist naturally or were established as a result of human influence as follows:

Natural Forests

Natural forests are diverse and comprise a wide range of forest ecosystems that are categorized into montane forests, western rainforests, coastal forests, and dryland forests. Montane forests are located in the central and western highlands and on mountains along the Ugandan border, rainforests are located in western Kenya, and coastal forests and dryland forests are located in the coastal region, and in the arid and semi-arid regions of the country, respectively. Natural forests, forming the majority of Kenya's closed canopy forest area, are biologically rich and contain a high concentration of endemic plant and animal species. They are managed by KFS, with some areas managed as national parks and game reserves by the Kenya Wildlife Service (KWS), while a smaller area falls under the authority of local governments (GATSBY Charitable Foundation 2014). Montane forests are the most critical in providing clean water to Kenya. Mount Kenya, Aberdare Range, Mau Forest Complex, Mount Elgon, and Cherangani Hills (MENR 2016) are the primary montane types and are popularly known as the ''Five Water Towers.'' They are dominated by two major subtypes, mixed indigenous forests and bamboo dominated forests.

Plate 17: Closed canopy Natural forest within Mt. Kenya Forest Ecosystem

Forest plantations

Forest plantations are categorized as state-owned plantations or private forest plantations. State-owned plantations cover an approximate area of 136,000 hectares. The predominant species are Pines and Cypress (86%), Eucalyptus (10%), and the rest are indigenous hardwood and softwood plantations (Food and Agriculture Organization of the United Nations [FAO] 2015). They are managed by KFS for the production of sawlogs, pulpwood, and transmission poles and in total, they produce about 2,181,400 m3 of wood products annually. Private forest plantations are estimated to cover about 100,000 hectares spread across the country. They are predominately fast-growing Eucalyptus species grown

to provide posts, transmission and building poles, sawn timber, fuelwood, and charcoal. The tea and tobacco industries are among the leading investors in fuelwood plantations to dry their products.

Plate 18: Industrial forest plantations within the Mau Forest Ecosystem

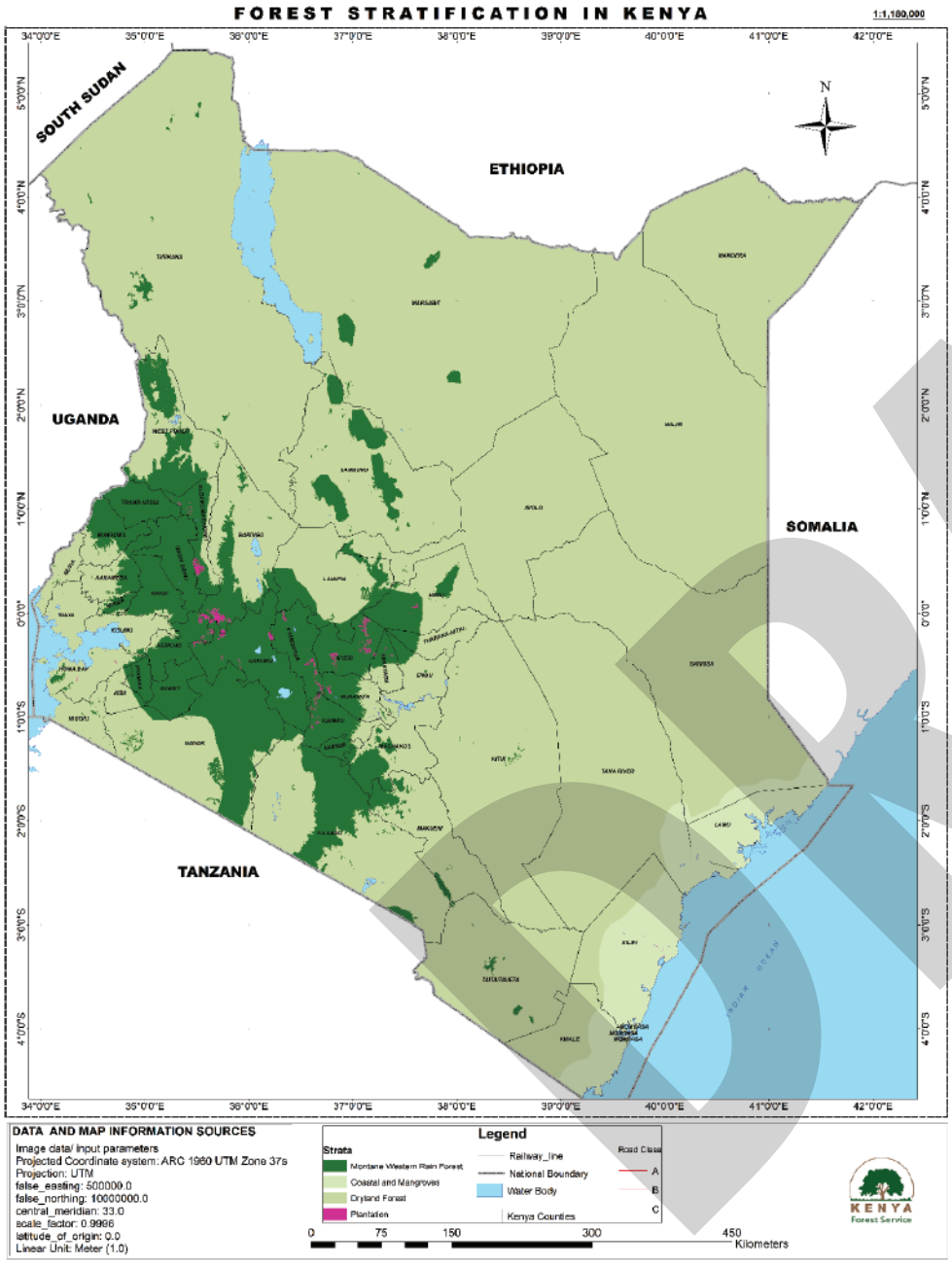


Figure 43: Forest Strata in Kenya

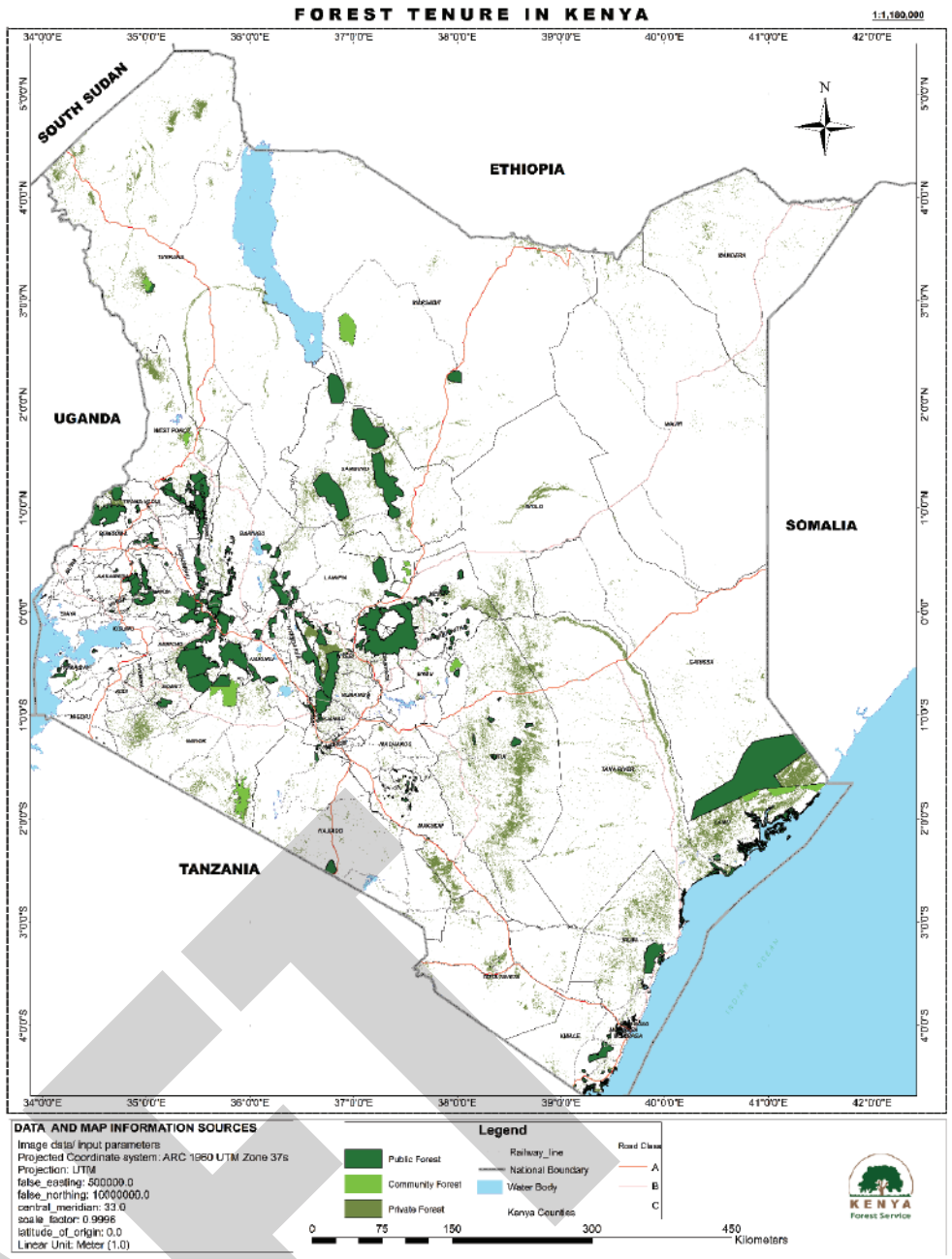


Figure 44: Forest Classes based on land tenure

Status of the National Forest and Tree cover

Kenya has been keen on mapping forest resources as an intervention geared towards sustainable forest management. Accordingly, the country has continuously deployed remote sensing technologies and associated platforms to generate national data on forest cover and Land Use Land Cover (LULC) maps, which have been guiding management decisions and policy formulation.

According to the Kenya National Forest Resource Assessment report of 2021, the Country has **7,180,000.66 Ha** of land area under trees and **5,226,191.79 Ha** covered by forests. These statistically represents percentage forest and tree covers of **8.83%** and **12.13%** respectively. Wooded grasslands account for the highest vegetation cover in Kenya, representing approximately **83**% of the total land area. This vegetation type is concentrated mainly in the Arid and Semi arid lands (ASAL).

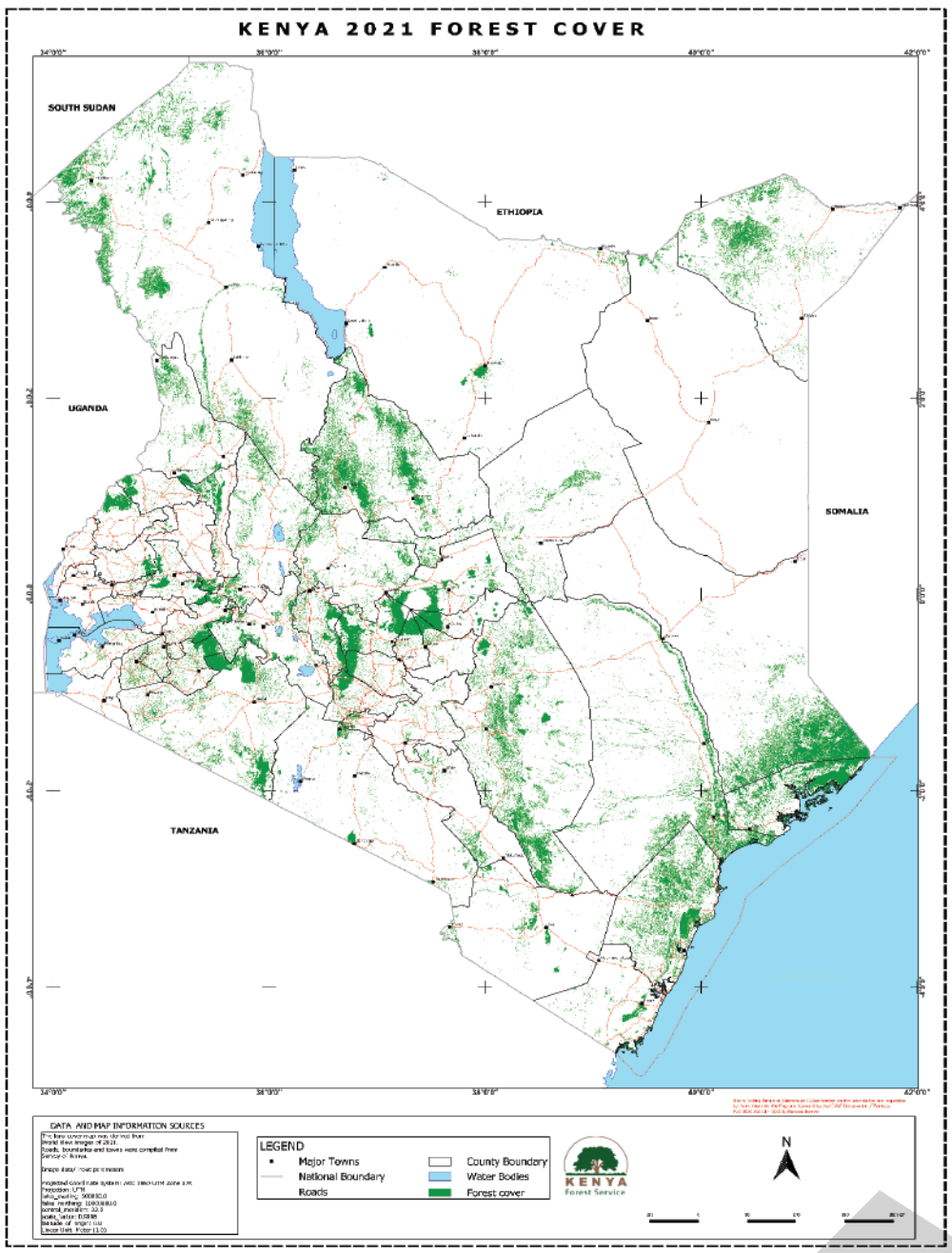


Figure 45: National Forest Cover as at 2021

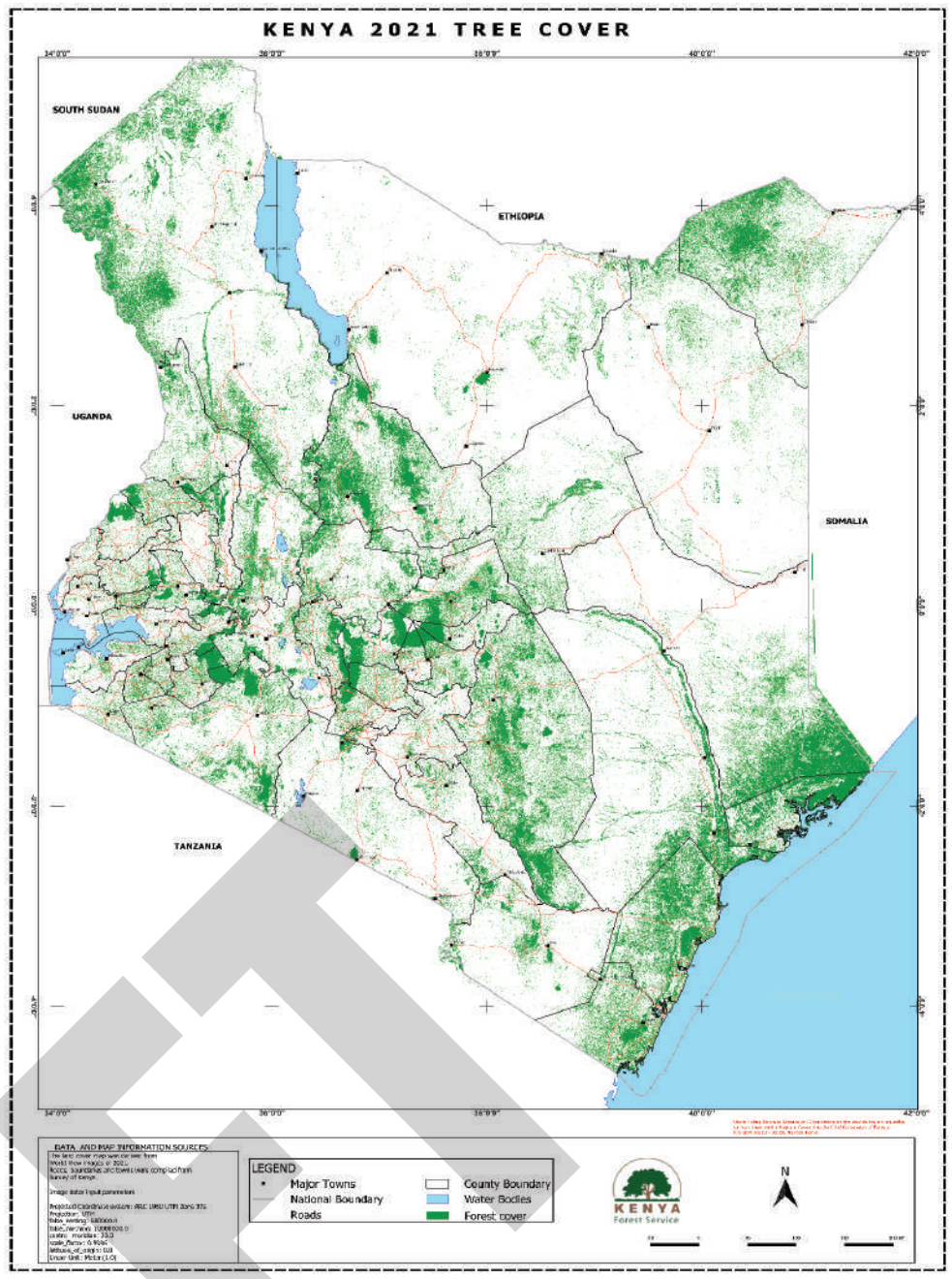


Figure 46: National Tree Cover as at 2021

Distribution and trends of forests in Kenya

Deforestation and forest degradation continue to pose significant challenges driven by among others pressure for conversion to agriculture, urbanization and other developments, unsustainable utilization of forest resources, inadequate forest governance and forest fires. The country has been experiencing sharp decline in forest cover and canopy distribution between 2002-2018 as indicated in table X below. With accelerated corrective efforts however, the trend has been changing between 2018- 2021. Worth mentioning also is the fact that the technology deployed for 2021 National forest resource assessment involved high resolution imagery. This is unlike the previous assessments where the assessments were based on low to medium resolution imagery.

Land Use Strata	2002		2006		2010		2014		2018		2021	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	area	%
Dense Forest	2,057,649	3.5	2,139,703	3.6	2,463,674	4.2	2,558,363	4.3	2,205,189	3.7	1,756,715	2.97
Moderate Forest	1,021,083	1.7	657,767	1.1	889,327	1.5	609,436	1.0	816,174	1.4	1,648,860	2.79
Open Forest	591,035	1.0	522,508	0.9	525,469	0.9	415,061	0.7	441,173	0.7	1,820,617	3.08
Total Forest	3,669,768	6.2	3,319,978	5.6	3,878,470	6.6	3,582,861	6.1	3,462,536	5.9	5,226,192	8.83

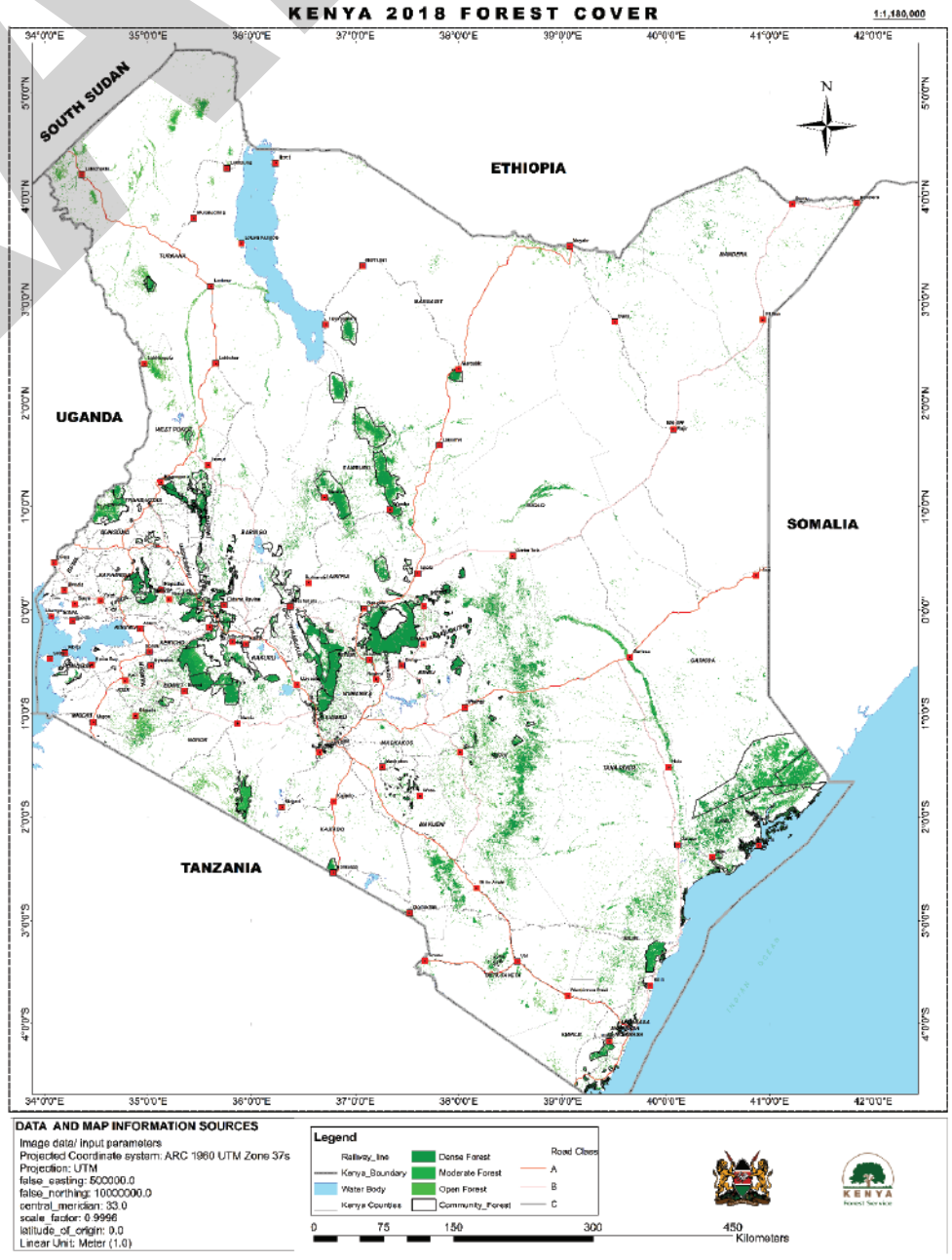


Figure 47: Forest cover map 2018

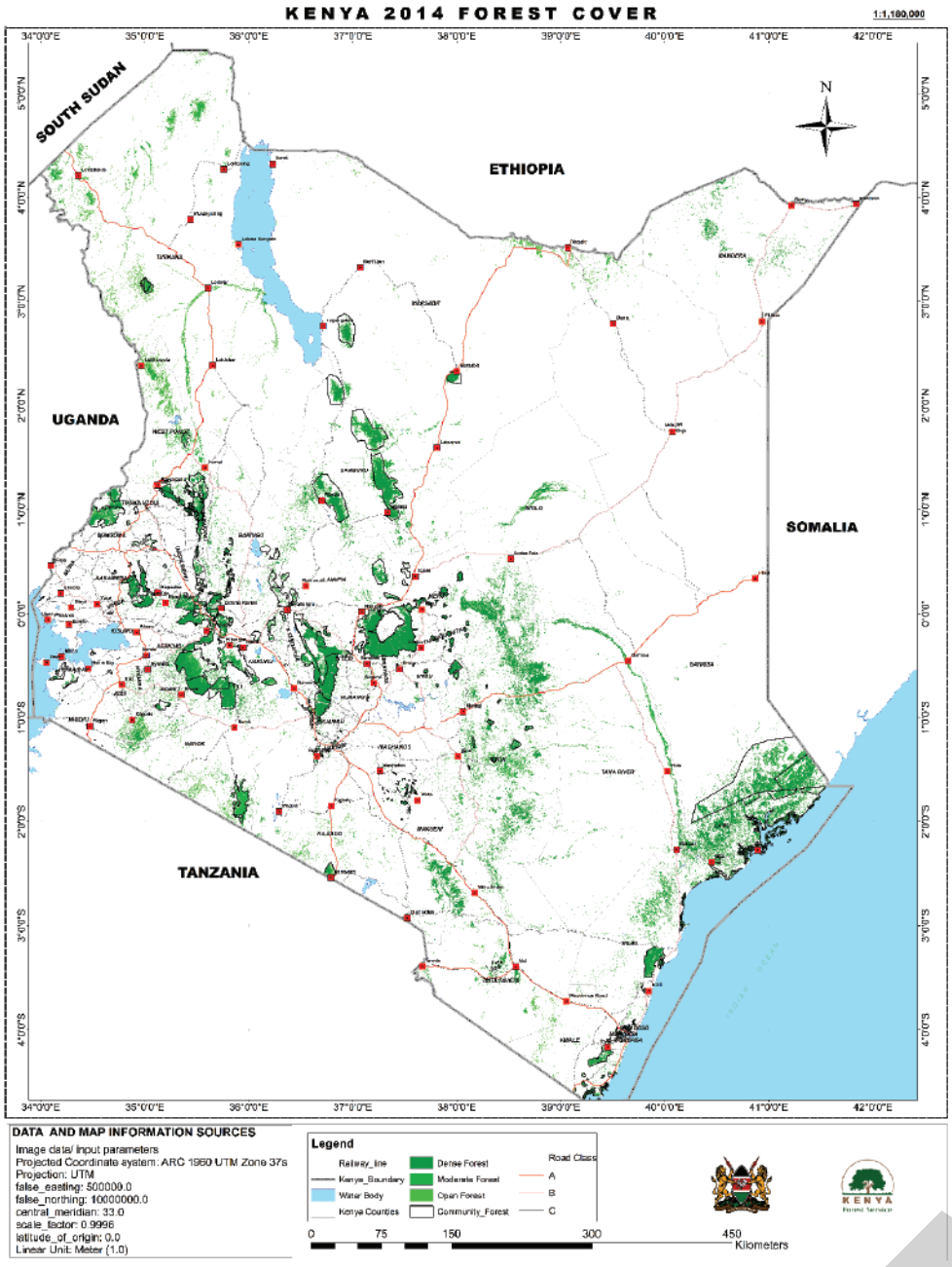


Figure 48: National forest cover 2014

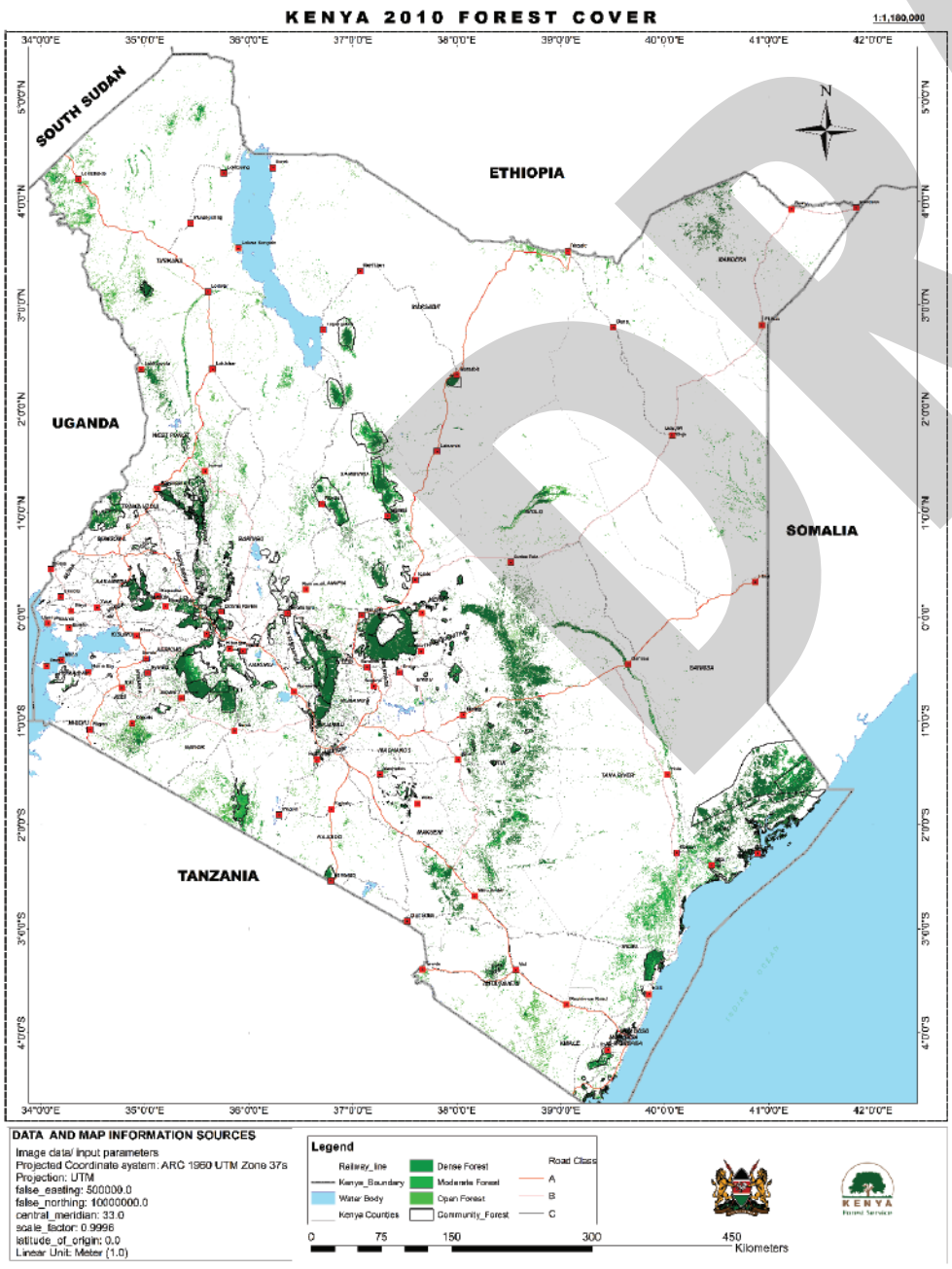


Figure 49: Forest Cover Map 2010

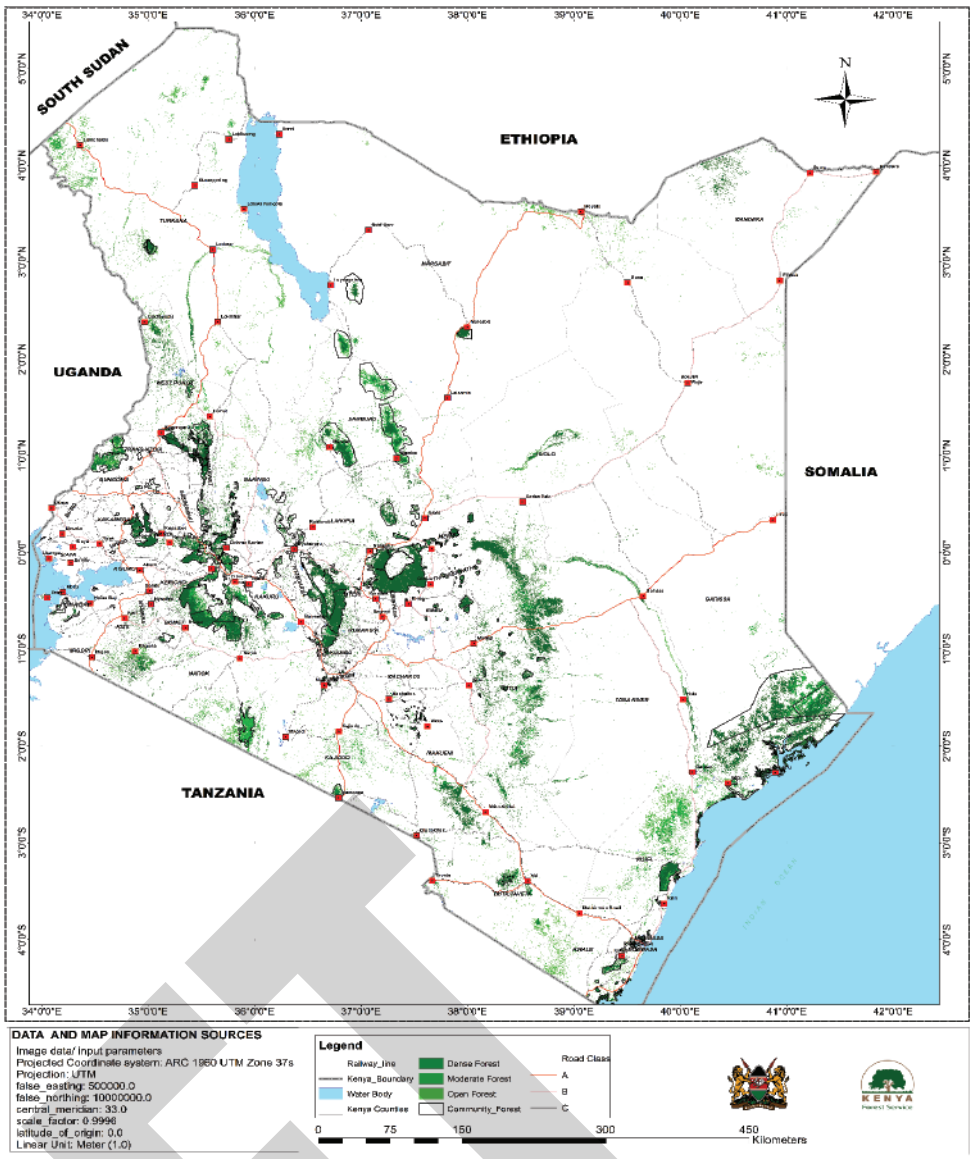


Figure 50: Forest Cover Map 2006

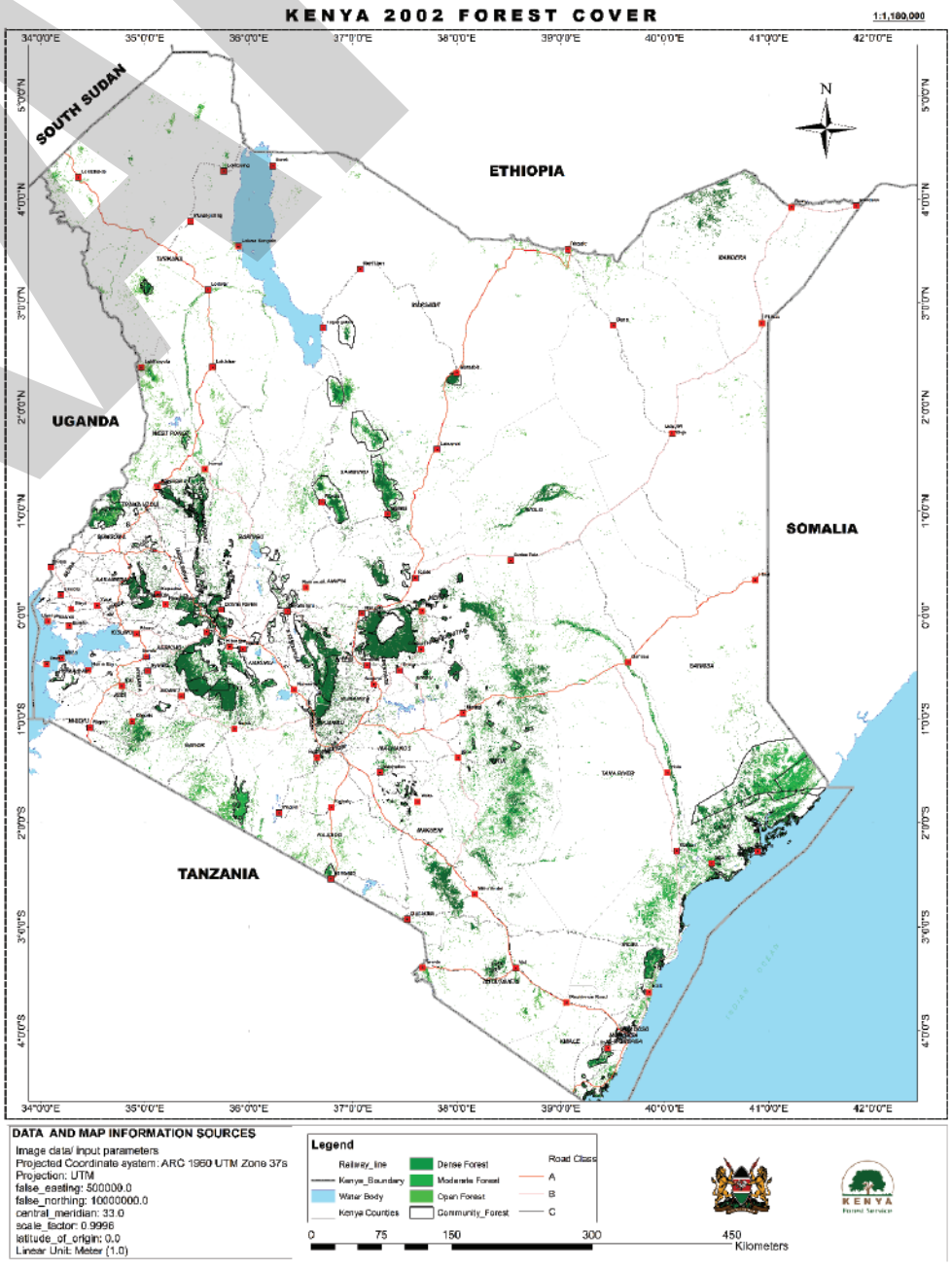


Figure 51: Forest Cover Map 2002

Critical forest ecosystems in Kenya

Kenya has a large diversity of ecological zones and habitats, including tropical rain forest, lowland and mountain forests, wooded and open grasslands, semi-arid scrubland, dry woodlands, inland aquatic, as well as coastal and marine ecosystems.

The Mau Forest Ecosystem

The Mau Forest Complex is one of the Kenya's major five water towers and is the single most important water catchment. It forms a fragile forest ecosystem which is the largest closed-canopy forest in the Country. The forest is a catchment for several rivers that drain into Lake Victoria and critical lakes and wetlands in the Rift Valley. It is also the source of the Mara River that is the lifeline for Maasai Mara National Reserve in Kenya which is the eighth Wonder of the World under UNESCO due to its unique annual migration of the wildebeests between Mara National Reserve in Kenya and Serengeti National Park in Tanzania. The MFC is also very rich in flora and fauna through the ecological services it provides, it is a natural asset of national importance that supports key economic sectors in Kenya, including energy, tourism, agriculture and water.

Kakamega Tropical Rain Forest

Kakamega Forest is known to be the eastern-most fragment of the Guineo-Congolian lowland rainforest belt, which once stretched from Kenya across Uganda, East and Central Africa to the West African coast. The ecosystem is an important watershed for some of the rivers that flow into Lake Victoria. It is valuable to the people living around it, as a source of timber, fuel-wood, herbal medicines, building materials, food, income and viewed by part of the population as new land for agriculture and settlement. Further the ecosystem services from the Forest ecosystem such as the microclimate that supports commercial and small holder tea and sugarcane farming, dairy and food production; and water supply to rural and urban centres downstream, is yet to be appropriately included in the national economic valuation.

The ecosystem is a unique sanctuary for many endemic insects, plants and birds with between 10 to 20% of the animal species in the Forest that are nationally unique. The huge variety of birds, reptiles and insects make it a specialist eco-tourism attraction for bird watchers and wildlife photographers.
The very things that make Kakamega forest important for local communities are leading to its undoing. Agriculture and settlement expansion have cleared large swaths of forest cover, as has logging. Harvesting of vegetation for medicine, such as removing the bark of African cherry trees for sale at home and abroad, is threatening both the plants themselves and the animals that depend on them.

Dryland forests

Kenya has 24.5 million ha of semi-arid dryland forests commonly called "bush lands", which are habitat to more than 70% of Kenya's wildlife. Interspersed in the drylands are pockets of mountains with higher rainfall where indigenous forests occur. Examples are Mount Marsabit, Mathews Range, Mount Kulal, Nyiro and Loima Hills. Although frequently stressed by drought, these drylands forests and the bushlands around them are rich in biodiversity and have the potential to supply marketable commodities on a sustainable basis such as gums and resins, aloe, charcoal, essential oils, silk, edible oil, fruits, honey and timber. Indeed, the drylands forests are habitats for endangered and/or vulnerable species such as the African elephant (Loxodonta Africana, VU), lions, Grevy's zebra (Equus grevyi, EN1), and the wild dog (Lycaon pictus, EN).

Figure 52: Wooded grasslands in Wajir County

The Kirisia forest is in Samburu County which is largely arid and semi-arid, dotted with indigenous forests and woodlands on hilltops and plateaus. Kirisia Forest (locally known as Leroghi) is a block of 91,452 hectares of gazetted dry upland forest reserve, covering the Kirisia Hills at an altitude of 2000 – 2200 m (Watai and Gachathi, 2003). The forest and the ecosystem around it are widely recognized as critical for maintaining the Samburu Heartland as a functioning ecosystem, and particularly its role as a key habitat for wildlife and carbon storage.
The forest ecosystem consists of 59,198 ha dry cedar/olive forest, 20,400 ha bush, 1,066 ha bamboo, 1,130 ha grassland and 150 ha plantation. Kirisia receives a mean annual rainfall of 600 – 750 mm, falling in three rainfall peaks in a year; with the driest Months occurring in January and February. It enjoys a relatively warm climate with mean annual temperature of between 24 and 33o C (Jaetzold and Schmidt, 1983)

Coastal Forests

Coastal forests are the forests of the coastal strip of east Africa (TFAP, 1989) and they are composed of mangrove forests of the salt-water coasts, the forests of the mountain systems and the lowland forest patches. The coastal forests of Kenya cover Five Counties: Lamu, Malindi, Tana River, Kilifi, Kwale and Mombasa and have a forest cover of 965,642.70 Ha contributing 0.185% of the total forest cover in Kenya (KNFRA,2021). For millennia, coastal forests have supported livelihoods both locally and regionally and played a major role as high conservation value ecosystems (Wass 1995). However, they are increasingly facing a number of threats which include a growing population and increased anthropogenic activities such as illegal logging, poaching, charcoal burning and agriculture expansion, all activities leading to increased deforestation.

Mangrove Forests

Mangrove forest constitute approximately 61,271 Ha of the total coastal forest and are heavily exploited for subsistence needs and are threatened by various infrastructure projects leading to significant losses, up to 80% in some areas. Mangrove forests are found in tidal estuaries, creeks, and protected bays along the entire coastline. Through Proclamation No. 44 of 30th April 1932, mangroves were declared government forest reserve. Under this "Gazette Notification for Mangrove Forests in Kenya" all land between high water and low water marks are described as mangrove areas. These forests are currently managed by the Kenya Forest Service (KFS) either alone; or with KWS when they fall in the marine protected area.

Kaya Forests

Coastal forests host over 50 sacred Kayas which are residual patches (from two to two hundred hectares) of once-extensive diverse lowland forest. The Kaya forests are botanically diverse and have a high conservation value and owe their existence to the beliefs, culture, and history of the nine coastal Mijikenda ethnic groups. Kayas support non-consumptive economic activities like culturally sensitive tourism. According to local traditions, the kaya forests historically sheltered small fortified villages. The sites of the original settlements, often marked by forest clearings, were maintained by the communities led by their Elders, as sacred places of ritual, and burial grounds. Cutting of trees and destruction of vegetation around these sites was prohibited the main aim being to preserve the surrounding 'Kaya' forest as a screen or buffering environment for the clearings. The Government has from 1992 gazetted a number of them as National Monuments through the National Museums of Kenya.

Forest protection and security

For effective protection of forest resources, KFS has a directorate of Forest Protection and Security established pursuant to Section 16 of the FCMA, 2016. The directorate is responsible for protection of all forests and provision of security to personnel, critical installations and equipment of the service. KFS recruits and trains forest rangers at the Forest Law Enforcement Academy (FoLEA). The rangers undergo a rigorous basic paramilitary training among other forest law enforcement courses for a period of nine months. Upon graduation, the rangers are deployed to carry out forest protection including; foot patrols, aerial surveillance, forest crime investigation and prosecution, forest fire detection and response among others.

In the spirit of participatory forest management, KFS works closely with forest adjacent communities to enhance forest protection. Community scouts operating under the umbrella of Community Forest Associations help to complement the efforts of the forest rangers. Among the roles that community scouts perform include; forest fire detection and suppression, provision of intelligence information on illegal logging and encroachment and insect pest and diseases observation.

Plate 19: Forest Rangers on routine patrol

Challenges and opportunities in forest resource conservation and management

Although efforts have been made to sustainably manage Kenya's remaining natural forests and develop a plantation-based supply for wood products manufacturers, many challenges remain. The first challenge facing Kenya's forest sector is overcoming a supply deficit of industrial raw materials as a result of unsustainable management of its forests in the last three decades. Restocking of harvested industrial plantations by KFS has been lagging behind schedule with an estimated 3,000 hectares being replanted verses more than 6,000 hectares of mature plantations harvested annually (FAO 2015).
Increasing population pressure and associated demand for agricultural land and wood products poses a great challenge to the forestry sector in Kenya. Efforts to conserve natural forests and to ensure sustainable provision of goods and services from the forests requires partnerships between local communities and KFS.

Anthropogenic activities such as mining, overexploitation of forest resources, urbanization and agriculture have resulted in loss and degradation of forests in Kenya. Conversion to non-forest uses to accommodate mega infrastructure development projects such as sea ports, air ports, railway lines and roads have impacted negatively on the forest resources.

Adverse effects of climate change remain a major threat to conservation and sustainable management of forest resources. Prolonged drought coupled with desertification present the main drawback to reforestation and afforestation efforts. Massive investment in low-cost irrigation technologies is the only way out of this situation.

Opportunities exist to improve output and returns from forestry investments. Foremost, management of forest plantations should be market-oriented. Given that Kenya's forest plantations are managed to produce multiple wood products, an integrated harvesting system from the forest to the consumer would increase efficiency and output and result in higher revenues (Ototo and Ogweno 2006).
Another opportunity to improve output is to encourage the use of climate smart energy solutions in households, which would consume less firewood and charcoal. It is estimated that this could lead to savings of up to 960,000 m^3 of wood fuel per year (UNEP 2016). This is substantial and can help to decrease the current fuelwood deficit in the country and help reverse forest degradation.
Despite the challenges, the forestry sector continues to play an important role in Kenya and has great potential to grow. There is a sizable local market for forest products as well as in the greater East African and global markets. Efforts should be tailored toward increasing forest production and improving conversion recoveries at wood processing facilities. At the end of the day, adoption of innovation throughout the forest supply chain coupled with strong enforceable government policy will move Kenya's forest sector forward.

HABITAT DIVERSITY IN KENYA CONSERVATION AREAS

The land cover as habitat for biological diversity was categorized into 10 classes by the Directorate of Resource surveys and Remote Sensing (DRSRS). These were primarily from remote sensing perspective and the classes include: Dense Forest (above 65% canopy cover), Moderate Forest (40 % to 65% canopy cover), Open Forest (15 % to 40% canopy cover), Annual Crops, Perennial Crops, Open Grasses, Wooded grass, Water body, Vegetated Wetland and Otherland. Landsat Satellite Imageries (spatial resolution 30m) were used by DRSRS to generate the land cover data. For the purpose of this work, data at 4 year interval covering 2002, 2006, 2010, 2014 and 2018 was used to generate land cover maps to show habitat diversity within 8 conservation areas in Kenya.

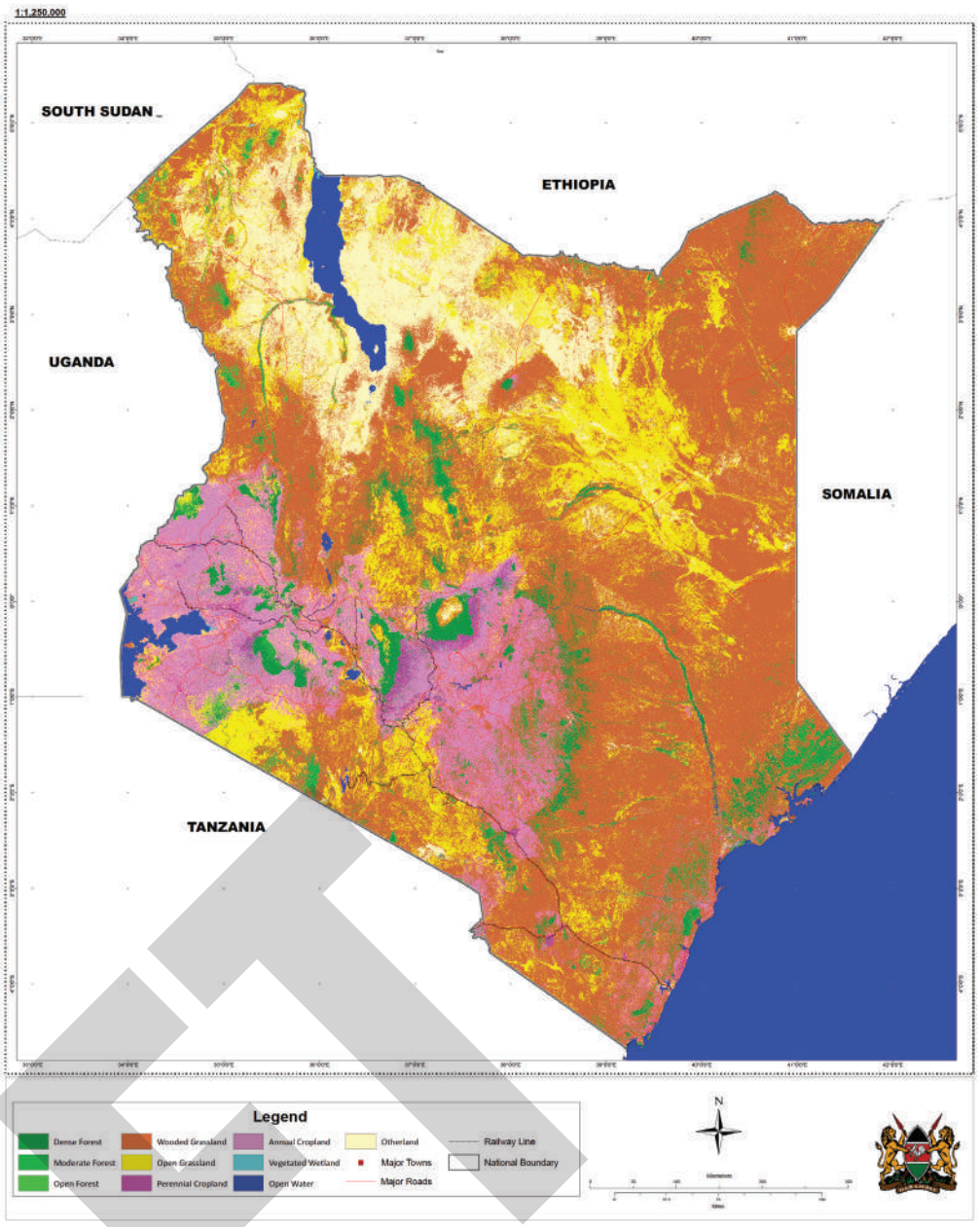


Figure 53: Spatial Distribution of Land Cover Types in Kenya in 2018
Source: DRSRS, 2018

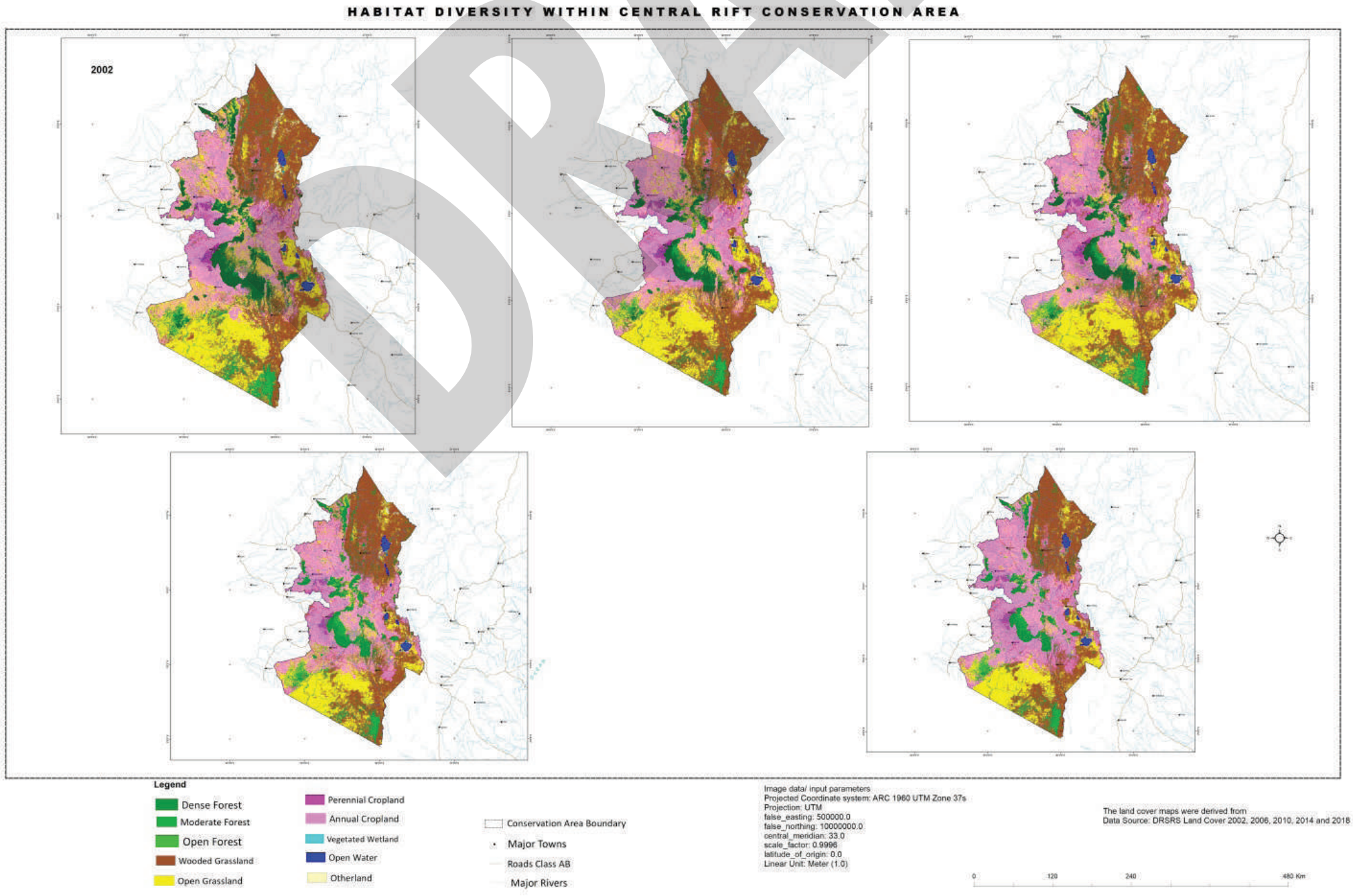


Figure 54: Habitat diversity within central rift conservation area

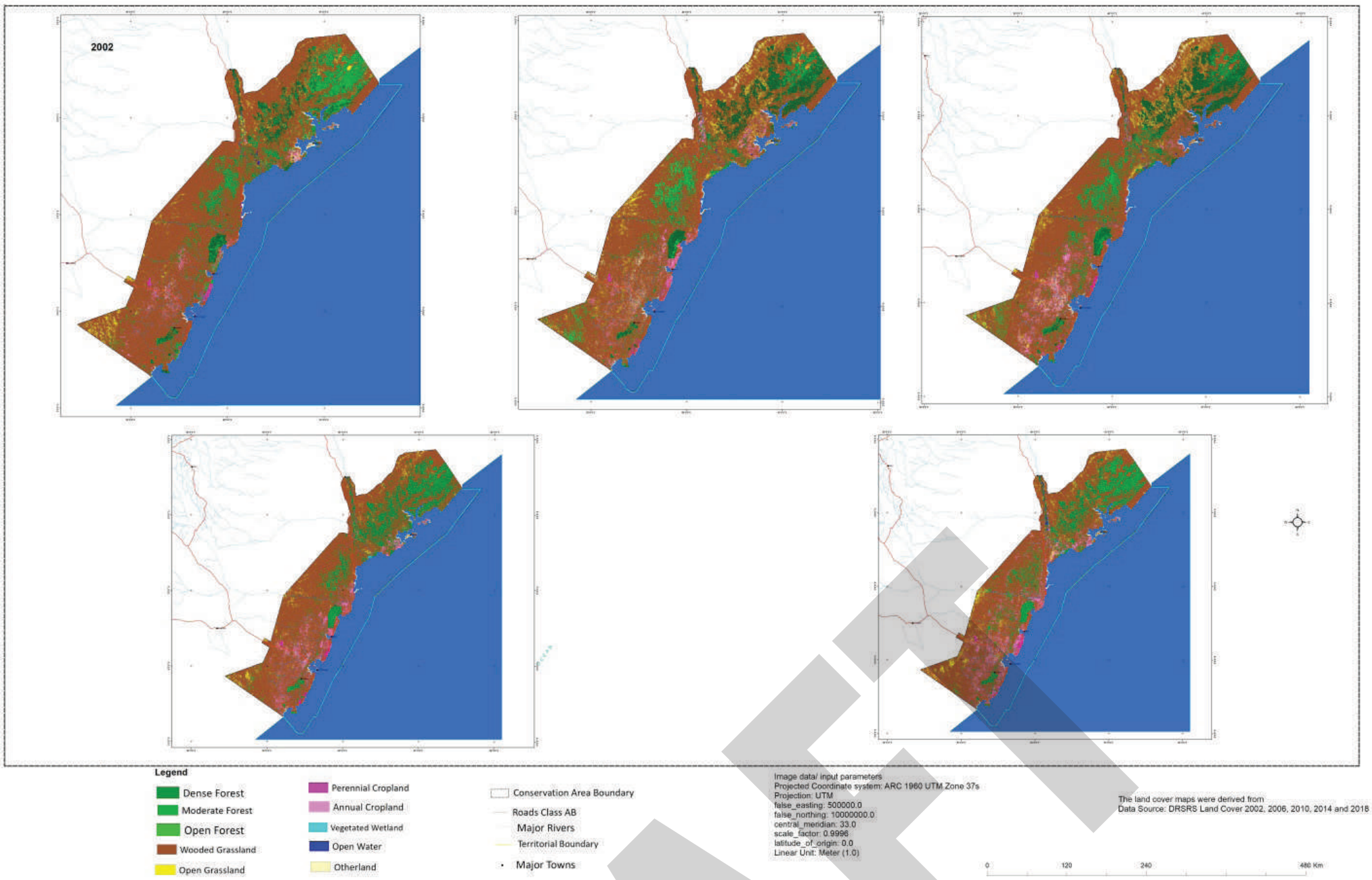


Figure 55: Habitat diversity within coast conservation area

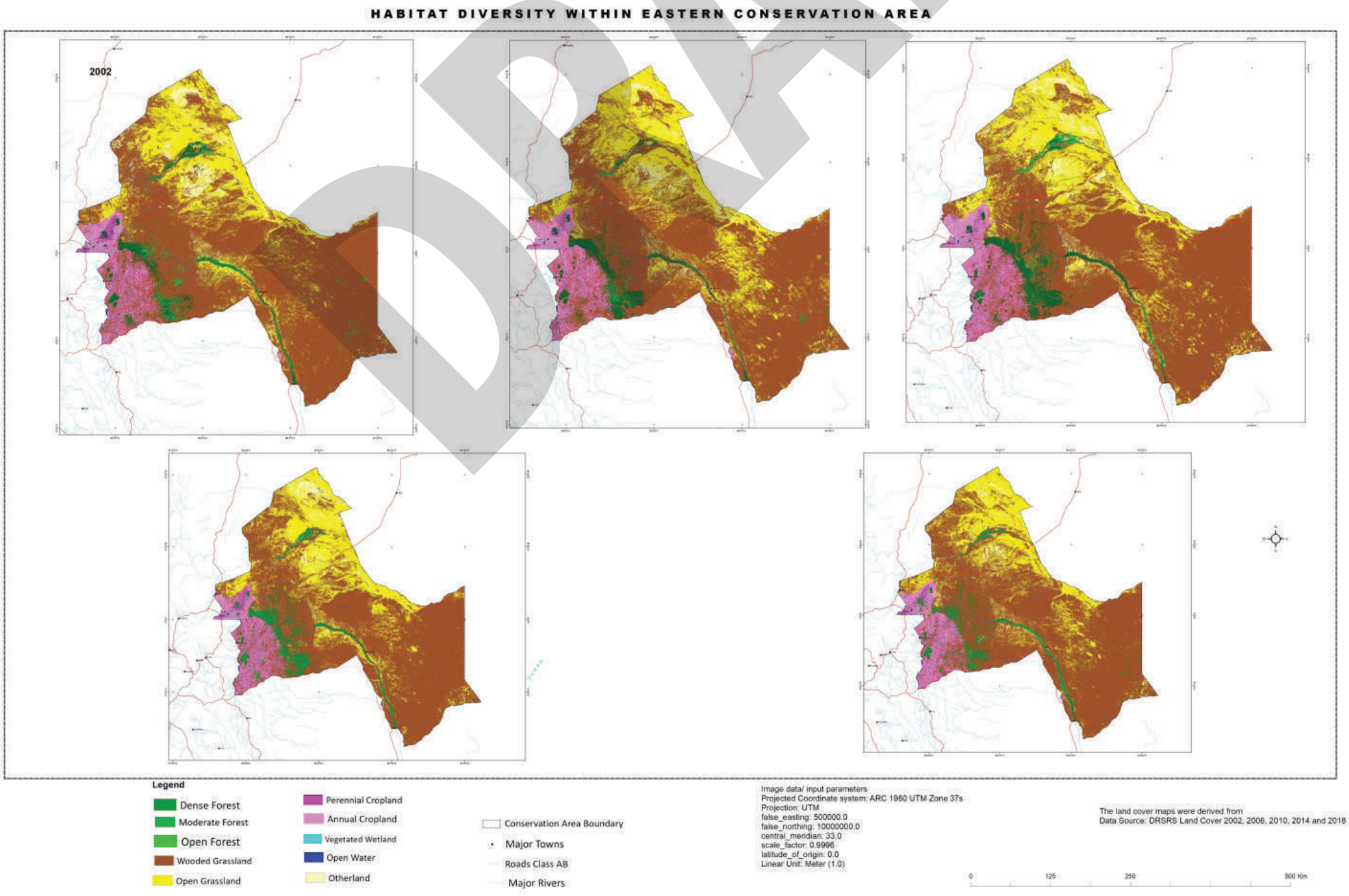


Figure 56: Habitat diversity within eastern conservation area

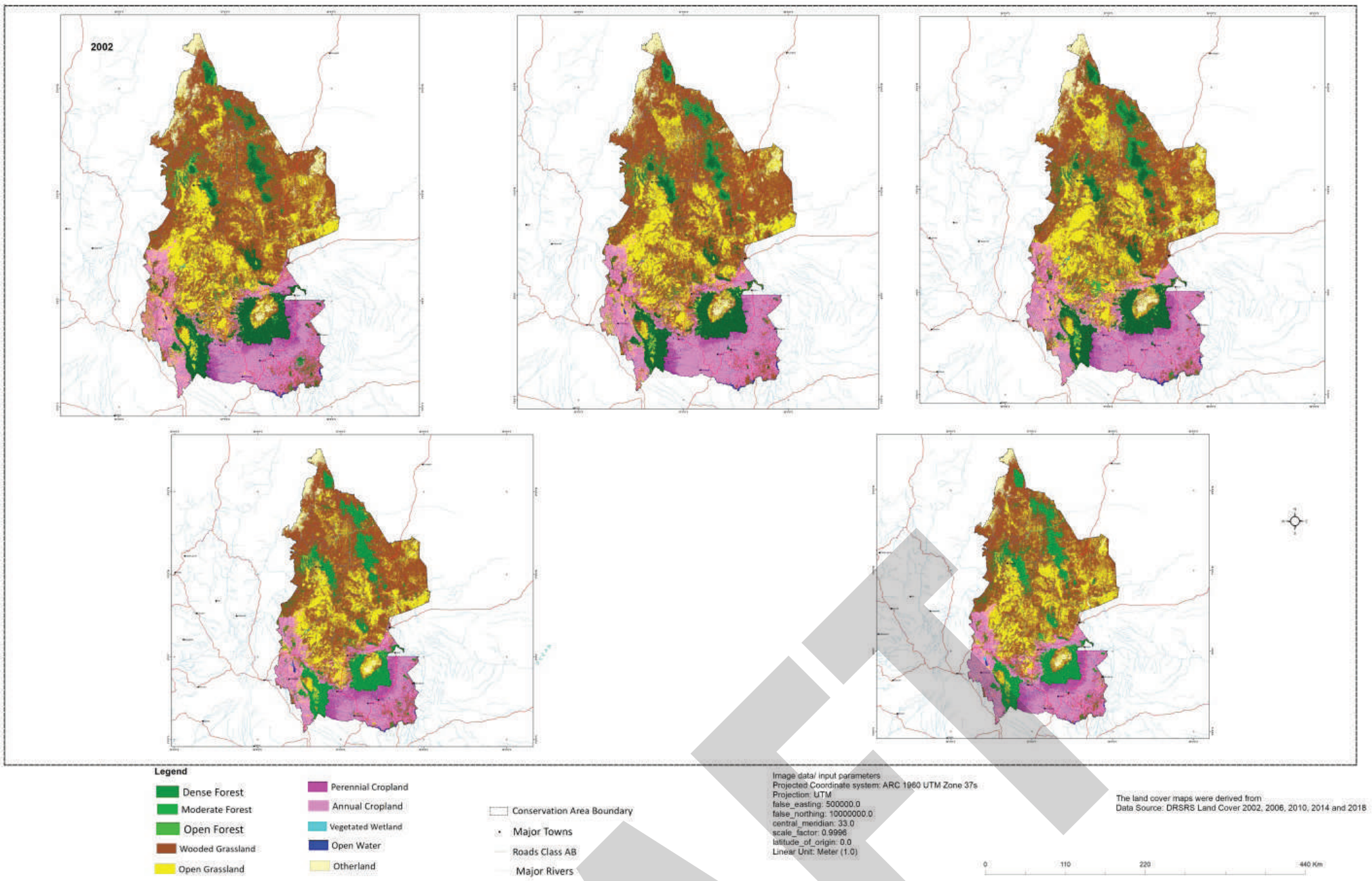


Figure 57: Habitat diversity within mountain conservation area

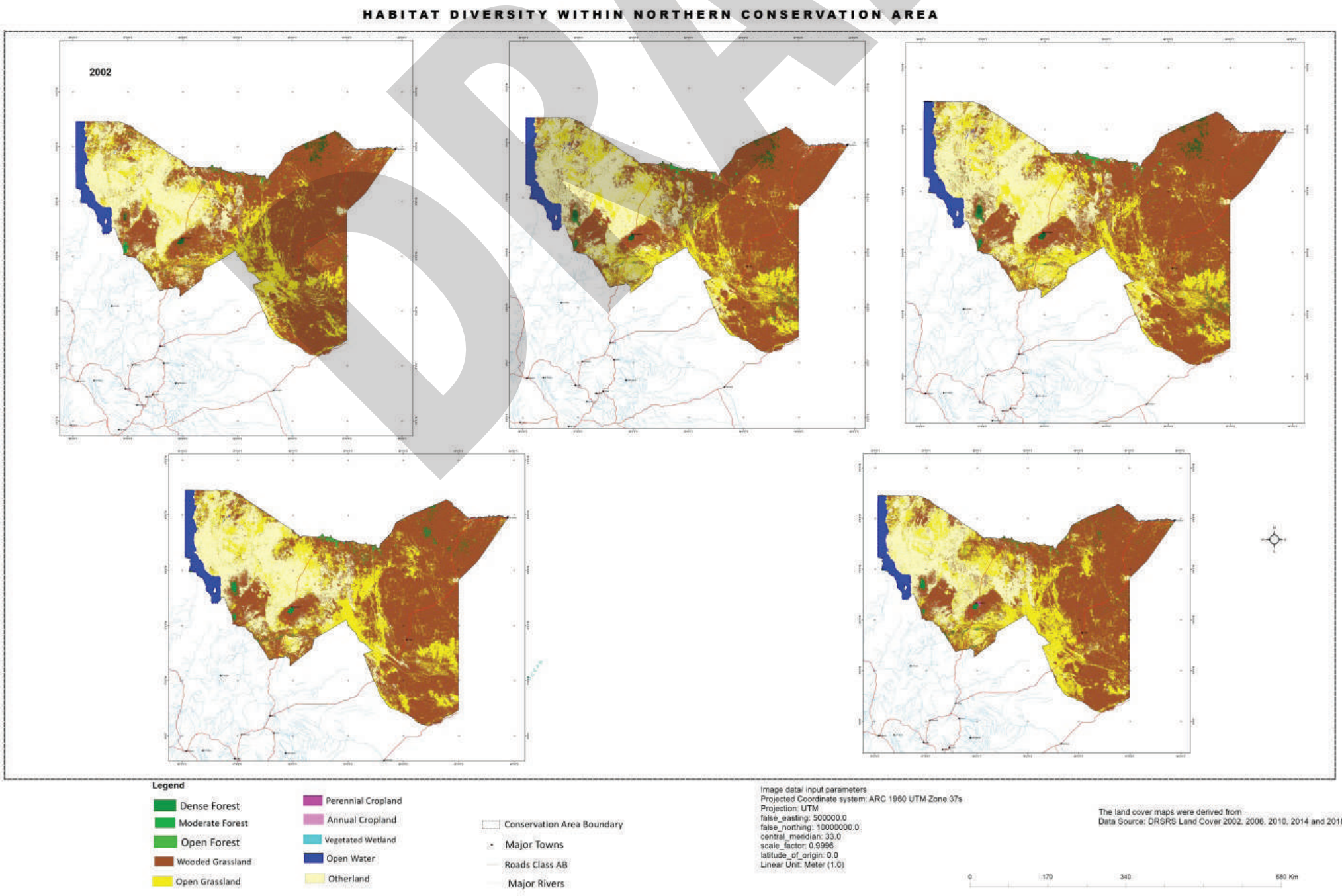


Figure 58: Habitat diversity within northern conservation area

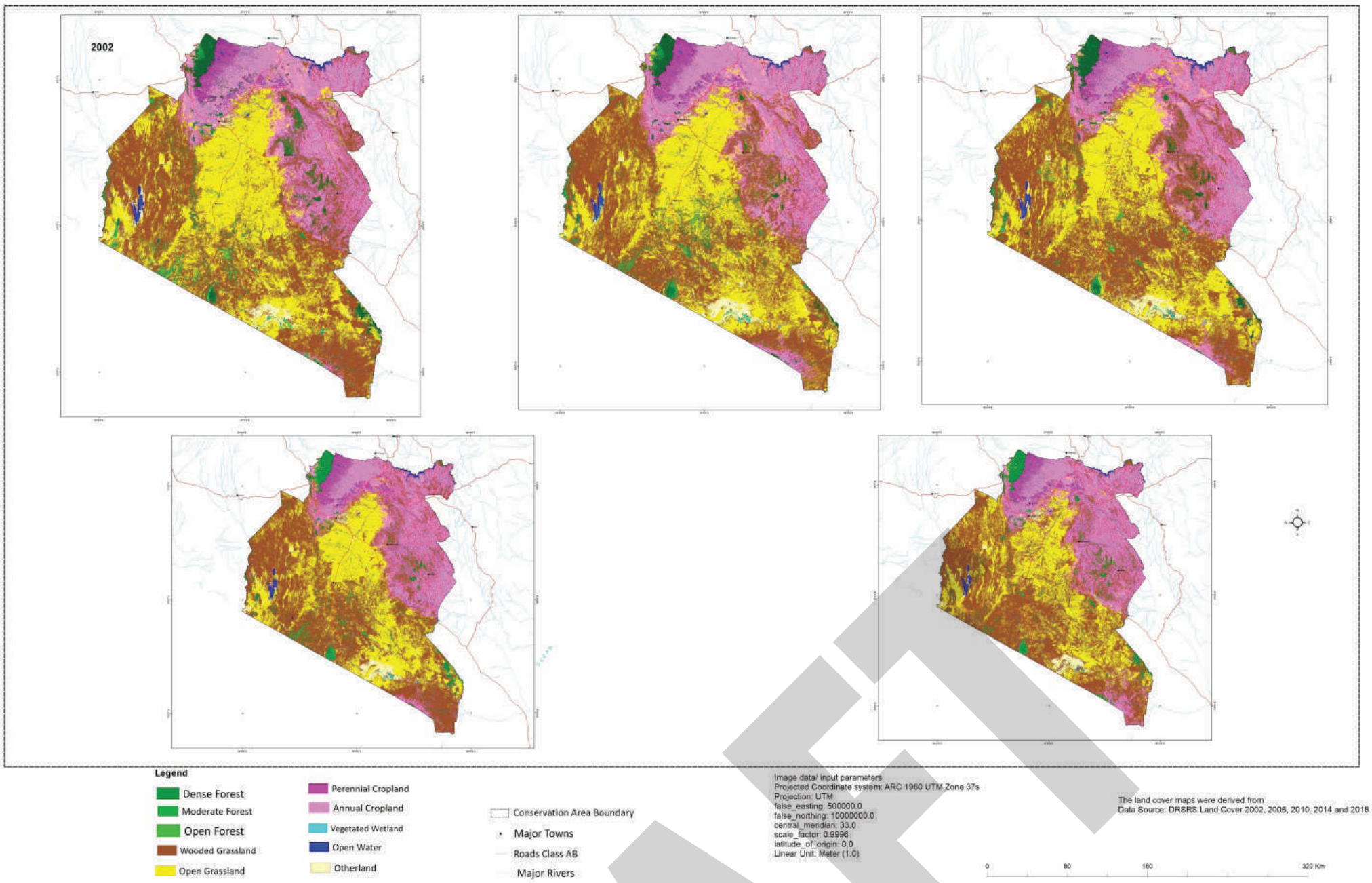


Figure 59: Habitat diversity within southern conservation area

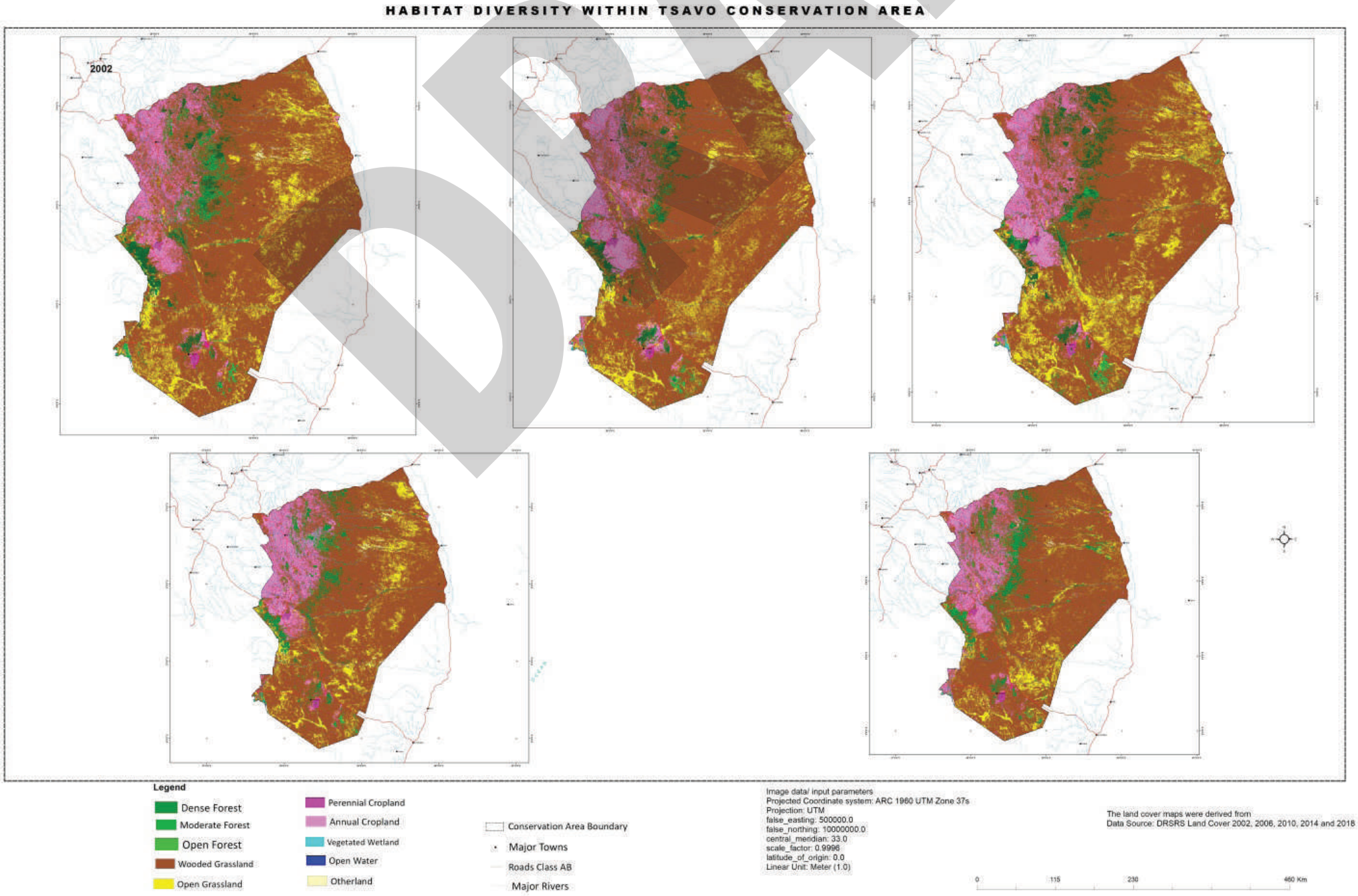


Figure 60: Habitat diversity within tsavo conservation area

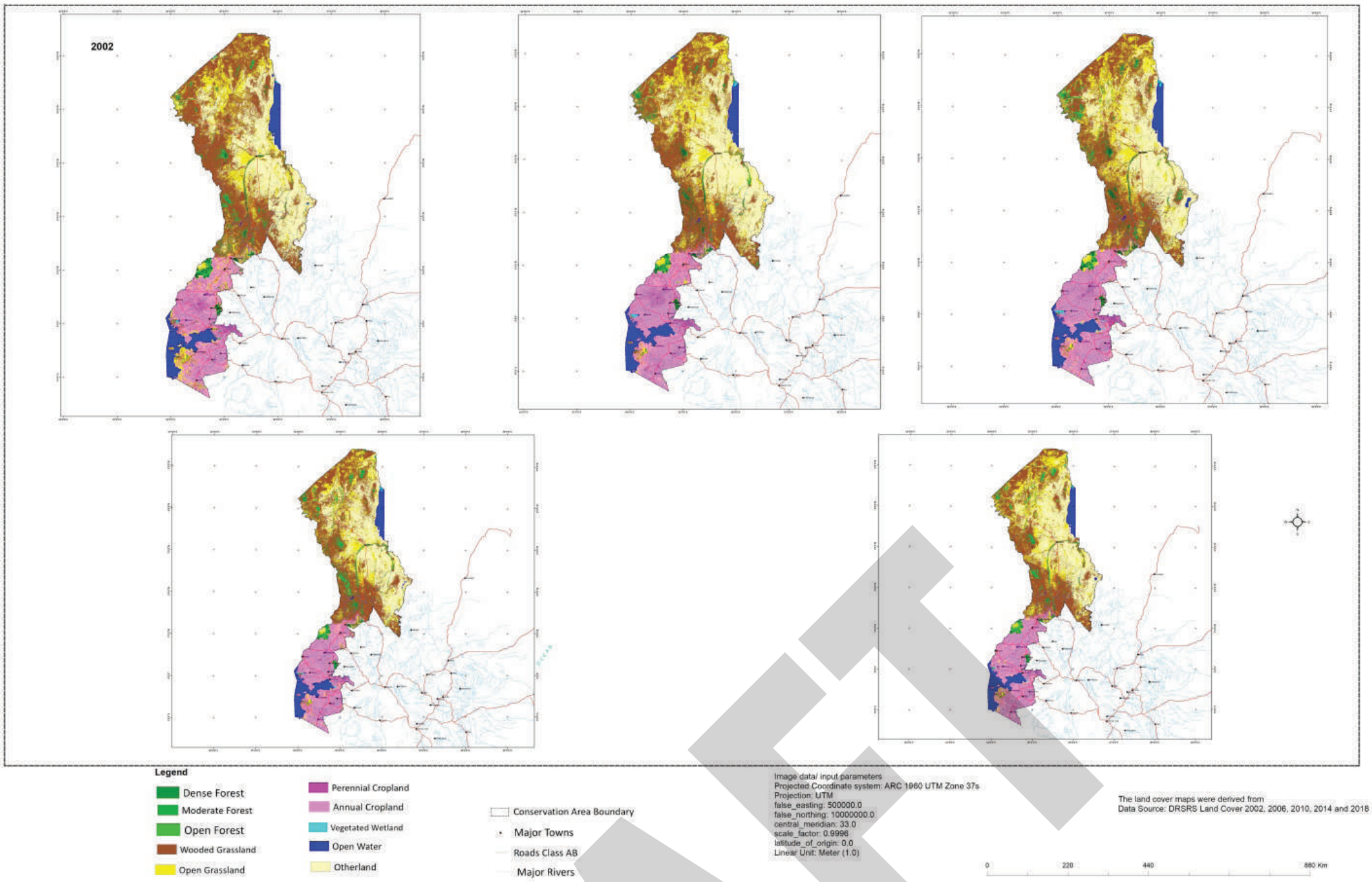


Figure 61: Habitat diversity within western conservation area

Introduction

Kenya is endowed with a high diversity habitats that support a vast variety of wildlife species. The array of these habitats include: coastal/marine ecosystems, freshwater and saline lakes, tropical montane forests, savannah plains and arid and semi-arid habitats. In terms of wildlife species, Kenya's list of species exceeds 30,000 but is far from complete due to the paucity of biodiversity surveys and collections. Such diversity of habitats and wildlife resources are indicators of healthy ecosystems and contribute to the stability and resilience of an ecosystem (Pimm & Raven 2000) which in turn contributes immensely to society through provision of ecosystem goods and services.

Wildlife resource contributes to the socio-economic well-being of Kenya through a variety of ways. Wildlife is a major tourist attraction, accounting for over 12 per cent of the Kenya's Gross Domestic Product (GDP); and provides many jobs and livelihood across the country. Moreover, Wildlife tourism has Multiplier effects in other Industries such as agriculture, horticulture, transport, and communications. Thus, improve the economic development and livelihood of the citizen. The five critical water towers namely: Mt. Kenya, Aberdare, Chyulu, Mt. Elgon and Marsabit are within the national parks. It was estimated that approximately, 70% energy sector (electricity) supply is generated from some of wildlife protected areas such Mt. Kenya, Aberdare, Hells Gate National Park and Nasolot National Reserve.

Kenya's Wildlife Diversity.

Kenya is renowned for its spectacular wildlife, the rich tapestry of its environments and ecosystems. Its dry savannah ecosystems play host to dramatic wildlife spectacles like the world-famous Wildebeest (Connochaetes taurinus) migrations of East Africa and are inhabited by flagship species such as the African Elephant (Loxodonta Africana) and the Critically Endangered Eastern Black Rhinoceros (Diceros bicornis michaeli). Kenya also has many other rare and endemic mammals: including the Endangered Grevy's Zebra (Equus grevyi), primates such as the Tana River Crested Mangabey (Cercocebus galeritus) and the Tana River Red Colobus (Procolobus rufomitratus rufomitratus), antelopes including the Sitatunga Tragelaphus spekii, Bongo Tragelaphus eurycerus and Roan Hippotragus equinus, and a variety of large cats—African Lion (Panthera leo); Cheetah (Acinonyx jubatus); and Leopard (Panthera pardus), as well as the Striped (Hyaena Hyaena hyena).
Kenya's marine waters and contiguous coastal forests are also inhabited by a variety of endangered species, including the Green Turtle (Chelonia mydas) and the Sokoke Pipit (Anthus sokokensis), respectively. This high level of species richness and diversity of habitat types has led to a number of conservation areas in Kenya being recognized as "conservation hotspots."

Wildlife Conservation in Kenya

The management and conservation of wildlife resources which broadly includes all non-domestic biodiversity that is all flora and fauna in terrestrial, aquatic, and marine habitats is spearheaded by the Kenya Wildlife Service (KWS). KWS is a state corporation mandated to sustainably manage Kenya's wildlife resources in collaboration with all conservation actors for the benefit of nature and humanity. KWS directly manages all terrestrial and marine National Parks and some terrestrial and marine National reserves in the country and performs the following nationwide conservation service: a) provision of wildlife and visitor security in all wildlife jurisdictions, b) management of human wildlife conflict, c) regulation of wildlife use and user rights, d) jointly with the under which KWS falls, formulation and implementation of wildlife policies and e) domestication and implementation to international Multilateral Environmental Agreements (MEAS) that have been ratified by the country. Other Key actors in wildlife conservation include: 1) The wildlife research and training institute (WRTI) with the mandate of conducting and coordinating wildlife research as well as training in wildlife management, 2) a number of county governments which manage National reserves and 2) the citizenry either privately and communally through wildlife conservancies and private or public ranches represented by the umbrella organization called Kenya wildlife conservancies associations (KWCA) and 3) non state corporates including local and international NGOs most of whom are members of the umbrella framework called the Conservation Alliance of Kenya (CAK).

Categories of Wildlife Conservation Areas in Kenya

National Parks

A national park under the Wildlife conservation and management act 2013 (WCMA) is defined as an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means. All National parks in Kenya are managed by the Kenya Wildlife service. There are 24 Terrestrial Parks occupying 29,504 KM2 which is 5.08% of Kenyan's land. There are also a further 4 Marine National Parks namely kisite, Watamu, Malindi, Mombasa Marine National parks occupying in total 76 Km2

National Reserves

A National reserve is an area of community land declared to be a national reserve under the WCMA 2013 or under any other applicable written law. Kenya has 31 terrestrial National Reserves occupying 17,358.8 Km2 which is 3% of Kenyan's total area. National Reserves are managed by County government with technical advice from KWS, apart from Marsabit, Mt. Kenya, Mwea, Kakamega and Shimba Hills which are managed by KWS. These Reserves are distributed in 21 out of the 47 Counties. Kenya has six (6) marine national reserves located in the coastal region consisting of Lamu, Kilifi, Mombasa and Kwale counties with a total acreage of 871km2. Diani Chale and Kiunga. Kiunga Marine National Reserve is the largest, followed by Mombasa Marine National Reserve while Mpunguti is the smallest. Malindi-Watamu Arabuko-Sokoke is approved as internationally recognized by UNESCO as Man & Biosphere Reserve (letter Réf.: SC/EES/NBC/19/KN).

Sanctuaries

A wildlife sanctuary is an area of land or land and water set aside and maintained by the government, community, individual or private entity for conservation for protection for one or more species of wildlife. There are six National Sanctuaries in Kenya located in Naivasha, Lake Elementaita, Samburu, Kisumu and Homa Bay. They cover 265.79Km2 total land.

Plate 20: Entrance gate at the impala widlife sanctuary

Sanctuaries are created for various reasons amongst them: spectacular views and abundant birdlife (e.g., Lake elementaita); conservation education and rescue centers e.g., Kisumu impala sanctuary); or due to historical reasons. Lake Simbi, Ondago swamp (in Homa-Bay County) and Maralal National (Samburu County) sanctuaries fall under the County Government jurisdiction. Maralal town has encroached fully into the Maralal Sanctuary.

Plate 21: Rich birdlife at lake elementaita sanctuary

Conservancy

A conservancy is defined in WCMA 2013 as land set aside by an individual landowner, body corporate, group of owners or a community for purposes of wildlife conservation in accordance with the act provisions of that Act. in the recent times, conservation effort has been focused on encouraging establishment of conservancies as means to gain space for wildlife and provide livelihoods to local communities. The list of conservancies is growing by the day due to conservation effort and as at December 2018, there were over 160 conservancies in the country registered by KWCA covering a total of 63,600 Km2 or 11% of Country's area. Of these conservancies, four are marine conservancies, 76 are community, 58 private and 26 are group ranches. In terms of stage of operation, there were 110 are operational, 42 emerging and 8 proposed conservancies as at December 2018. The largest community conservancy in the country is the Melako 5467Km2 (Marsabit county) followed by Malkahalaku conservancy which covers 4800Km^2 and Lokichar 4540Km^2 (Turkana County).

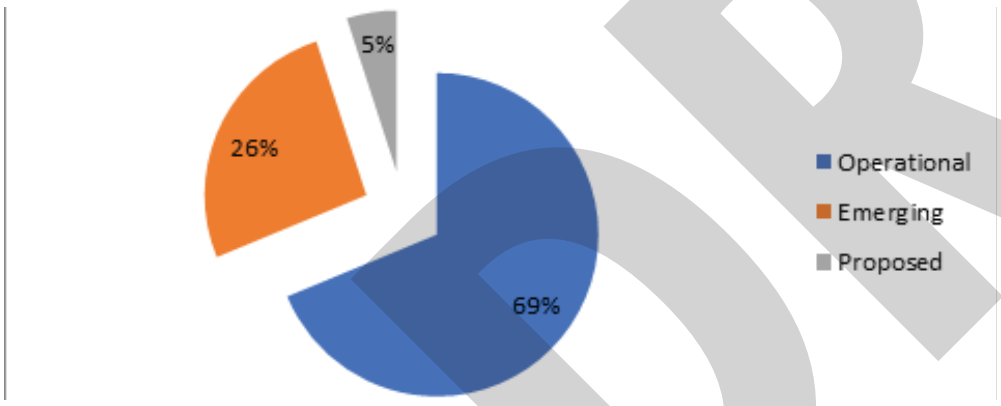


Figure 62: Locations of state designated protected areas.

Plate 22: The east african oryx is an antelope native to east africa with two sub species -the common beisa oryx pictured here and the fringe eared oryx.

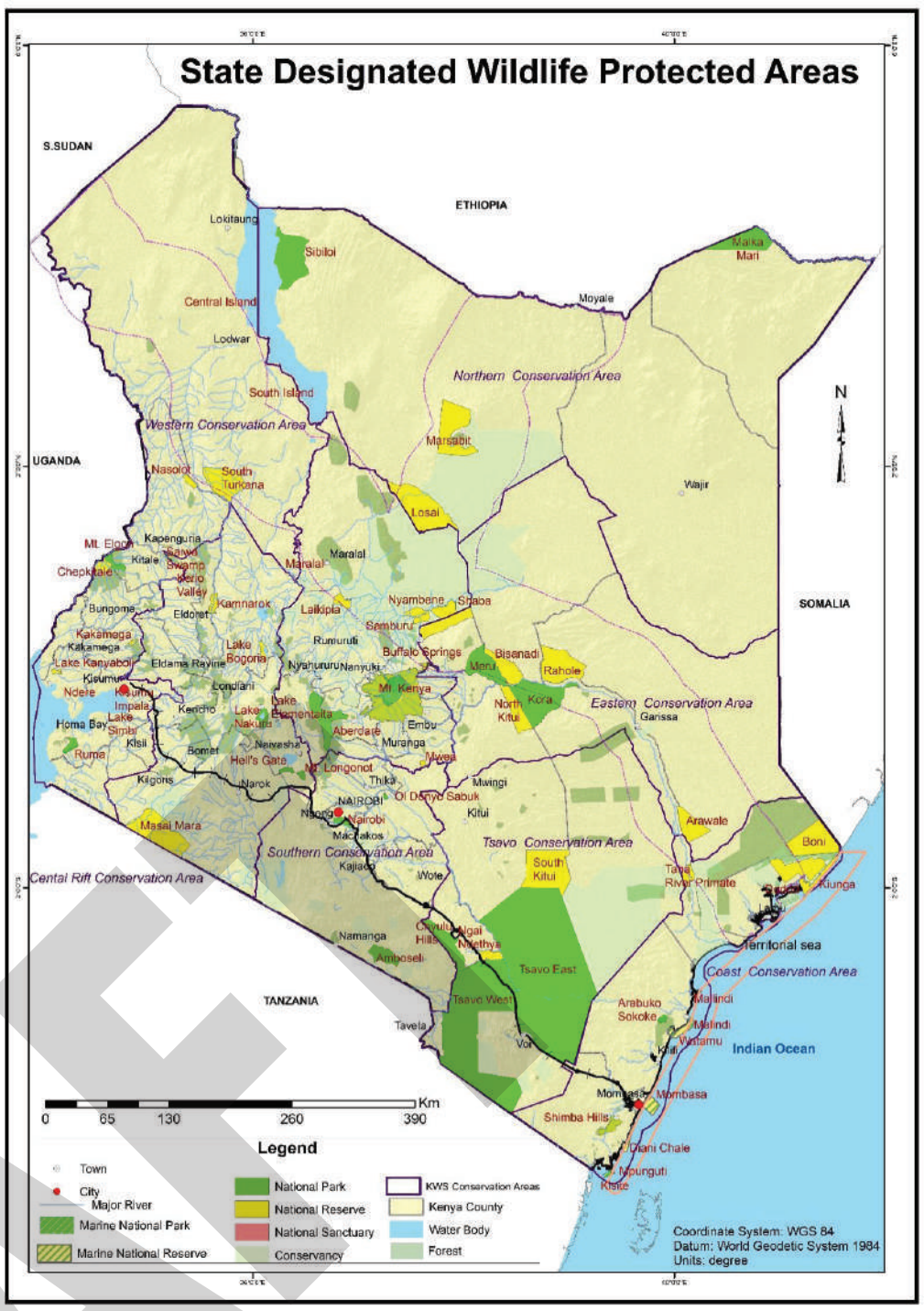


Figure 63: Locations of state designated protected areas.

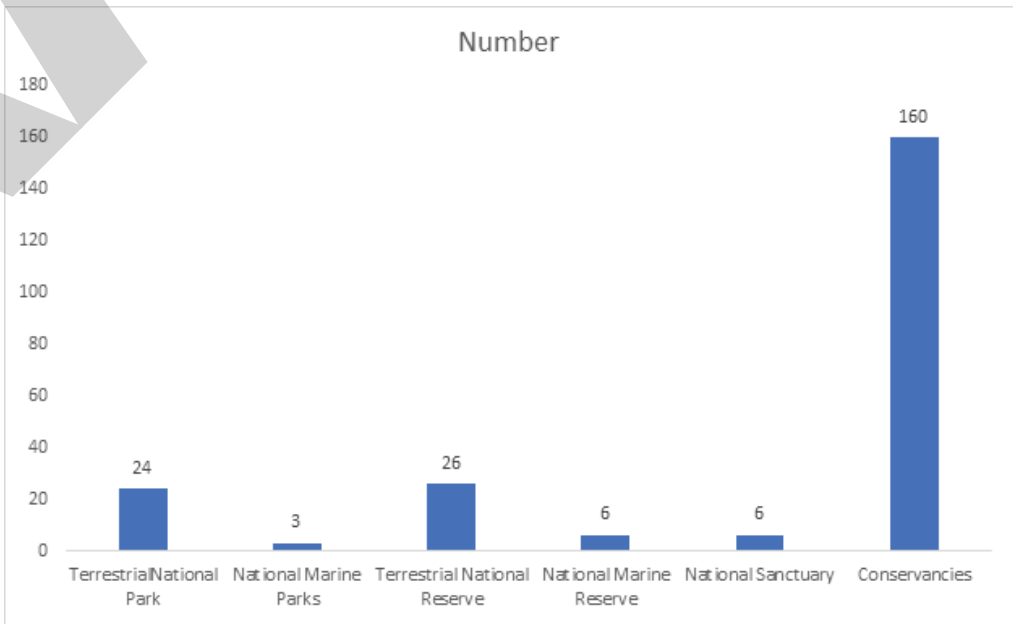


Figure 64: Categories of wildlife protected areas in Kenya.
Source: KWS

Table 29: *Kenya's National Park and Reserves and institutions managing them.*

NO.	NAME	Category	Management	AREA (Sq.KM)	GAZZETMENT_ YEAR
1	Kisite Marine NP	Marine National Park	KWS	28.00	1978
2	Mombasa Marine NP	Marine National Park	KWS	26.00	1986
3	Watamu Marine NR	Marine National Park	Malindi County	10.00	1968
4	Malindi Marine NP	Marine National Park	Malindi County	6.00	1968
5	Diani Chale Marine NR	Marine National Reserve	Kwale County	75.00	1995
6	Mpunguti Marine NR	Marine National Reserve	Kwale County	11.00	1978
7	Kiunga Marine NR	Marine National Reserve	Lamu County	250.00	1979
8	Mombasa Marine NR	Marine National Reserve	Mombasa County	200.00	1986
9	Watamu Marine NP	Marine National Reserve	KWS	10.00	1968
10	Malindi Marine NR	Marine National Reserve	Malindi County	213.00	1968
11	Aberdare NP	National Park	KWS	765.70	1950
12	Amboseli NP	National Park	KWS	392.00	1974
13	Arabuko Sokoke NP	National Park	KWS	6.00	1990
14	Central Island NP	National Park	KWS	5.00	1983
15	Chyulu Hills NP	National Park	KWS	471.00	1983
16	Hell's Gate NP	National Park	KWS	68.26	1984
17	Kora NP	National Park	KWS	1787.00	1989
18	Lake Nakuru NP	National Park	KWS	188.00	1968
19	Malka Mari NP	National Park	KWS	876.00	1989
20	Meru NP	National Park	KWS	870.00	1966
21	Mt. Elgon NP	National Park	KWS	169.00	1968
22	Mt. Kenya NP	National Park	KWS	715.00	1968
23	Mt. Longonot NP	National Park	KWS	52.00	1983
24	Ndere Island NP	National Park	KWS	4.20	1986
25	Nairobi NP	National Park	KWS	117.00	1946
26	Oldonyo Sabuk NP	National Park	KWS	18.00	1967
27	Ruma NP	National Park	KWS	120.00	1983
28	Saiwa Swamp NP	National Park	KWS	2.00	1974
29	Sibiloi NP	National Park	KWS	1570.00	1973
30	South Island NP	National Park	KWS	150.50	1983
31	Tsavo West NP	National Park	KWS	9065.00	1948
32	Tsavo East NP	National Park	KWS	11747.00	1948
33	Proposed Marsabit NP	National Park	KWS	347.00	
34	Arawale NR	National Reserve	Garissa County	533.00	1974
35	Bisandi NR	National Reserve	Isiolo County	606.00	1979
36	Buffalo Springs NR	National Reserve	Isiolo County	131.00	1985
37	Chepkitale NR	National Reserve	Bungoma County	178.20	2000
38	Dodori NR	National Reserve	Lamu County	877.00	1976
39	Kakamega NR	National Reserve	Kakamega County	44.70	1985
40	Kamnarok NR	National Reserve	Keiyo County	87.70	1983
41	Kerio Valley NR	National Reserve	Baringo County	66.00	1983
42	Laikipia NR	National Reserve	Laikipia County	165.00	1991
43	Lake Kanyaboli	National Reserve	Siaya County	41.42	2010
44	L.Bogoria NR	National Reserve	Baringo County	107.00	1970
45	Losai NR	National Reserve	Marsabit County	1806.00	1976
46	Masai Mara NR	National Reserve	Narok County	1510.00	1974
47	Mt. Kenya NR	National Reserve	Nyeri County	2124.00	2000
48	Mwea NR	National Reserve	Embu County	68.00	1976
49	Nasolot NR	National Reserve	West Pokot County	92.00	1979
50	Mwingi NR	National Reserve	Kitui County	745.00	1979
51	Nyambene NR	National Reserve	Isiolo_Meru Couties	640.60	2000
52	Rahole NR	National Reserve	Garissa County	1270.00	1976
53	Samburu NR	National Reserve	Samburu County	165.00	1985
54	Shaba NR	National Reserve	Isiolo County	239.00	1974
55	Shimba Hills NR	National Reserve	Kwale County	192.51	1968
56	South Kitui NR	National Reserve	Kitui County	1833.00	1979
57	South Turkana NR	National Reserve	Turkana County	1091.00	1979
58	Tana River Primate NR	National Reserve	Tana River County	169.00	1976
59	Ngai Ndethia NR	National Reserve	Kitui	212.00	1976
60	Tsavo Road & Railways NR	National Reserve	KWS	5.27	1943
61	Marsabit NR	National Reserve	Marsabit	1122.00	1967
62	Boni National Reserve	National Reserve	Garissa/Lamu	1339.00	1976
63	Kisumu Impala Sanctuary	National Sanctuary	KWS	0.34	1992
64	Lake Elementaita Wildlife Sanctuary	National Sanctuary	KWS	25.34	2010
65	L. Simbi Sanctuary	National Sanctuary	Homa Bay	0.42	2000
66	Maralal Sanctuary	National Sanctuary	Samburu County	5.00	1988

Source: KWS

Establishment of wildlife protected areas in Kenya

The first protected area was Tsavo Road and Railway National Reserve before the second world of 1939-1945. This was followed by Nairobi, Tsavos and Aberdare National Parks. No protected areas were established between 1951 and 1963, this may have been attributed by the struggle for independence. After independence, approximately 56 protected areas were established. There has been sharp increase in the number of protected areas in 1970s while a decline in the subsequent years (Fig……..).

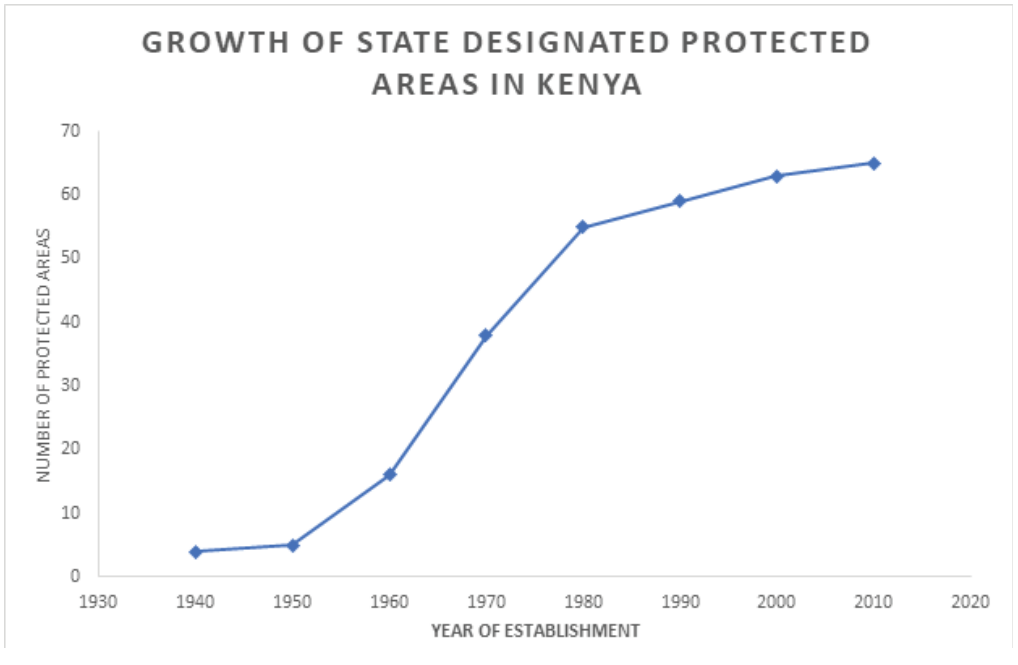


Figure 65: Growth of state designated protected areas in Kenya

Protected Areas	Total No.	Total Area (sq. km)
National Reserves	29	17,358.8
National Parks	23	29,504
Marine National Reserves	5	493
Marine National Parks	4	272
National Sanctuaries	4	265.79
Conservancies	160	63,600

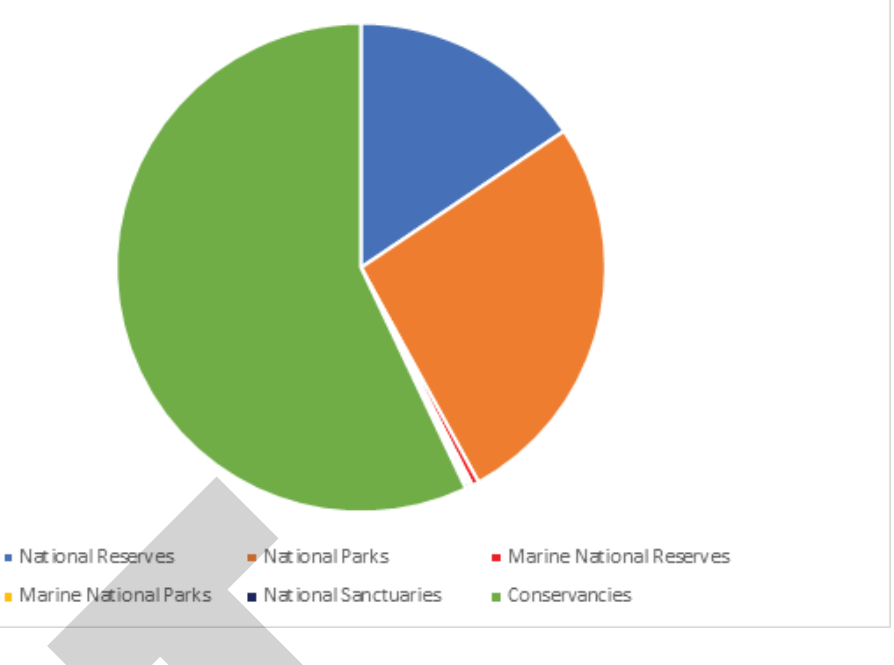
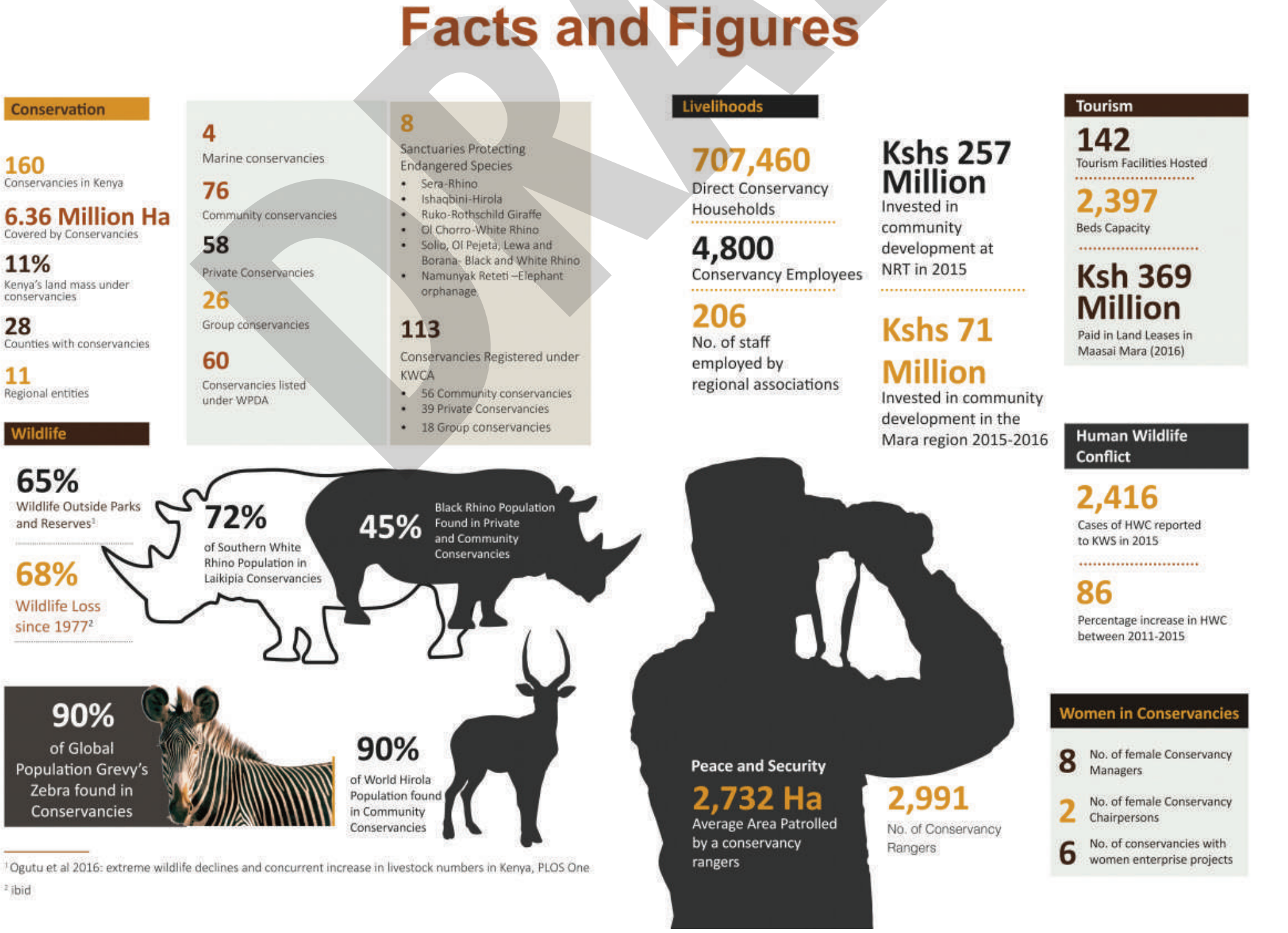


Figure 66: Protected areas by land size

Sizes of protected areas as per categories

In terms of land mass, National Parks occupy the largest chunk of land (29,504 km2) followed by the National Reserves (17,358.8 km2) while marine national reserves (493 km2), Marine National Parks (272 km2) and national sanctuaries (31.15 km2) occupy the least land mass. (table… The figures in the brackets represents the number in each of the wildlife protected areas.



Conservancies

Conservancies: transforming communities while safeguarding our iconic wildlife.

As at 2018, Kenya had of 167 conservancies, which cover over 6.35 million hectares of land (11% of Kenya's land mass), directing benefiting 930,000 households and directly providing job opportunities to over 4,500 conservancy employees.
In addition to sparking the development of social amenities in rural communities and hosting large numbers of wildlife, conservancies in Kenya are home to some of the world's most endangered species, such as the Black and White Rhinos, Grevy's Zebras, Hirola, Wild Dog, Giraffes and Elephants.

Impacts Of Conservancies

- In Southern Kenya, for example, home to the iconic Maasai people and the great wildebeest migration, 15 conservancies have secured half a million acres of pristine habitat. The lion's population has doubled, and 3,000 households earn more than $4million annually.
- In the northern rangelands, communities in 36 conservancies are more able to survive drought by accessing pasture and water in 44million acres of secure land. Conflict over pasture and water are reported to have reduced and less wildlife have been killed and for the very first time in many years rhinos are back into community land.

Plate 23: Baby Nachami Born in Sera Community Conservancy Samburu
Credits Northern Rangelands Trust

- At the coastal region, rare and endangered wildlife like wild dog and the world's most rare antelope the hirola are protected by local people. Today there are three times more hirolas in Ishaqbini conservancy than there were 20 years ago. Other endangered species such as the black and white rhinos, grevy zebras, giraffes and elephants are found on community lands.

Plate 24: White Giraffe in Ishaqbini Conservancy
Credits Northern Rangelands Trust

County Snapshot

- Kajiado County hosts the highest number of conservancies (24). Following closely is Taita Taveta County with 22 and Narok 17.
- Although Marsabit County hosts only five (5) conservancies, they cover the largest extent (1.4 million ha), followed by Turkana County with four (4) conservancies at 1.04 million ha and Tana River County, which has four (4) conservancies spread across 674,000 ha.
- A majority of private conservancies are found in Laikipia covering a total of 150, 000ha while the largest group conservancy is the Mara North covering 29,000ha.
- Malhkalaku Conservancy is the largest community conservancy covering 839,000 ha. This is followed by Melako (550,000 ha) in Marsabit and Lokichar in Turkana(454,000 ha).

Wildlife corridors

Wildlife migratory corridors connect core habitats and are critical for species' survival and long-term viability of ecosystems. In the african savannah, animals disperse Or migrate across landscapes in response to intrinsic factors (e.g. breeding); external or environmental factors (drought, floods, diseases, fires), to access vital resources such as pasture, water, breeding grounds; to reduce the risks of predation; and to enhance genetic health (mating),among others. Migration is essential for sustaining resilience of large populations in the face of variable rainfall, which is highly correlated to availability and shortage of forage. Connectivity conservation recognizes the importance of physical connection and linkages between isolated habitats that increase the effective area available to wildlife. Restoration of wildlife habitats helps to improve the integrity of ecosystems; and are an essential strategy in maintaining landscape patterns and ecological processes that promote the survival of species in environments modified by both natural events and anthropogenic activities, and reverses the effects of habitat fragmentation. Wildlife dispersal areas and migratory corridors are key elements in the conservation connectivity framework proposed.
Source(wildlife migratory corridors and dispersal areas: Kenya rangelands and coastal terrestrial ecosystems July 2017 Report number: isbn: 978-9966-107-19-0affiliation: Kenya ministry of environment and natural resource)

Links to the Information

https://kwcakenya.com/conservancies/status-of-wildlife-conservancies-in-kenya/
https://www.nrt-kenya.org/
https://www.researchgate.net/publication/319136741_Wildlife_Migratory_Corridors_and_Dispersal_Areas_Kenya_rangelands_and_Coastal_Terrestrial_Ecosystems

Administration units in Management of Wildlife Resources

For KWS's effective and efficient management and administration, the country has been divided into eight Conservation Areas. These are Northern Conservation Area-NCA (Figure 67); Mountain Conservation Area-MCA (Figure 68); Coast Conservation Area-CCA (Figure 69); Southern Conservation Area-SCA (Figure 70); Western Conservation Area-WCA (Figure 71);, Eastern Conservation Area-ECA (Figure 72); Central Rift Conservation Area -CRCA (Figure 73); and Tsavo Conservation Area-TCA (Figure 74). The headquarters of the Kenya Wildlife Service is in Nairobi. The conservation area maps below clearly show the national parks, national reserves, national sanctuaries and conservancies.

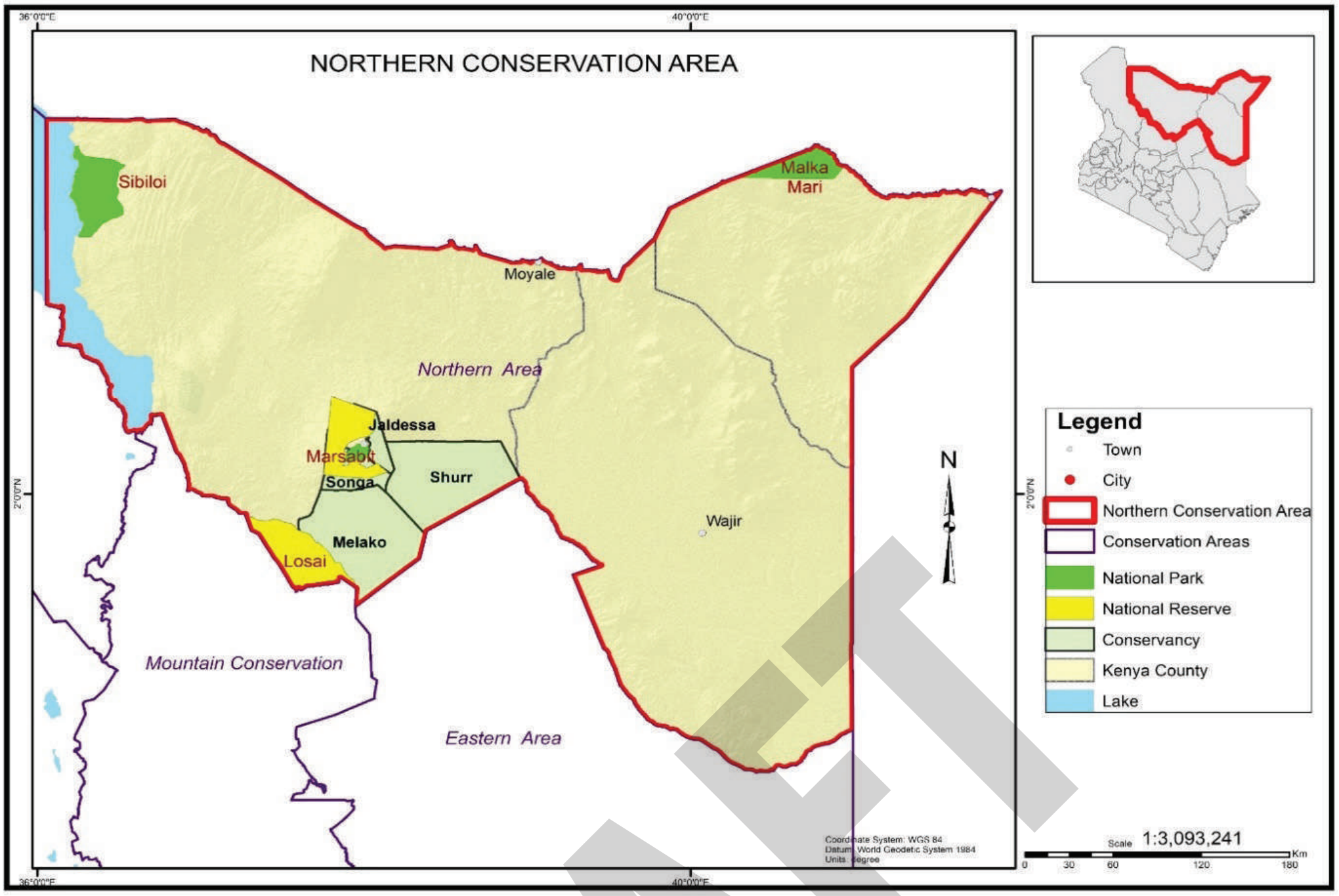


Figure 67: Northern Conservation Area

The NCA has 5 National Parks and 2 National Reserves.

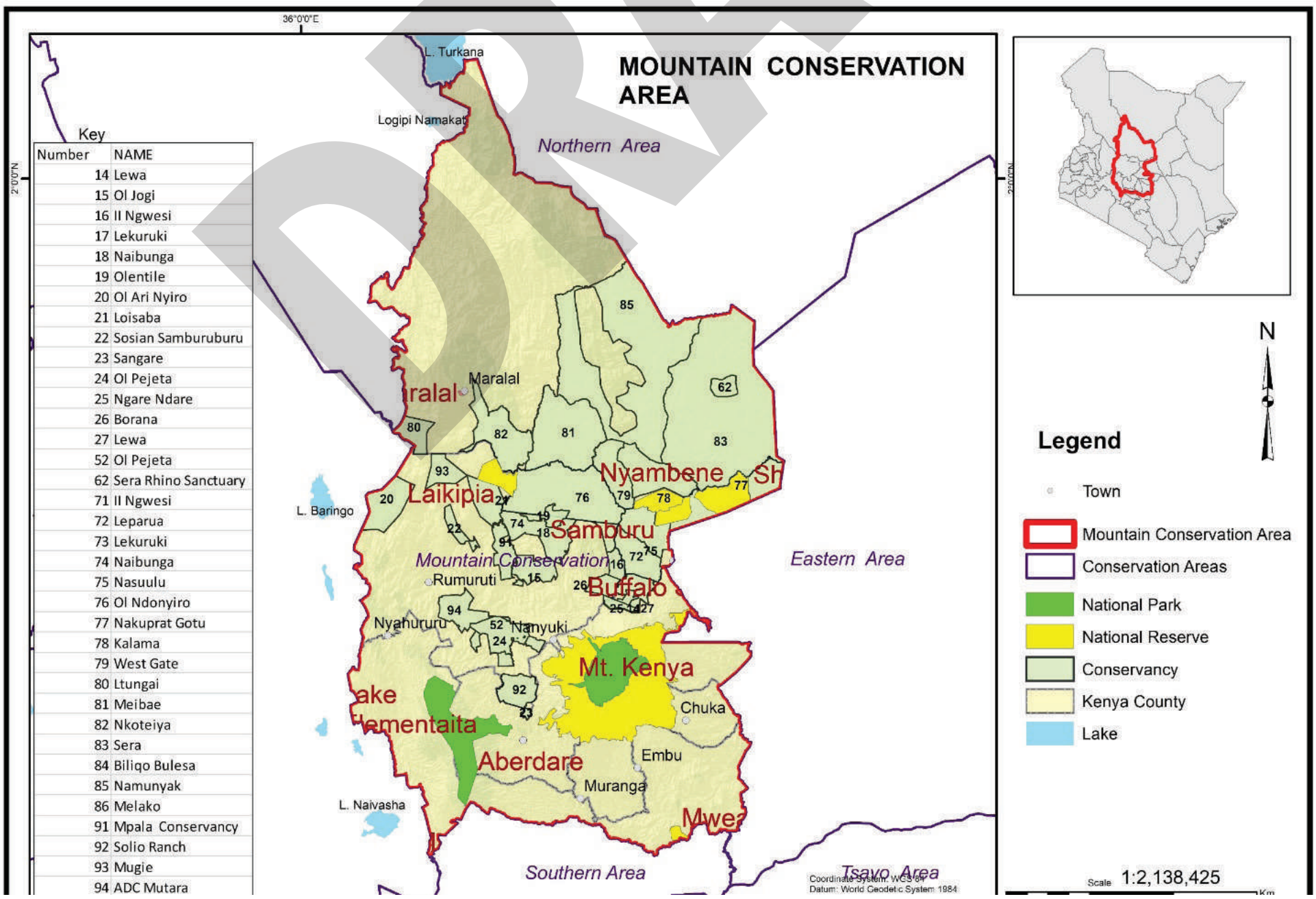


Figure 68: Mountain Conservation Area

The MCA has 3 National Parks, 6 National Reserves and 1 National Sanctuary

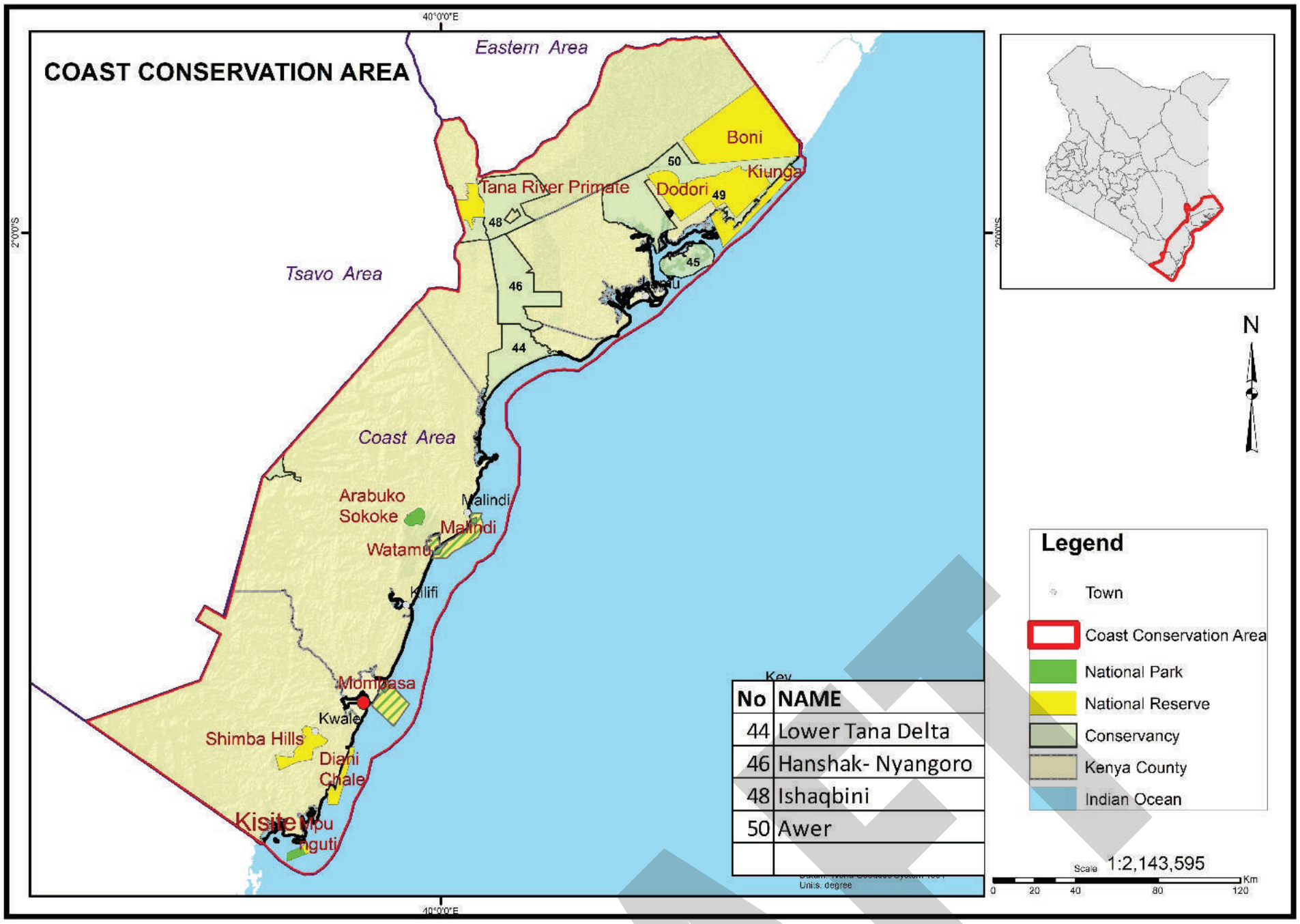


Figure 69: Coast Conservation Area

The CCA has 3 Marine National Parks, 6 Marine National Reserves, 2 National Parks and 4 National Reserves

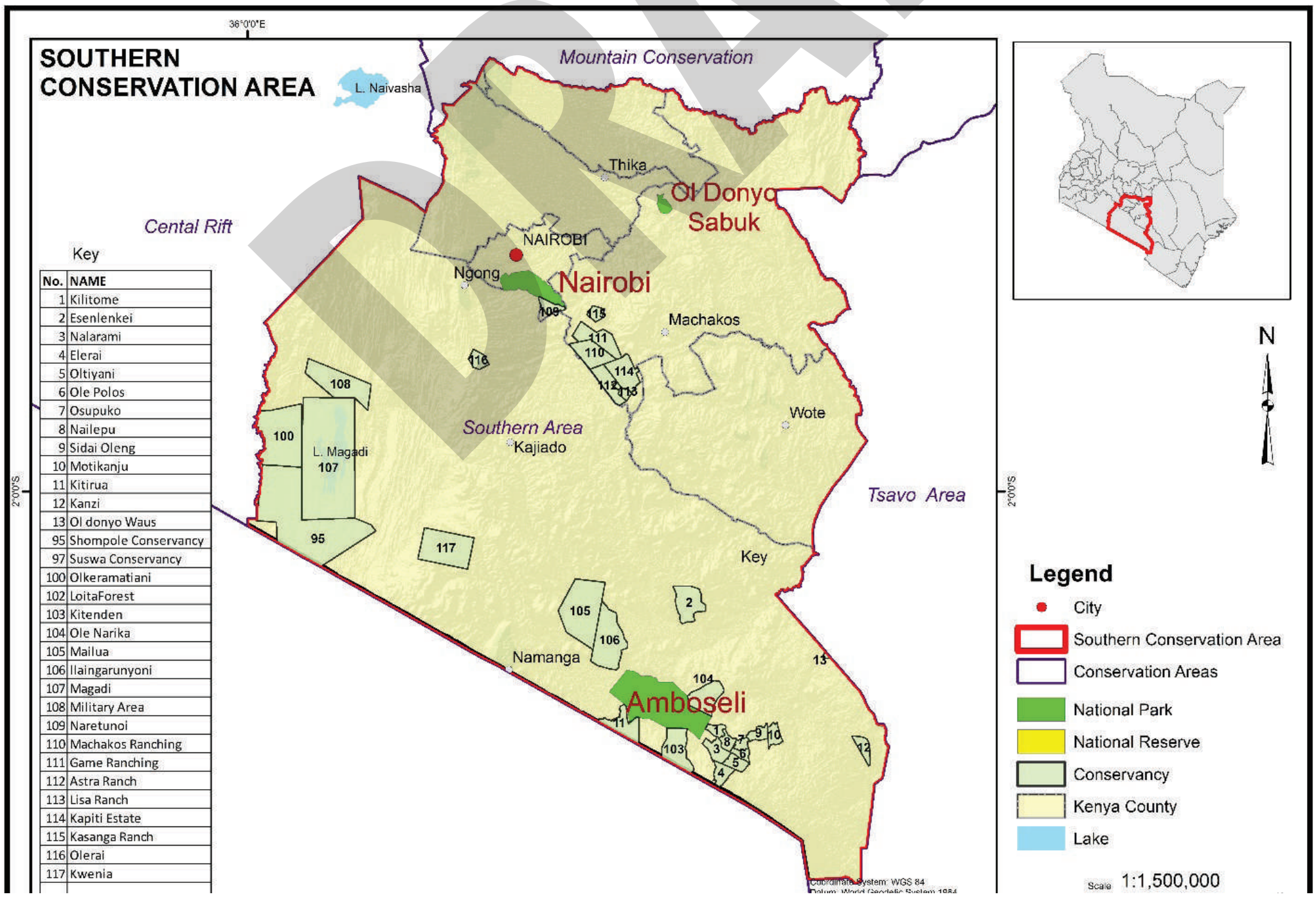


Figure 70: Southern Conservation Area

The SCA has 3 National Parks

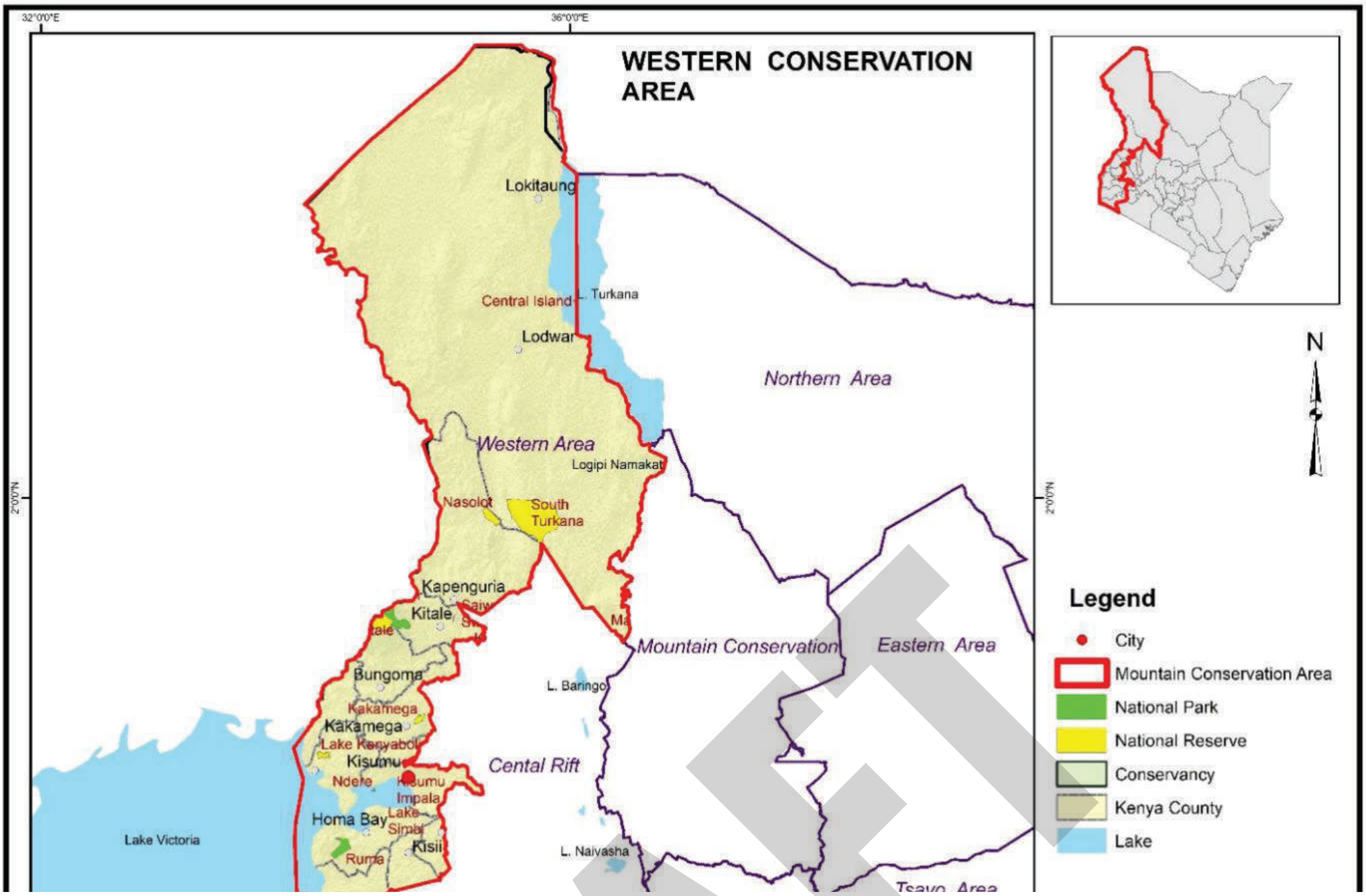


Figure 71: Western Conservation Area

The WCA has 4 National Parks, 4 National Reserves, and 4 National Sanctuaries

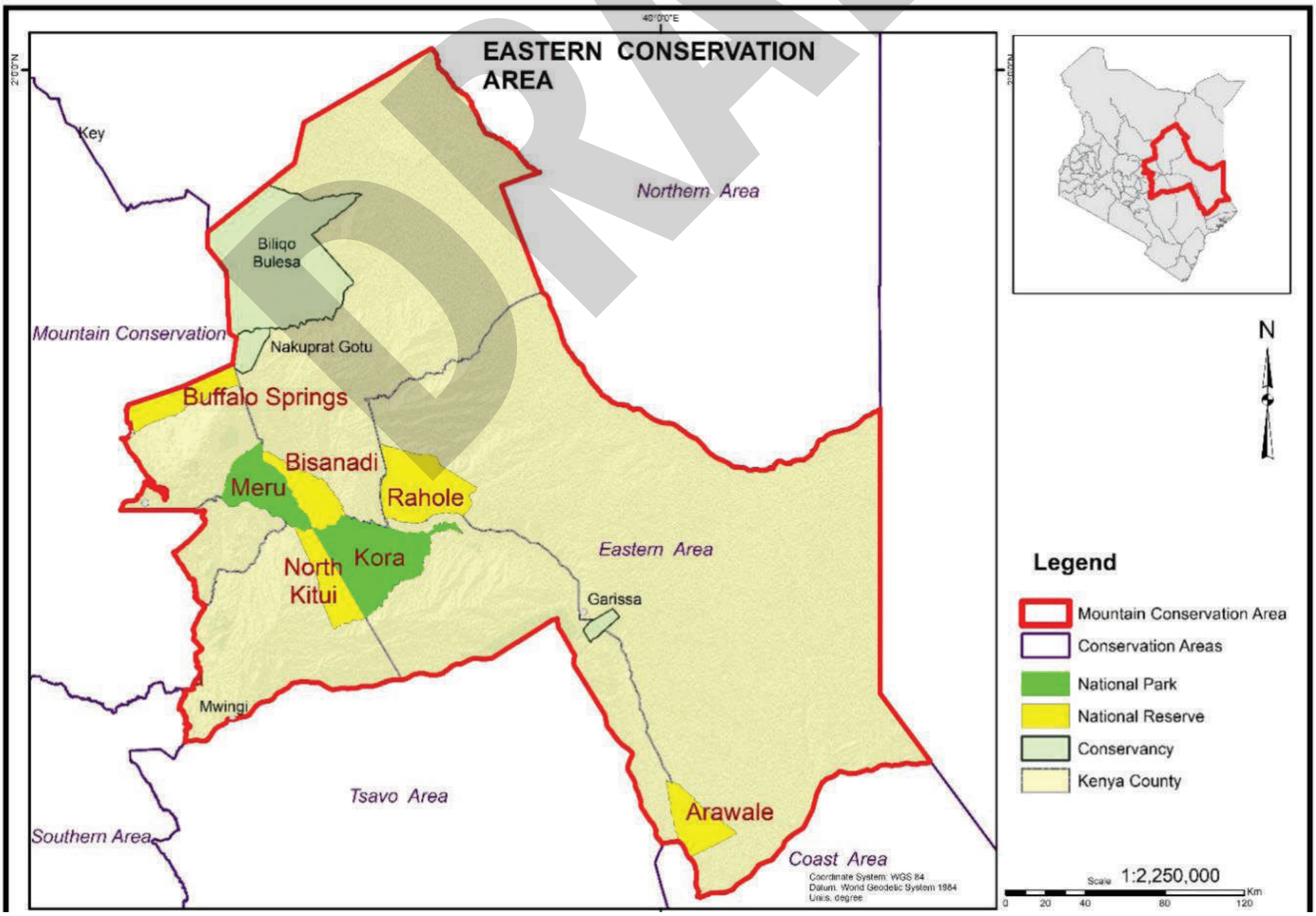


Figure 72: Eastern Conservation Area

The ECA has 2 National Parks and 6 National Reserves

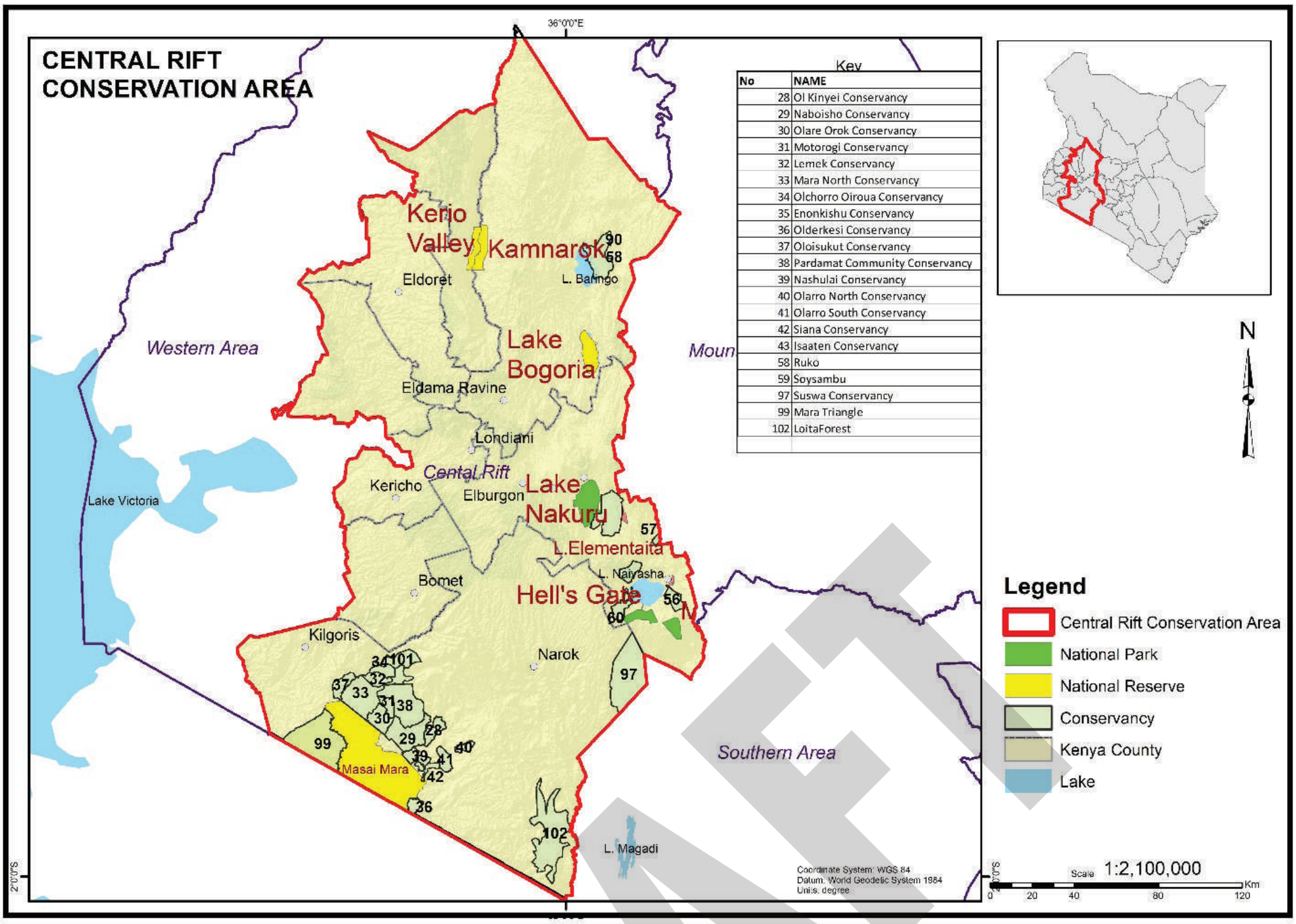


Figure 73: Central Rift Conservation Area

The CRCA has 3 National Parks, 4 National Reserves and 2 National Sanctuaries

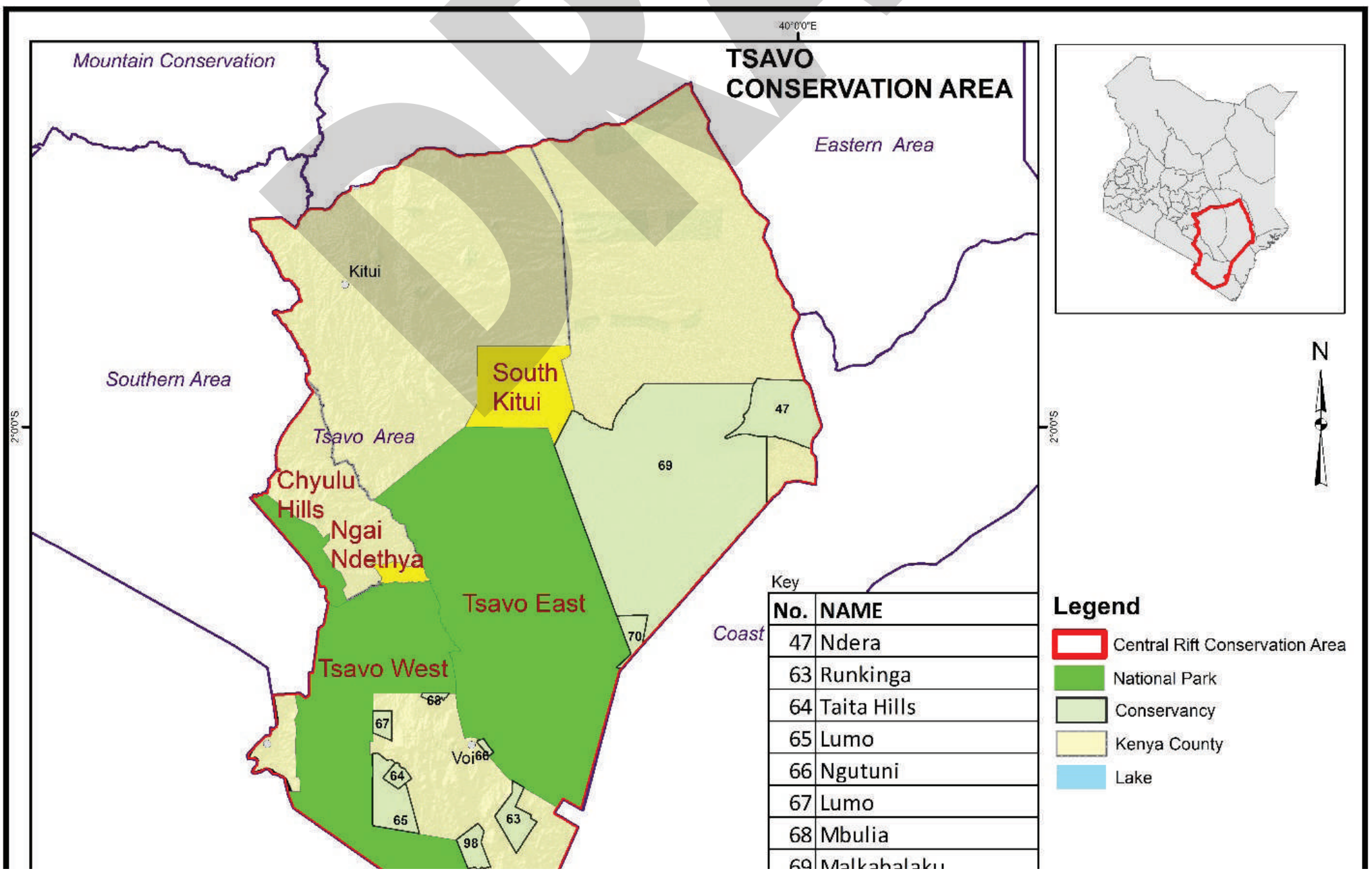


Figure 74: Tsavo Conservation Area

The TCA has 3 National Parks and 3 National Reserves

Abundance and distribution of large wild mammalian populations

High abundance of wildlife particularly large mammals is found in the Arid and semi- arid regions of the country. These areas are characterized by comparatively sparse and lower human population that is dominated by pastoral communities. The highest abundance of wildlife in in the southern rangelands of the country from the Maasai Mara in the west and down to Tsavo Mkomazi ecosystem in the East. There is also significant high densities of wildlife in the central Kenya regions of Laikipia- Samburu and the Eastern coastal belt northwards to North easter regions

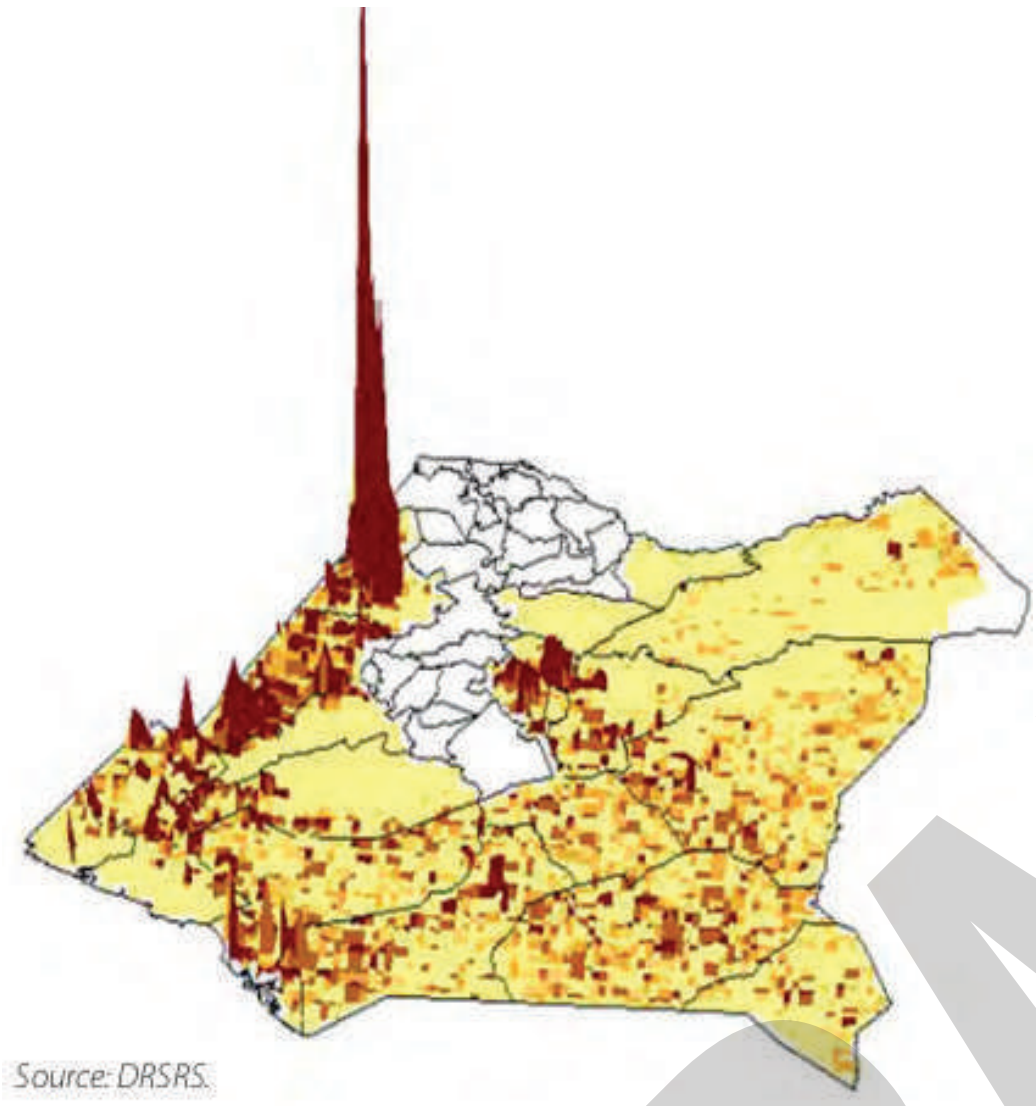


Figure 75: three-dimensional depiction of total wildlife abundance and distribution in Kenya. The higher the raising column the higher the abundance,

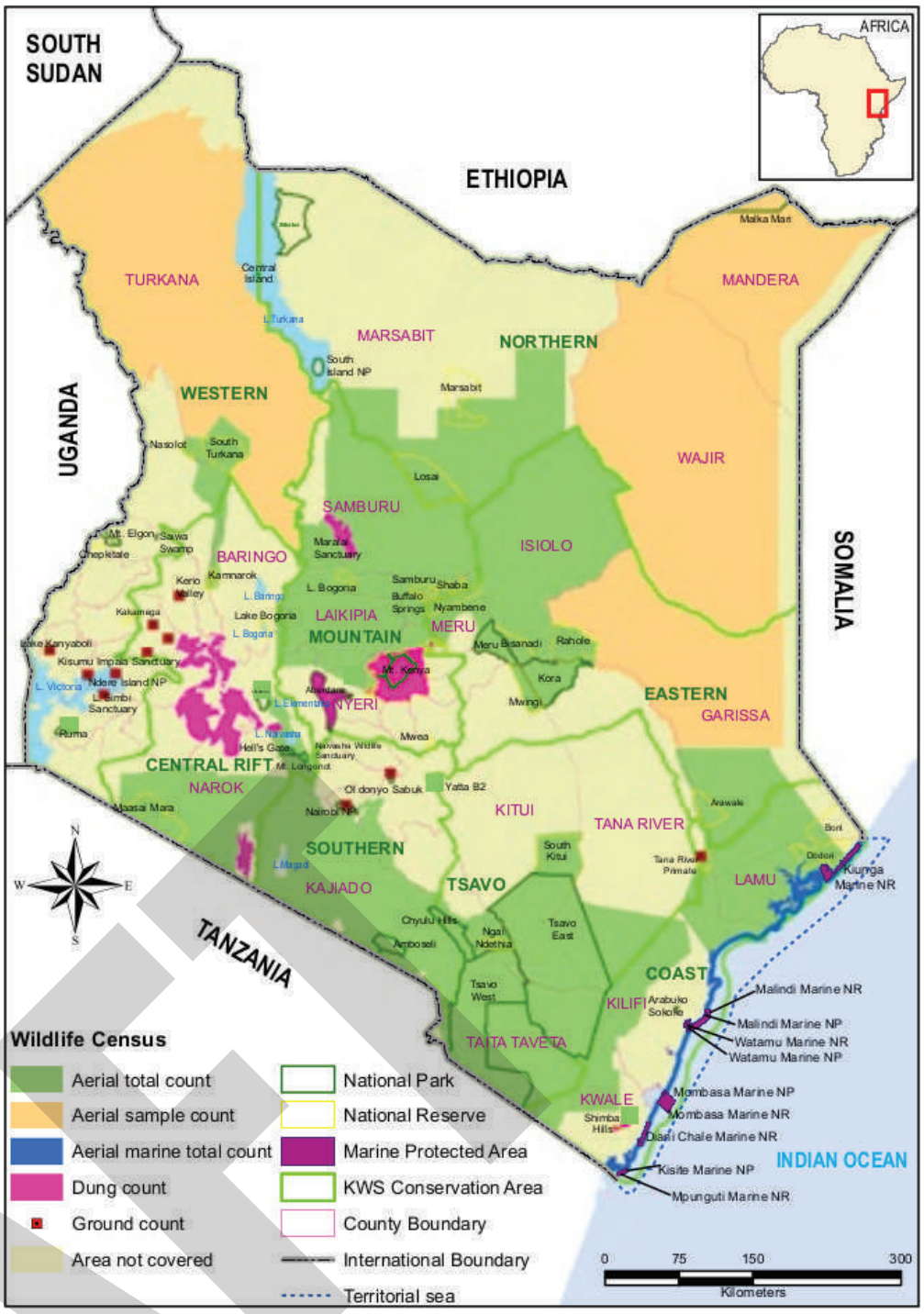


Figure 76: Distribution and population status of select charismatic species.

Recent status large mammals

Monitoring of wildlife populations is essential for management of wildlife. Regular data on distribution and abundance of wildlife populations is useful in informing the development of park and ecosystem management plans, documenting status and trends of wildlife populations, identifying threats and assessing impact of management interventions. For expansive lands, aerial survey of wildlife is usually used as is most efficient. For this reason therefore, KWS undertakes Ecosystem-wide aerial total count of wildlife are undertaken after every 3-5 years by KWS in key priority ecosystem that harbor high density of large mammals. These major ecosystems are Tsavo- mkomazi ecosystem, Laikipia-Samburu-Marsabit ecosystem, Amboseli-West Kilimanjaro & Magadi-Natron ecosystem and the Maasai Mara ecosystem. Other ecosystems are surveyed but less frequently due to resource limitation. Aerial survey is applicable mainly for large mammalian animals. Other methods (call back for lions, camera traps for small mammals, Dung count etc.) apart from the aerial census are used in determining populations of other wildlife species.

In the year 2021, a nationwide wildlife census was undertaken mostly using aerial total and sample counts as well as other taxa specific appropriate methods. This was the first ever survey of this magnitude.

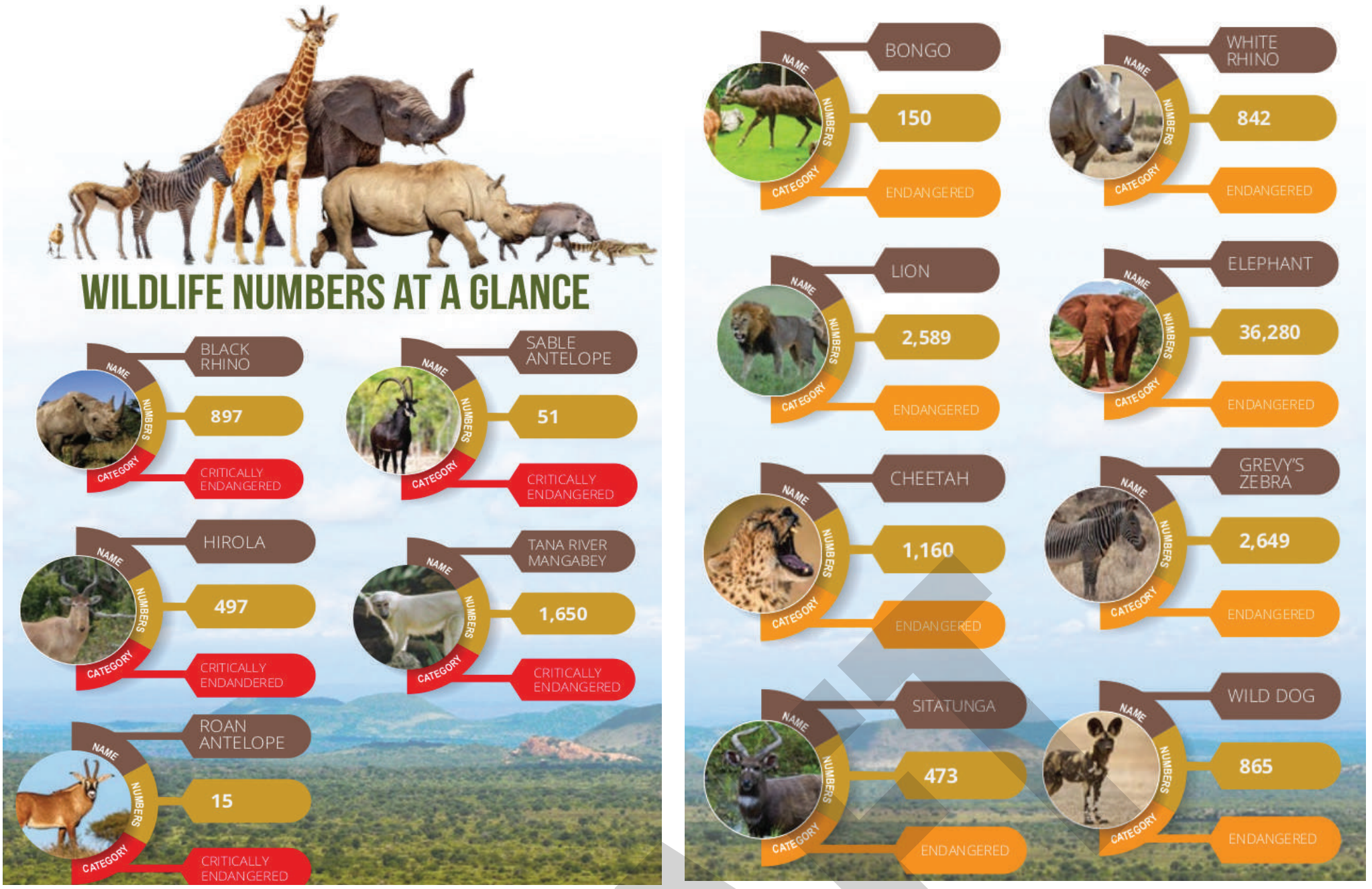
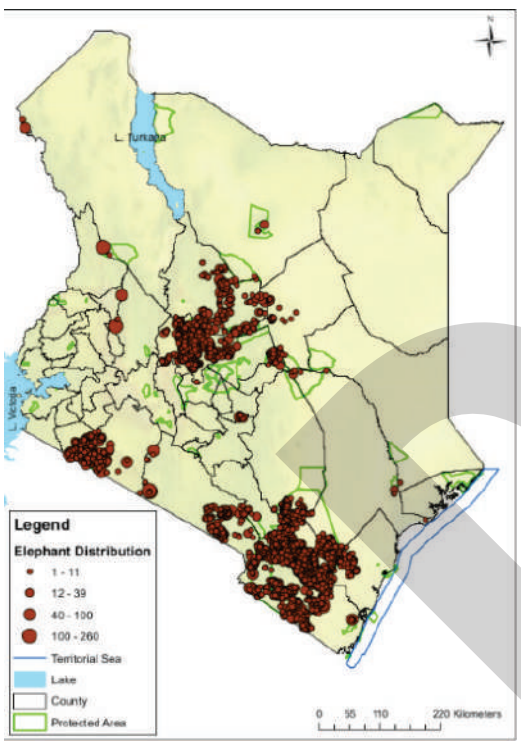
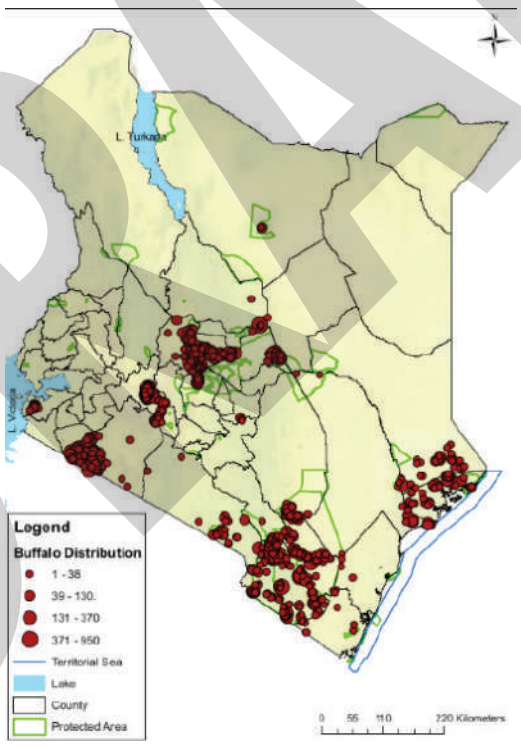


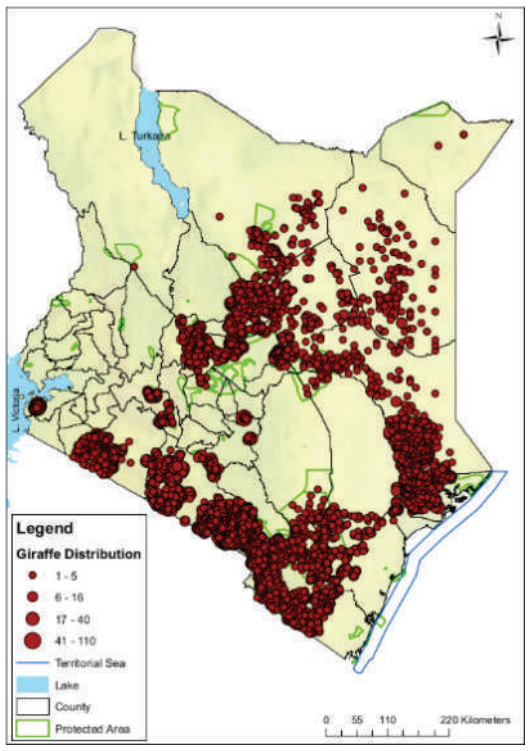
Figure 77: Endangered species



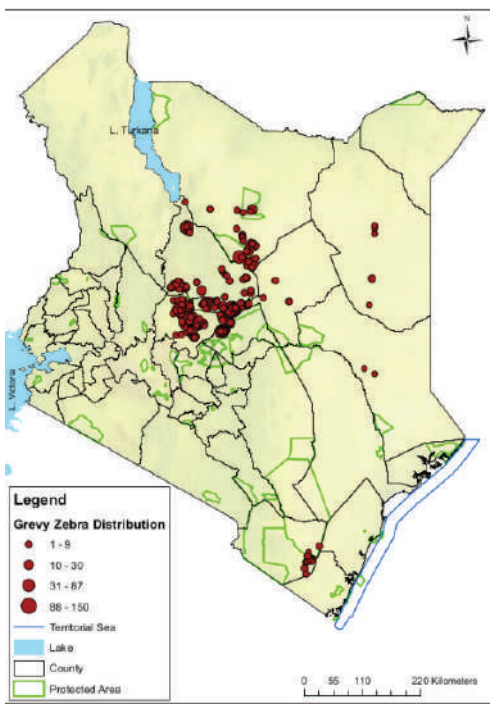
Elephant



Buffalo

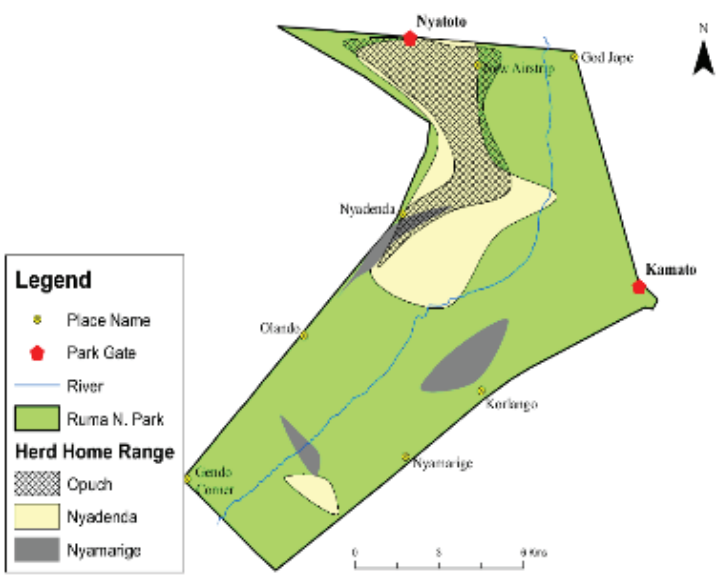


Giraffe



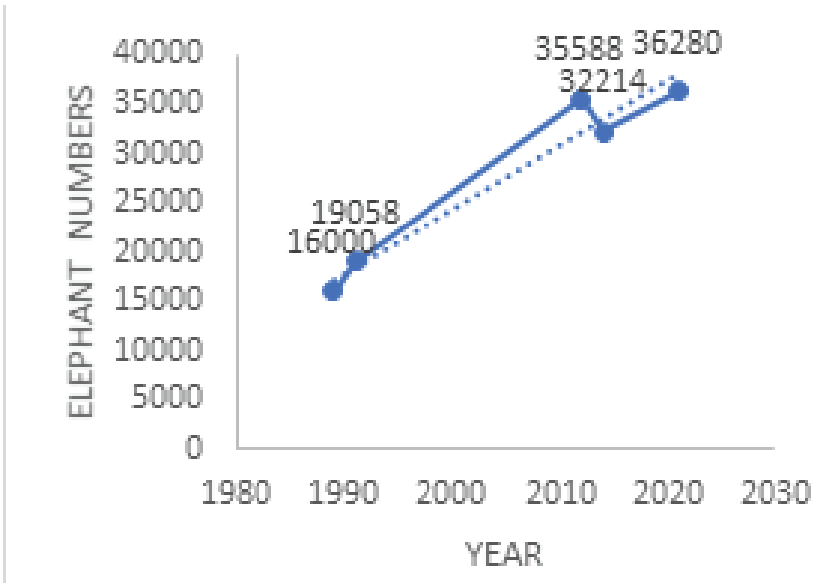
Grevyi Zebra

White and black rhinos

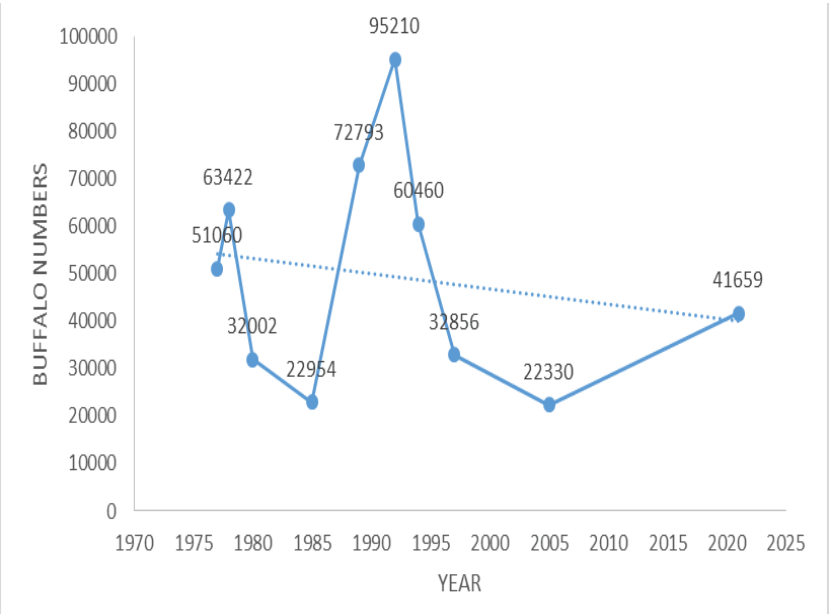


Roan

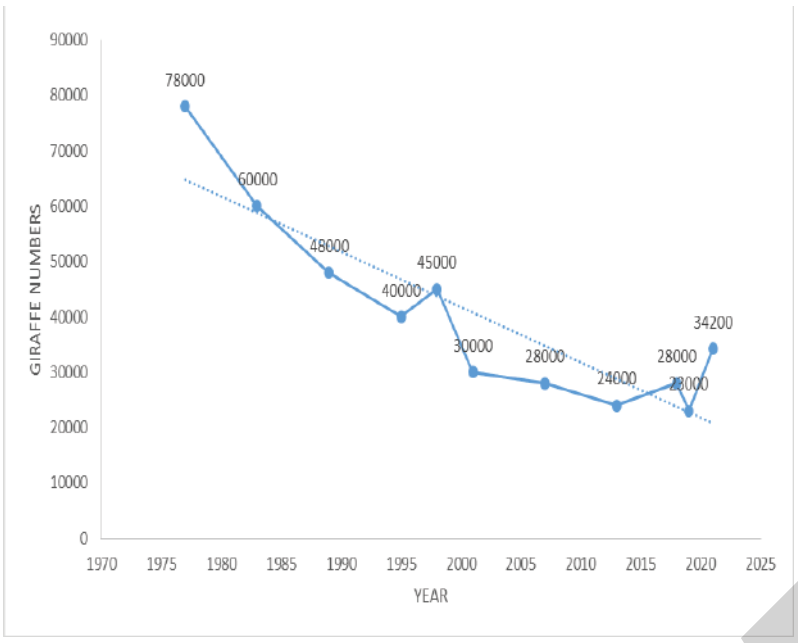
Figure 78: Species Distributions as per 2021 census



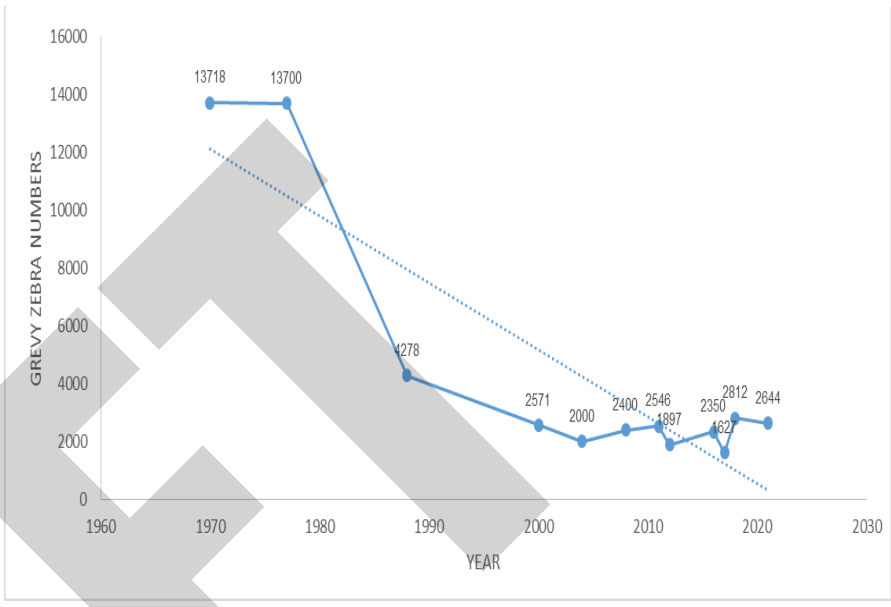
Elephant



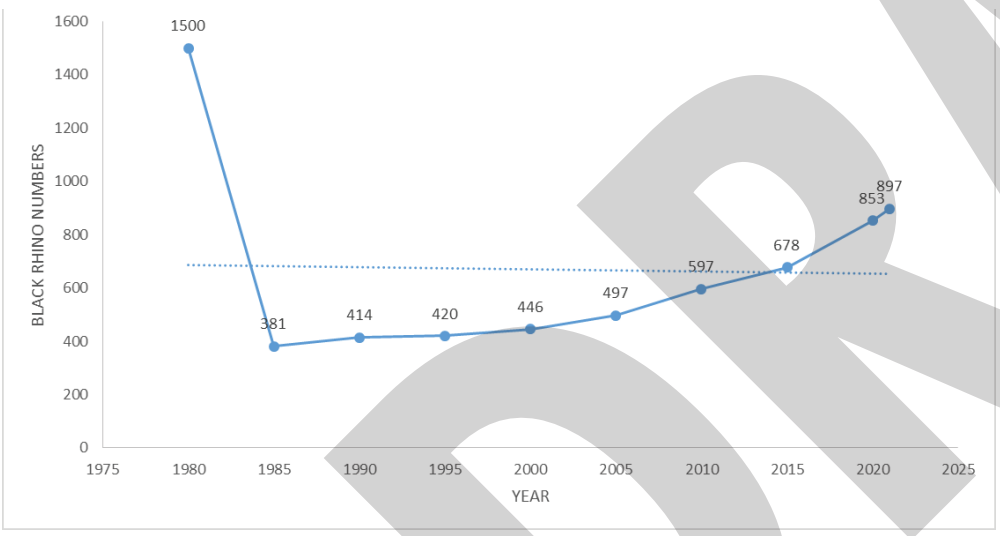
Buffalo



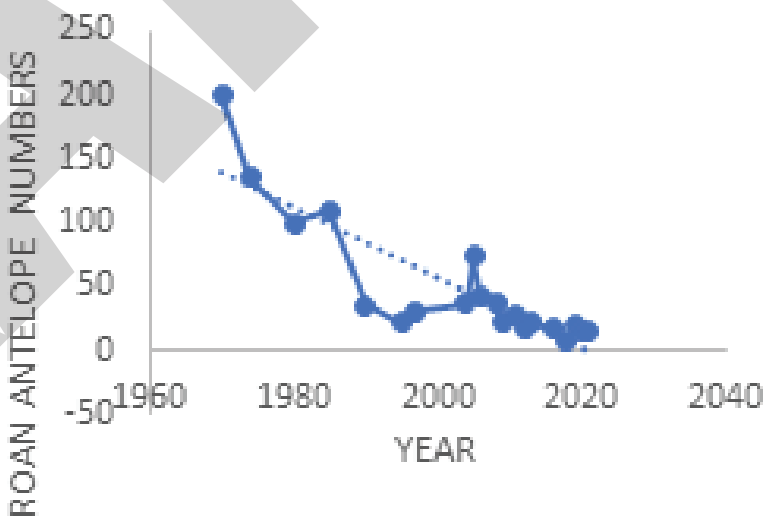
Giraffe



Grevyi Zebra



Black Rhino



Roan Antelope

Figure 79: Population Trends for some select species.

Threat categorization and listing of species.

The World Conservation Union (IUCN) has provided a criterion and ranking of threats for species in the red data book. Besides the above IUCN categories, Kenya in the WCMA 2013 has a list in the WCMA 2013- schedule 6 of 242 species that are deemed to be are various levels of threats. The Kenyan categorization introduced an extra category of protection of species called “protected”. The six schedule has six categories, thus critically endangered, endangered, vulnerable, near threatened, threatened and protected.

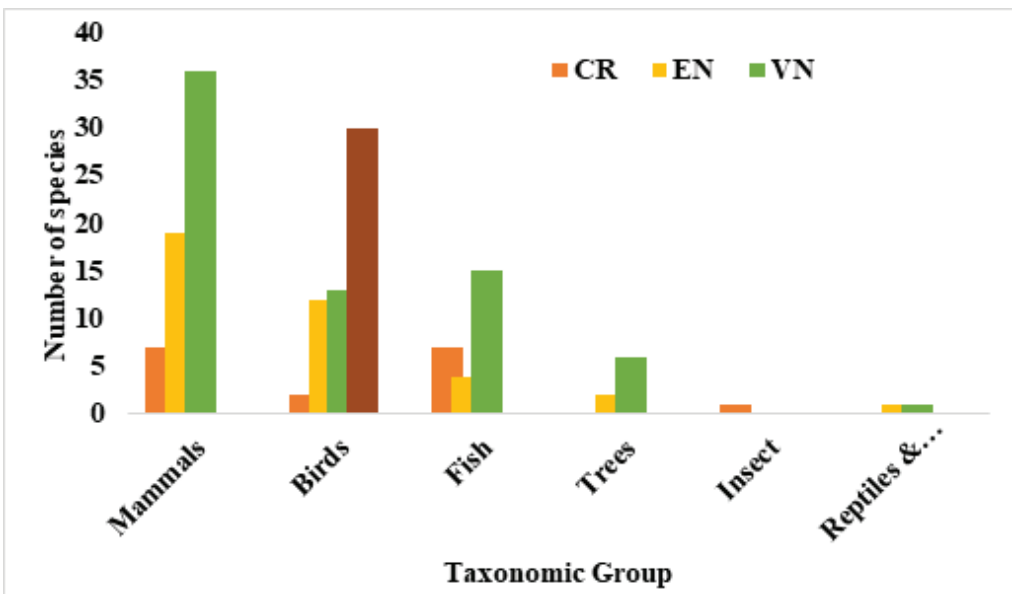


Figure 80: Threat listing of species by taxa. Critically endangered (CR), Endangered (EN), Vulnerable (VU) and Near Threatened (NT)

Threat Category	Explanation
Critically endangered (CR)-	Extremely high risk of extinction in the wild
Endangered (EN)	High Risk of extinction in the wild
Extinct (EX)	No Known individuals remaining
Extinct in the wild (EW)	Known only to survive in captivity, or as a naturalized
Population outside its historic range	
Vulnerable (VU)	High risk of endangerment in the wild
Near Threatened (NT)	Likely to become endangered in the near future
Least concern (LC)	Lowest risk. Does not qualify for a higher risk Category.
Widespread and abundant taxa are included in this category	
Data Deficient (DD)	Not enough data to make an assessment of its risk of extinction. Has not yet been evaluated against the criteria

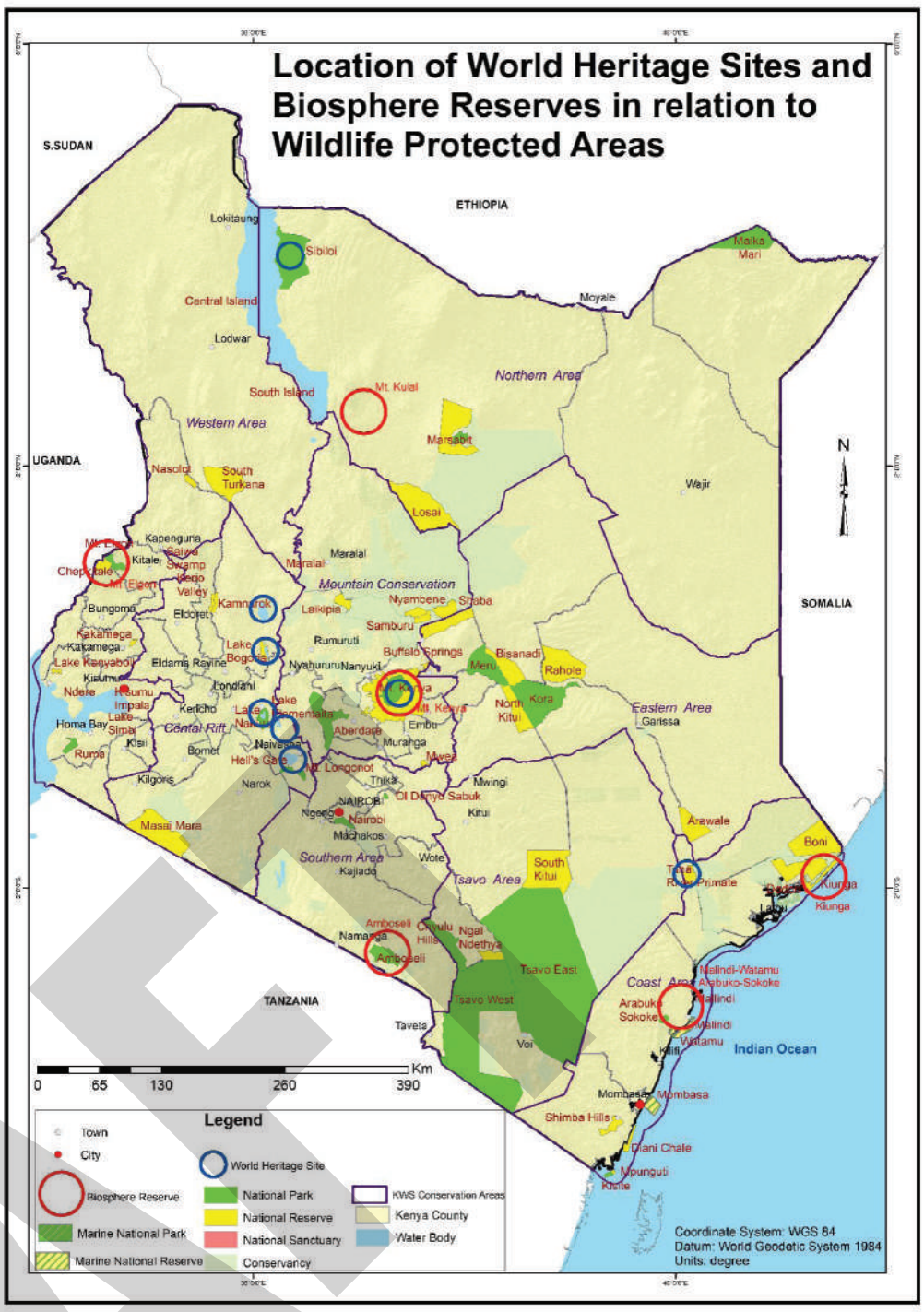
Table 30: *Summary of the sixth schedule- Listed species by taxa*

Taxonomic group		CR	EN	VN	NT	T	Protected	Total
Mammals		7	19	36	0	0	0	62
Birds		2	12	13	30	0	37	94
Fish		7	4	15	0	0	0	26
Trees		0	2	6	0	0	0	8
Insect		1	0	0	0	0	0	1
Reptiles & Amphibians	*Snakes*	0	1	1	0	0	10	12
	Frogs	1	5	1	0	0	7	14
	Toads	0	0	0	0	1	3	4
	Tortoise	0	0	0	0	1	0	1
	Terrapin	0	0	0	0	0	1	1
	Gecko	0	0	0	0	0	2	2
	Skinks	0	0	0	0	0	2	2
	Lizard	0	0	0	0	0	3	3
	Chameleon	0	0	0	0	0	6	6
	Turtles	1	2	0	0	1	4	8
Total		**19**	**45**	**73**	**30**	**3**	**75**	**244**

Critically endangered wildlife species

Kenya has 19 listed critically endangered species as listed in six scheduled of the WCMA 2013. Of these, 7 mammals (Aders duikers, Tana crescent Mangabey, Hirola, Rone antelope, Black rhino, eastern Mountain bongo, and the red colombus), two are birds (Taita apalis and Taita thrush), six are fish (Victoria tilapia, Lake Chala tilapia, Singidia tilapia, Jipe tilapia, Rainbow sheller, and Lake Victoria deep water catfish) one insect (Montane dancing jewel), one turtle, two reptiles (Hawksbill turtle, and Du Toit's Torrent Frog)

World heritage sites



4.1.8 Conservation Challenges

Kenya's megafauna loss is estimated at average of 68% in the last 40 years (ref). The major causes of species loss include: 1) the cascading effects of habitat loss through fragmentation, degradation and climate change, 2) inadequate institutional capacity for effective management and response to human-wildlife conflict and wildlife crime 3) human population growth leading to resource use pressures, escalating poverty, and limited livelihood options.

Human Wildlife conflict (HWC)

HWS is defined in WCMA 2013 as the interaction between human and wildlife that results in negative impacts on human social and economic or cultural life, conservation of wildlife or the environment. Predominantly HWCs occurs on private and communal lands where human habitation intersects with ranging area of wildlife. Since about (65-70%) of wildlife reside outside protected areas, the area of co-existence between people and livestock is significant magnifying HWCs.

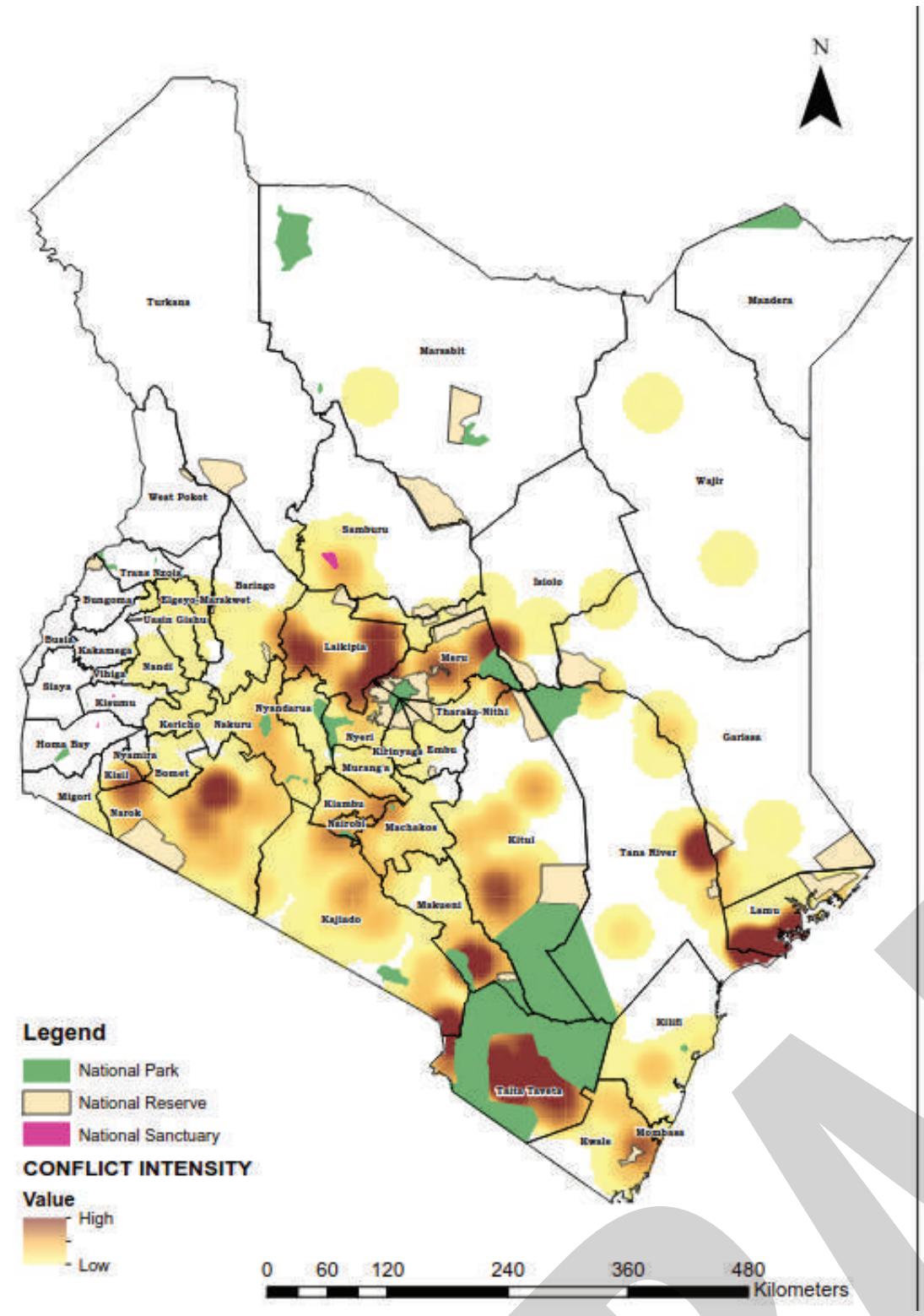


Figure 88: HWC hotspots in the country

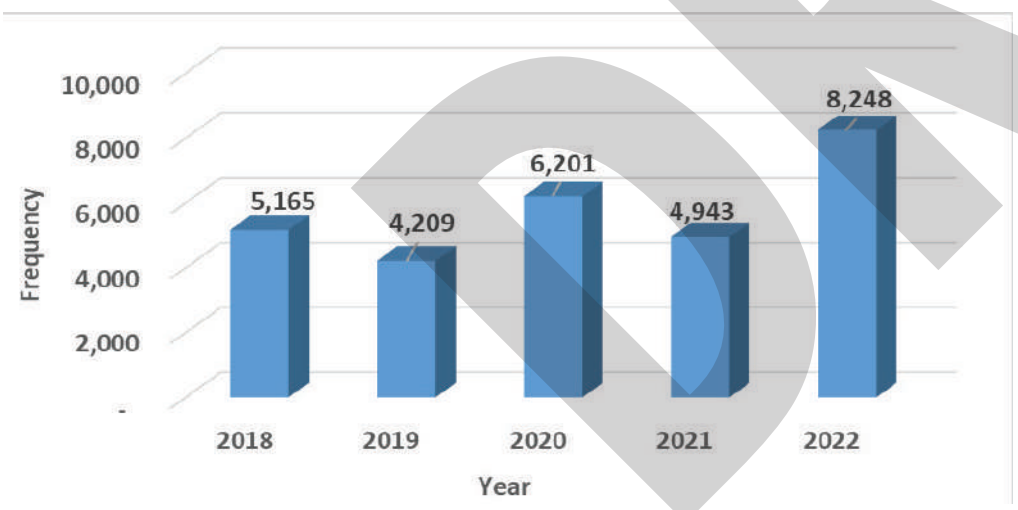
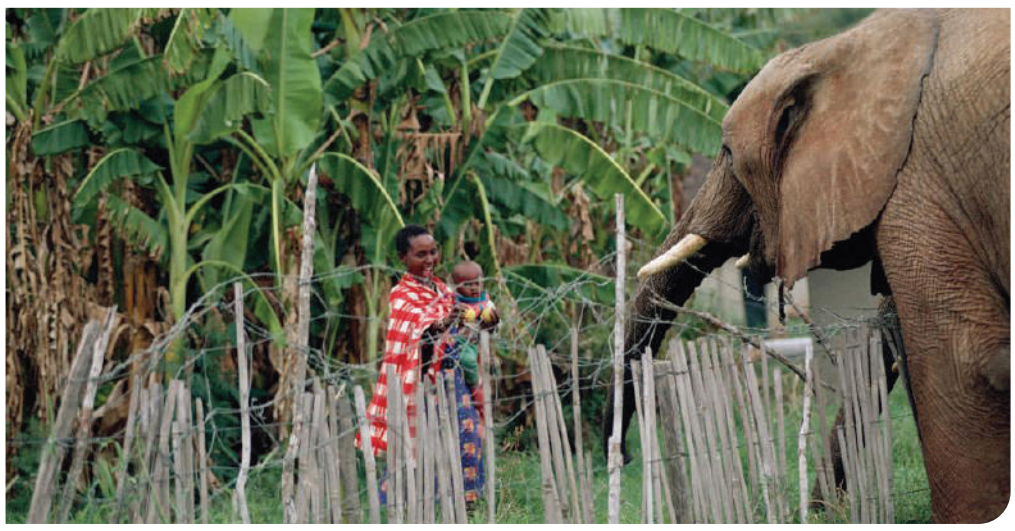
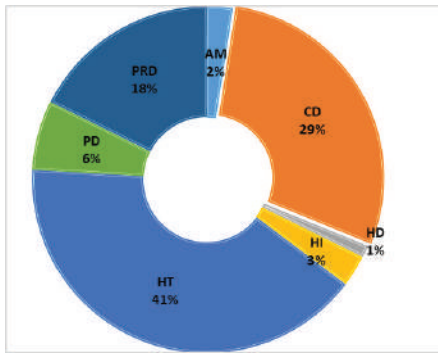


Figure 83: FIVE YEAR COMPARATIVE ANALYSIS OF HWC INCIDENTS 2018 TO 2022

- 28,766 HWC incidents were reported
- 2022 had the highest incident rate of Human wildlife conflicts followed by 2020
- 67% increase in human wildlife conflict incidents in 2022 as compared to 2021





HI = Human Injury
HT = Human threat
HD = Human death
CD = Crop Damage
PRD = Predation
PD = Property Damage
AM = Animal Mortality

Figure 87: Type and relative prevalence of HWCs

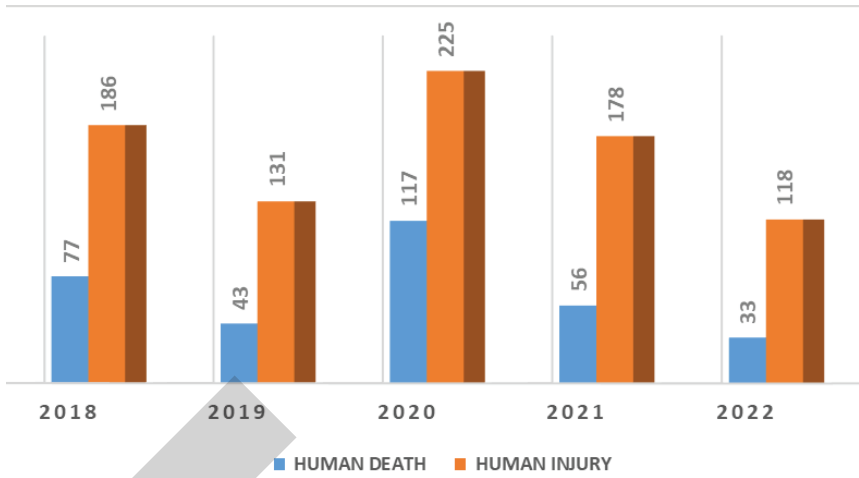


Figure 84: FIVE YEAR COMPARATIVE ANALYSIS OF HUMAN ATTACK (Death & Injury) INCIDENTS 2018 TO 2022

- 326 Cumulatively number of people killed.
- 838 Cumulatively number injured.
- 2020 recorded highest incident rates for both death and injuries followed by 2018

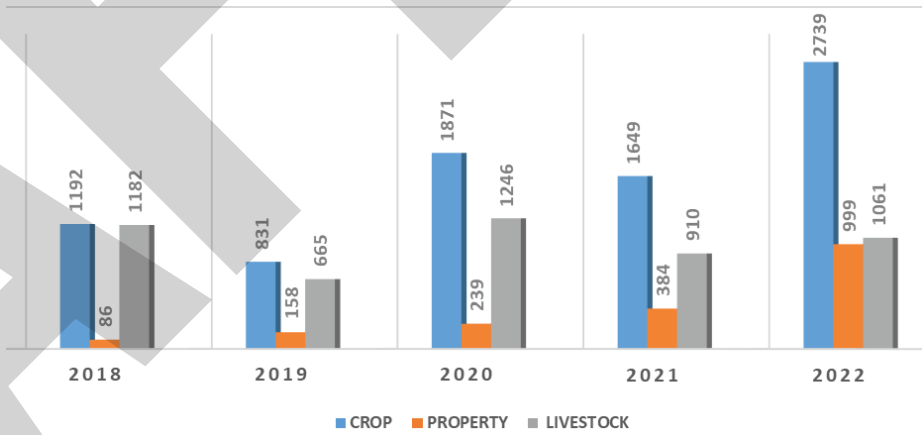


Figure 86: FIVE YEAR COMPARATIVE ANALYSIS OF ATTACKS ON PROPERTY) INCIDENTS 2018 TO 2022

- 15,212- total number of incidents of attacks on properties reported
- Crop destruction & livestock attacks were the most prevalent conflicts.
- 2022 had the highest incident rate of crop destruction followed by 2020.
- 2020 & 2018 – had highest livestock incidents reported respectively.

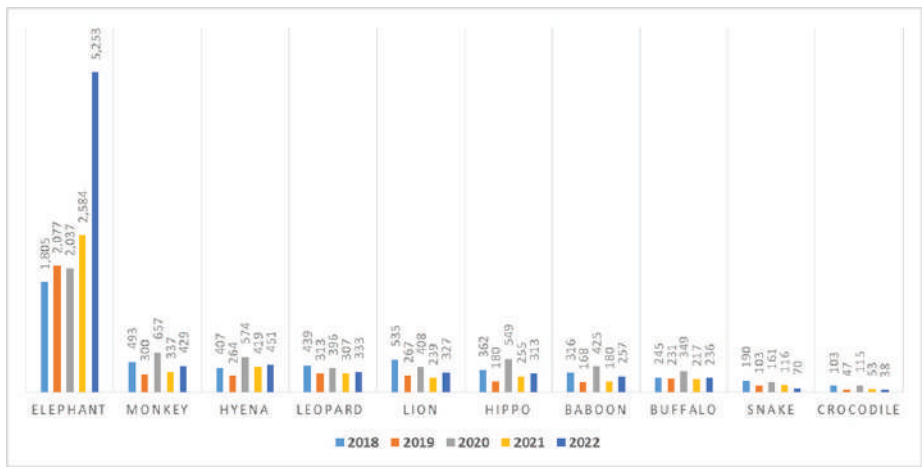


Figure 85: 10 WILDLIFE SPECIES RESPONSIBLE FOR HIGHEST RECORDED INCIDENTS 2018 TO 2022

- 326 Cumulatively number of people killed.
- 838 Cumulatively number injured.
- 2020 recorded highest incident rates for both death and injuries followed by 2018

Management of Human wildlife conflicts

The Government of Kenya is continuously applying different management measures to address these challenges and threats. In addition, the WCMA 2013 aims to create a fair and just relationship between people and wildlife by ensuring that there are opportunities for people to benefit from wildlife without threatening ecosystems and habitats. Existing strategies for managing Human wildlife include:

A) **Preventative strategies: These are measures put in place to try to hinder HWC incident from happening in the first place: They include:**

1. Installation of wildlife barriers e.g., electric fences, bee fences, moats,
2. Early warning systems that can alert of impending cases e.g., wildlife tracking with geo-fencing.
3. Wildlife deterrents e.g., predator lights, predator proof bomas
4. Proactive and preemptive patrols
5. Land use planning and good land management

B) **Mitigative and adaptive strategies: These are measure put in place once conflict has occurred to reduce intensity of conflict to allow coping with the conflict they include:**

1. Undertaking animal drives
2. Problem animal control (PAC)
3. Translocation of problem animals (PAC) and where lethal control is not desirable.
4. Compensation for life and property damages
5. Conservation education and awareness
6. Management of plants and animals' invasive species

Land use and habitat fragmentation

There are a lot of pressure emanating from different land uses around the protected areas. Crop production around protected areas act as attractants to wildlife and thus increase human wildlife conflicts. The increase in crop production areas means that more wildlife habitats are converted to crop areas thereby diminishing wildlife dispersal areas and wildlife corridors

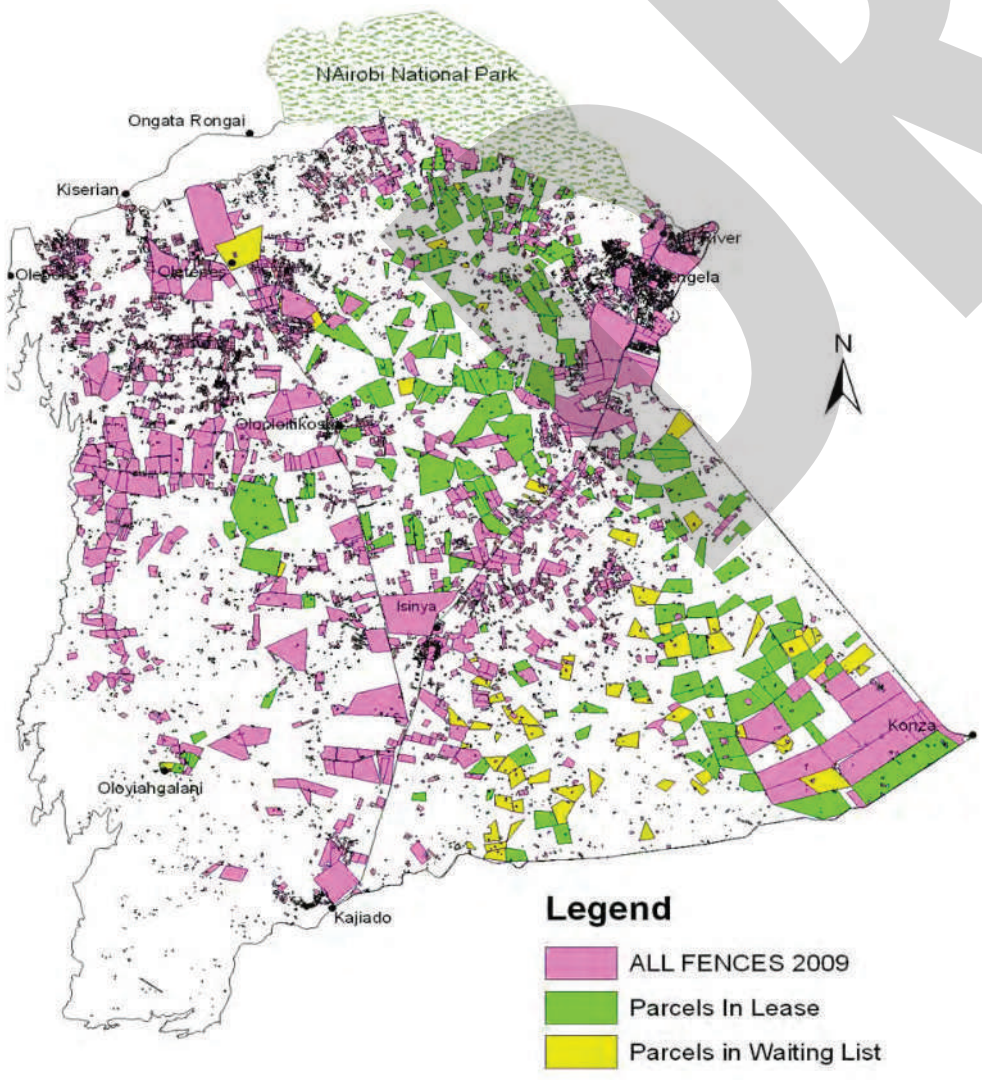


Figure 81: Illustration of habitat fragmentation. Map of dispersal area for the Nairobi National Park ecosystem showing status of fenced parcels of land as at 2009. The situation is even more fragmented now.

Wildlife crime and illegal activities

Pouching for bush meat is a major threat to Kenya's wildlife resources. In terms of counties, Kajiado and Nakuru top in the list of areas with rampant bush meat harvesting perhaps due to settlement and encroachment of wildlife corridors which inhibit the free movement of the wildlife resources. A summary of the cases reported for prosecution regarding bush meat is provided in

Figure 82: Figure 13 Bush meat cases analyzed in the forensic lab for prosecution purposes in 2015

Table 31: *species of wildlife targeted for bush meat*

No.	County	No. Of Cases	Species Identified
1.	Kajiado	51	Zebra, common eland, impala, cattle, Grant's gazelle, wildebeest, Plain's zebra, dikdik, Thompson's gazelle, giraffe
2.	Nakuru	17	Plain's zebra, warthog, buffalo, Donkey, Blue wildebeest
3.	Lamu	11	Lesser Kudu, Buffalo, Waterbuck, Hippopotamus, Buffalo
4.	Narok	10	Plain's zebra, hippopotamus, Common Eland, buffalo, Red fronted gazelle
5.	Mombasa	8	Green sea turtle, loggerhead sea turtle, leopard, rhino
6.	Machakos	8	Hartebeest, wildebeest, Plain's zebra
7.	Tana River	7	Buffalo, waterbuck, elephant
8.	Taita-Taveta	6	Impala, elephant, common warthog
9.	Garissa	5	Giraffe, lesser kudu
10.	Kilifi	4	Donkey, Green Sea turtle, Hippopotamus, dikdik
11.	Nairobi	4	Donkey, Common Eland, elephant
12.	Laikipia	4	Buffalo, rhino
13.	Malindi	4	Bush pig, Elephant, Grey francolin, dikdik
14.	Makueni	3	Elephant, Cheetah, Leopard
15.	Wajir	2	Giraffe
16.	Kitui	2	Elephant
17.	Garissa	1	Giraffe
18.	Kisii	1	Cheetah
19.	Nyeri	1	Aadvark
20.	Isiolo	1	Degraded exhibit
21.	Nyandarua	1	Bushbuck
22.	Nanyuki	1	Bushbuck

Source: KWS's Wildlife Status Report

Infrastructural projects and wildlife conservation

The mega projects such as Standard Gauge Railway (SGR), highways, dam construction, powerlines and lapsset corridor pass through protected areas. This affects wildlife by reducing the wildlife numbers through road kills, segment wildlife home ranges and reduce wildlife food.

SGR passes through Tsavos, Nairobi National Park and other wildlife conservancies in Naivasha. Kenya Electricity Transimission Company (KETRACO), lines 400KV, pass through Tsavo National Parks, Taita Taveta, Machakos and Kajiado wildlife conservancies. The Turkana wind power project in Marsabit covers an area of 400km2 and its transmission lines to Suswa pass through Samburu National Reserve, Namunyak Conservancy in Samburu. The Meru wind power station constructed a 400MW lies in the Nyambene National Reserve.

The Geothermal wells (Olkaria) were sunk inside the Hells Gate National Park reducing wildlife habitats and this will increase competition among wildlife species for leftover space and food. Due to this unfolding pressure on wildlife spaces, wildlife will relocate to other areas--including the nearby flower farms around Lake Naivasha. This will likely increase the human-wildlife conflict. The massive dust driven up by drilling steam wells, which typically goes on 24 hours a day for 60 days for each new well, settles on the leaves of surrounding vegetation. This blocks photosynthesis, reducing food supply for the many large herbivores that have made Hell's Gate famous. Geothermal waste brines spill regularly from broken culverts and overflowing brine pools built by KenGen inside the park. The brines run into the park's natural waterways and gorges, from which both wild animals and the livestock tribe drink. Waste brines contain highly concentrated minerals which can include toxins such as arsenic, boron, and mercury that can poison surface and groundwater. An intersection map that overlays the various infrastructural projects with the wildlife protected areas is provided in Figure 89.

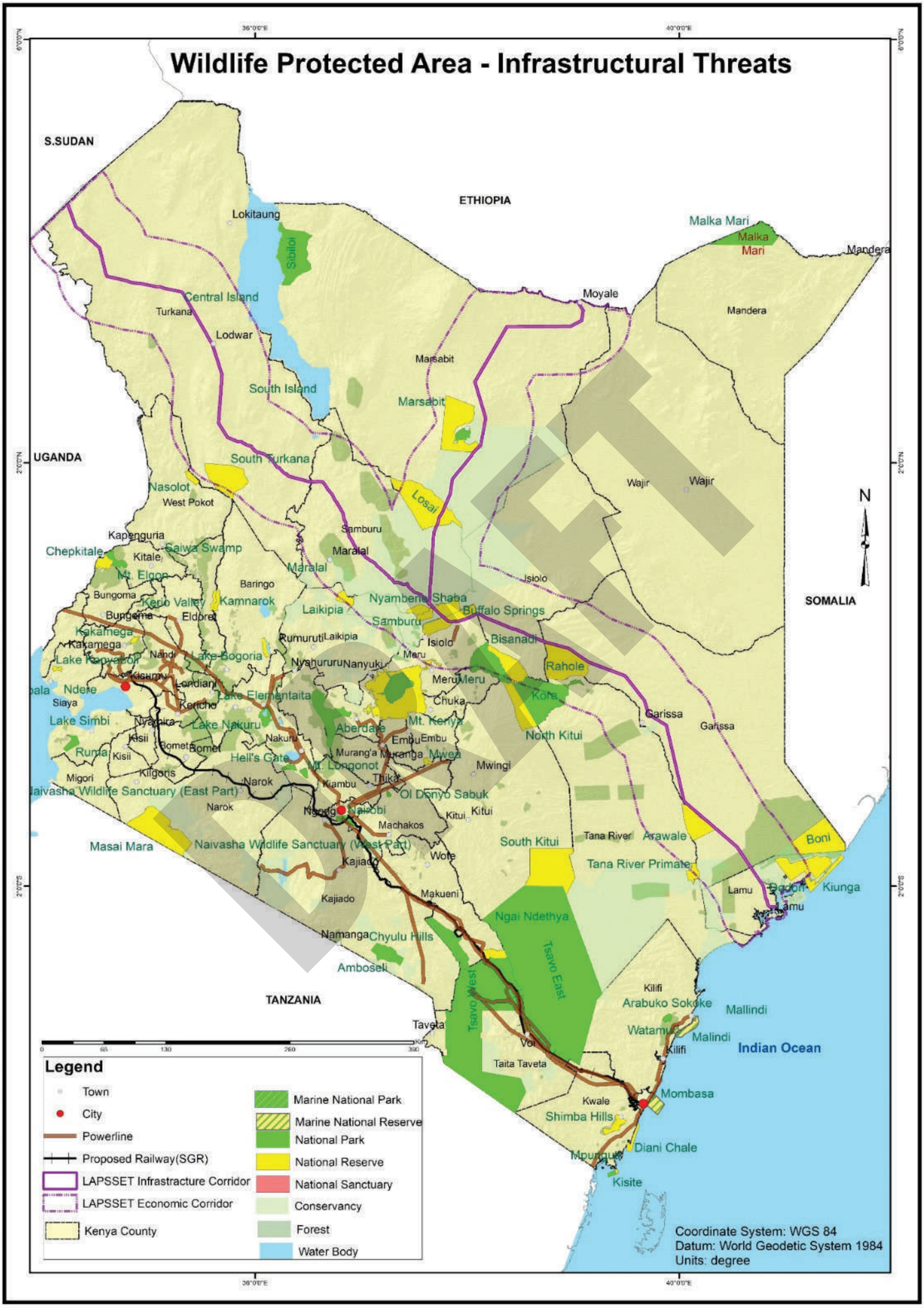


Figure 89: Infrastructural threats to wildlife protected areas

Plant Diversity

Plant communities play a major role in the important ecosystem functions and are used to identify the different ecosystems such as the forest, grassland, woodland, etc. These ecosystems are defined by the different soil types and climatic conditions that are responsible for the distribution of species and diversity. Areas which receive high and regular rainfall patterns such as the central highlands, western and coastal regions have the highest plant species richness compared to the drier north and Eastern regions. Plant species has high distribution in montane areas such as Mount Kenya, Cherangany area, Mount Elgon, Taita Hills; Kakamega and Nandi Forests; Coastal which include Shimba Hills and forests along the coastal area. These montane areas has distinct plants characteristics unique to the different habitats from the high altitude Afromontane to the coastal lowlands.

Kenya is endowed with 7018 species which are distributed across 240 plant families.The Endemic species are 535and threatened and near threatended species are 356 (5.8%). The various botanical exploration initiatives to documentation of the available plant species in Kenya from 1995 to 2015 has led to the gradual increase from 6,302 to 7018 species.

Plant Conservation Status

Kenya is endowed with 7018 species which are distributed across 240 plant families. An estimated number of 356 plant species (5.8%) are classified by the IUCN red list of threatened species as Threatened or Near Threatened, and 535 as Endemic species. Endemic species are species that are restricted to a limited geographic area or ecological habitat. Out of 356 species, Critically Endangered (CR) species are 21, Endangered Species 83, Vulnerable Species 128, and Near Threatened Species are 56. Threatened species are particularly common in the Fabaceae, Euphorbiaceae and Rubiaceae families. While, the 535 Kenyan endemic plants are dominated by species from Euphorbiaceae (Euphorbia family) that has the highest number of species followed with Leguminosae(bean family), Rubiaceae(coffee family), and Asteraceae(sunflower family). The Coastal Forests such as Kaya forests and the Arabuko Sokoke National Park are dominantly hotspot, hosting about 95 of these threatened plant species.

Species of Economic importance

Most living organisms depend on plants as a primary food resource, 80% of the food derived from plants are from 17 plant families (SOWP, 2017). Kenya has about 65 Aloe species in the wild, of which about 50% are endemic and well adapted to dry semi-arid conditions. Various communities in Kenya exploit these species for medicinal and cosmetic use. Two recently discovered species in 2020 are Aloe ngutwaensis from Makueni County and Aloe allochroa from Elgeyo Marakwet County.

Conservation Threats

The Flora composition is increasingly threatened by human modification of the landscape. The land-use changes have a major impact on biodiversity as compared to climate change, this is because the actions are rapid and immediate as opposed to climate change which is a much slower process. (Verburg et al.,2011). The Alien Invasive Plant Species (AIPS) is increasingly becoming a threat to biodiversity conservation through their capability of destroying indigenous plant species distribution on the landscape. AIPS spread is facilitated by increasing cross-border trades and development projects such as road constructions.

Plate 25: Opuntia ficus indica

Plate 26: Eichhornia crassipes

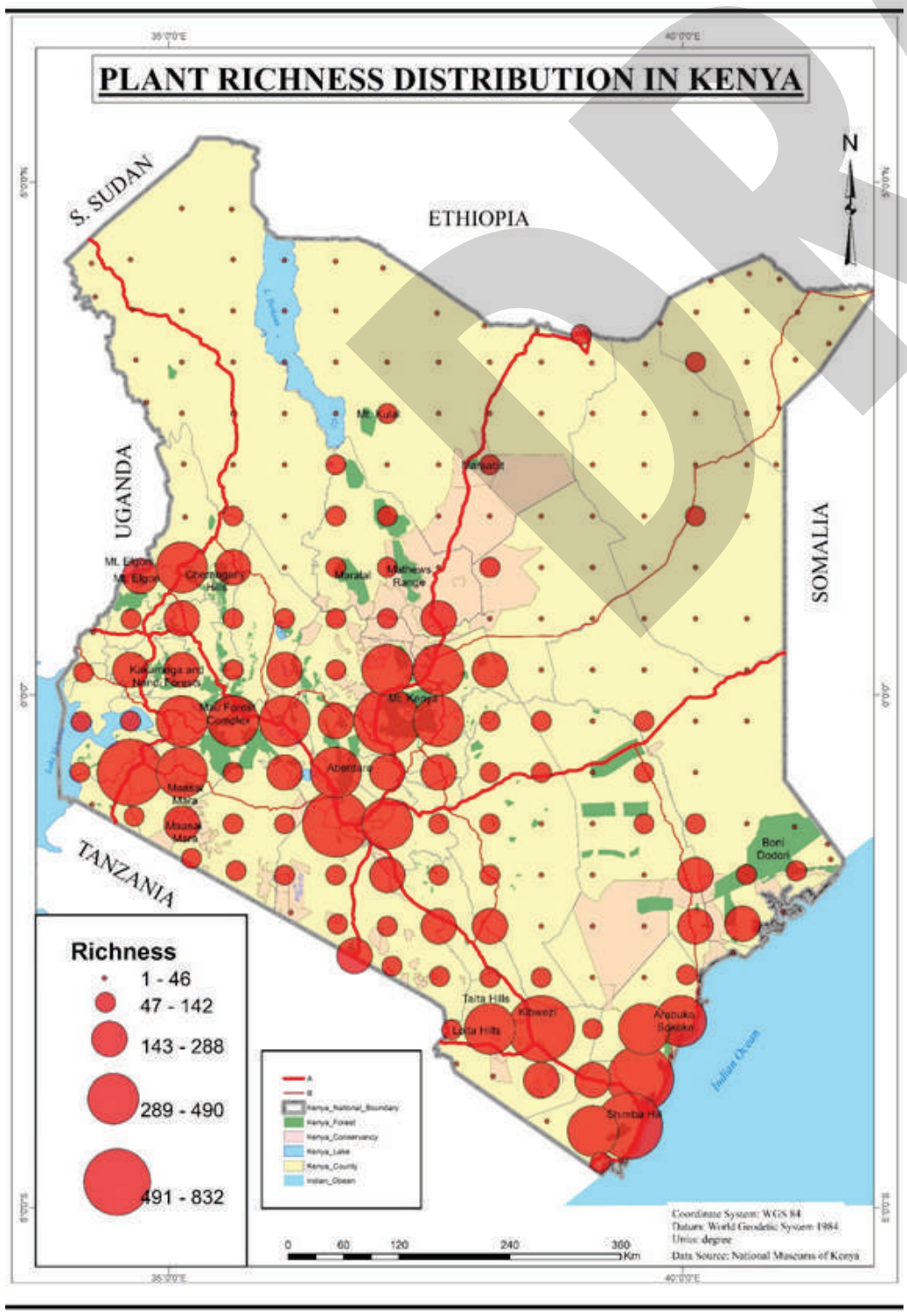


Figure 90: Plant richness distribution in kenya

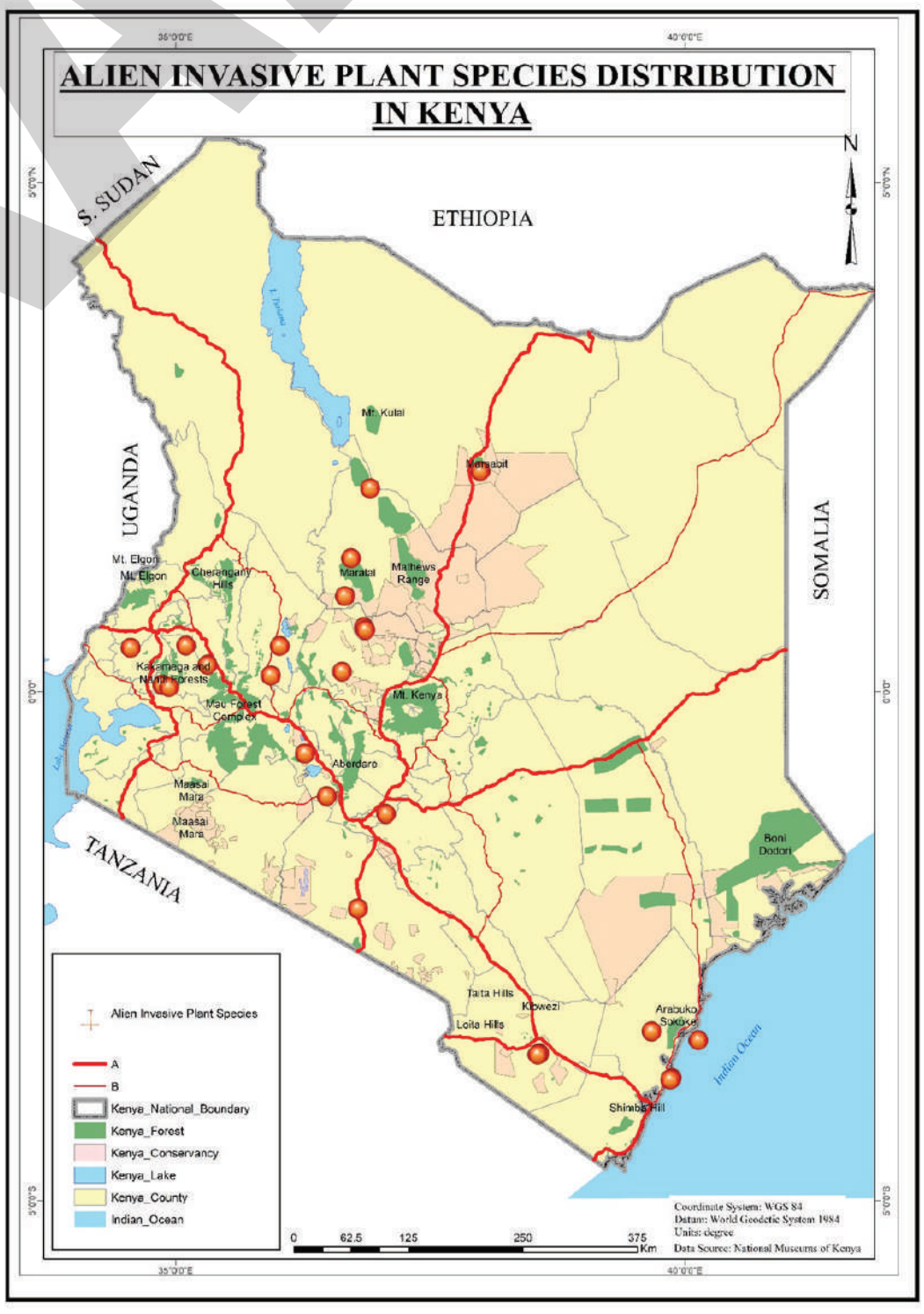


Figure 91: Alien invasive plant species distribution in kenya

Reptiles and Amphibians

Amphibians and Reptiles are a group of cold-blooded vertebrates. However, the difference between the groups is that amphibians spend early part of their lives in aquatic habitat but exploit terrestrial habitats when adult; while reptiles live on land and have epidermal scales covering part or the entire surface of the body. The major groups of amphibians in Kenya are frogs, toads and caecilians. They live on both land and water. Their dependency on water, especially the strictly aquatic early life stages, underscores the importance of wetland habitats. While reptiles include the snakes, lizards, tortoises, turtles and terrapins, and crocodiles. These species occur across all the ecosystems of the country ranging from the marine to the moorlands of Mt Kenya.

Plate 27: Eastern Forest Cobra (Naja subfulva)

Amphibians and Reptile Conservation Status

There are four main centers of distribution of reptiles in Kenya including: Lowland coastal forests, Taita Hills, central highlands and Lake Victoria basin (Figure 52). Overall species richness for both reptiles and amphibians shows relatively low species occurrence in the north and north eastern Kenya. This disparity could be attributed to lack of suitable habitats in the arid and semi-arid lands (ASALs). However, another plausible reason is perhaps related to historical logistical constraints to research and data collection such as poor infrastructure and insecurity. There are 382 species of reptiles (269) and amphibians (113) in Kenya. The 269 species of reptiles include 127 snake species, 126 lizards, 5 tortoises, 10 turtles and terrapins and 1 crocodile which occur across diverse habitats in Kenya (Spawls et al, 2018; Uetz, 2019). On the other hand, a total of 113 species of amphibians have been documented in Kenya (Frost, 2019; .Channing and Howell, 2006). The level of endemism of Kenyan reptiles and amphibians is remarkable. There are 32 (11.9%) and 22 (19.5%) Kenyan endemic species of reptiles and amphibians respectively (Uetz, 2019; Frost, 2019) . This underscores the national conservation importance of these taxa considering the fact that some are highly range-restricted. Endemic Reptile Species

Table 32: Threatened reptiles and amphibians

Taxa	Vulnerable	Endangered	Critically Endangered	Totals
Reptiles	6	4	3	13
Amphibians	3	6	1	10

Endemic Reptile Species

1. Agama caudospinosa Elmenteita Rock Agama
2. Agama hulbertorum Ngong Agama
3. Kinyongia asheorum Mount Nyiro Bearded Chameleon
4. Kinyongia boehmei Taita Hills Blade-horned Chameleon
5. Kinyongia excubitor Mount Kenya Hornless Chameleon
6. Trioceros kinangopensis Mount Kinangop Alpine Chameleon
7. Trioceros marsabitensis Mount Marsabit Chameleon
8. Trioceros narraioca Mount Kulal Stump-nosed Chameleon
9. Trioceros ntunte Mount Nyiru Montane Chameleon
10. Trioceros nyirit Pokot Chameleon
11. Trioceros schubotzi Mount Kenya Side-striped Chameleon
12. Hemidactylus barbierii Lake Turkana Gecko
13. Hemidactylus modestus Tana River Gecko
14. Hemidactylus mrimaensis Kaya Mrima Gecko
15. Lygodactylus grandisonae Bunty's Dwarf Gecko
16. Lygodactylus wojnowskii Mount Kenya Dwarf Gecko
17. Adolfus alleni Mount Kenya Alpine Meadow Lizard
18. Philochortus rudolfensis Turkana Shield-backed Ground Lizard
19. Meizodon krameri Tana Delta Smooth Snake
20. Thrasops schmidti Meru Tree Snake
21. Amblyodipsas teitana Taita Hills Purple-glossed Snake
22. Aparallactus turneri Malindi Centipede-eater
23. Epacrophis boulengeri Lamu Worm Snake

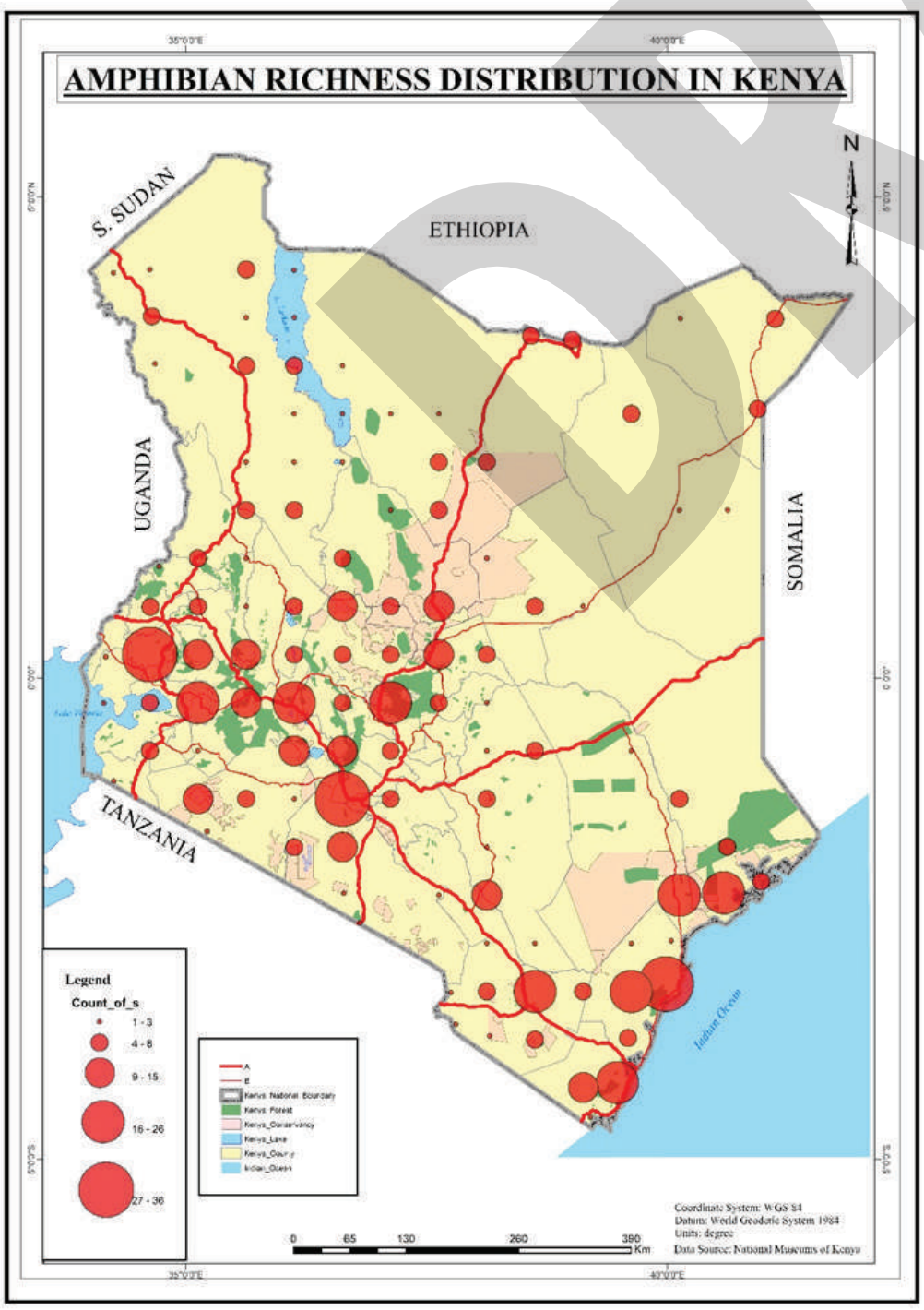


Figure 92: Amphibian richness distribution in kenya

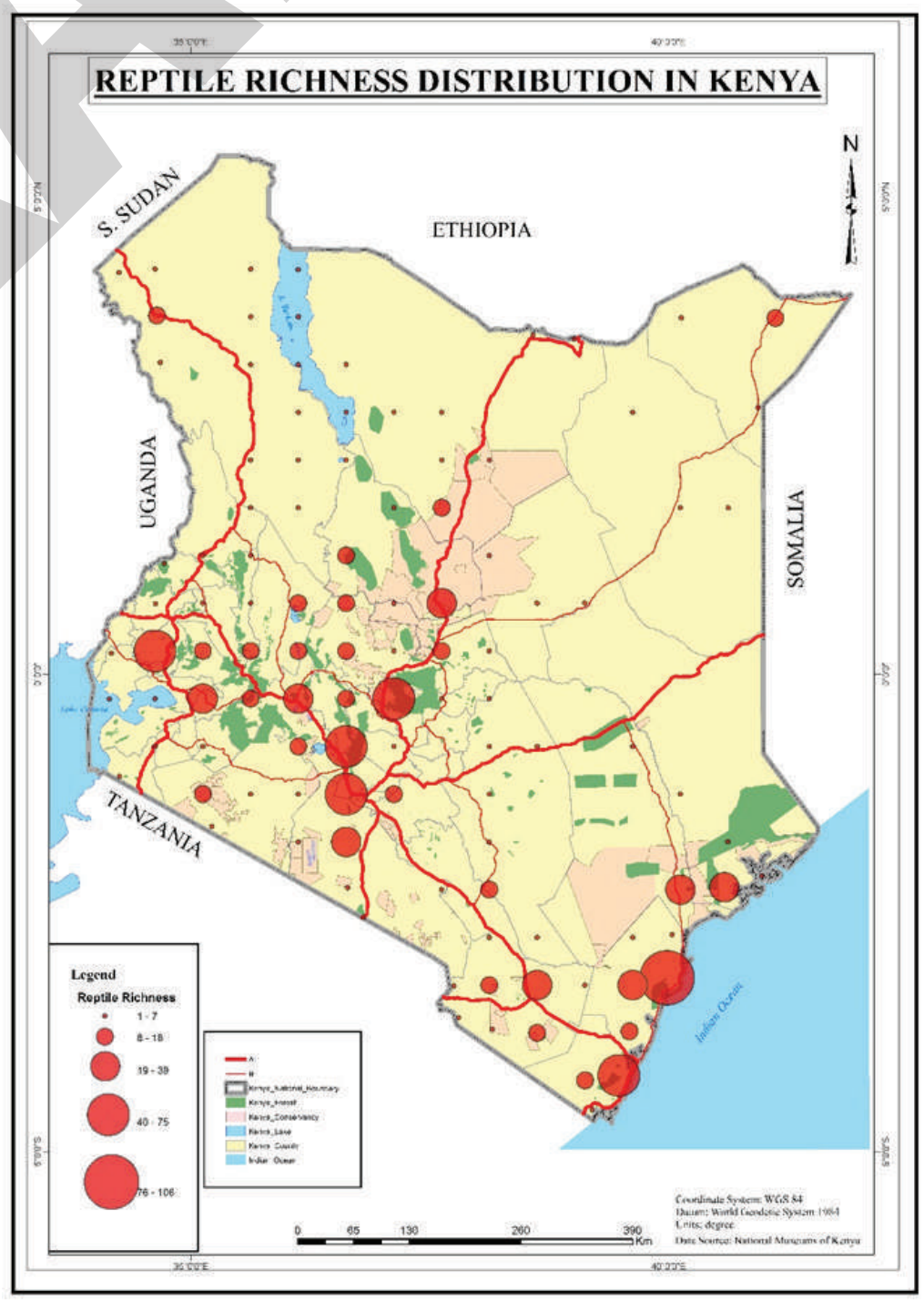


Figure 93: Reptile distribution in kenya

24. Epacrophis drewesi Drewes' Worm Snake
25. Leptotyphlops keniensis Mount Kenya Worm Snake
26. Afrotyphlops kaimosae Kakamega Blind Snake
27. Afrotyphlops nanus Kenyan Dwarf Blind Snake
28. Letheobia mbeerensis Mbeere Gracile Blind Snake
29. Atheris desaixi Mount Kenya Bush Viper
30. Bitis worthingtoni Kenya Horned Viper
31. Montatheris hindii Kenya Montane Viper

Pelusios broadleyi Lake Turkana Hinged Terrapin

Endemic Amphibian Species

1. Agama caudospinosa Elmenteita Rock Agama
2. Agama hulbertorum Ngong Agama
3. Kinyongia asheorum Mount Nyiro Bearded Chameleon
4. Kinyongia boehmei Taita Hills Blade-horned Chameleon
5. Kinyongia excubitor Mount Kenya Hornless Chameleon
6. Trioceros kinangopensis Mount Kinangop Alpine Chameleon
7. Trioceros marsabitensis Mount Marsabit Chameleon
8. Trioceros narraioca Mount Kulal Stump-nosed Chameleon
9. Trioceros ntunte Mount Nyiru Montane Chameleon
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12. Hemidactylus barbierii Lake Turkana Gecko
13. Hemidactylus modestus Tana River Gecko
14. Hemidactylus mrimaensis Kaya Mrima Gecko
15. Lygodactylus grandisonae Bunty's Dwarf Gecko
16. Tomopterna gallmanni Gallmann's Sand Frog
17. Tomopterna monticola Olengarua Sand Frog
18. Boulengerula changamwensis Changamwe Caecilian
19. Boulengerula denhardti Tana River Caecilian
20. Boulengerula niedeni Sagalla Caecilian
21. Boulengerula spawlsi Spawls' Boolee
22. Boulengerula taitana Taita Hills Caecilian

Species Economic Importance

Ecological role of amphibians and reptiles in balancing of nature is vital in environment. Amphibian larvae are critical in controlling malaria by feeding on vector transmitting mosquitoes. In general, the species role in trophic levels brings an important balance in ecosystem food web. Different species of reptiles and amphibians have considerable impact on human livelihoods (MENR, 2015). These include both extractive and non-extractive services. Most of these species are associated with key socio-economic benefits. There are various business enterprises focusing on provision of goods such as meat and leather from crocodiles. In addition, they are used in international pet trade. These species also play an important role in the tourism sector within reptile parks. However, there are plenty of untapped opportunities for sustainable utilization of reptiles and amphibians.

Venomous snakes pose serious public health concerns. World Health Organization (WHO) listed snakebites as a Neglected Tropical Disease (NTD) at the World Health Assembly in 2017. Globally, an estimated 1·8–2·7 million people develop serious clinical illness from snake bites annually. This burden more prevalent in Kenya and the rest of sub-Saharan Africa. According to Ochola et al (2018), the snake bite incidence from four hospitals in Kenya ranged from 2.7 – 6.7/1,000,000/year.(Figure 100). This might be an under-estimate considering that only small fractions of cases are reported to the hospitals.

Plate 28: Savanna ridged frog (Ptychadena anchietae)

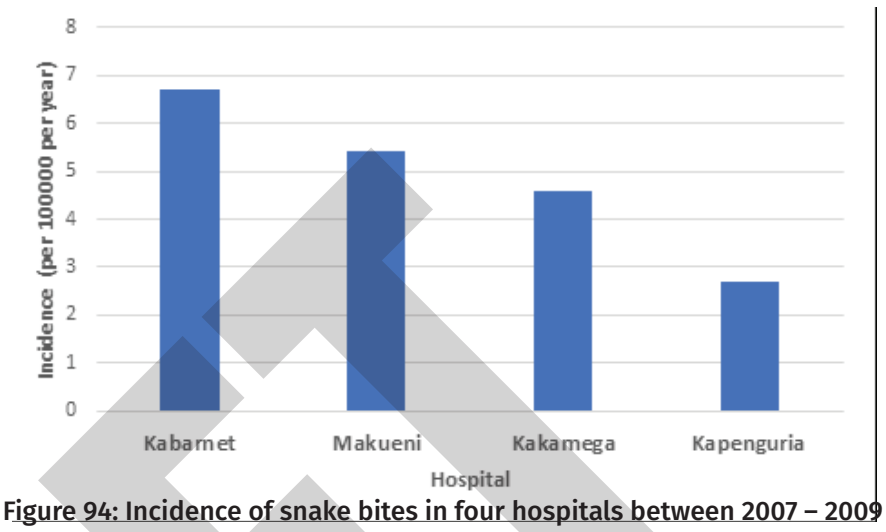


Figure 94: Incidence of snake bites in four hospitals between 2007 – 2009

Conservation Threats

A total of 23 species of reptiles and amphibians are threatened with extinction (Table 55). Some of the threats to these species include habitat loss, over-exploitation (e.g. through collection for international trade), poor attitudes, diseases, pollution, and climate change. Generally, lower vertebrates such as reptiles and amphibians don't attract much attention and are frequently persecuted or killed indiscriminately. Amphibians are particularly sensitive to environmental changes such as release of chemicals into aquatic ecosystems. Other critical habitats such

Plate 29: Argus reed frog (Hyperolius argus)

Plate 30: Leopard tortoise (Stigmochelys pardalis)

Invertebrates

Invertebrates are animals that do not have or develop a vertebral column (backbone). They are multicellular, ectotherms and change forms as they undergo metamorphosis during growth and development. Invertebrates form about 97% of all animals, about 1.25 million species of invertebrates have been described globally. Invertebrates is a diverse group in terms of size, shape, symmetry and form occurring in all habitats including grasslands, forests, wetlands, drylands, deserts, marine and fresh water, soil and parasitic life. Various groups that comprise invertebrates in Table 33 below.

Table 33: *Diversity of invertebrates*

Group	Distinctive feature	Examples
Arthropoda	Jointed appendages and exoskeleton	Insects, arachnids, crustaceans
Mollusca	Soft-bodied with a mantle	Snails, bivalves, squids and octopus
Annelida	Segmented worms	Earthworms and leeches
Cnidaria	Hollow-intestined organisms	Jellyfish, hydra and corals
Nematoda	Unsegmented worms	Roundworms
Porifera	Pore bearing organisms	Sponges
Echnidermata	Spiny skin organisms	Sea urchins and sea stars
Platyhelminthes	Soft unsegmented body	Flatworms

Species Conservation Status in Kenya

Kenya about 25,150 invertebrate species has been described. However, there are records that are yet to be described while many more invertebrate species are yet to be recorded. There is an increasing trend of number of species described and number of threatened species in Kenya as shown in Table 35 below.

Table 35: *Number of threatened species in Kenya*

Year	1990	1995	2000	2010	2015
Number of species	25,000	25,010	25,025	25,050	25,150
% threatened species	100 (0.4%)	115 (0.5%)	125 (0.5%)	158 (0.6)	170 (0.7%)

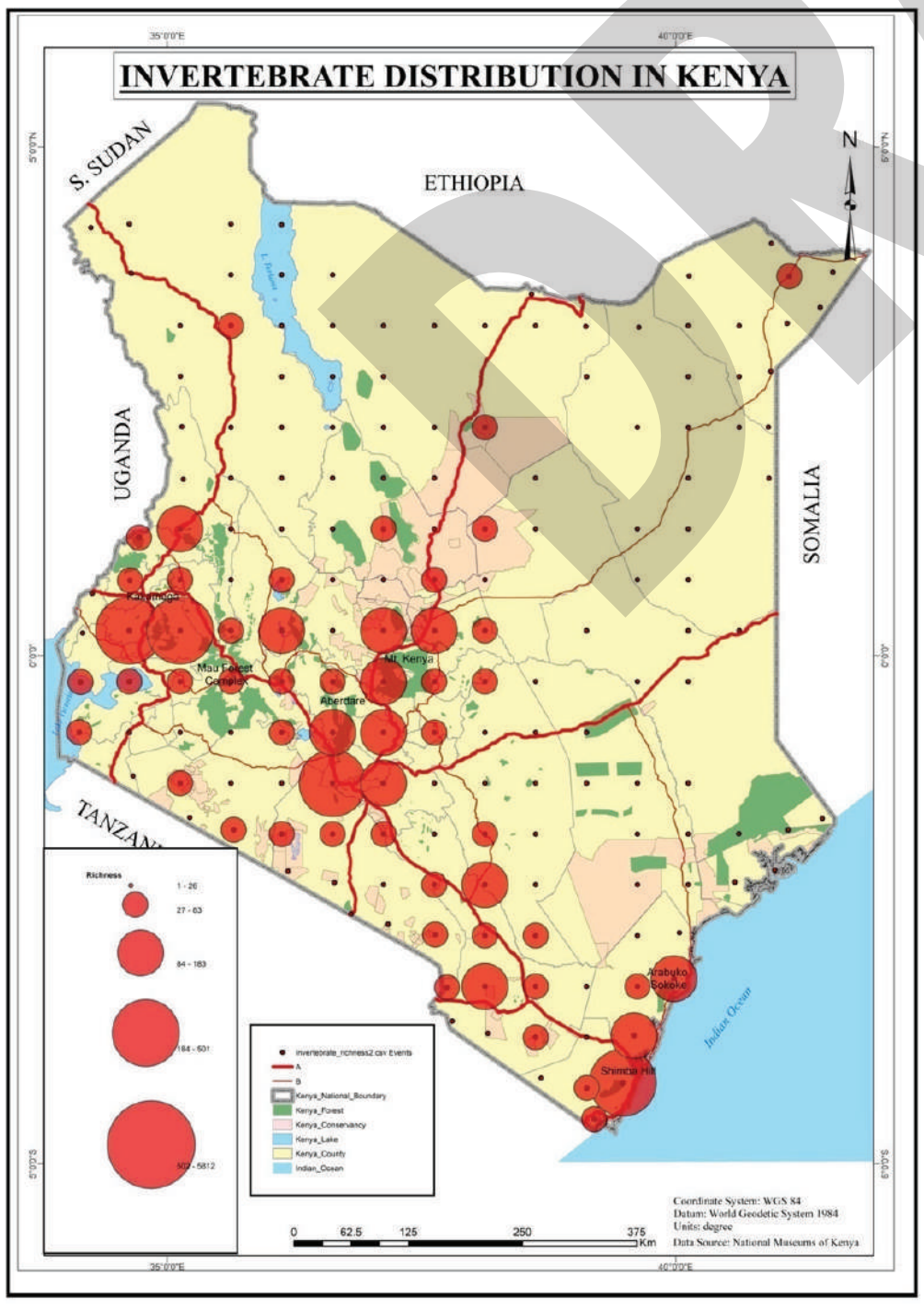


Figure 95: Invertebrate distribution in Kenya

Arthropods account for majority of the described species with insects being the most diverse group. Some of described species in the various groups are shown in table 3 below.

Invertebrates are fairly distributed in all parts of the country with high species richness occurring in protected areas like Arabuko-Sokoke and Kakamega forests, Shimba and Taita hills, Tsavo, Nairobi, Aberdare and Mt. Kenya National Parks (Fig…). In these major biomes several invertebrate species are endemic or near-endemic thus calling for conservation of biomes.

Table 34: *Number of species by anthropod group*

Arthropod group	Number of species listed in Kenya
Beetles	9000
Butterflies	900
Bees	800
Ants	650
Crustaceans	343
Dragon flies	194
Thrips	60

Invertebrate Species Conservation Importance

Invertebrates are very diverse and they are critical to ecosystem functions as they perform important economic and socio-cultural roles in our societies.

a) Nutrient recycling

Diverse invertebrates like crabs, dung beetle and Black soldier fly (BSF) break down organic waste while termites with help of symbiotic bacteria break down cellulose in wood, and ants as they feed they are actively involved in nutrient recycling thus releasing/availing nutrients to the environment (Van Huis, 2013).

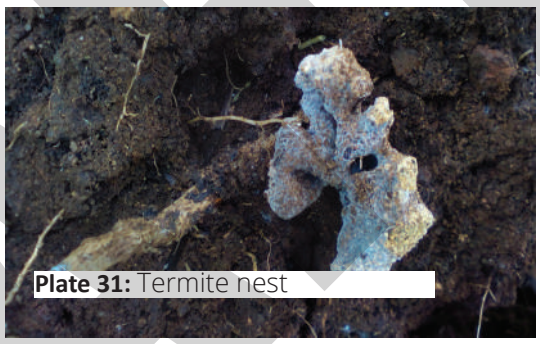


Plate 31: Termite nest

Plate 32: Dorylus molestus

b) Bio-monitoring

Invertebrates exhibit various responses to environmental and anthropogenic changes. Some species have restricted range in terms of their habitats while others are endemic. These species are very sensitive to environmental destruction, pollution, habitat fragmentation and climate change (Melodie, 1998). Results of insect population, abundance and richness studies are highly effective and informative indicators of ecosystem functions. These results are useful in making appropriate and effective decisions on habitat health, associated threats and possible restoration/management policies. Some key insects groups used for bio-monitoring and the changes and threats indicated are highlighted in Table 36.

Table 36: *Number of threatened species in Kenya*

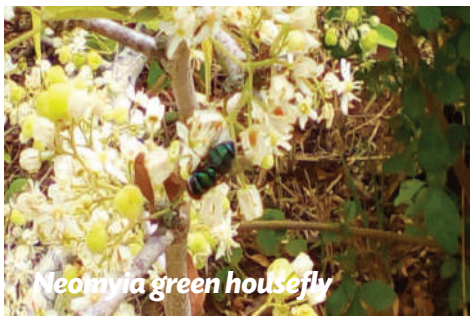
Key insect group	Change indicated
Beetles	Forest degradation, pollution and management
Butterflies and flies	Forest disturbances and general habitat quality
Bees	Changes in general habitat quality
Grasshoppers and bugs	Grassland habitat disturbance and management
Bees, butterflies and beetles	Habitat fragmentation
Dragonflies, stoneflies, mayflies, caddisflies and aquatic beetles	Water quality and aquatic habitat integrity
Collembolans, beetles and butterflies	Landscape and ecosystem sustainability

Plate 33: Eudicella smithi tetraspilota

Plate 34: Synagris aestauns

c) Pollination

Terrestrial invertebrates are involved in pollination of both wild and cultivated plants and grasses when feeding or visiting plants for brooding and roosting. Through pollination, invertebrates directly influence plant diversity, food and


Neomyia green housefly


Coeliades forestan

nutrition security because 87.5% plants rely on pollination to reproduce (De Luca & Vallejo-Marin, 2013).

d) Pests of crops, trees and stored products

Diverse groups of invertebrates like cotton-stainers, scale insects and aphids (Hemiptera), fruit fly (Diptera) and fall army worm, cut worms and stalk borers (Lepidoptera) are pests in agricultural fields, forests, rangelands and


Plate 35: Mylabris aperta taborensis


Plate 36: Papilo demodocus

orchards. Angoumois moth, warehouse moth, flour moth (Lepidoptera), silverfish (Zygentoma) and grain weevil, drugstore beetle, and granary weevil (Coleoptera) are pests of store products

e) Bio-control agents for pests (natural enemies)

Parasitic and predatory wasps and weaver ants (Hymenoptera), Tachnid fly and Hover fly (Diptera), Rove and ladybird beetle (Coleoptera), spiders (Aranea),

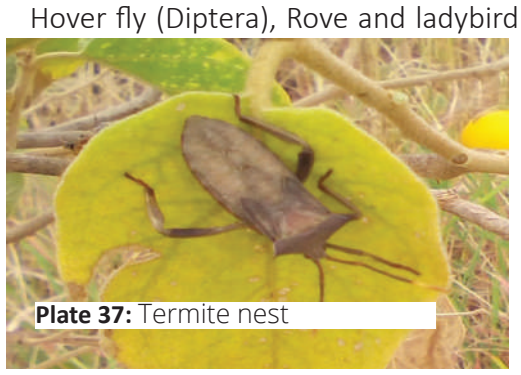


Plate 37: Termite nest

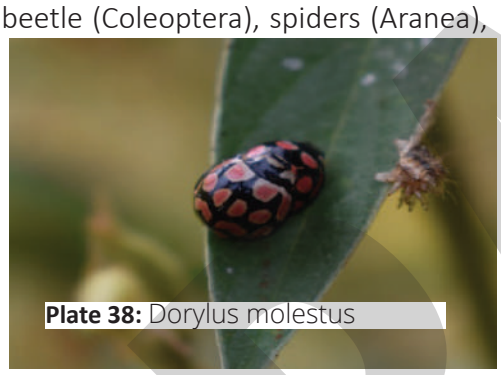


Plate 38: Dorylus molestus

predatory bugs (Hemiptera) and praying mantis (Mantodea) are farmers' friends because they help to keep pest population under check by preying and parasitizing pests of crops, orchards, forests and grasses (Van Huis, 2013).

f) Influence on biodiversity distribution

Invertebrates influence distribution of plants through parasitizing on parts of plants and seed dispersal to new habitats for regeneration and colonization.

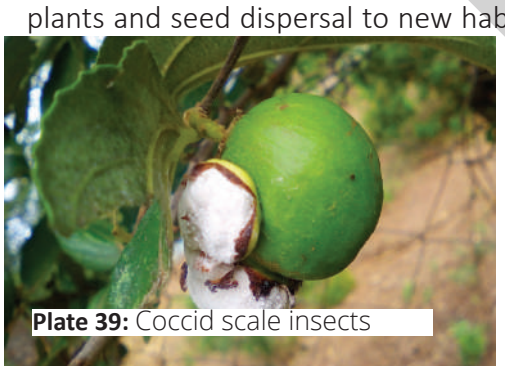


Plate 39: Coccid scale insects

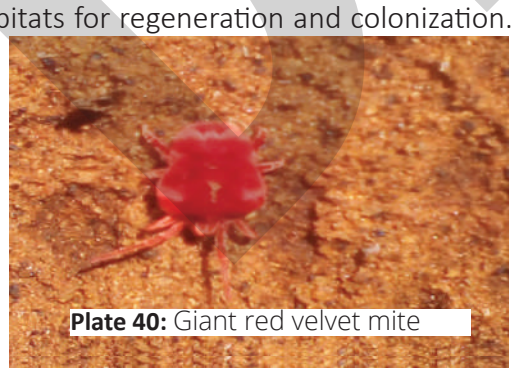


Plate 40: Giant red velvet mite

Likewise some invertebrates (lice, mosquitoes, fleas, sand flies, ticks and mites) are vectors of both veterinary and medical diseases. This acts as a natural population control and affects the utilization of natural resources as areas infested by vectors are lowly populated thus affecting animal distribution.

g) Vectors of medical and veterinary diseases

Vectors are living organisms that carries and transmits disease causing pathogen from one animal to the other. Most vectors transmits the pathogens from an infected animal to uninfected one during feeding as most of them are blood-sucking (WHO, 2017). Table 5 below highlights some vectors and the medical disease they transmit.

Table 37: *Number of threatened species in Kenya*

Vector	Disease transmitted
Aedes mosquitoes	Chikungunya, Dengue fever, yellow fever, Rift valley fever, lymphatic filariasis and Zika
Anopheles mosquitoes	Malaria and lymphatic filariasis
Culex mosquitoes	West Nile fever, lymphatic filariasis and Japanese encephalitis
Sandflies	Leishmaniasis and phelebotomus fever (Kala azar or sandfly fever)
Ticks	Tularaemia, tick-borne encephalitis, relapsing fever, Crimean-Congo haemorrhagic fever
Triatomine bugs	Chagas disease (American trypanosomiasis)
Tsetse flies	Sleeping sickness (African trypanosomiasis)
Fleas	Plaque from rats to human beings, and rickettsiosis
Black flies	Onchocerciasis (River blindness)
Aquatic snails	Schistosomiasis (bilharzia)
Lice	Typhus and louse-borne relapsing fever

Table 38: *Number of threatened species in Kenya*

Order	Scientific name	Common name	Local/Kiswahili name
Orthoptera	Ruspolia differens	Longhorn grasshopper	Senene
Orthoptera	Ruspolia nitidula	Grasshopper	Senene
Orthoptera	Gryllus bimaculatus	Two-spotted cricket	Nyenje
Orthoptera	Acheta domesticus	House cricket	Nyenje
Isoptera	Macrotermes bellicosus	Termite	Kumbikumbi
Isoptera	Macrotermes subhyalinus	Termite	Kumbikumbi
Hymenoptera	Apis mellifera	Honey bee	Nyuki
Diptera	Hermetia illucens	Black soldier fly	
Lepidoptera	Bunae alcinoe	Common emperor	Maungu
Lepidoptera	Cirina forda	Pallid emperor moth	Maungu

h) Insects as food and feed

1,900 insects species form part of diet for more than 2 billion people (Van Huis, 2013) in many parts of the world especially in tropical countries (DeFoliart, 2018). In addition, sea foods (shellfish) like lobsters, crayfish, shrimp and crabs are rich in lean protein, fats and minerals that boost immunity, help in weight loss, promote brain and heart health (NHS, 2015). Commonly consumed insects in Kenya are shown in table 6 below.

i) Invertebrates for ecotourism attraction


Plate 41: Junonia natalica


Plate 42: Echinometra sp

Invertebrates have different pigmentation and pigmentation formats thus some are domesticated or reared under captivity due to their aesthetic value which earns the farmers/institutions revenues and creates employment. In addition, rearing these invertebrates leads to their conservation because their biology and ecology are studied to ensure they thrive well in captivity. Examples are butterfly house in Fort Jesus, Mombasa and Watamu Marine Park.

Invertebrate Species Conservation Threats

1. Excessive, unnecessary and broad use of inorganic pesticides. Inorganic pesticides are not target specific thus when used they kill both the pest and the beneficial invertebrates.
2. Habitat loss through cutting down host plants and burning down grasslands to create farms and room for urban centers. The outcome is reduction of


Plate 43: Overgrazing leads to habitat destruction


Plate 44: Bush burning kill insects and destroys habitat

vegetation cover which acts as floral resources for pollinators and food for many invertebrates.

3. Habitat degradation as a result of pollution and other anthropogenic effects in ecosystems, like overgrazing and grassland burning.
4. Climate change is changing ecosystems thus leading to redistribution of different invertebrates and also poses a challenge of extinction.

Way forward

1. Farmers should be trained in order to adopt environmental conscious methods of pest control like use of organic pesticides and integrated pest and pollinator management (IPPM).
2. Public awareness to be created on the importance of conserving some resources for invertebrates in farms and urban areas by leaving edge vegetation to provision roosting, breeding and feeding sites for invertebrates..
3. Government authorities to ensure intensive environmental impact assessments (EIAs) are done and public participation is undertaken before implementation of projects to avoid destructions of important biomes.
4. Edible invertebrates' identity, biology and ecology need to be assessed so as to do mass production in order to improve on food and nutrition security especially in the rural areas where they naturally occur and are consumed, and food insecurity is rampant.
5. Environmental watchdog institutions like water towers agency, water resource management authority and NEMA among others to ensure industries adhere to waste and sewerage disposal to curb pollution of aquatic ecosystems.
6. A checklist of all endemic and near-endemic invertebrate species to be developed in order to ensure they are assessed and listed in IUCN, and CITES if they fall in those categories. The listing will help in making conservation decisions for the listed invertebrate species.
7. More invertebrates' ecotourism centers to be established in all major invertebrates biomes in Kenya. This will ensure domestic and foreign tourists can have a fast taste of what is occurs in that biome without going for lengthy exhausting safaris in the biomes where they may not spot the different invertebrates.
8. Learning institutions to establish pollinator gardens in order to stimulate understanding and appreciation of roles played by invertebrates.

Birds

Birds are important part of our world by performing a variety of important ecosystem services and functions. Their beauty, diversity and ability to bring us great joy and pleasure are widely reflected in our poetry, art, literature and crafts. This diversity of bird community assemblages in Kenya, reflects a diverse range of habitats from montane forest in the west to semi-arid scrub in the north and mangrove forests in the southeast (Fanshawe and Bennun, 1991). Kenya has diverse habitat types that host different bird species on the wider landscape. The landscape is interspersed by forest, wetland, grassland, arid and semi-arid ecosystems among others (Bennun and Njoroge, 1991). Owing to the country's geographical location, our land mass provides a major migration route for waterbirds, raptors and passerines en route from the Palaearctic region to their non-breeding grounds in sub-Saharan Africa (Fanshawe and Bennun, 1991). The major migratory flyways in Kenya include the 550 km long coastline and the chain of lakes stretching along the Rift Valley from Turkana in the north to Magadi in the south (Map below). Our country lies within key endemic bird areas (Figure xx) which consist of the 9 restricted range species of the Kenya Mountains Endemic Bird Area (EBA) and 7 of the East African coastal forests EBA. We also have small portions of other EBAs: Tanzanian Malawi Mountains; Serengeti plains; Jubba and Shabeelle valleys.

Birds Conservation Status in Kenya

Kenya has one of the richest avifauna in Africa with about 1,100 species recorded (Appendix 1). Of these, 800 species are residents, 60 species are afro-tropical migrants moving within the continent and Madagascar while 170 are Palaearctic migrants that journey from Eurasia each winter. Some 230 species are entirely forest dependent and 110 require undisturbed habitat. The diversity of bird species places the country in a high priority for conservation. Owing to this, Kenya is a member state and a signatory to various conventions that are targeted to protection and conservation of species e.g. CMS, CITES, RAMSAR, CBD. The most significant avian biomes are Somali-Masai with 94 out of 129 species in Kenya; East African Coast with 29 out of 38 species; Afrotropical Highlands with 70 out of 226 species; and the small Lake Victoria Basin with 9 out of 12 species. The easternmost part of the Guinea-Congo Forest biome holds 43 out of 277 species and Sudan-Guinea Savanna holds 13 out of 55 species.

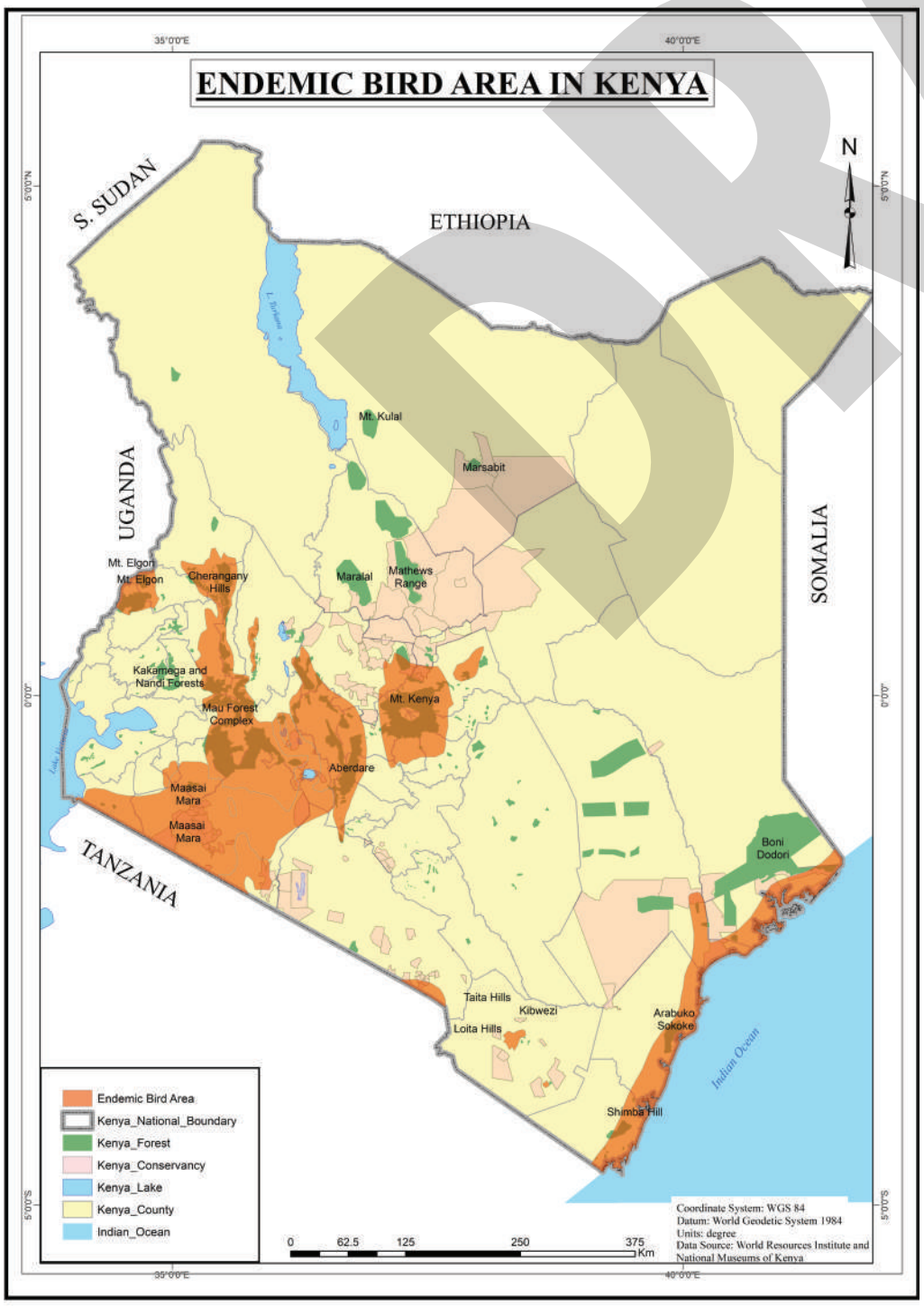


Figure 96: Endemic Bird Areas

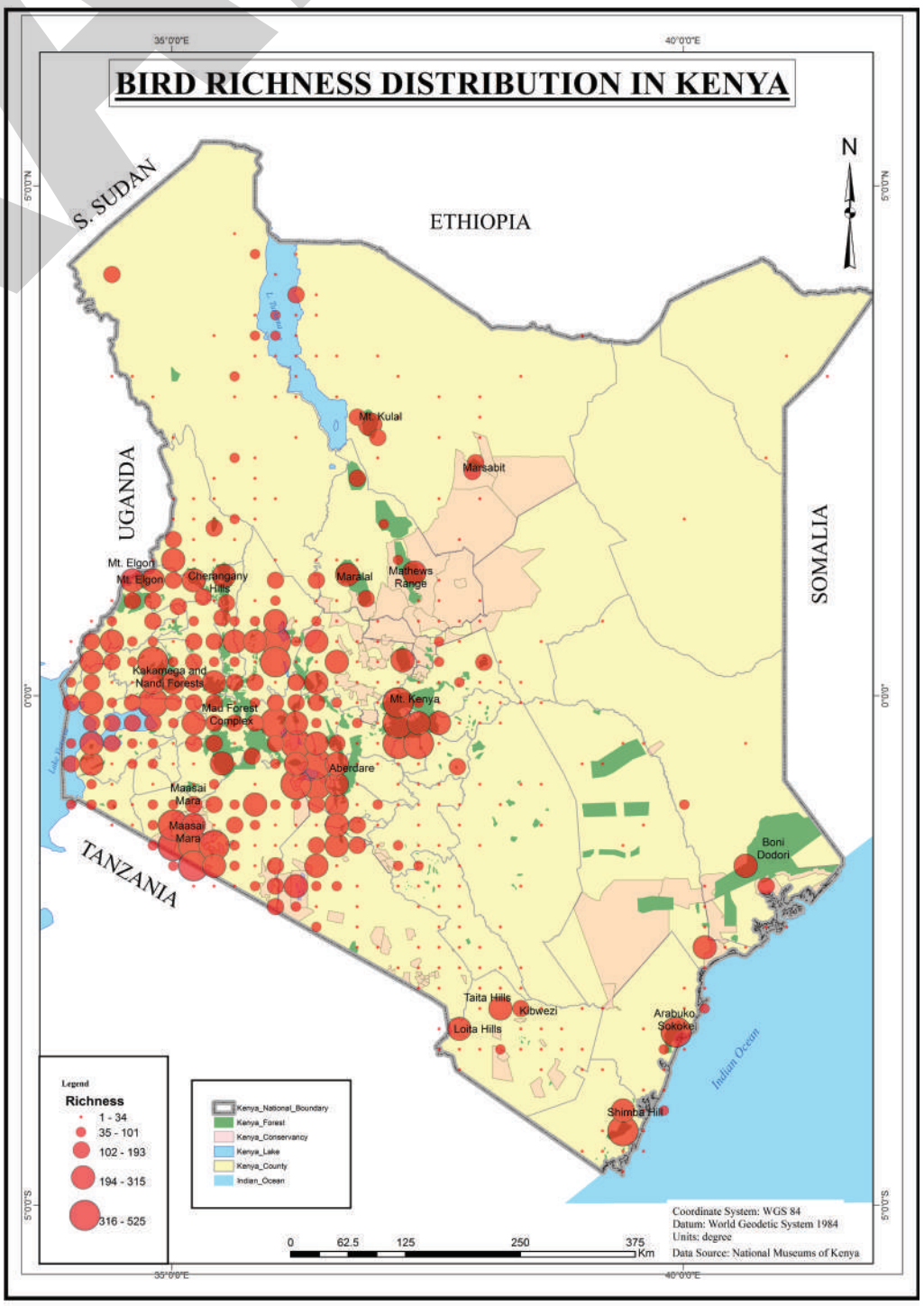


Figure 97: Map showing species richness in Kenya

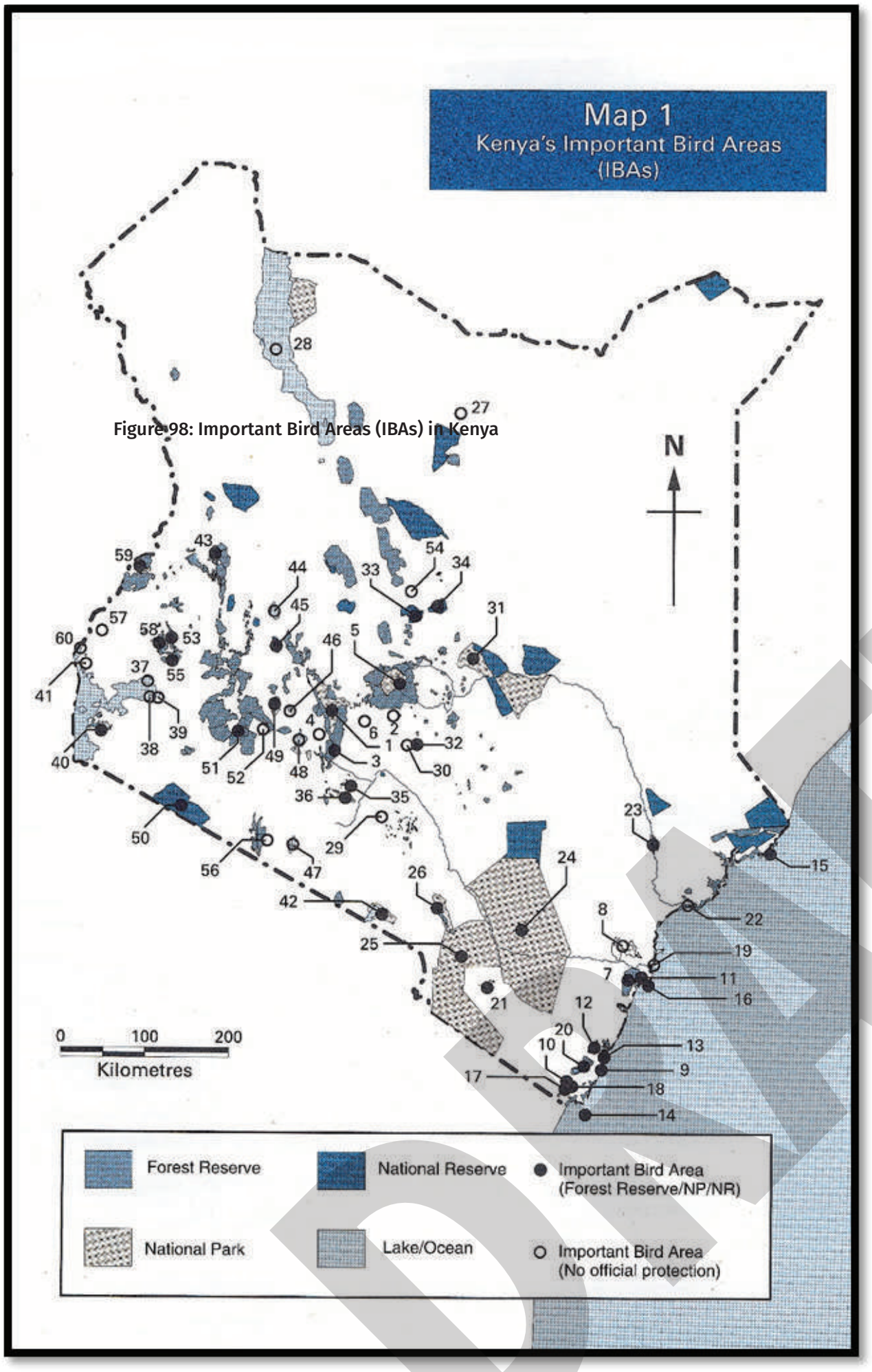


Figure 98: Important Bird Areas (IBAs) in Kenya

Table 39: *lists of endemic, near endemic and threatened species in Kenya*

Status	Species Number
Near Endemic	44
Endemic	2
Near Threatened (NT)	-
Vulnerable (VU)	14
Vulnerable (VU) and Endemic	1
Endangered (EN)	6
Endangered (EN) and Endemic	3
Critically Endangered (CR) and Endemic	2

Table 40: *Key to IBA sites to IBA map*

SITE CODE	SITE NAME	SITE CODE	SITE NAME
1	Aberdare Mountains	32	Mwea National Reserve
2	Kianyaga Valleys	33	Samburu/Buffalo Springs National Reserves
3	Kikuyu Escarpment Forest	34	Shaba National Reserve
4	Kinangop Grasslands	35	Dandora Ponds
5	Mt Kenya	36	Nairobi National Park
6	Mukurweini Valleys	37	Dunga Swamp
7	Arabuko-Sokoke Forest	38	Koguta Swamp
8	Dakatcha Woodland	39	Kusa Swamp
9	Diani Forest	40	Ruma National Park
10	Dzombo Hill Forest	41	Yala-Swamp
11	Gede Ruins National Monument	42	Amboseli National Park
		43	Cherangani Hills
12	Kaya Gandini	44	Lake Baringo
13	Kaya Waa	45	Lake Bogoria National Reserve
14	Kisite Island		
15	Kiunga Marine	46	Lake Elmentaita
16	National Reserve	47	Lake Magadi
17	Mida Creek, Whale Island & Malindi/Watamu Coast	48	Lake Naivasha
		49	Lake Nakuru National Park
18	Marenji Forest		
19	Mrima Hill Forest	50	Masai Mara
20	Sabaki River Mouth	51	Mau Forest Complex
21	Shimba Hills	52	Mau Narok/Molo Grasslands
22	Taita Hills Forests		
23	Tana River Delta	53	North Nandi Forest
24	Tana River Forests	54	Ol Donyo Sabache
25	Tsavo East National Park	55	South Nandi Forest
26	Tsavo West National Park Chyulu Hills Forests	56	South Nguruman
		57	Busia Grasslands
27	Dida Galgalu Desert	58	Kakamega Forest
28	Lake Turkana	59	Mt Elgon
29	Machakos Valleys	60	Sio Port Swamp
30	Masinga Reservoir		
31	Meru National Park		

Plate 45: Jackson's Francolin Pternistis jacksoni (LC

Plate 46: Sokoke scops owl, Otus ireneae (EN)

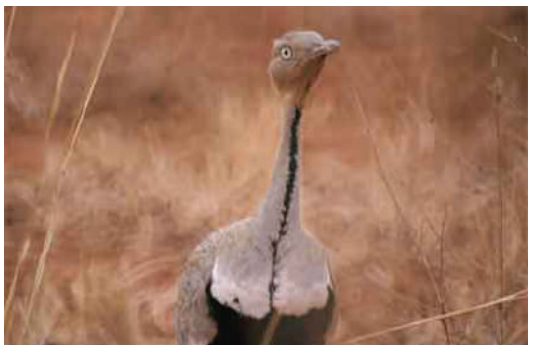


Plate 47: Black-bellied Bustard Lissotis melanogaster (LC)

Plate 48: Sharpes Longclaw Macronyx sharpei (EN)

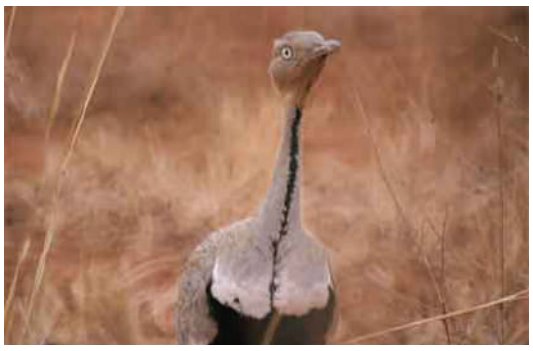


Plate 49: Black-bellied Bustard Lissotis melanogaster (LC)

Plate 50: Sharpes Longclaw Macronyx sharpei (EN)

Species Economic Importance

Bird diversity support and regulate ecosystem services through predation, pollination, scavenging, seed dispersal, seed predators, and ecosystem engineers. Many seed- and fruit-eating species are consider agricultural pests but also are an important source of food.

Birds are valued for their cultural importance e.g. their feathers have traditionally been used for human self-adornment, symbolising status, wealth, vitality and ardour. The beauty of birds is a great attraction to mankind. This has attracted the participation of rural communities in their protection and conservation initiatives.

Birds have been used as bio-indicators due to their sensitivity to habitat changes. Data on birds can be used to influence environmental policies and their implementation especial with regards to development projects e.g. infrastructure, windfarm locations and layouts.

In Kenya, waterbird monitoring has been ongoing for 30 years across all rift – valley lakes. The resulting data present the status and trends of the species and their habitats that can be used to inform policy and management decisions for ecosystem management. The rich diversity of birds makes the country a suitable destination for bird tourism. Bird watching can be done in any part of Kenya and there are good sites close to major centres of population. Recent economic contributions have been seen in bird watching which has become a popular tourism activity, contributing directly to the National Economy.

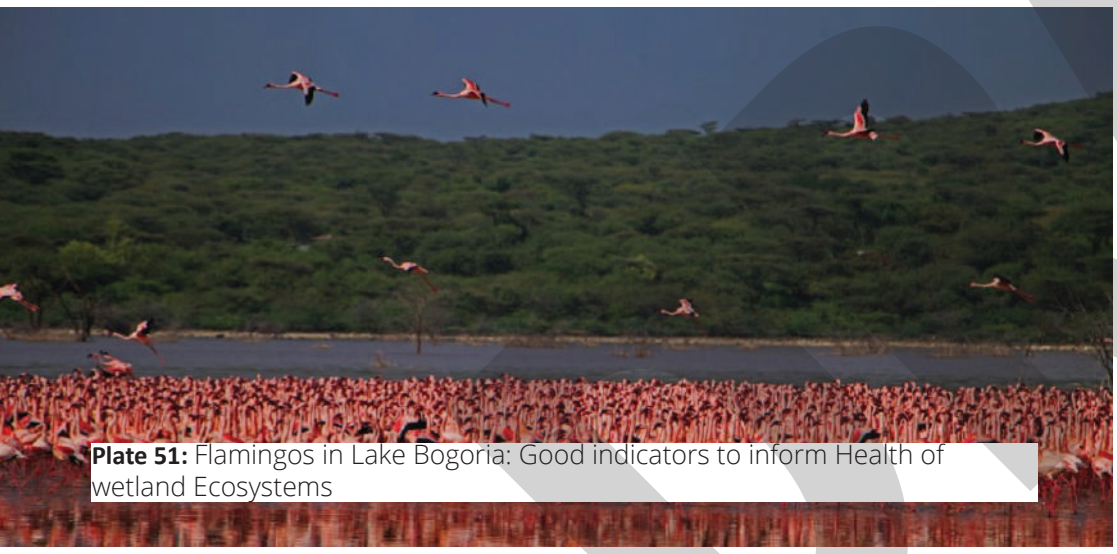


Plate 51: Flamingos in Lake Bogoria: Good indicators to inform Health of wetland Ecosystems

Conservation Threats

Birds' species across the globe are faced with threats from human activities. Land use changes cause loss of habitat for birds which leads to disappearance of some species and decline in populations. Climate change predisposes habitats to degradation and responsible for recent shifts in the timing of migratory birds. The threats driving the extinction crisis are many and varied. Humans are responsible for most of the threats to birds. Foremost among them are: agricultural expansion and intensification, which impacts 1,091 globally threatened birds (74%); logging, affecting 734 species (50%); invasive alien species, which threaten 578 (39%) species; and hunting and trapping, which puts 517 (35%) species at risk. Climate change represents an emerging and increasingly serious threat—currently affecting 33% of globally threatened species—and one that often exacerbates existing threats Most species are impacted by multiple threats and many threats are interrelated. For example, land clearance for agriculture is often preceded by deforestation or wetland drainage.

Plate 54: Water Hyacinth in Lake Naivasha.

Plate 53: Vulture Poisoning in Game reserves (Direct and or Indirect).

Plate 52: Agricultural activities in the Taita Hills Forest.

Plate 55: A vulture

Small Mammal Diversity

"Small mammals" is a term used as a descriptive name of mammals whose body weight is than 5 kilograms (Stoddart 1975, Odhiambo 2003) irrespective of taxonomic affinity. By this definition, some large rodents such as crested porcupine are left out, while some primates such as Galagos are included. Many people have however used the term to refer to Rodents, shrews and bats (Davies 2000, McCain 2005, Hoffmann 2010), irrespective of the body weight. Here, the word small mammal is used to refer to members of the following taxonomic groups regardless of body weight: Rodentia (rats and mice), Eulipotyphla (white toothed shrew, Mole shrews), Chiroptera (micro and fruit bats), Macroscelidea (elephant shrewsor sengis), Afrosoricida (tenerec and golden moles), Hare and rabbits, and Hedgehogs.

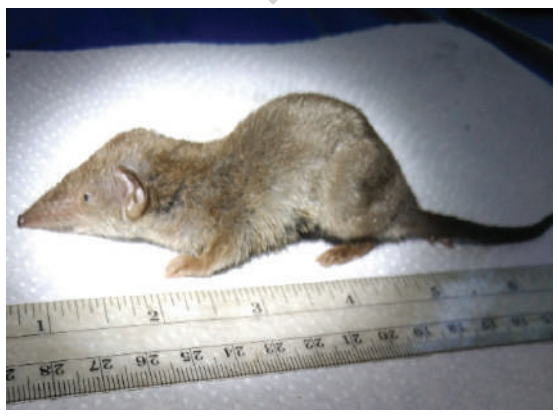
Mammals are members of a taxonomic class of animals that are warm blooded, possessing vertebral column and are distinguishable by having the following unique features:

- mammary glands capable of producing milk in females,
- hair or fur on their body
- 3 bones in the middle ear that facilitates transmission of the sound for hearing
- Lower jaw that connects directly to the skull bone
- Muscular diaphragm that separates the thoracic cavity and abdominal cavity
- 2 sets (milk and permanent) teeth of differentiated into incisors and molars at least
- Non-nucleated red blood cells

There are about 5,490 species of mammals including Homo sapiens (human beings) in the world (Wilson & Reeder 2005, Kingdon 2013), though recent estimate that included molecular-based taxonomic revisions have recently announced 6415 species. The ability of mammals to regulate internal body temperature has in considerable ways enabled them to occupy variety of habitat, climatic conditions and as such found in every continent of the World.





Small Mammal Conservation Status

Of the 1100 mammal species in African continent (Wilson & Reeder 2005), about 413 species are represented in Kenya (NMNH, Database accessed on 2nd Sept 2019). The number of species represented by collected voucher specimens (as databased by NMNH) indicates 413 species of mammals occur in Kenya, which is nearly 50% of African total. Members of this group are in essence taxonomic orders, representing 7 of the 13 mammalian orders in Kenya. More importantly, the rodents and bats constitute over 50% of the mammalian species in the World and in deed in Kenya. Specifically, of the 413 mammal species in Kenya, 25% (107 species) are rodents while 26% (108 species) are bats. That means for every 2 mammal we randomly encounter, one is either a rodent or a bat. Furthermore, rodents also lead in terms of individual numbers.

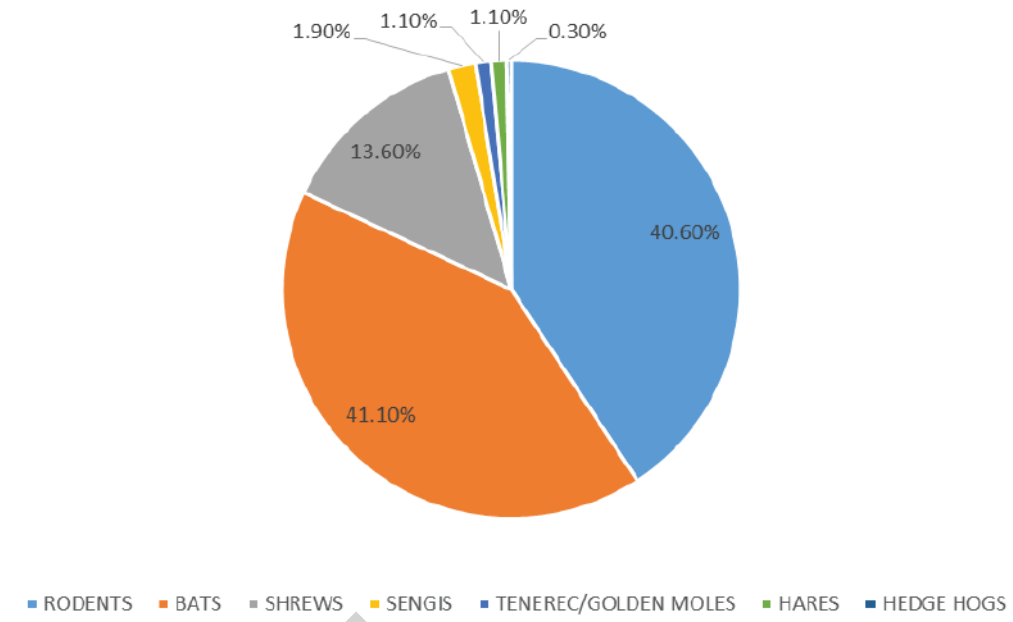


Figure 100: Small mammals species composition within each order in Kenya

It is important to note that Kenya is one of the richest countries in terms of small mammal species diversity and endemicity. For instance despite of its land and seas space size, Kenya is the third (3rd) richest country in Africa in number of shrew species (Eulipotyphla). This is after disproportionally large DRC and Cameroun. It is 4th in Africa in terms of numbers of endemic shrews. This wealth of natural heritage stems from a mix of ecosystems that the country sits on including Dry and Wet Savanna, Lowland and highland forest and coastal forest and woodlands, among others.

The rich diversity and abundance among many groups of small mammals is largely due to their ability to partition and adapt to all kinds of microhabitat in all biomes in Kenya. The most successful group are rodents and bats. Members of these two groups are found everywhere ranging from Coastal shoreline to the top of the mountain. They are also found in hot arid conditions in Suguta valley through wet Savanna to the cold forests on top of the high mountains.

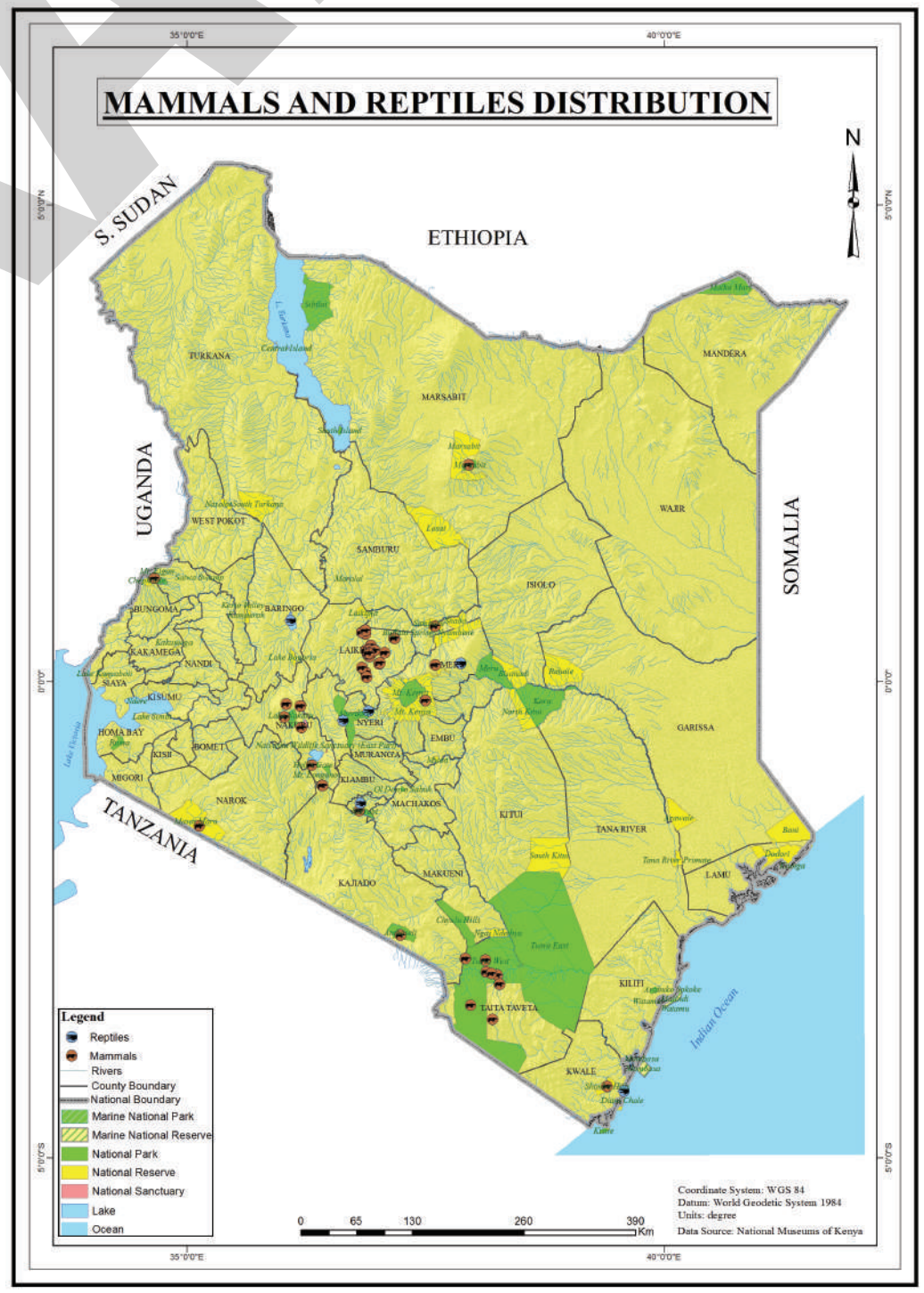


Figure 99: Mammals richness distribution in Kenya

Despite the wide distribution of small mammals at group level, individual species commonly have localized distribution. A general ecological pattern is that: majority of species are restricted to specific habitats that they are adapted to. Few species are generalists that whose members can occur in a variety of habitats. For instance, Cape hare, Lepus capensis occur in dry and wet Savanna, similar to multimummate rat, Mastomys natalensis. Both are also distributed within lowland forest with sufficient openings. Sharp contrast to this is Golden Elephant shrew, endemic to Kenya and only occurs in coastal forest and nowhere else on earth.

Generally, Wet Savanna and forest ecosystems host more species of small mammals than other ecosystems in Kenya (table 1). However it is important to note that species poor ecosystems host endemic species and therefore need equal conservation effort and commitment.

Table 41: *Patterns of distribution of small mammals in various ecosystem types and urban in Kenya*

	Arid	Semi-arid	Wet savanna	Lowland forest	Upland forest	Moorland	Urban
RODENTS	3	15	32	19	27	8	5
BATS	5	23	28	25	21	4	9
SHREWS	1	3	3	5	9	5	1
SENGIS	0	1	2	3	0	0	0
TENEREC/G MOLES	0	0	0	1	1	0	0
HARES	0	1	2	1	1	1	0
HEDGE HOGS	1	1	1	1	0	0	0
TOTALS	10	44	68	55	59	18	15

The most range restricted group in Kenya are the Afrosoricids: tenerecs and golden moles. There are only two species in this mammalian order: Giant otter shrew (Potamogale velox) and Golden mole (Chrysochloris stuhlmani). Both are found in western Kenya in unpolluted and pristine forest floor respectively. Kenya is their eastern most range. Historically, the species are distributed in Uganda, DR Congo extending as far west as forest habitat in Central Nigeria in West Africa along the equatorial rain forest range in Africa. Currently however, the Giant otter shrew is restricted to Yala river in Kakamega. Golden mole on the other hand is only found under the litter in pristine parts of Cherangani and Mt Elgon forests in Kenya. The populations of these two species are isolated from completely from west African ones (Stephenson et al 2016 in IUCN Redlist).

Endemism is the ecological state of a species being unique or restricted to a particular defined geographic region or location, such as an island, nation, country or other defined zone, or habitat type. When an species said to be endemic to Marasbit forest, then it means it found only in Marsabit forest and nowhere in Kenya and in deed nowhere else on earth. A species may be endemic to a habitat because it is dependent on specific ecological conditions or resources that are unique to a range restricted habitat. Examples include Giant Thicket rat, Grammomys gigas of Mt Kenya Forest, Golden-rumped shrew, Rhynchocyon chrysopygus of Arabuko Sokoke forest. Species which are endemic to habitats that are themselves restricted to single locality are more likely to go extinct especially if existing as a single small population. This is because they are likely to be exterminated by single stochastic events such as fire, epidemics, flooding etc. Some species are endemic but widespread in single general region and several types of habitats. Recently described Kenya endemic, wood mouse, Hylomyscus kerbispeterhansi found in Mau, Cherangani and Mt Elgon is a classic example. Compared to the Giant Thicket rat, a single fire incidence of flooding or epidemic is less likely to strike Mt Elgon, Mau or Cherangani at once. Never the less, endemic species are national heritage which must be preserved jealously by all, as individuals, private and public organizations whether national regional or internationally based.

Species of Economic importance

Small mammals comprising Rodents, Shrews, Sengis and Bats constitute important ecosystem component that plays key ecological roles that naturally sustain our ecosystem. The roles range from pollination (especially bats (zookory (rodents and shrews), regulation of population of potentially vermin invertebrates such as pests and diseases vectors as well as serving as prey to other animals such as snakes raptors and among others. Recent studies on Mt. Kenya for example have demonstrated that cherished charismatic large mammals such as Leopard and Hyena significantly depend on small mammals as prey to survive on a mountain where apparently antelopes and duikers are hard to access. Small mammals therefore are therefore integral part of ecological resources upon which both plants and other animals with direct benefit to human, depend on. Knowledge on their ecological distribution, and status is key to effective management of associated resources.

Small mammals especially rodents and bats serve as pollinators and seed dispersers of indigenous plants that help in the natural regeneration, reforestation and maintenance of vegetation composition across multiple landscapes (Kingdon 2015, Kingdon 2013, Bruce and Webala 2012). For instance, Baobab tree, an iconic tree in Savanna biome depends on fruit bats for pollination as it opens its flowers at night when other pollinators such as birds and bees are asleep (Kunz 2011). Seed caching rodents play important role in the germination, recruitment of the involved plant species and by consuming the seed serve as natural control of the population and distribution (Sunyer et al 2013).

Many species of small mammals including certain species of bats, rodents, hares and sengis are delicacies among some communities in Kenya and elsewhere in Africa. They provide nutritional source of protein in rural settings where protein deficiencies are frequent incidences. Even though this has been a cultural historical practice time immemorial, it has apparent risks. Two most significant risks are: 1) infection by diseases and 2) over exploitation of some rare species which may lead to extinction.

Some species of rodents and bats however, have been implicated in the maintenance and spread of certain viruses, bacteria, protozoa associated with human diseases. Multimumamate rat (Mastomys) species have been implicated in the spread of plague, Yersinia pestris. On the other hand, Marburg virus responsible for infectious haemorhagic fever has been isolated from Egyptian fruit bat, Rousettus aegypticus in parts of the country where fatal human cases have been recorded. Currently there are programs by National agencies to profile small mammal species harboring microbes pathogenic to human. The agencies lead by National Museums of Kenya, Kenya wildlife Service, Kenya Medical Research institute and Jomo Kenyatta University of agriculture are generating data that will guide development of conservation and disease prevention strategies regarding these small mammal species.

Certain groups of small mammals especially rodents consume agricultural crops in farms and stores. About 25 species of rodents serve as pests (Makundi and Oguge 1999). Principal crop pest rodent species include but not limited to Black rat, Rattus rattus, Norways roof rat, Rattus norvegicus, Mutimummate rat, Mastomys natalensis, Unstriped ground squirrels: Xerus rutilans Striped ground squirrel Xerus erythropus, Crested porcupine, Hystrix cristata. Crop yield loss in the field and in stores caused by rodent pest may range from 5 to 30% per year among small holder farms (Makundi et al 2001, Mulungu et al 2010).

Conservation Threats to Small mammal Species

- Bush fires
- Cultivation
- Forest clearance (for agriculture and settlement)
- Selective logging
- Hunting (bushmeat activities)
- Overgrazing by livestock

Current mitigation instruments

- Setting up conservation areas
- Government parks and reserves
- Community based and private conservancies
- Conservation awareness towards endangered species and what need to be done
- International infrastructure
- Multilateral agreements
- Regional agreements and guidelines
- Funding
- Research to improve knowledge necessary for effective conservation

CHAPTER

04

AGRO-BASED AND LIVESTOCK RESOURCES

Overview

Agriculture plays a vital role in Kenya's economy and food security. In 2021, crop and livestock production accounted for about 20 percent of the Gross Domestic Product (GDP), 43 percent of the total exports, 12 percent of formal employment and 70 percent of informal employment in the rural areas (Kenya National Bureau of Statistics [KNBS], 2022). There are two major crop production systems in the country; namely, the rain-fed and irrigated systems. Rain-fed crop production takes up 96 percent of all cultivated areas (Government of Kenya [GoK], 2016) and is predominantly small-scale carried out on 0.2 to 3-hectare farms within two cropping seasons in most places. The long rains season starts from March to May, while the short rains are experienced from October to December. Crops contribute about 69 percent of the total agricultural output and marketed produce, of which the small-scale farms account for 73 percent of this (GoK, 2010; KNBS, 2022). However, the agricultural output varies across the country owing to the diverse soil and climatic conditions. The diversity of agro-climatic resources also explains the rich reservoir of domesticated food, industrial and horticultural crops in the country. The major crops grown are maize, rice, wheat, millet, sorghum, potato, cassava, arrow roots, beans, green grams, coffee, tea, sugar cane, cotton, sunflower, pyrethrum, tobacco, barley, cut flowers, vegetables and fruits.

Like crops, livestock production depends on rainfall and plays an important economic and socio-cultural role. The sub-sector supplies the domestic requirements of milk, meat, eggs, honey wool, manure, hides and skins, while accounting for 31 percent of the total marketed agricultural products (KNBS, 2022). It also provides other intangible benefits, such as rural employment, draught power, insurance against drought, prestige, a measure of wealth, performance of traditional ceremonies, and a medium for paying the bridal price (Kosgey et al., 2004). The key livestock enterprises comprise beef and dairy cattle, sheep, goats, camels, pigs, bees, poultry (chicken, pigeons, ducks, geese, turkeys, ostrich and guinea fowls) and emerging livestock (rabbits, quails, crocodiles, ostriches and guinea fowls). These livestock enterprises are produced under either extensive, semi-intensive, or intensive production systems. Generally, about 60 percent of the livestock population is found in the ASALs, where nomadic pastoralism, ranching and agro-pastoralism are practiced.

Both crop and livestock production in Kenya are supported by key land-based resources; especially, climate, topography and soils. These resources determine the suitability and potential of land for specific agricultural uses. The increasing threats of degradation call for sustainable management of land resources to advance agricultural development, food security, nutrition and incomes.

POLICY FRAMEWORK

The crop and livestock sub-sectors are governed by a number of policies, strategies and legislation. Even though most of the policies, strategies and legislations have been largely successful in stimulating agricultural development in the country, there is need for revision and consolidation of some considering the current realities. Major weaknesses have been observed in areas of regulation, facilitation, promotion and development of the sector. These weaknesses have affected the performance of enterprises in both the crop and livestock sub-sectors. The key policies and strategies are summarized in Table 1.

LAND RESOURCE BASE

Land is Kenya's most precious natural resource and a factor of agricultural production, encompassing soils, climate, topography, water, vegetation, biodiversity, and other natural resources. The complex interactions between this set of resources are essential for determining the productivity and sustainability of agro-ecosystems. Kenya's landmass is about 582,646 km2, out of which 1.9 percent (11,230 km2) is under water, 14 percent (81,416 km2) is of medium to high agricultural potential with fertile soils and adequate rainfall, and the remaining 84.1 percent (490,000 km2) comprises the ASALs, where low soil fertility, erratic rainfall, high evapotranspiration and frequent droughts are typical (Mati, 2016). The medium and high potential lands support over 80 percent of the Kenyan population, while the ASALs support the remaining 20 percent, in addition to wildlife and livestock. The productive capacity of these lands is finite, the limits of which are set by climate, soil, landform and management practices. Accordingly, information on land resource endowments and potentials is essential for optimal land use management and sustainable intensification of Kenya's agricultural systems.

Since its inception in 1972, the Kenya Soil Survey (KSS) Section at the Kenya Agricultural and Livestock Research Organization (KALRO) has conducted several land resource inventories, digitized the data and developed a national biophysical database in a Geographical Information System (GIS), which can support specific and multi-purpose land use planning. This GIS-based biophysical database has allowed for the delineation and visualization of unique agro-ecological zones (AEZs) within which soils, climate and landforms have been quantified and matched with the requirements of specific crops. Hence, it is possible to establish the actual production potentials, as well as the nature and extent of changes needed to improve agricultural performance and food production in different areas.

Soil Resources

Soil is a component of land originating from the gradual breakdown of underlying rocks, and is composed of minerals, organic materials, air and water. Its formation is governed by complex interactions between climate, topography, parent material, time and living organisms, including vegetation and human beings. Soil is at the heart of most processes in the agro-ecosystems, delivering an array of environmental and socio-economic services that support life on Earth, productive agricultural landscapes and human well-being. For instance, it provides a medium for plant growth, anchoring support for organisms and human structures, habitat for flora and fauna, as well as protection for archeological treasures (Plate 1). In addition, soil filters, absorbs and transforms pollutants and is responsible for purifying water, recycling materials, and regulating climate, biogeochemical and hydrological processes, including infiltration, percolation, drainage, flow and storage of water. With such important ecosystem functions, there is need for judicious management and protection of soils for sustained food security, rural livelihoods and agricultural resilience in consonance with Vision 2030 and Sustainable Development Goals (SDGs). Sufficient information

Table 42: *Main policies relevant to crop and livestock production in Kenya*

Policy/ strategy	Description
Kenya Vision 2030	The national economic policy for all sectors, including agriculture and the environment.
Agricultural Sector Transformation and Growth Strategy 2019-2029	The strategy is to transform the agricultural sector into a vibrant and modern commercial sector that sustainably supports Kenya's development in the context of devolution
Sessional Paper No. 2 of 2008 on Livestock Policy	Aims at achieving sustainable development of the livestock industry while improving and conserving animal genetic resources. It guides effective control of animal diseases and vectors, and directs the increase of the competitiveness of the livestock industry
National Agriculture Sector Extension Policy 2012	Aims to empower the extension clientele through sharing information, imparting knowledge and skills and changing attitudes for efficient management of resources and improved quality of livelihood
National Food Security and Nutrition Policy 2018-2027	Aims to achieve safe food in sufficient quantity and quality to satisfy the nutritional needs for optimal health of all Kenyans. It also aims at providing accessible and affordable food, and protects vulnerable populations using innovative and cost-effective safety nets.
National Agricultural Research System Policy 2021	Aims at an integrated national agricultural research system that guides and supports the development of an innovative, commercially-oriented, and modern agricultural sector.
Environment and Development Policy	Seeks to achieve conservation of natural resources, soil fertility and biodiversity, as well as fostering afforestation, and protection of catchment areas
National Seed Policy, 2010	Gives a clear direction for the sustainable seed industry development in order to avail adequate high-quality seed and planting material to the users
Climate Smart Agriculture Strategy 2017-2026	The strategy is to adapt to climate change, build resilience of agricultural systems, while minimizing emissions for enhanced food and nutritional security and improved livelihoods.
Agricultural Policy 2021	The policy is the basis of legislation, strategies, plans, projects and programmes for the country's agricultural development.
National Livestock Policy 2019	The Livestock Policy covers key issues relating to: farm animal genetic resources, livestock feeds and nutrition, inputs, animal diseases and pests, livestock marketing, research and extension and food security.
Range Management and Pastoralism Strategy, 2021-2031	The strategy has clear objectives of reducing land degradation while increasing land productivity; sustainably exploring the existing natural resources, development and adoption of appropriate technologies; support enterprises development and marketing of products; and promotion of other sustainable livelihoods in the rangelands besides livestock production.

Plate 56: Soil as a medium for growing our crops. Photo credit: KALRO

on soil resources is necessary for this purpose.

Currently, the Exploratory Soil Map (ESM) of Kenya at 1:1 million scale (Sombroek et al., 1982), Kenya Soil and Terrain (KENSOTER) dataset at 1:1 million (Batjes and Gicheru, 2004), International Soil Reference and Information Centre (ISRIC) soil grids at 250 m spatial resolution (Hengl et al., 2015), and National Accelerated Agricultural Inputs Access Programme (NAAIAP) soil fertility report (NAAIAP, 2014) constitute the national soil information base for agricultural decisions. Unlike the ESM and KENSOTER data, which were created using traditional soil mapping methods and represent soil information by choropleth maps with a discrete model of spatial variation, the ISRIC soil grids, which were generated using state-of-the-art digital soil mapping techniques depict the continuous spatial variation of soil properties, and provide quantitative estimates of map quality. Besides these, there are also several reconnaissance (scale between 1:100,000 and 1:250,000), semi-detailed (scale between 1:20,000 and 1:50,000), and detailed (scale larger than 1:20,000) soil maps and reports, which can provide information for multi-purpose land use planning, farm planning and feasibility studies for proposed projects at the county level.

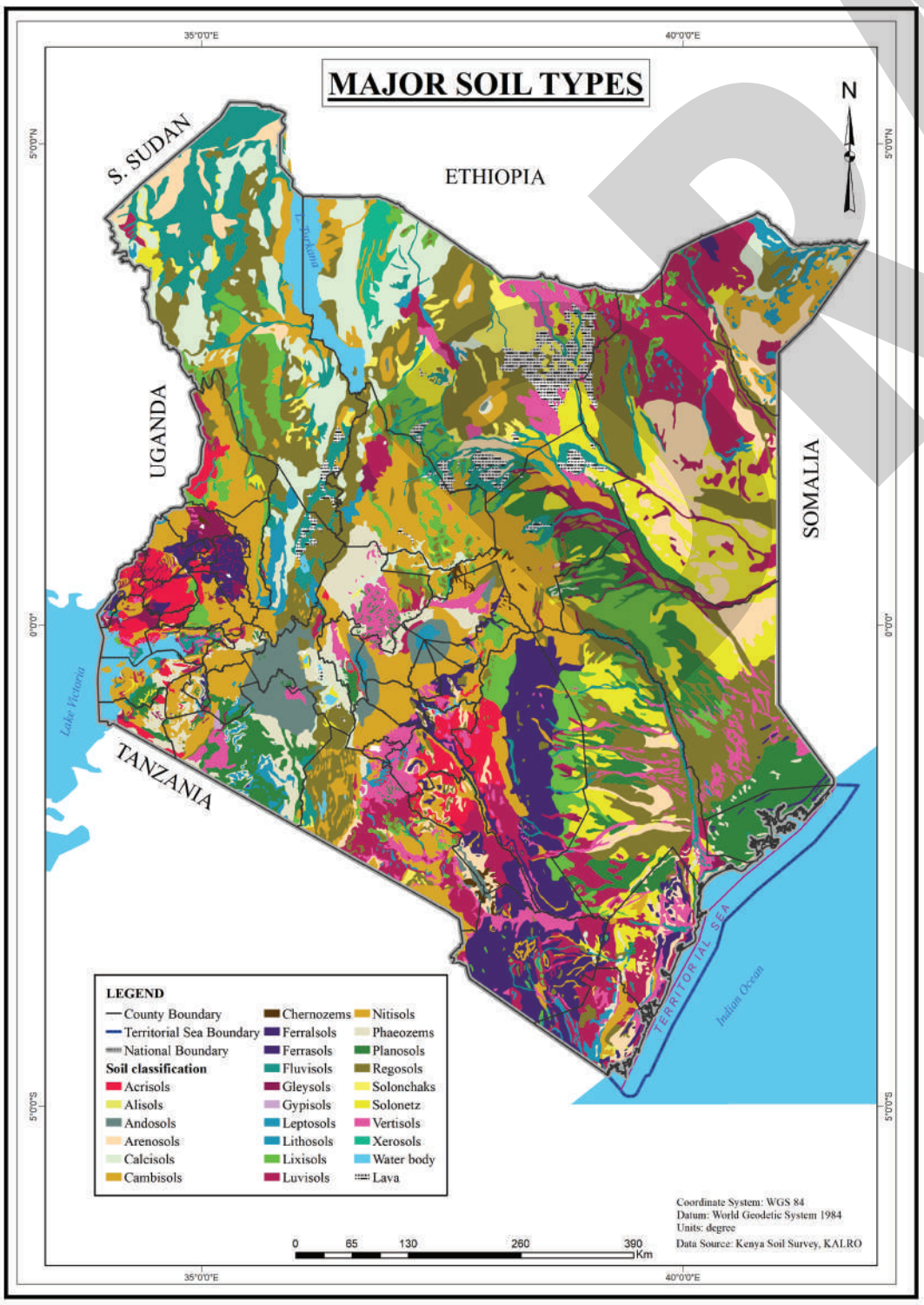


Figure 101: Distribution of the major soil types across Kenya. The different colours indicate variations in the chemical, physical, and biological characteristics of the soils.

Major Soil Types

Kenya is generously endowed with soil resources, which vary with age, as well as climatic, biotic, topographic and geologic conditions. Based on the Reference Soil Groups of the World Reference Base (WRB) classification scheme (IUSS Working Group WRB, 2015), 23 major soil groups can be distinguished; namely, Acrisols, Alisols, Andosols, Arenosols, Calcisols, Cambisols, Chernozems, Ferralsols, Fluvisols, Gleysols, Gypsisols, Leptosols, Lithosols, Lixisols, Luvisols, Nitisols, Phaeozems, Planosols, Regosols, Solonchaks, Solonetz, Vertisols and Xerosols (Table 2). Regosols are the most dominant covering about 15.3 percent of the country. The others are Cambisols (11.2%), Luvisols (8.3%), Solonetz (6.5%), Planosols (6.5%), Ferralsols (6.2%), Fluvisols (6.1%), Arenosols (5.6%), Calcisols (5.6%) and Lixisols (5.3%). Figure 101 clearly shows the spatial arrangement of these Reference Soil Groups on Kenya's land surface. Luvisols, Arenosols and Solonetz are widespread in the north-eastern and coastal areas, while Calcisols and Regosols are dominant in the north-western parts. Acrisols occur mainly in western (e.g., Busia and Kakamega), although large contiguous zones are also found in the eastern parts, particularly in Machakos. Cambisols, Nitisols and Andosols occupy most of the Kenyan highlands, while Ferralsols are distributed around Kitui and Taita-Taveta with a few pockets appearing in Bungoma and Uasin Gishu. Planosols are confined in Lamu and Narok with sporadic occurrences in Isiolo and Garissa. Most of the soil groups can be found in the ASALs and have limitations for crop production (e.g., high erodibility, sodicity and salinity) owing to the hot and dry conditions, as well as the low and unpredictable rainfall. However, they sustain natural ecosystems and are good for the development of pastoral resources (e.g., pasture) for extensive livestock production (Omuto, 2013). Soils with high crop production potential are few and occupy a small proportion of the country.

Key Soil Fertility Properties

Sustainable agriculture, food security, rural livelihoods and provision of ecosystem services in Kenya depend on healthy soils with sufficient amounts of nutrients. The macro-nutrients, which are required in large amounts by crops for optimal growth and yields are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and Sulphur (S) (White and Brown, 2010), coupled with adequate levels of pH and soil organic matter (SOM). Similarly, the micro-nutrients, including Iron (Fe), Manganese (Mn), Zinc (Zn) and Copper (Cu) are essential, but needed in very low concentrations. Deficits of N, P and K limit plant growth and maturity, while low SOM and pH levels affect the other soil chemical, physical and biological properties, such as structure, permeability, porosity, bulk density, water holding capacity, nutrient retention and availability, mobility and concentrations of toxic ions (e.g., Aluminium and Fe), ecology and activities of micro-organisms, and uptake of water by plants (Osman, 2014). Figure 2, 3, 4 and 5 show the status and spatial patterns of some of the key soil fertility properties; that is, N, K, carbon (C) and pH. Such maps can be instrumental for the spatial targeting of agricultural investments and best-fit management interventions, as well as for estimating the yield gaps. However, it is also worth noting that the country's soil fertility status is quite dynamic, except in the natural ecosystems where it is more or less stable. The fertility varies not only in space, but also over time. Presently, nutrient depletion and SOM decline are attributed to several factors, including removal of crop residues, leaching, soil erosion and over-exploitation of soil nutrient reserves (nutrient mining) without proper compensating investments in soil fertility management (Zingore et al., 2015). For example, Stoorvogel and Smaling (1990) reported that N, P and K were being mined at the average annual rates of 42 to 46, 1 to 3 and 29 to 36 kg ha-1, respectively, in Kenya, while the average annual rate of fertilizer use in Africa is about 13 to 20 kg ha-1 (Lal and Stewart, 2019). This situation might worsen with the projected changes in population and climate.

Table 43: *Characteristics, potential and limitations of the major soil types in Kenya*

Soil group	Description and management	Agricultural Potential
Acrisols (Acid soils)	Strongly weathered acid soils with higher clay content in the subsoil, low levels of plant nutrients and organic matter, high levels of aluminium, and are susceptible to erosion. Preservation of the surface soil with its organic matter and prevention of erosion are requisite.	Silviculture and low intensity pasture. If climate permits, acid-tolerant tea, coffee, pineapple, cashew nuts and oil palm can be supported. Other crops can be grown after liming and fertilization.
Alisols	Very acid soils with higher clay content in the subsoil than in the topsoil, high-activity clays in the clay-rich horizon, low base saturation in the 50-100 cm depth, and high nutrient-holding capacity.	Shallow-rooting crops, low-volume grazing, Aluminium and acid-tolerant crops e.g., tea, cashew, and coffee
Andosols (Volcanic ash soils)	Dark soils developed from recent volcanic deposits with a thick, loose, granular, dark grey to black topsoil. They are very porous, coarse, or fine-textured, and have low bulk density, high organic matter content, high water storage capacity and high silt content. The soils have high natural fertility; however, problems with phosphorous fixation and micro-nutrients occur. Remedial measures include application of lime, silica, organic matter and phosphate fertilizer.	Wide variety of crops including sugar cane, tobacco, sweet potato, tea, vegetables, wheat and orchard crops.
Arenosols (Sandy soils)	Coarse-textured and deep sandy soils, including soils in residual sands after in situ weathering of quartz-rich parent material, and soils in recently deposited sands, such as dunes in deserts and beaches. The topsoil has low organic matter, nutrient-holding capacity, and moisture storage capacity. They are prone to wind erosion if vegetation has not developed.	Extensive (nomadic) grazing, root and tuber crops, coconut, cashew, ground nut. Small grains, melons, pulses and fodder crops are also possible when irrigated.
Calcisols (Desert soils)	Soils with substantial accumulation of calcium carbonates (lime) mostly occurring in arid and semi-arid environments, and often associated with highly calcareous parent materials.	Extensive grazing, drought-tolerant and fodder crops (e.g., sunflower and sorghum). Full productive capacity realized when fertilized and irrigated.
Cambisols (Young soils)	Young soils lacking distinct horizons, but with slight evidence of soil-forming processes, such as variations in colour and a soil structure with significant amounts of weatherable primary minerals. They have high natural fertility and make good agricultural land.	A wide variety of crops
Chernozems	Blackish (or dark brown) soils rich in organic matter with a granular structure and a neutral pH. Secondary calcium carbonate deposits occur within 50 cm of the lower limit of the humus-rich horizon. Chernozems are little weathered, highly fertility and show high biological activity. The texture is usually clay. Preservation of the good soil structure through timely cultivation and careful irrigation prevents erosion. Application of phosphate fertilizers is required for high yields	Wheat, barley, maize and vegetable.
Ferralsols (Red and yellow tropical soils)	Strongly weathered and leached red or yellow soils, with indistinct horizon differentiation. The soils have good physical properties (e.g., great soil depth, good permeability and stable micro-structure), but low nutrient-holding capacity. The natural fertility of many of these soils is restricted to the topsoil and related to the organic matter content. Maintaining soil fertility by manuring, mulching, fallowing, agroforestry, and prevention of surface soil erosion is important. Further, fertilizer selection and the mode and timing of fertilizer application determines the success of agriculture on Ferralsols.	A wide variety of crops and soy bean
Fluvisols (Alluvial soils)	Young soils developed on deposits (alluvium) in flooded areas, such as flood plains, river fans, valleys, tidal marshes, deltas, lakes and mangroves. They have no horizon differentiation, but show a layering of sediments. They have an organic matter content that decreases irregularly with depth and they receive fresh sedimentary material at regular intervals. The fertility of most Fluvisols is good, but varies, depending on their texture and the nutrient content of soils and rocks from which the alluvial deposits originate.	Paddy rice and many dry land crops with some form of water control
Gleysols	Poorly drained mineral soils, which are saturated with ground water for long periods. They display reddish, brownish or yellowish colours in the upper part of the soil where oxygen is present, in combination with greyish/ bluish colours deeper in the soil where oxygen is reduced. Often Gleysols are found with wetland vegetation (e.g. grass, reeds, and sedges), and show little soil development apart from accumulation of organic matter in the surface layer and rust mottling.	Arable cropping after installation of a drainage system to lower the groundwater table.
Gypsisols	Soils with substantial accumulation of secondary gypsum (calcium sulfate) commonly found in the driest parts of the arid areas.	Extensive grazing
Leptosols/ Lithosols (Thin soils)	Very thin (shallow) soils over hard rock, very gravelly material, or highly calcareous deposits. They are common in hilly and mountainous regions on slopes with excessive and erosive run-offs; hence, their topsoil is not rich in organic matter. Steep slopes with shallow and stony soils can be transformed into cultivated land through terracing, the removal of stones by hand and their use as terrace fronts	Wet season grazing and some tree crops
Lixisols	Slightly acid soils with clay-enriched subsoil, low-activity clays at certain depths, high base saturation in the 50–100 cm depth, and low nutrient-holding capacity and organic matter. They lack a well-developed structure and are prone to erosion and crusting. Tillage and erosion control measures (e.g., terracing and contour ploughing) can help to conserve the soils. Recurrent input of fertilizer is a pre-condition for continuous cultivation.	Low-volume grazing, growing of perennial crops, or annual crops with improved pasture
Luvisols	Moderately to strongly weathered soils, having higher clay content in the subsoil than in the topsoil, high base saturation in the 50–100 cm depth, and low organic matter in the topsoil. They a well-developed structure, contributing to a good water-holding capacity. Due to their relatively high base saturation and presence of weatherable primary minerals, Luvisols have moderate natural fertility. They also form a strong sealing on the surface which may cause water run-offs leading to severe erosion.	A wide variety of crops
Nitisols	Deep, well-drained and porous red soils developed from highly weathered basic iron-rich rocks. They have diffuse horizon boundaries, clay texture, marked structural stability and fair water-holding properties, as well as low to high organic matter content, cation exchange capacity and base saturation. The soils have a high degree of phosphorous fixation and are quite resistant to erosion. Nitisols are very productive; however, their high phosphate-fixing capacity calls for application of phosphate fertilizers.	Plantation crops, such as cocoa, coffee, rubber and pineapple, and wide variety of food crops
Phaeozems (Dark grey forest soils)	Dark coloured and non-acidic soils having high organic matter (humus), high base saturation (over 50%) and leached more intensively. They have a high natural fertility due to the high organic matter content and an abundant supply of mineral nutrients. Phaeozems are porous, fertile soils and make excellent farmland.	A wide variety of crops
Planosols	Soils with a light-coloured horizon showing signs of periodic water stagnation and abruptly overlies a dense, slowly permeable subsoil with significantly more clay.	Extensive grazing, wheat and silviculture
Regosols	Weakly developed mineral soils in unconsolidated medium and fine-textured materials. They show only slight signs of soil development and are extensive in eroding lands and accumulation zones, particularly in the ASALs and mountainous terrain	Extensive grazing
Solonchaks (Saline and Salt-affected soils)	Strongly saline soils with high concentrations of soluble salts. They are largely confined to the ASALs and coastal regions, where saline groundwater comes close to the surface, or where evapotranspiration rates considerably exceed precipitation. Salts dissolved in the soil moisture remain behind after evaporation and accumulate on, or just below, the surface.	Extensive grazing of sheep, goats, camels and cattle
Solonetz (Alkali soils and Sodic soils)	Soils with a dense, strongly structured, clay-rich subsoil that has high amounts of sodium. The soils have a pH between 8.5 and 10. Their natural fertility is low to moderate due to relatively low organic matter content in the topsoil.	Grazing
Vertisols (Black cotton soils)	Heavy clay soils, which are plastic and sticky when wet, and hard when dry. They expand during the wet seasons and shrink markedly during the dry seasons, developing large cracks. Vertisols are imperfectly, or poorly drained with low infiltration rate, low permeability and difficult tillage. The natural fertility of these soils is moderate.	Cotton, wheat, sorghum and rice, but adapted management is a precondition for sustained production.
Xerosols	Soils developed under dry climatic conditions, having weak topsoil with low organic matter. Most of these soils are calcareous and have textures ranging from loamy sand to clay. In many places, these soils are saline or sodic.	

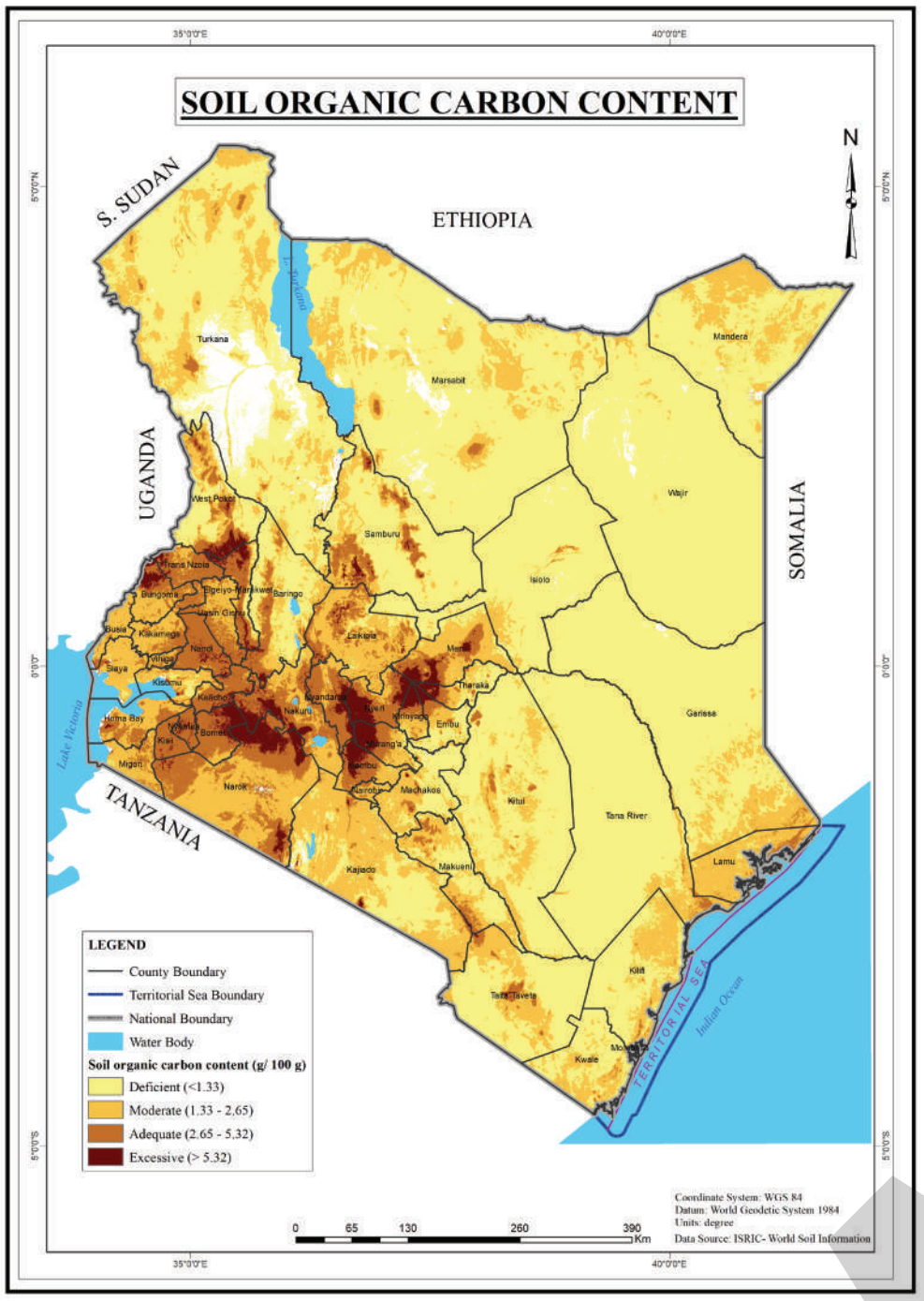


Figure 102: Map of soil organic carbon content in Kenya

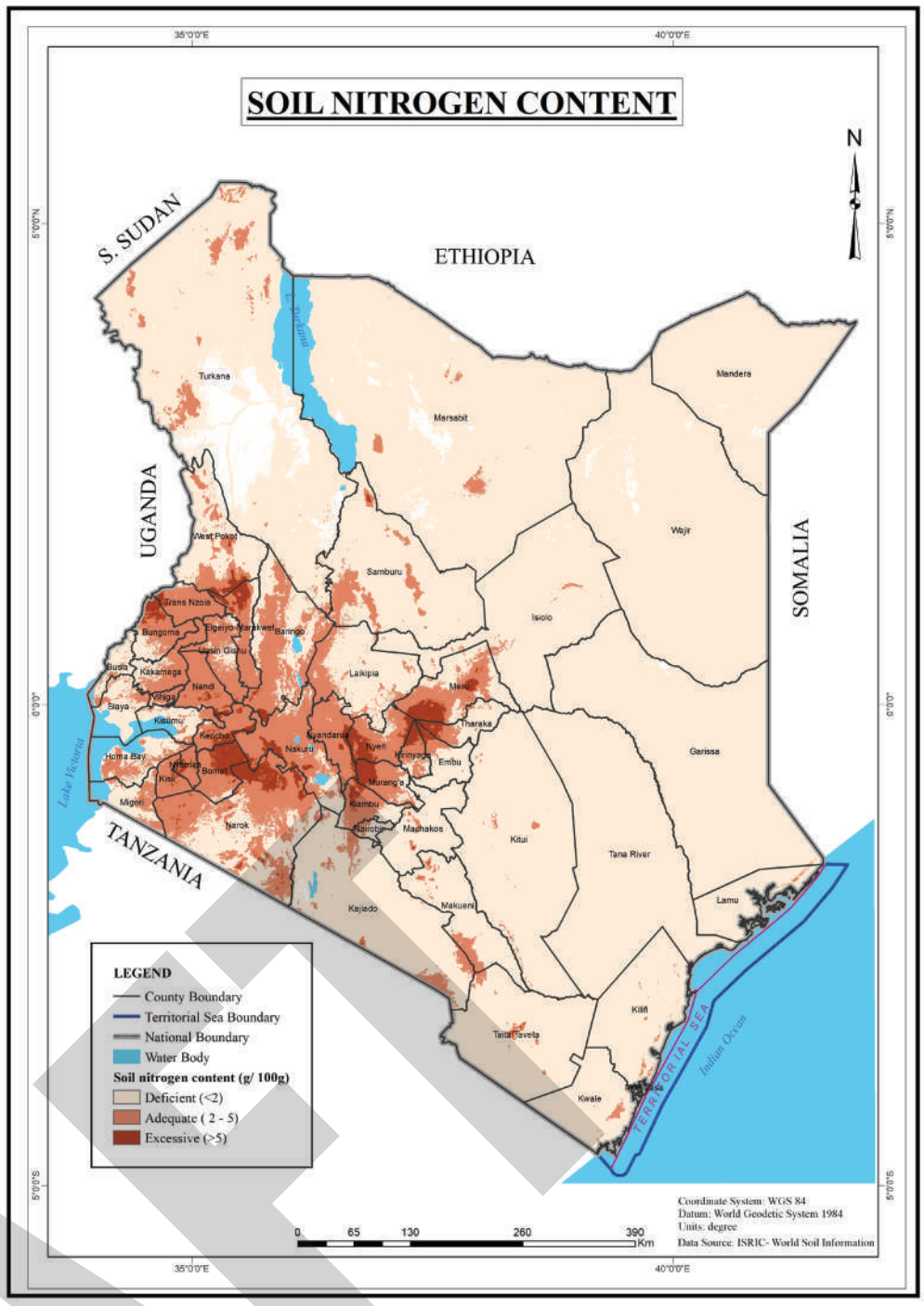


Figure 103: Map of soil nitrogen content in Kenya

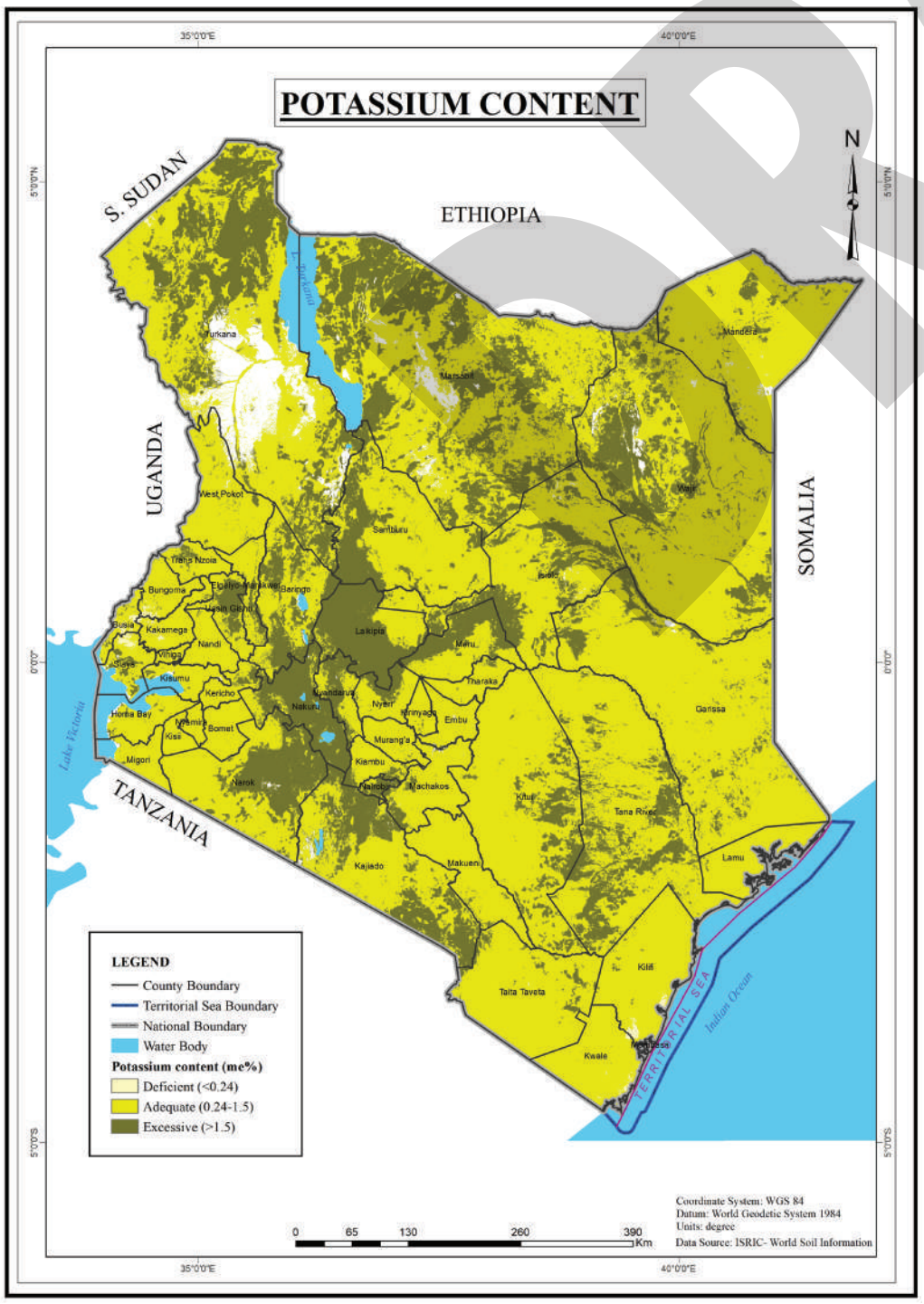


Figure 104: Map of Kenya potassium content

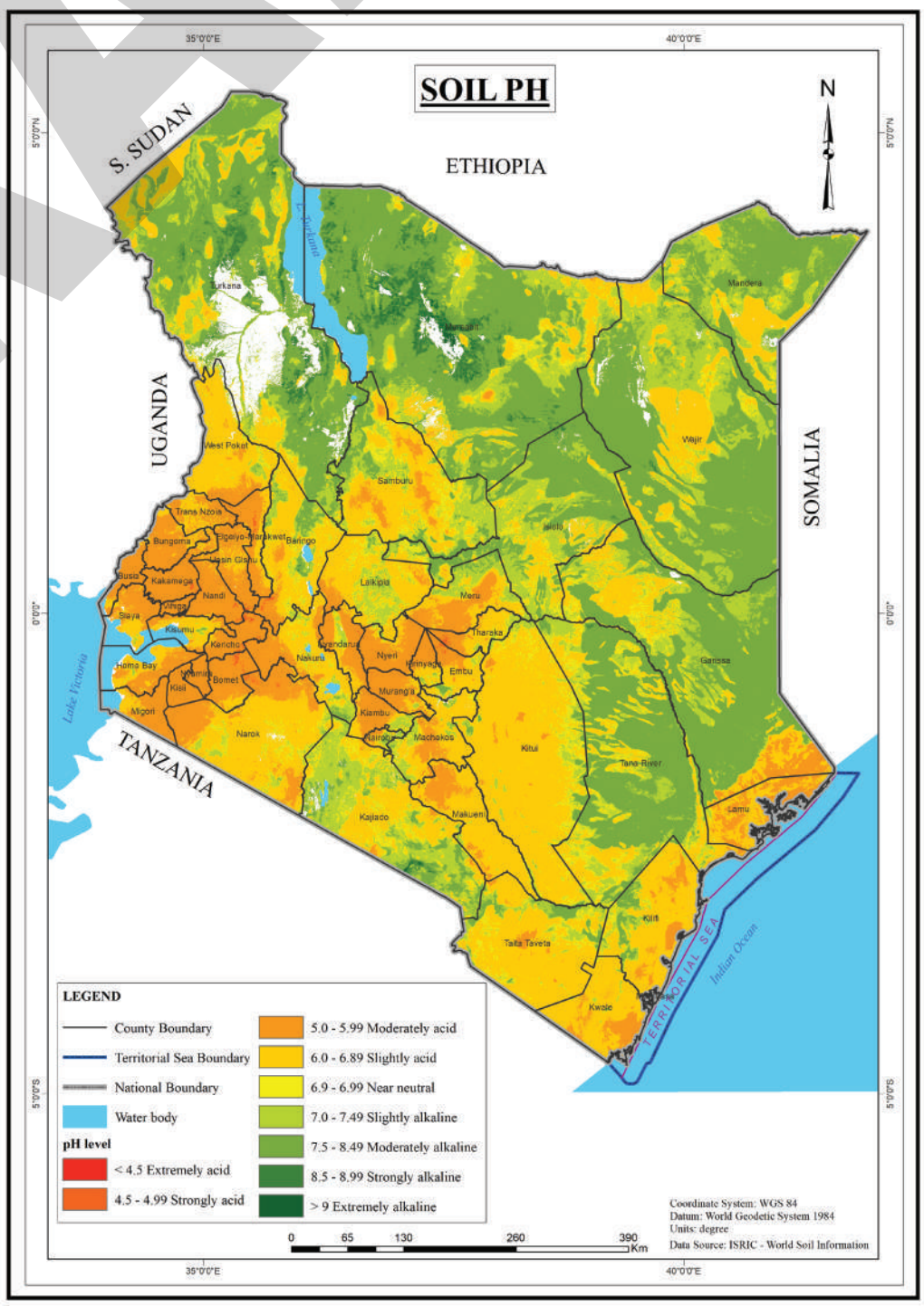


Figure 105: Map of Kenya soil pH

Climatic Resources

As part of its natural endowment, Kenya has a moderate tropical climate, which is determined by its proximity to the equator, altitude, diverse topographical features, presence of large water bodies (e.g., Lake Victoria and the Indian Ocean), as well as the movement of the Inter-Tropical Convergence Zone (Maina-Gichaba, 2013). Among the climatic factors, rainfall, temperature, solar radiation, evaporation and humidity are the major determinants of the conditions needed for crop and livestock production. In terms of rainfall, the country experiences two seasonal rainfall peaks of the long rains (March to May) and short rains (October to December) in most places, except in the very high-altitude areas, which have one long rainy season. April is the wettest month in all regions with average cumulative rainfall fluctuating between 86 and 148 mm, while August seems to be the driest month with only 10 mm of cumulative rainfall on average, except in the westernmost parts where cumulative rainfall can range between 35 and 102 mm (D'Alessandro et al., 2015; Figure 6).

Similarly, the spatial distribution of rainfall in Kenya is quite uneven, varying from 150 to 500 mm in the arid east and northeast of the country, from 500 - 1000 mm in the semi-arid regions, and from 1000- 2700 in the more humid areas in the highlands and near Lake Victoria (Table 43; Figure 106). Only 17 percent of Kenya confined to the narrow coastal belt extending from the Tanzanian border to Malindi, the central and western highlands, and parts of

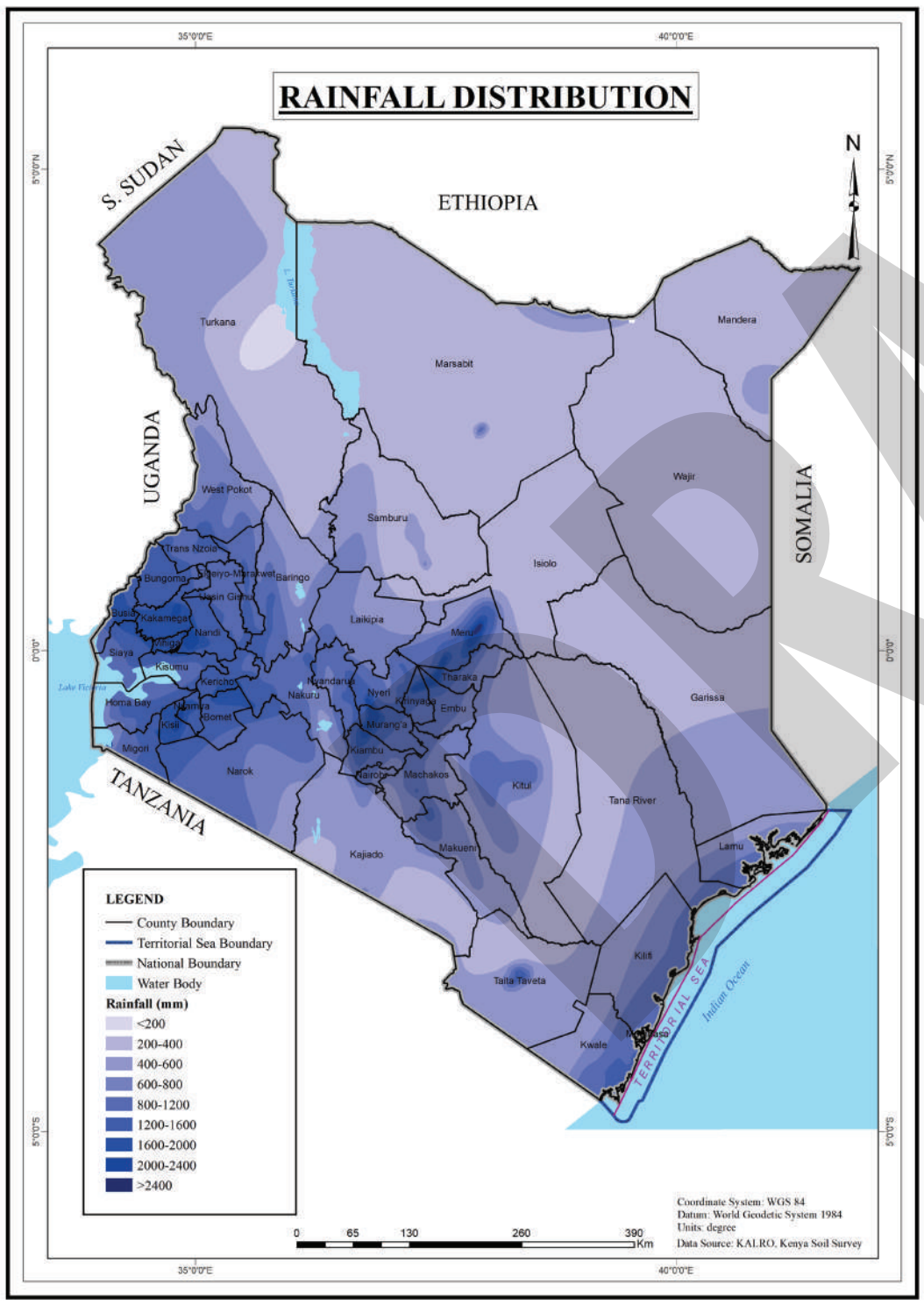


Figure 106: Rainfall distribution in Kenya

the central Rift Valley receive adequate and reliable annual rainfall exceeding 760 mm (Obiero and Onyando, 2013). The average potential evaporation varies from less than 1,200 mm to 2,500 mm (Table 3).

Concerning the thermal regime, mean annual temperatures range from less than 10º to 30º C. Low temperatures characterize the Central and Rift Valley highlands, such as Kericho, Nandi and Nyandarua counties, while high temperatures are typical of the arid regions of northern and eastern Kenya, including Mandera and Turkana counties.

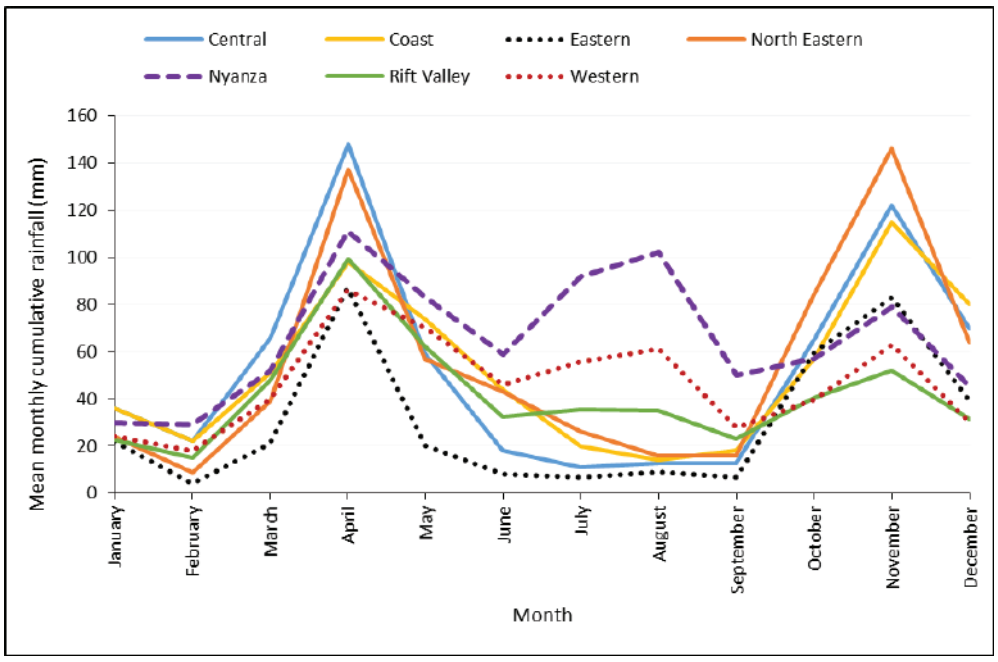


Figure 107: Monthly rainfall pattern by region. Source: D'Alessandro et al. (2015)

Agro-Climatic Zones

The Agro-Climatic Zones (ACZs) map (Figure 8) shows the distribution of Kenya's climatic resources and the similarity of areas in terms of moisture availability and temperature considering the climatic requirements of leading crops (see also Table 3 and 4). Zones I, II III and IV, which occupy about 17 percent of Kenya's land area are humid to semi-humid environments with moisture indices above 50 percent and medium to very high agricultural potential. The mean annual temperatures in these areas are below 18º C and rainfall ranges between 1,000 and 2,700 mm. In addition, zones V, VI and VII, which account for over 80 percent of the land area are semi-arid to very arid areas with moisture indices below 50 percent and low to very low agricultural potential. Most arid and semi-arid regions have relatively high temperatures with rainfall varying from 150 to 900 mm.

Table 44: *Moisture availability zones*

Zone	Climatic designation	r- Annual rainfall (mm)	Eo – Annual potential evaporation (mm)	r/ Eo (%)	Agri-cultural potential if soils are good	Possible cropping and livestock systems	% of total land area
I	Humid	1,100-2,700	1,200-2,000	> 80	Very high	Coffee, tea, pyrethrum, wheat, barley, sugarcane, maize, cassava and cotton	12
II	Sub-humid	1,000-1,600	1,300-2,100	65-80	High		
III	Semi-humid	800-1,400	1,450-2,200	50-65	High to medium		
IV	Semi-humid to semi-arid	600-1,000	1,550-2,200	40-50	Medium	Barley, maize, cotton, sunflower, ground nuts and cashew nuts	5
V	Semi-arid	450-900	1,650-2,300	25-40	Medium to low	Sorghum and millet	15
VI	Arid	350-550	1,900-2,400	15-25	Low	Ranching	22
VII	Very arid	150-350	2,100-2,500	< 15	Very low	Range land	46

Source: Sombroek et al. (1982)

Table 45: *Temperature zones*

Zone	Mean annual temperature (o C)	Altitude (m)	Climatic designation	General description
9	< 10	> 3,050	Cold to very cold	Afro-alpine highlands
8	10-12	2,750-3,050	Very cool	Upper highlands
7	12-14	2,450-2,750	Cool	
6	14-16	2,150-2,450	Fairly cool	Lower highlands
5	16-18	1,850-2,150	Cool temperate	
4	18-20	1,500-1,850	Warm temperate	Midlands
3	20-22	1,200-1,500	Fairly warm	
2	22-24	900-1,200	Warm	
1	24-30	0-900	Fairly hot to very hot	Lowlands

Source: Sombroek et al. (1982)

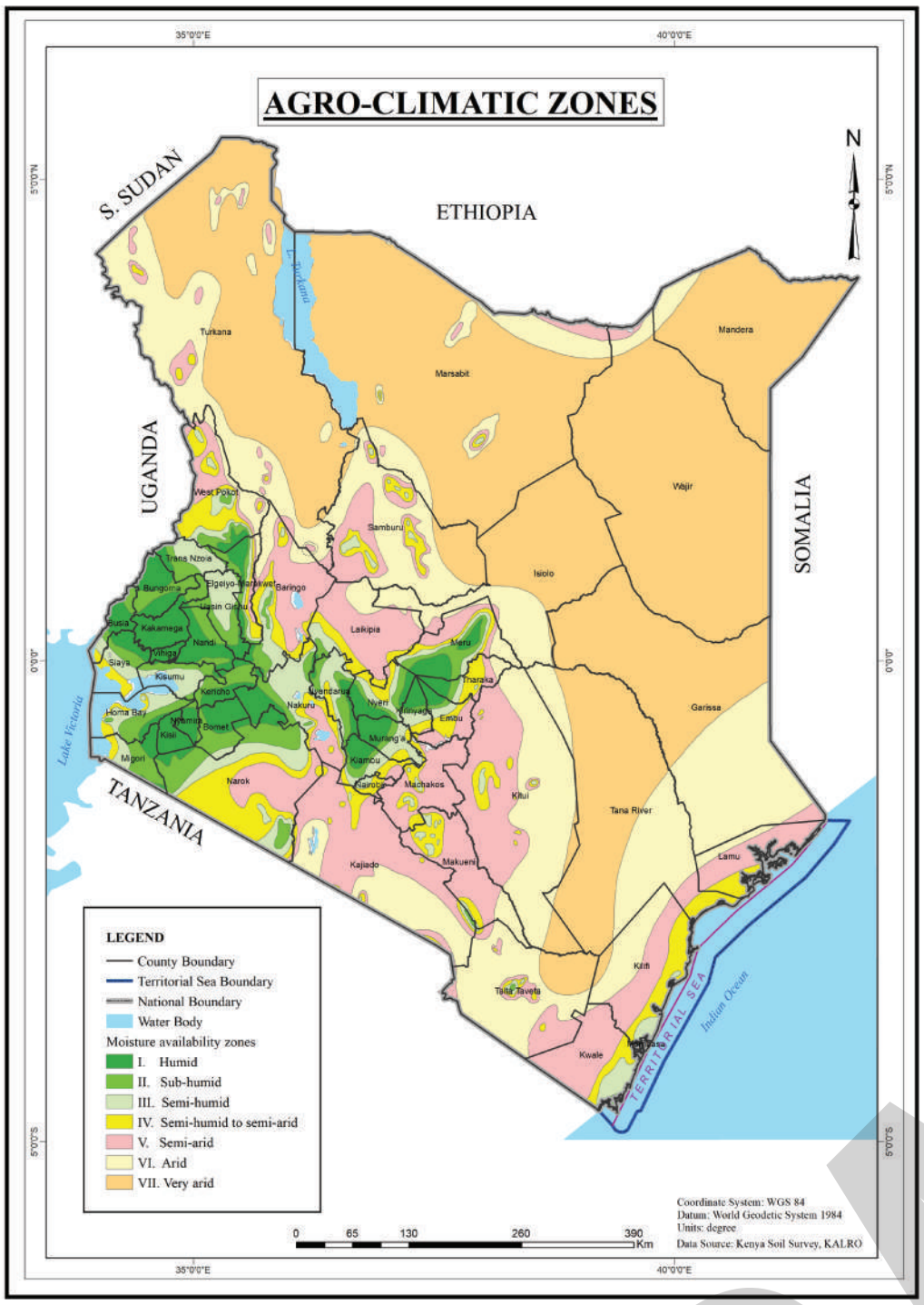


Figure 109: Agro-climatic zones in Kenya

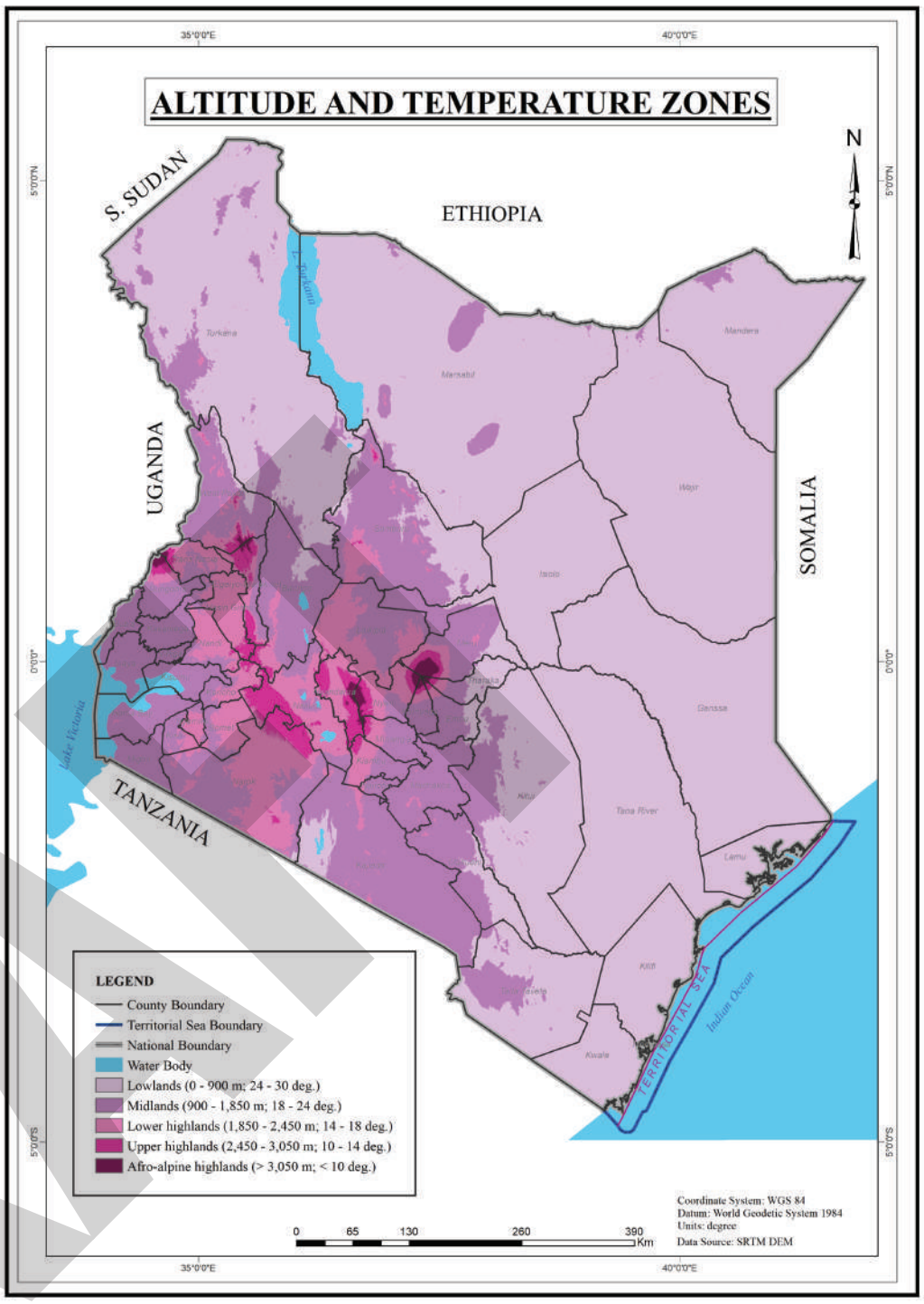


Figure 108: Altitude and temperature zones in Kenya

Topographic Resources

Like soils and climate, Kenya is notable for its distinctive topographic profile. The altitude stretches from sea level near the Indian Ocean at the coast to about 5,200 m (17,057 ft) at the peak of Mt. Kenya, the highest mountain in the country (Figure 9). Based on this altitudinal range, the country is divided into seven major topographic regions with characteristic landforms (Maina-Gichaba, 2013):

1. Coastal belt
2. Coastal plains
3. Low plateaus
4. Northern plains
5. Central highlands
6. Great Rift Valley
7. Western (Nyanza) plateaus

The coastal belt is a low-lying fertile region, with a broken coastline that is fringed with beaches, coral reefs, creeks and offshore islands. This belt is adjoined by a gradually rising coastal plain, which is generally dry, lies on sedimentary rocks with some igneous intrusions, and is covered by savanna and thorn bush. The coastal plains give way to the low plateaus, notably the Nyika plateau, which covers almost the entire north-eastern part of the country. The high plateau on the south-western part is bisected by the Great Rift Valley, a long line of escarpment, 50 to 65 km wide, 600 to 1000 m deep, extending from Lake Turkana in the north to Lake Natron in the south. In the valley, there are numerous volcanoes, hot springs and large lakes, including Lake Baringo, Bogoria, Nakuru, Naivasha, Elementaita and Magadi. The central highlands resulted from the volcanic activity associated with the formation of the Rift Valley. They encompass the elevated areas in the central portion of the Rift, such as the Aberdare Ranges, Mt. Kenya, Mau Escarpment and Cherangany Hills. To the west of the Rift, the Nyanza plateau descends to the plains that border Lake Victoria, while to the north, the land drops to the northern plains, covering the low-lying, rugged and arid regions around Lake Turkana.

In general, the landforms, which characterize the topographic regions were formed through both external and internal forces; whereby, the internal forces constantly elevated the Earth's surface, while the external forces (e.g., erosion) constantly degraded such elevations to level the surface. This topographic diversity also influences the climatic, soil and drainage conditions, which ultimately affect crop and livestock production in Kenya.

Crop Production

In Kenya, crops are produced under rain-fed and irrigated systems, with the rain-fed system accounting for over 90 percent of all production. The associated products are classified as either food or industrial (cash) crops based on their use after harvest. Food crops are further classified into (i) cereals (maize, wheat, sorghum, rice and millet) (Plate 57), (ii) pulses (beans, pigeon pea, cowpea, chickpea and green grams); and (iii) roots and tubers (sweet potato, Irish potato, cassava, arrowroot and yam). The staple food crops are maize, rice, wheat, sorghum, potato, cassava, vegetables and beans, while the main industrial crops are tea, coffee, sugar cane, pyrethrum, barley, tobacco, sisal, cotton, sunflower, coconut and bixa (GoK, 2010). Production of horticultural crops, ranging from cut flowers and vegetables to fruits, nuts, herbs and spices is also an important driver of economic growth.

Figure 10 presents the gross value of agricultural production at current prices from 2005 to 2020 (Food and Agricultural Organization of the United Nations [FAO], 2022). The value of crops shows incremental tendencies from 2005 to 2020. In 2020, the gross value of crop production was estimated at USD 9,879 million (KES 987.9 billion).

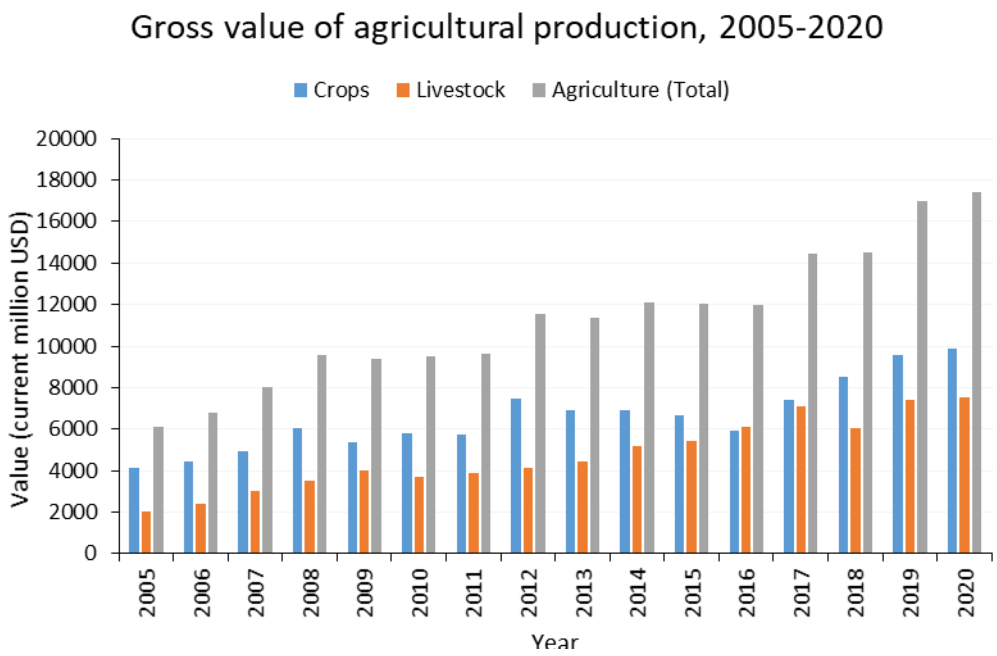


Figure 110: Gross value of agricultural production, 2005-2020. Source: FAOSTAT

Plate 57: Sorghum crop growing in a farmer's field. Photo credit: KALRO

Plate 58: Maize production under irrigated conditions. Photo credit: National Irrigation Authority

Plate 59: Vegetable production on vertical gardens for healthy and organic lifestyles in the urban areas. Photo credit: KALRO

Land Suitability for Rain-fed Crop Production

Kenya's agriculture is influenced by factors, such as climate, soils and topography. Such agro-ecological factors also determine the suitability of an area for particular land use. Agro-ecological zonation forms the basis of knowledge regarding the suitability and potential of land for agriculture in Kenya. Unlike the ACZs, AEZs are smaller units of the Kenyan landscape (Table 46) that are differentiated not only by the climatic requirements, such as temperature and moisture availability of the leading crops, but also by the soil and terrain conditions (Jaetzold et al., 2010). The resultant agro-ecological units are similar in terms of suitability for particular land uses, agricultural potentials, constraints, and environmental impact. Agro-ecological zonation is fundamental for optimal utilization of the country's ecological (natural) potential and alleviation of the escalating pressure on the biophysical land resources from competing land uses.

Apart from agro-ecological zonation, KSS has also performed other crop-specific analyses following the FAO framework (FAO, 1976) to augment and provide more details about the current suitability of land areas for rain-fed agriculture in Kenya. The analysis involves matching and overlaying the soil, climatic and topographic attributes of land with the requirements of specific crops in a GIS, the outputs of which are different crop suitability maps (see Figure 111 to Figure 113).

BOX 1.1: CROP SUITABILITY

A crop suitability map gives a better impression of the biophysical potential of land across spatial scales, and is important for targeting, expanding and intensifying the production of a specific crop in ideal areas where ecosystem services are less strained and minimal technological and infrastructural investments are required.

Table 46: *Agro-ecological zones of the tropics*

Main zones / Belts of Zones.	0 Per-humid	1 Humid	2 Sub-humid	3 Semi-humid	4 Transitional	5 Semi-arid	6 Arid	7 Per-arid/ very arid
TA Tropical Alpine Zones Ann. mean 2-10° C	Glacier / Mountain swamps	Cattle-Sheep Zone			Sheep Zone			* High altitude deserts
UH Upper Highland Zones Ann. mean 10-15° C Seasonal night frosts	Forest Zones	Sheep-Dairy Zone	Pyrethrum-Wheat Zone	Wheat-Barley Zone	Ranching Zone	Nomadism Zone		
LH Lower Highland Zones Ann. mean 15-18 ° C Mean min. 8-11° C Normally no frosts		Tea-Dairy Zone	Wheat/ Maize-Pyrethrum Zone	Wheat/ Maize - Barley Zone	Cattle-Sheep-Barley-Maize Zone	Ranching Zone	Nomadism Zone	
UM Upper Midland Zones Ann. mean 18-21° C Mean min. 11-14° C		Coffee-Tea Zone	Main Coffee Zone	Maize-Marginal Coffee Zone	Sunflower-Maize Zone	Livestock-Sorghum Zone	Ranching Zone	Nomadism Zone
LM Lower Midland Zones Ann. mean 21-24° C Mean max. > 14° C		Sugarcane Zone	Marginal Sugarcane Zone	Maize-Cotton Zone	Maize-Marginal Cotton Zone	Livestock-Millet Zone	Ranching Zone	Nomadism Zone
L Lowland Zones IL Inner Lowland Zones Ann. mean > 24° C Mean min. > 31° C		* Rice-Taro Zone	* Rice-Sugarcane Zone	* Cotton Zone	* Sorghum - Groundnut Zone	Livestock-Millet Zone	Ranching Zone	Nomadism Zone
CL Coastal Lowland Zones Ann. mean > 24° C Mean min. < 31° C		* Cocoa-Oil Palm Zone	Rice-Sugarcane Zone	Coconut-Cassava Zone	Cashew nut-Marginal Cotton-Cassava Zone	Livestock-Millet Zone	Ranching Zone	Nomadism Zone

Source: Jaetzold et al. (2010)

Note: The uppermost row in the matrix represents the moisture availability zones, while the leftmost column indicates the temperature belts. For instance, UH3 stands for a semi-humid upper highland zone suitable for wheat and barley. An asterisk (*) denotes a zone that does not occur in Kenya

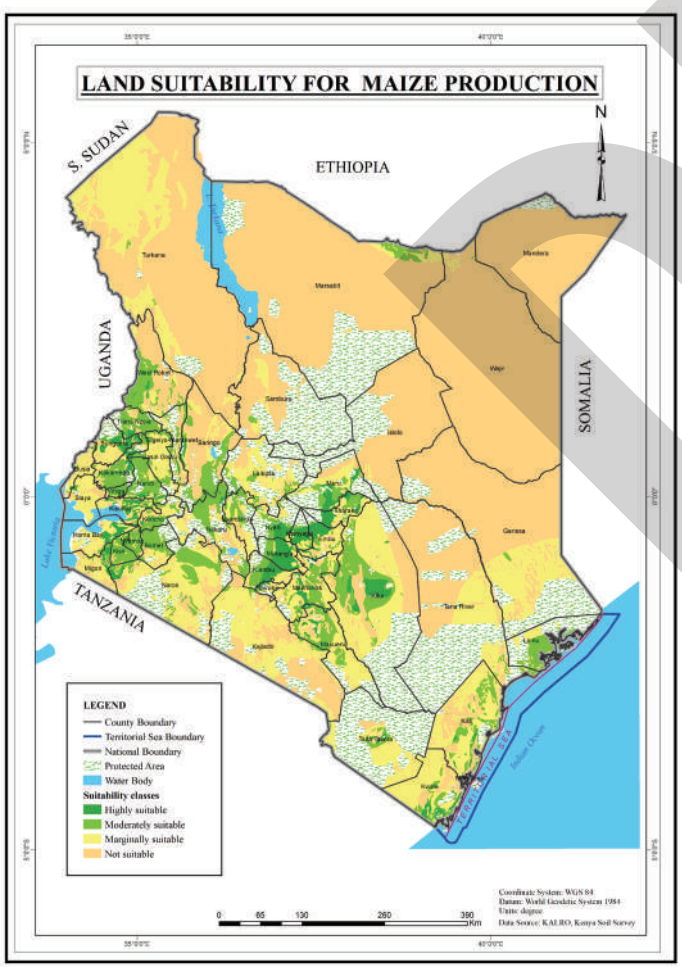


Figure 111: Land suitability for wheat production

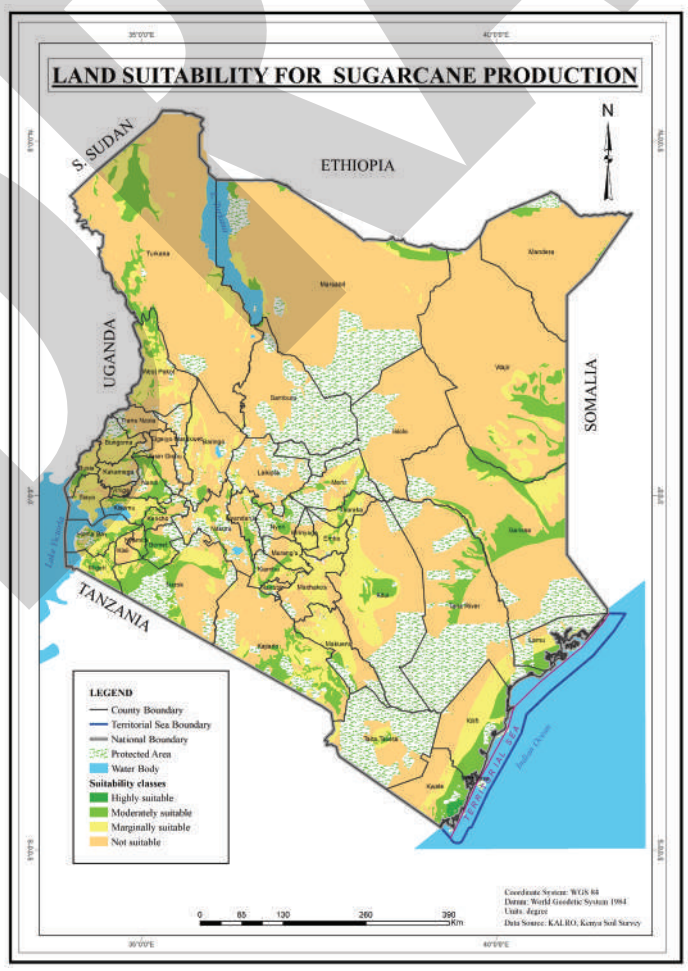


Figure 112: Land suitability for sugarcane production

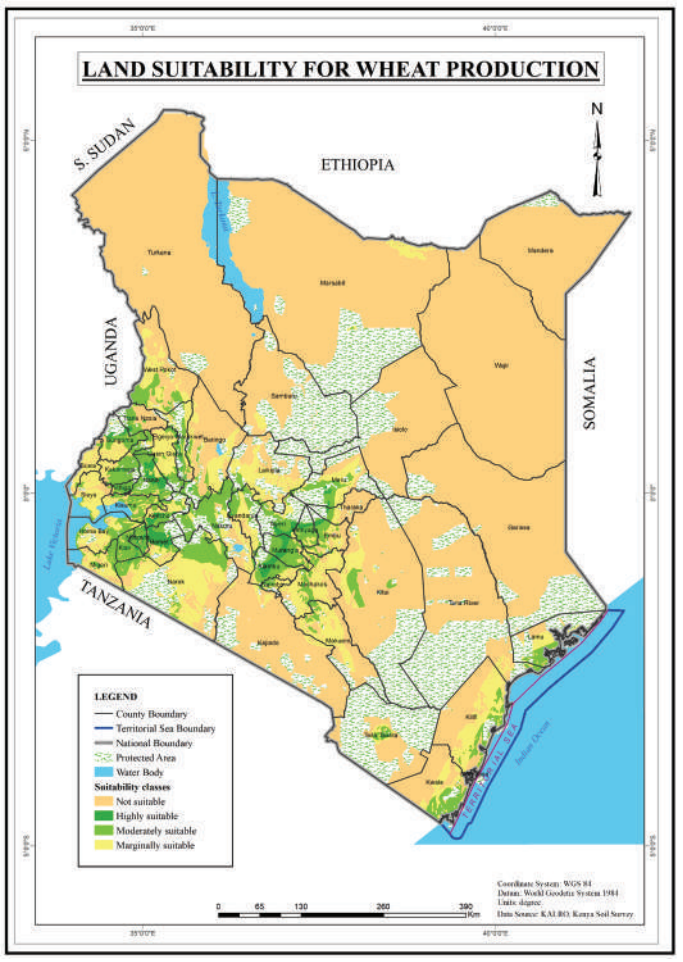


Figure 113: Land suitability for maize production

Trends in Crop Production

Generally, the production of major crops has grown over time (Figure 16 to 18). For example, between 1990 and 2021, maize production increased from approximately 2.3 to 3.3 million tons, bean production from 0.4 to 0.7 million tons, Irish potato production from 0.8 to 2.1 million tons, and rice production from 0.04 to 0.2 million tons at the annual growth rates of 1.7, 3.2, 4.2 and 4.6 percent, respectively (Table 6; Figure 16 and 17). These impressive growth rates can be attributed to the expansion of the areas under cultivation and increment in the yields of the crops. For example, during the same period, the acreage of beans, Irish potatoes and rice expanded at the annual rates of 2.4 (from 0.5 to 1.2 million ha), 2.9 (from 0.1 to 0.2 million ha) and 3.9 percent (from 0.01 to 0.03 million ha), respectively. Cassava, sorghum and millet production also exhibited similar trends. Regarding industrial crops, tea and sugarcane production has been on the rise, whereas coffee and barley production has been on the decline (Figure 116). The negative growth in barley and coffee production has mainly been contributed by the sustained reduction in their yields and acreage since 1990.

Table 47: *Compound annual growth rates of production, yield and area of major crops*

Crop	1990- 2001			2001- 2011			2011- 2021			1990- 2021		
	Area (Ha)	Prod. (Tons)	Yield (Hg/ ha)	Area (Ha)	Prod. (Tons)	Yield (Hg/ ha)	Area (Ha)	Prod. (Tons)	Yield (Hg/ ha)	Area (Ha)	Prod. (Tons)	Yield (Hg/ ha)
Wheat	-1.24	-1.27	-0.03	-0.86	-0.92	-0.05	-0.61	0.23	0.84	-0.27	0.43	0.70
Maize	1.55	0.19	-0.34	0.38	0.01	-0.37	2.73	1.75	-0.96	1.88	1.74	-0.14
Beans	4.11	-2.94	-6.77	1.15	2.23	1.07	-0.65	2.04	2.71	2.35	3.20	0.82
Irish potatoes	4.54	1.42	-2.98	5.69	-2.39	-7.64	0.16	11.56	11.40	2.89	4.20	1.27
Paddy rice	-0.14	0.60	0.74	-1.33	3.74	5.14	7.69	4.95	-2.54	3.89	4.55	0.64
Cassava	3.18	0.36	-2.74	-0.60	0.04	0.64	-1.26	0.45	1.73	0.45	1.75	1.30
Sorghum	1.33	-0.81	-2.11	-0.77	2.91	3.71	4.91	1.57	-3.18	2.48	2.66	0.18
Millet	-0.20	-3.12	-2.93	0.12	-1.95	-2.07	-1.52	1.00	2.56	1.08	2.67	1.57
Tea	2.17	9.42	7.10	3.83	3.68	-0.14	3.74	2.77	-0.93	3.38	4.18	0.78
Coffee	1.30	-3.43	-4.67	0.35	-1.35	-1.69	-2.32	-2.52	-0.21	-1.51	-3.02	-1.54
Sugarcane	1.33	-1.18	-2.48	0.23	0.57	0.34	4.01	3.79	-0.21	2.04	1.52	-0.51
Barley	0.03	3.20	3.17	-1.88	-3.89	-2.05	-1.21	-2.24	-1.04	-0.86	1.39	2.28

Source: Calculated using FAOSTAT data

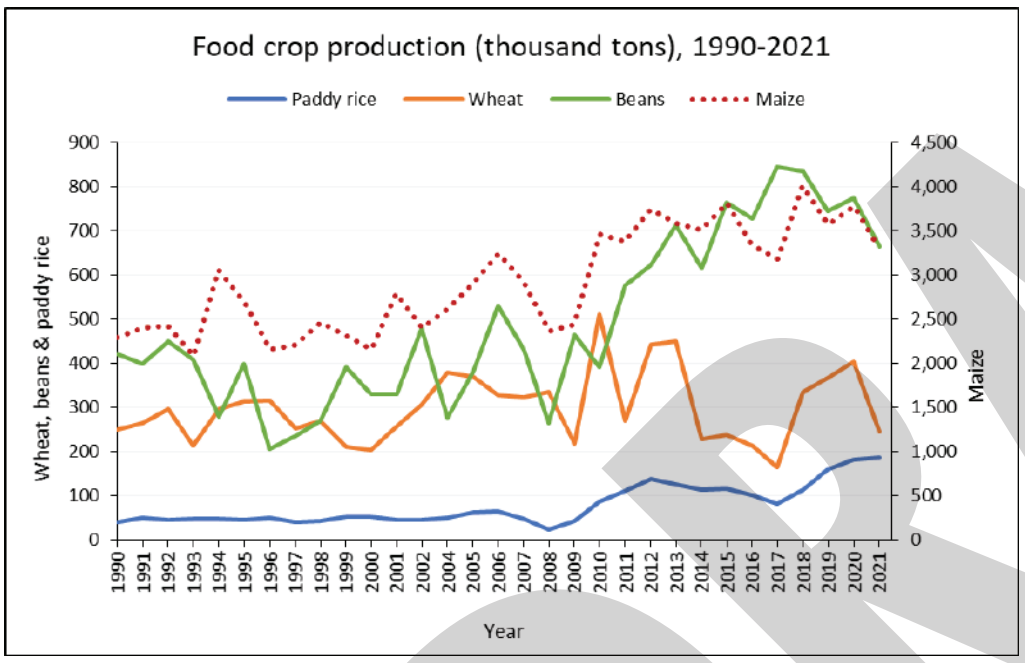


Figure 114: Maize, beans, wheat and rice production, 1990-2021. Source: FAOSTAT

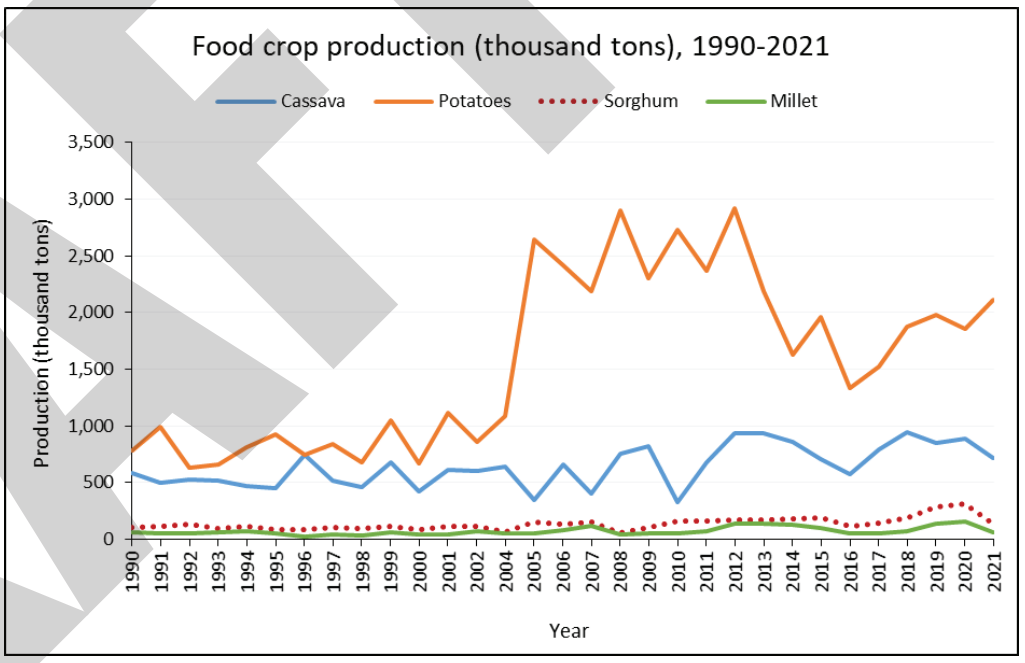


Figure 115: Cassava, potato, sorghum and millet production, 1990-2021. Source: FAOSTAT

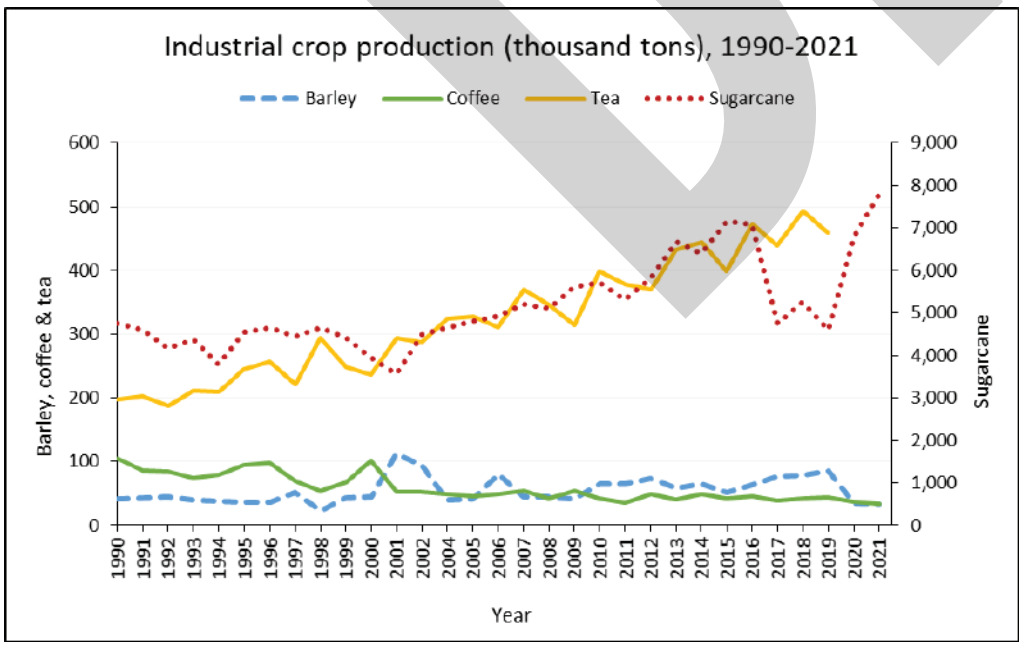


Figure 116: Tea, coffee, sugarcane and barley production, 1990-2021. Source: FAOSTAT

Livestock Production

Over 70 percent of Kenya's livestock is found in the arid and semi-arid counties, such as Turkana, Wajir, Garissa, Kajiado, Narok, and Marsabit, where production is mainly carried out by pastoralists, including the Maasai, Turkana, Pokot, Borana, Rendille and Somali. Livestock production plays an important economic and socio-cultural role in Kenya, contributing about 4 percent of the GDP, 18 percent of the agricultural GDP and 50 percent of the agricultural labour force (KNBS, 2022). Domestic livestock also contributes substantial earnings to households through the sale of livestock and livestock products, as well as supplies the local requirements of meat, milk and other products, while accounting for about 31 percent of the total marketed agricultural products. Moreover, the sub-sector earns the country substantial foreign exchange through export of live animals, hides and skins, dairy products, and processed pork products. It is also a significant user of products from feeds, drugs, vaccines and equipment manufacturing industries, and a major source of raw materials for agro-processing industries. The key livestock enterprises are beef, dairy, sheep, goats, camel, poultry, pigs and emerging livestock (e.g., Ostriches) (Plate 60).

Plate 60: Plate 3: Cattle grazing in a semi-arid environment. Photo credit: Sosian Ranch

Livestock Production Systems

Kenya has a wide range of agro-climatic conditions. The humid, sub-humid and semi-humid zones are associated with intensive and semi-intensive production of livestock, whereas the semi-arid, arid and very arid zones are characterized by extensive production under free-range, pastoralism and ranching.

Dairy Production Systems

Kenya's dairy industry is the second largest contributor to the agricultural GDP. Dairy cattle population is estimated at 2.2 million kept under intensive, semi-intensive and extensive systems of production (FAO, 2018; KNBS 2019), with the intensive and semi-intensive systems comprising about 85 percent of all dairy farms (Table 49). These production systems are mainly dependent on rainfall, soils, altitude, temperatures, humidity, and dairy products market availability.

Beef Production Systems

The beef industry is an important contributor to the Kenyan economy in terms of agricultural GDP, value and employment, especially in the ASALs where beef production is the main economic activity. Like in dairy, beef production systems are dependent and affected by rainfall, soils, temperatures and humidity. There are three main classes of the beef production system; namely, extensive grazing system (both pastoralism and ranching), semi-intensive grazing system (agro-pastoralism), and intensive (feedlot) (Table 48).

Table 49: *Dairy production systems*

Production system	Description	Proportion of farms	Cattle population
Zero grazing (Intensive)	This system involves confinement of exotic high-grade dairy animals (Friesian, Ayrshires, Guernsey and Jersey), high level of management, and optimal feeding and animal health practices. The scale of operation ranges from small-scale (1-20 cows) to large scale (more than 20 cows). Cattle are stall-fed and milk production is high, averaging 15-30 litres of milk per cow per day; hence, most of the milk is sold to the market. Intensive dairy farms are concentrated in the mid- and high-altitude AEZs, such as Mt. Kenya and central Rift Valley regions, where cereal and other cash crops are grown. The system is also found in many urban and peri-urban areas in the humid and sub-humid zones.	1% large-scale; 40% small-scale	303,116 large-scale; 1,555,354 small-scale
Semi Zero grazing (Semi-intensive)	Farmers let the animals, mainly crosses and exotic breeds, graze freely or within paddocks during the daytime, and enclose them at night when feed supplements are provided during milking. Mostly, dairy cattle are also raised together with other animals, such as chicken, sheep, goats and donkeys. Semi-intensive dairy systems are concentrated in Mt. Kenya, central and north Rift Valley, coastal regions, and other areas where crop farming is practiced, such as the western and Nyanza regions. Production is relatively low in this system, averaging less than 6 litres of milk per cow per day; hence, most of the milk is consumed at home.	55%	2,141,791
Extensive grazing	This is a pasture-based production system dominated by exotic breeds and crosses of indigenous breeds. It is practiced in areas with large farms (controlled grazing with large herds) and in marginal and communal grazing lands (uncontrolled grazing with few animals). Under controlled grazing, animals are placed on natural and improved pastures within paddocks or strip grazing and supplemented with high-quality fodder, mineral licks and commercial concentrates. Uncontrolled grazing is characterized by free grazing in natural pastures and limited supplementation. Milk production is low compared to the intensive system, averaging between 4 and 11 litres of milk per cow per day. This system is found in North and South Rift Valley, Eastern and Coast Regions.	1% controlled; 4% uncontrolled	266,650 controlled; 238,823 uncontrolled

Table 48: *Beef production systems*

Production system	Description	Proportion of farms	Cattle population
Pastoralism (Extensive)	Pastoralism is a low-input low-output subsistence system, with indigenous cattle relying entirely on communal grazing areas and water sources. Pastoralism, including transhumance and nomadic pastoralism, is practiced in the ASALs.	34%	8,085,053
Ranching (Extensive)	Ranches are vast land areas having large livestock herds of about 150 animals on average. The cattle breeds range from crosses to exotic (Hereford, Angus, Charolais and Simmental), with an average meat yield of 240 kg per head. Most ranches are privately-owned and commercially-oriented, targeting the local niche and export markets. They contribute the most to beef exports and are common in Laikipia and Taita Taveta counties; although, there are a few government farms spread across the sub-humid and semi-arid zones. Ranches have the infrastructure for disease control, feeding and water storage.	11%	762,544
Agro-pastoralism (semi-intensive)	Agro-pastoralism is a low input-low output system practiced for subsistence in more regions of Kenya than any other beef production system. It predominates in the Coastal, Lower eastern, North Rift and South Rift regions. Agro-pastoralism involves growing crops and keeping mixed herds of beef cattle, with the average herd size being 10 to 12 animals. The animals graze extensively on communal lands, or paddocks, but are also fed on crop residues and other products as feed supplements, while their draught power and manure are used to increase crop production.	54%	5,420,342
Feedlot (intensive)	Feedlot is a commercially-oriented system where animals are kept for a short period (about 3 months), during which they are fattened and sold to prime beef markets. It is both a capital and labor-intensive system, with significant investments in feeding. Feedlot systems also have high biosecurity and animal health practices.	1%	42,990

Livestock and Livestock Products

Kenya has approximately 22.9 million cattle, 32.6 million goats, 24.8 million sheep, 4.4 million camels, 59 million chickens, 1.4 million donkeys and 0.7 million pigs (Ministry of Agriculture, Livestock and Fisheries [MoALF], 2022). Overall, the livestock population has been on an upward trend from 1990 to 2021 (Figure 19) owing to the increasing demand for livestock products following the rapid rise in population, urbanization and incomes. The fluctuations evident in the livestock numbers have been majorly attributed to severe drought events. In 2021, the gross value of all livestock was KES 752.6 billion, while livestock products were valued at KES 251.9 billion (FAO, 2022; MoALF, 2021) (Figure 10). The distribution of livestock in the country is determined by the environment, tradition and commercial viability. Many communities in the country have traditionally been associated with livestock keeping. The camel and donkey have traditionally been important draught animals among the pastoralists due to their adaptability. Sheep and goats are also important among nomadic pastoralists because of their utilization of scarce pasture and shrub resources for their optimal productivity. Other livestock species are common in other parts of the country driven by available feed resources, markets of livestock products and commercialization levels.

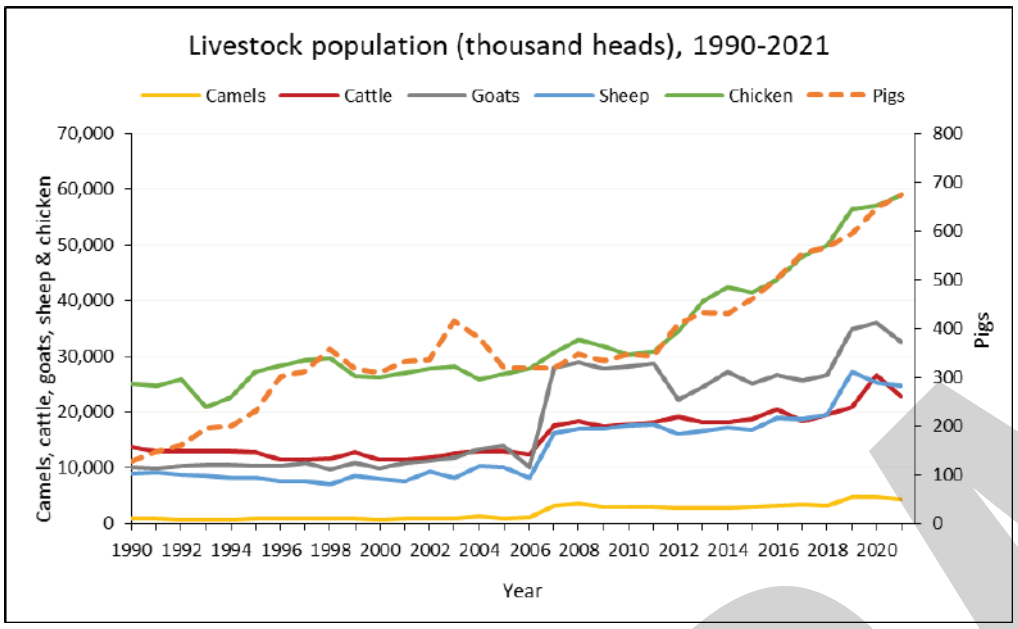


Figure 117: Livestock population trends, 1990-2021. Source: FAOSTAT

Beef Cattle

Beef cattle population is estimated at 13.6 million, the main species of which are the East African Zebu, Boran, Sahiwal and cross-breeds (Plate 4 and 5). The highest concentration of these cattle is in the ASALs, with beef being mainly derived from pastoral and agro-pastoral production systems. In 2019, about 322,144 tons of beef were produced valued at KES 127.5 billion (Ministry of Agriculture, Livestock and Fisheries [MoALF], 2019) (Figure 20). Most of the beef is consumed locally by the urban middle-income population, the consumption of which is expected to increase to 13.3 million tons by 2025.

Besides beef, hides are also derived from slaughtered cattle. They are used as raw materials in the leather industry, where the hides are tanned into wet blue and other finished leather products. A total of 3,438,124 pieces of hides valued at KES 350.9 million were produced in 2019 (Figure 118).

Plate 61: Improved Sahiwal bull. Photo credit: KALRO

Plate 62: Indigenous cattle at a watering point. Photo credit: MoALF

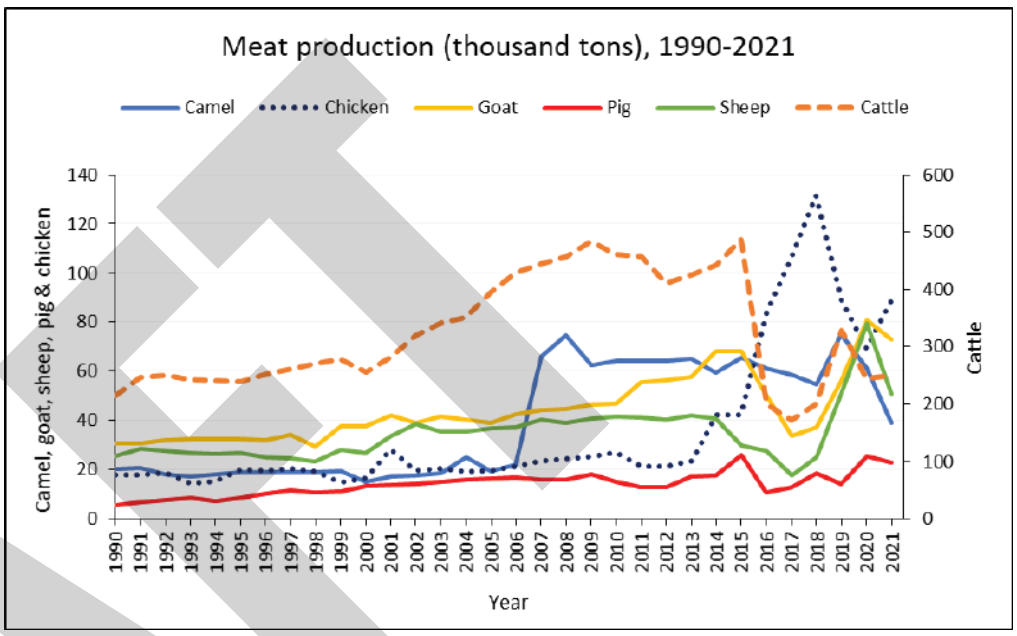


Figure 118: Meat production trends, 1990-2021. Source: FAOSTAT

Dairy Cattle

The country has a vibrant dairy industry, which supports about 1.8 million rural households and an additional 700,000 jobs along the dairy value chain. Dairy cattle are estimated at 2.2 million head and are mainly kept in medium- to high-rainfall areas, which also have high human population densities and corresponding consumer market. The primary dairy breeds are Ayrshire, Friesian, Guernsey, Jersey and cross-breeds (Plate 6). In 2021, the dairy cows produced 4.6 billion litres of milk valued at KES 236.7 billion (MoALF, 2021). About 90 percent of the marketed milk is produced by smallholder farmers in all production systems, and the per capita consumption of milk averages 117 litres per year (FAO, 2018).

Generally, there has been an increase in the production of milk in the country within the last ten years (Figure 119). Milk production is closely related to cattle population, but is higher where there is more intensification characterized by small landholdings and rearing of high-producing dairy cows in semi- or zero-grazing units. It is projected that milk production in the country will grow by between 4.5 and 5 percent annually in the next ten years and by the year 2030, it is envisaged that the annual milk production in Kenya will increase to about 12 billion litres.

Plate 63: Friesian dairy cow. Photo credit: Laban Robert

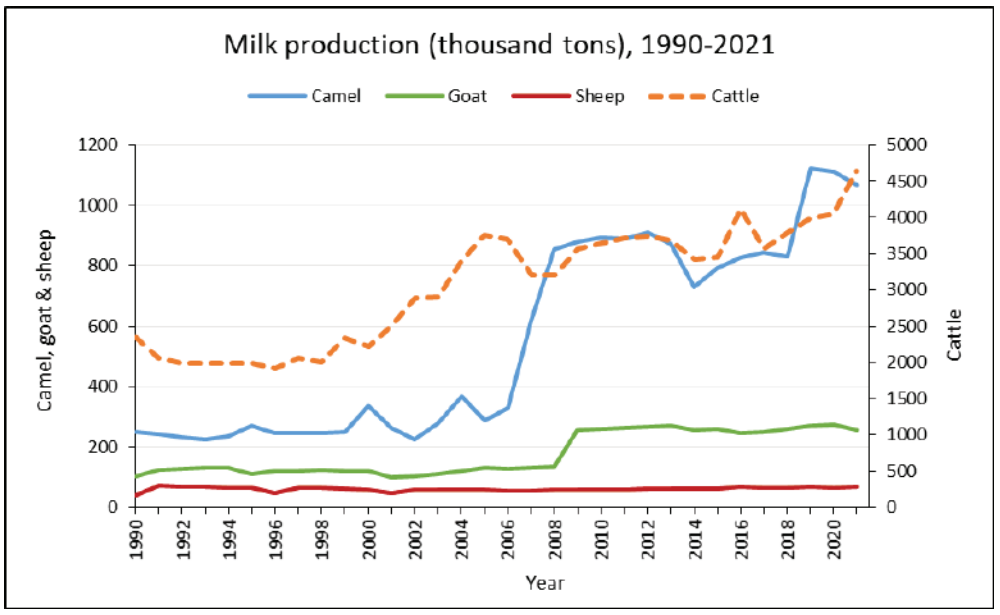


Figure 119: Milk production trends, 1990-2021. Source: FAOSTAT

Plate 65: A flock of Dorper sheep at a livestock market. Photo credit: MoALF

Sheep and Goats

Sheep and goats are important in pastoral households' food security and incomes owing to their short-generation intervals, high adaptability and versatile feeding habits. The bulk of these animals are reared in the ASALs under pastoralism and to a limited extent, ranching systems (Figure 118). The country has an estimated population of 28.3 million goats and 19.3 million sheep. Goats produce meat, mohair and milk, while sheep produce wool, milk and meat. In 2021, the sheep produced 1,505 tons of wool valued at KES 159.2 million and 50,842 tons of mutton valued at KES 26.3 billion, whereas the meat goats produced 73,063 tons of chevon valued at KES 39.6 billion (MoALF, 2021). With regard to milk, FAO (2019) estimated that the dairy goats produced about 228 million litres of milk worth KES 18.3 billion, while the sheep produced 86 million litres of milk worth KES 8.8 billion in 2018.

Apart from meat, wool and milk, skins are also derived from sheep and goats. A total of 2,864 thousand tons of skins valued at KES 143.2 million were produced in 2022 (Figure 120). Production of wool from sheep and mohair from goat is predominant in the high to medium altitude areas of the country. The wool sheep comprise the Merino, Corriedale, Hampshire Down, Dorset Horn and their crosses, while mohair goats consist mainly of the Angora goat. The potential for developing wool sheep and mohair goats is high owing to the reproduction efficiency and space utilization of these livestock species. However, the country has limited capacity to adequately process and do value-addition on these raw materials. Competition from imported finished products also heavily impacts the growth of the industry. Overall, sheep and goats have the potential to adequately supply all the animal products and by-products to meet domestic needs and also generate a surplus for export in the country.

Plate 64: A flock of Galla goats. Photo credit: KALRO

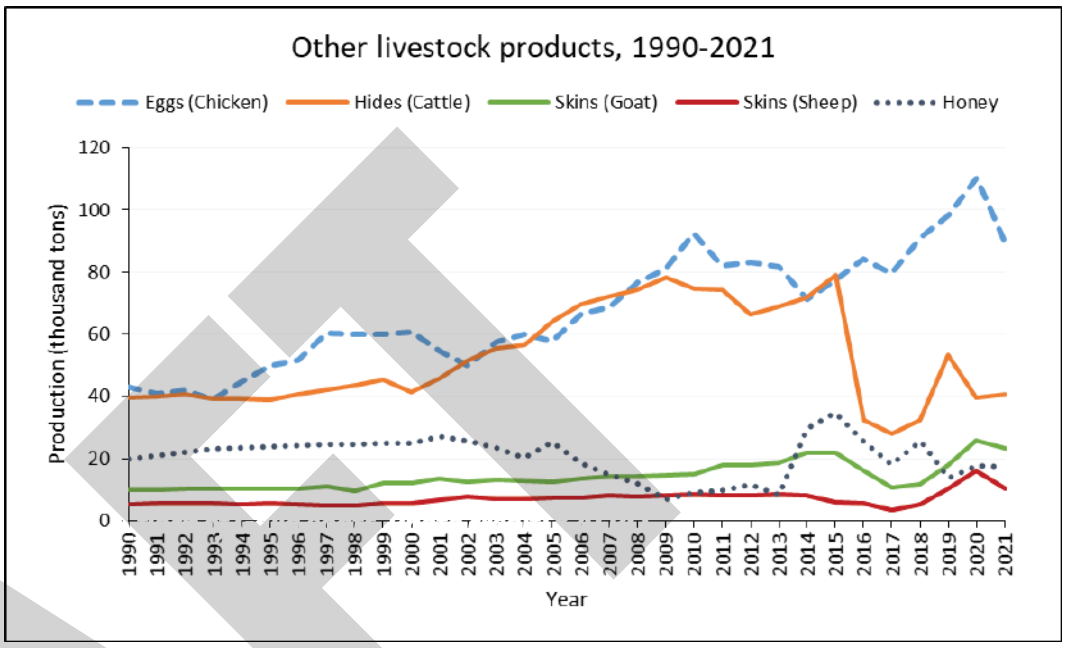


Figure 120: Hide, skin, honey and egg production trends, 1990-2021. Source: FAOSTAT

Camel

Camel keeping is mainly practiced in northern Kenya (Plate 9). The camel produces milk, meat, income and serves as pack animals. In 2021, 39,129.5 tons of meat were produced valued at KES 16.6 billion, and 1 billion litres of milk were produced valued at KES 89.1 billion (MoALF, 2021). Already, camel keeping has extended to the South Rift region and is expected in other parts of the country in the coming decades. The importance of the camel for food security is attributed to its ability to survive and continue being productive under drought conditions. There is a robust export demand for live camels in North Africa and the Middle East. Currently, the demand is mostly from Sudan, Somalia and Djibouti.

Plate 66: Camels at a watering point. Photo credit: MoALF

Pigs

Pig rearing under intensive systems has become a relatively well-established industry in the Kenyan market (Plate 10). It has withstood periodic fluctuations

common in the pig industry, moving from large-scale to smallholder farming. In 2021, the country produced about 23,107 tons of pork valued at KES 9.2 billion (MoALF, 2021). The pig's shorter life cycle coupled with good return rates and optimum feed efficiency makes it more suitable for farmers.

Plate 67: Pigs on a farm. Photo credit: KALRO

Poultry

Poultry is one of the most important livestock enterprises, especially in rural households in Kenya. The sector is highly heterogeneous consisting of a large number of small scale free-range and backyard indigenous chicken producers, small scale commercial layers and broiler farms, and a few industrial integrated layer and broiler farms (FAO, 2018). Overall, Kenya has over 40 million birds, 80 percent of which consists of free-ranging indigenous chicken (Plate 11), while 16.2 percent are commercial layers and broilers (Figure 19). Other poultry species like duck, turkey, pigeon, geese, ostrich, guinea fowl and quail constitute 3.3 percent and are becoming increasingly important. In 2021, the country produced over 89,450 tons of poultry meat and over 240 million egg trays, which were worth KES 131.7 billion (MoALF, 2021). Per capita consumption is approximately 0.56 kg of poultry meat and 45 eggs per year. The industry has a fairly well-developed input and service provision system along the value chain. However, importation of raw eggs, underdeveloped markets and unstructured marketing system affects its performance.

Plate 68: Improved indigenous chicken. Photo credit: KALRO

Bees

Bee-keeping is well established in Kenya and mostly practiced in the ASALs, where rain-fed agriculture is impractical. Besides contributing directly to household incomes and food security through the provision of honey and other products, bees (Plate 12) also play an important role in crop pollination. The country ranks third in honey production in the East African region, producing about 17,265 tons of honey and 5,783 tons of beeswax in 2021 worth KES 14.6 billion (FAO, 2022; MoALF, 2021). However, its production potential is estimated at over 100,000 and 10,000 tons of honey and beeswax, respectively.

Due to the low investment, variable costs involved and high demand, beekeeping is becoming increasingly popular in rural areas. In fact, the demand for honey is far above the supply worldwide and Kenya has the opportunity of benefitting from that gap. Unstructured marketing system, inadequate value addition on the products, competition from imported honey, poor quality honey due to inadequate quality control services, use of inappropriate bee equipment and rampant use of pesticides are some of the factors that impede the growth of apiculture industry.

Plate 69: The honey bee (left) and bee swarm (right). Photo credit: MoALF

Non-Conventional Livestock

Non-conventional livestock, also called emerging livestock, are animals that have recently been recognized and promoted in the country as an alternative farming activity and a bridge for animal protein deficit in the face of climate change. These animals include quails, guinea fowl, donkeys, ostriches, crocodiles, among others (Plate 13). They have not received adequate attention in terms of research and development. By law, except for the donkey, these animals are designated as wildlife. However, the Kenya Wildlife Service (KWS) policy and legal frameworks have allowed farming of these species provided a license is obtained. Commercial farming of these animals is progressively increasing due to demand for their products, such as eggs, meat, skin and feathers. The growing human population and urbanization have increased the demand for food of animal origin at unprecedented levels; therefore, there is a need to fully explore the opportunities that exist in farming food-producing animals.

Plate 70: A donkey at a watering point. Photo credit: MoALF

Major Issues affecting Crop and Livestock Resources

Land Degradation

Despite being the cornerstone of food security, ecological stability, rural livelihoods and agricultural resilience, land resources remain unappreciated, physically neglected and unsustainably managed, leading to widespread degradation in the country. Population growth is among the many underlying factors, which has driven the degradation of land resources in various ways. It has contributed to the influx of more people into the ASALs and range lands, overgrazing of pastures, encroachment on forests, cultivation of marginal lands, and fragmentation of land into uneconomical parcels. The ongoing land degradation manifests itself in multiple ways, including soil erosion, acidification, nutrient depletion, leaching, a decline in soil organic matter, structure, biodiversity and vegetative cover, surface sealing, compaction, floods and landslides. This compromises the health and capacity of the

land to produce and provide various ecosystem services, the effects of which could be unrecoverable within the human lifespan. Degradation also increases food insecurity levels and vulnerability to future shocks, whether climatic or economic. The end of this process could be human destitution and abandoned unproductive lands that can lead to conflicts and migration. Thus, understanding the patterns of land degradation and designing sustainable land management strategies is needed in order to protect agricultural and rangelands in Kenya.

Climate Change

There is growing evidence that climate change is occurring in Kenya. Changes in weather patterns and climate extremes have been observed over the last 50 years (GoK 2017); particularly, increased temperatures, frequency of intense rainfalls, melting of the glaciers that cover Mt. Kenya, and intensity of El Niño and La Nina events leading to more severe and frequent floods and droughts. These changes are expected to affect crop and livestock production and health, as well as Kenya's ability to develop. For example, increased rainfall and elevated CO2 will increase crop production and carbon inputs in the agro-ecosystems, but also accelerate the rates of soil erosion. Conversely, reduced precipitation along with the drying effects of higher temperatures will decrease crop growth, yields and carbon inputs in most systems. Even though elevated CO2 and higher temperatures will also be expected to stimulate plant growth, the attendant increase in the rates of soil respiration and decomposition will constrain the positive effects, resulting in either depletion or little net change in soil organic carbon (SOC) stocks. The depletion of SOC will, in turn, affect soil quality by undermining the physical, chemical and biological properties that determine soil fertility and functions. For example, depletion of SOC will reduce the activity and diversity of soil biota, nutrient supply, cation exchange capacity, aggregation and water-holding capacity, as well as increase CO2 emissions causing positive feedback to global warming. The resultant soil degradation will, in turn, reinforce the detrimental effects of temperature rise on crop yields, forage quality, and animal health. For instance, the temperature rise will aggravate livestock morbidity and death. It will also trigger shifts in disease spreading, outbreaks of severe diseases, or even introduce new ones, which may affect livestock that were previously not exposed to the diseases. Therefore, evaluating disease and livestock adaptation will be important to maintain their resilience.

Pests and Diseases

Pests and diseases cause heavy losses through deaths, reduced productivity and loss of markets for products, affecting food security and livelihoods. In the crop sub-sector, pests and diseases lead to either low yields, post-harvest losses, or total crop failure. For example, post-harvest disease pathogens like the Aspergillus flavus have been reported severally with catastrophic aflatoxin contamination and infections in crops (GoK, 2010). Invasive pests and diseases like the fall armyworms, desert locusts and the maize lethal necrosis disease (MLND) are controlled by the government, while all the other pests and diseases are managed on-farm by farmers. This poses a major challenge to most small- and medium-scale farmers due to the high costs of agro-chemicals and control equipment.

In the livestock sub-sector, notifiable, communicable, zoonotic, transboundary and trade-sensitive diseases are of major economic importance. The decline in public sector funding over the years has resulted in little success in controlling these diseases. As such, previously controlled diseases have re-emerged; for example, foot-and-mouth, anthrax, east coast fever, rinderpest and rabies. Besides, pests, such as ticks and tsetse fly have also contributed to the death of large herds of animals.

Land Fragmentation

The growing human population, the associated increase in demand for land, coupled with unsustainable land-use practices and environmental policies have encouraged subdivision of land into small uneconomic units both in the range- and arable lands. This manifests in different forms with adverse effects on crop and livestock productivity. In most cases, land fragmentation has taken the dimension of fencing and erecting barriers on grazing and croplands, and ultimately changing the land use. The challenge of land fragmentation is expected to persist, with the available land per capita reducing from a mean of about 1.5 ha per capita at present to about 0.3 ha by 2050 (GoK, 2007).

Development Projects

Even though increased government interest and projects in the rangelands, especially in Northern Kenya, aim at opening up such regions to more investment, it also exposes the range ecosystems to intense vulnerability and disruption. The North Eastern Transport Improvement Project (NETIP), which aims at improving road transport, digital connectivity and socio-economic status of the communities along the Isiolo-Wajir-Mandera road corridor, is a good example of such a national government project in the ASALs. Others include the Lamu Port-South Sudan-Ethiopia-Transport (LAPSSET) project and the North Eastern Development Initiative (NEDI). Such projects come with the development of socio-economic infrastructure along the road and open up the area to more human settlement.

Human, Livestock and Wildlife Interactions

The game in the farmlands and ranches poses a potential conflict between wildlife, livestock and humans. Due to the interaction of wildlife and livestock, diseases are transmitted from wildlife to livestock. There is also competition for natural resources, such as pasture and water between wildlife and livestock. The wildlife may sometime cause injury, or death to livestock and humans. There is, however, significant potential in gainfully exploiting wildlife resources through game ranches and conservancies. In addition, wildlife resources have the potential for exploitation as non-conventional livestock, which can enhance the livelihoods of the farming communities.

Conclusion and Recommendations

In conclusion, agro-based resources collectively form a considerable natural resource base for stimulating sustainable livelihoods, social cohesion and economic In conclusion, agro-based resources collectively form a considerable natural resource base for stimulating sustainable livelihoods, social cohesion and economic growth in Kenya. Hence, the protection and conservation of these resources is a prerequisite for sustained development, rural livelihoods and provision of ecosystem services. This implies that the existing agro-based resources should be exploited for crop and livestock production to meet the present needs of Kenyans, while ensuring their long-term productive capacity to perform various ecological functions. That is, the resources should be used without degrading their quality and their resilience to the adverse effects of climate change should be enhanced. To achieve this, the promotion of sustainable and climate-smart agricultural and livestock production technologies, innovations and management practices (TIMPs) is recommended. The TIMPs are manifold, ranging from rotational grazing and cropping to conservation agriculture, integrated nutrient management, agroforestry and soil and water conservation structures. Thus, agricultural- and rangeland resource management projects would benefit from objective selection and promotion of best-fit TIMPs that are well-matched to the natural and socio-economic conditions of specific agro-ecologies. One-size-fits-all should not be an option for promoting sustainable management of agro-based resources. The projects would also gain considerably from policies and approaches, which foster partnerships between governments, private sector and non-governmental organizations. This presupposes a facilitative policy environment.

POLICY STATEMENT

Land-based resources, such as soils, climate and topography underpin agriculture and food and nutrition security in Kenya. Therefore, a policy framework that advances the protection of these resources is requisite. The policies should support exploitation of land resources for crop and livestock production, utilizing proven climate-smart technologies, innovations and management practices to meet the present needs of Kenyans, without jeopardizing their long-term productive capacity to deliver ecosystem services.

CHAPTER

05

EXTRACTIVE RESOURCES

Petroleum Resources

Introduction

Kenya is endowed with many natural resources spread across the country. The resources range from fossil fuel such as oil, coal and gas, mineral and petroleum resources. The Natural Resources Bill 2022 established a system of benefit sharing in natural resource exploitation between resource exploiters, the national government county governments and. Mineral potential resources of a country are a function of its geology. Kenya's mineral endowment is directly related to its highly varied geology in terms of geochronology, tectonic history, geomorphological characteristic and geographical distribution of the constituent rock units.

The full potential of mineral resources is unknown and therefore untapped. With the recently completed countrywide airborne geophysical survey, followed up by detailed geological investigations Kenya will uncover its mineral wealth. At present the mining sector's contribution to Kenya's economy is relatively small (0.8% of GDP) with mineral sands ($150m/yr) and soda ash ($50m/yr) forming a major part of total output by value. The sector contribution to the GDP is expected to increase to 10% by 2030 (Source: State Department for Mining-SDM).

Petroleum Resource

Crude oil and natural gas, are generally referred to as petroleum. These are fossil fuels that are formed from the remains of prehistoric plants and animals They constitute organic material mixed with other sediments and are buried and compressed under high pressure and temperature in vast underground reservoirs where ancient seas were once located.The reservoirs can be found on land; onshore, or in the sea, Offshore

Crude oil varies in color but is usually black or dark brown and sometimes, the color can also be a tinge of red, green, tan or even yellow. The color variations indicate the distinct chemical compositions of different supplies of crude oil

Petroleum is the most important form of modern primary energy not only for Kenya but globally. Though the industry is relatively nascent in Kenya, it contributes about 57% of Global primary energy mix and 68% of Kenya's primary energy consumption . As of 2018, petroleum accounted for about 22% ofthe total primary energy consumed in Kenya. At the economic growth rate of 10% desired to achieve Vision 2030, it is projected that consumption rate will tremendously grow from the current 6.4 million MTto 12 million MT by 2030

Distribution of Petroleum in Kenya (Basins)

Kenya has sixty-three (63) Petroleum Exploration Blocks, (Kenya Gazette, 13th May 2016), issued under the Petroleum (Exploration and Production) Act, 1986 (Cap. 308). The blocks are spread across four basins

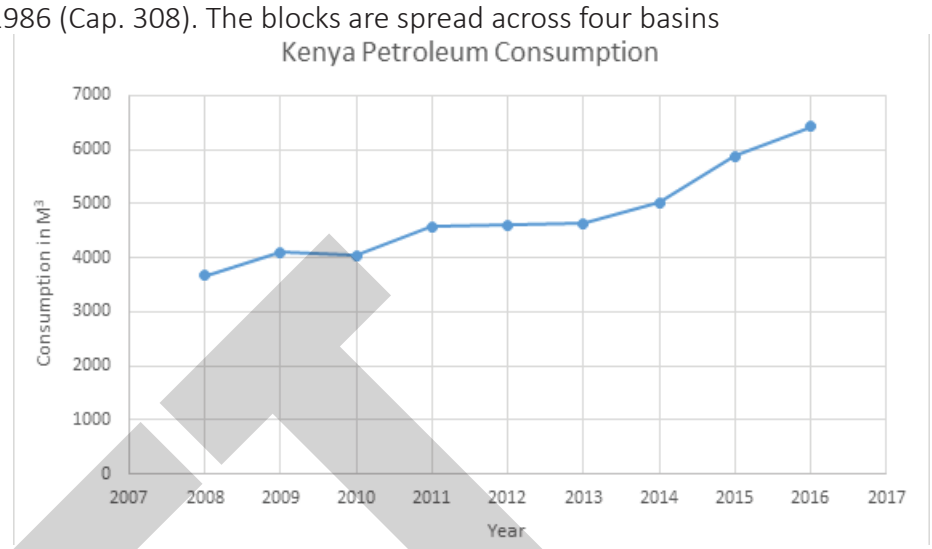


Figure 121: Petroleum basins in Kenya

Table 51: Kenya basins catchment area

S/No	Name of Basin	Number of Petroleum Blocks
1.	Anza	7
2.	Tertiary Rift	14
3.	Mandera	5
4.	Lamu	37
	Total	63

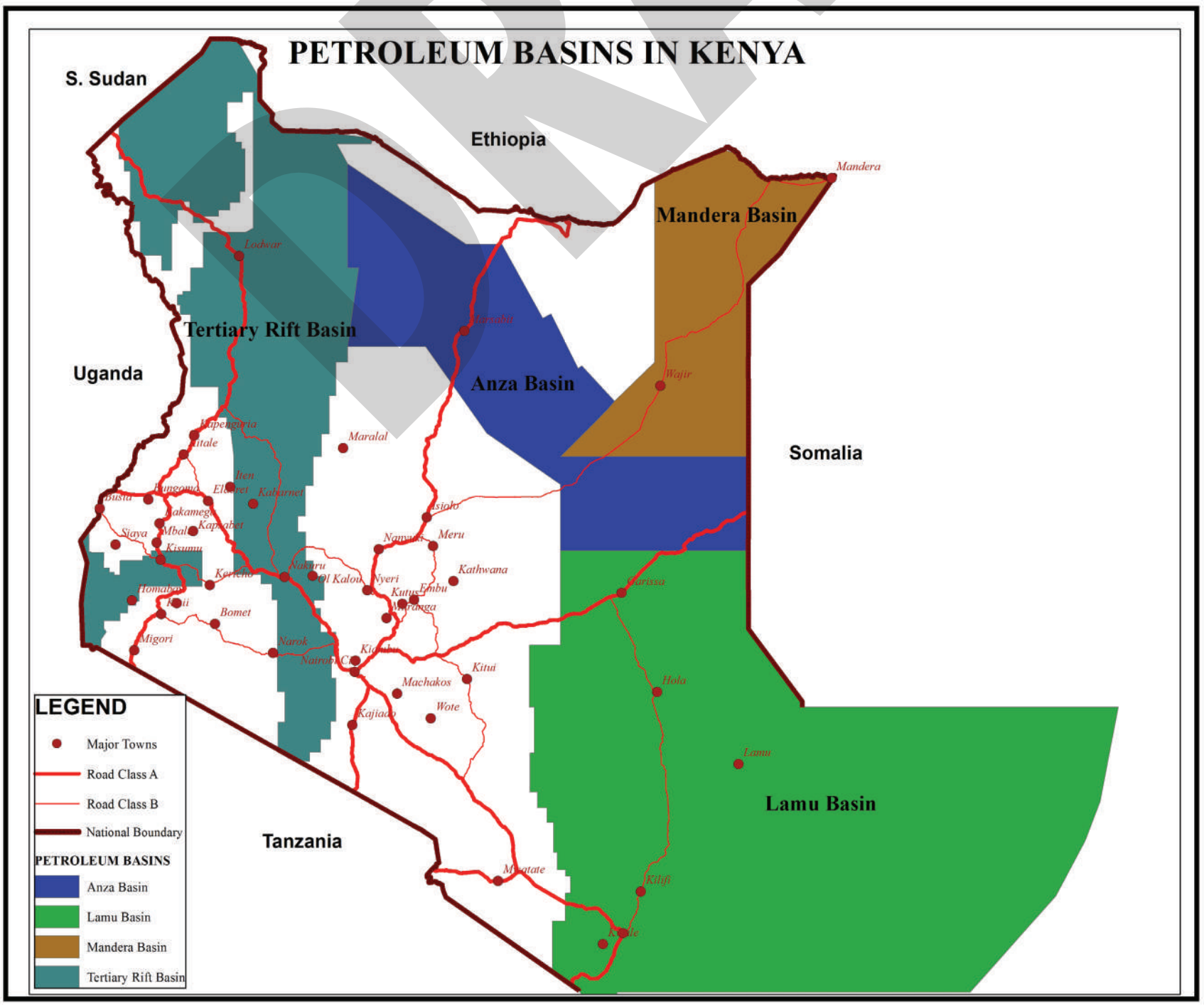


Figure 122: Petroleum basins in Kenya

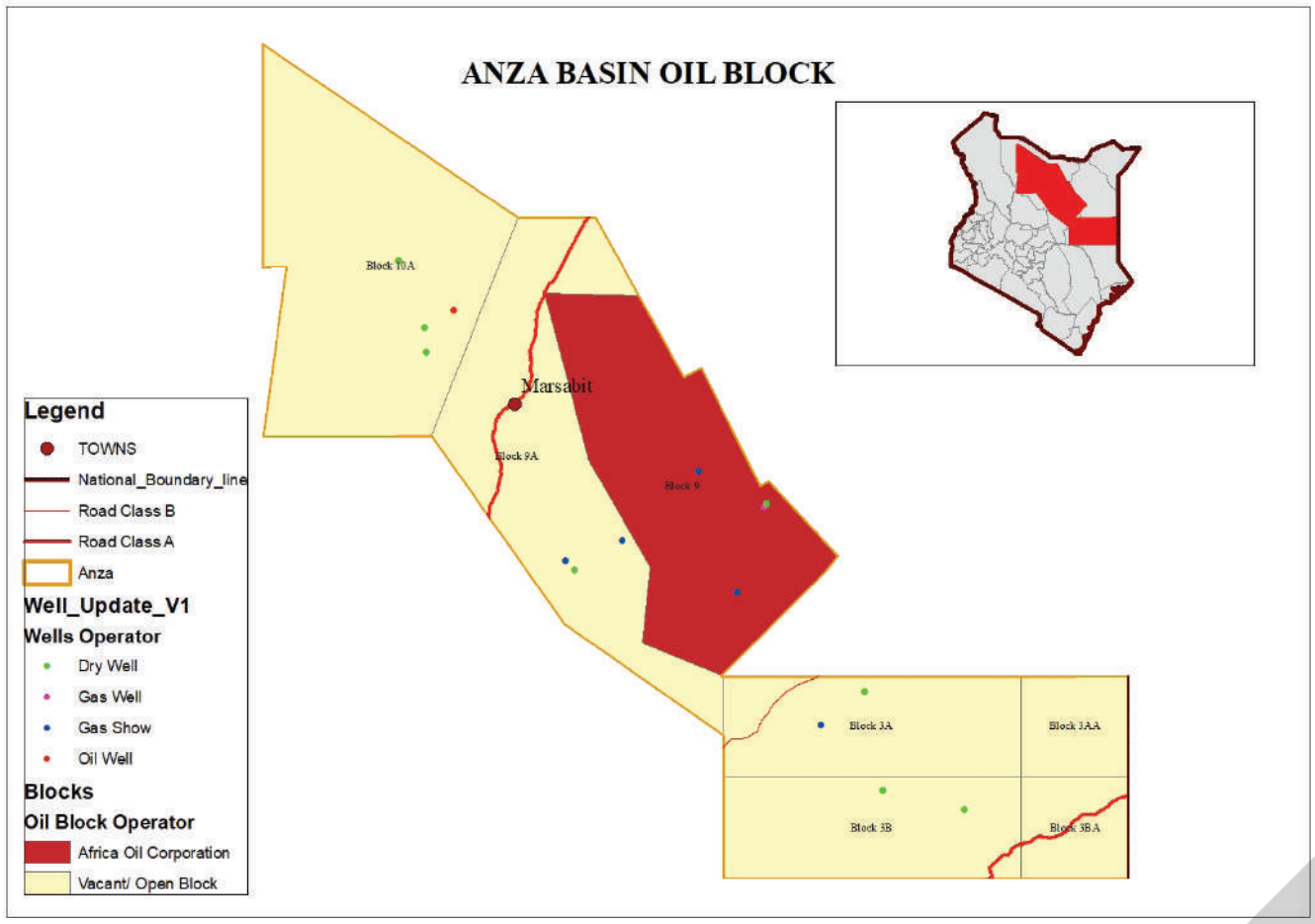


Figure 123: Anza basin oil block`

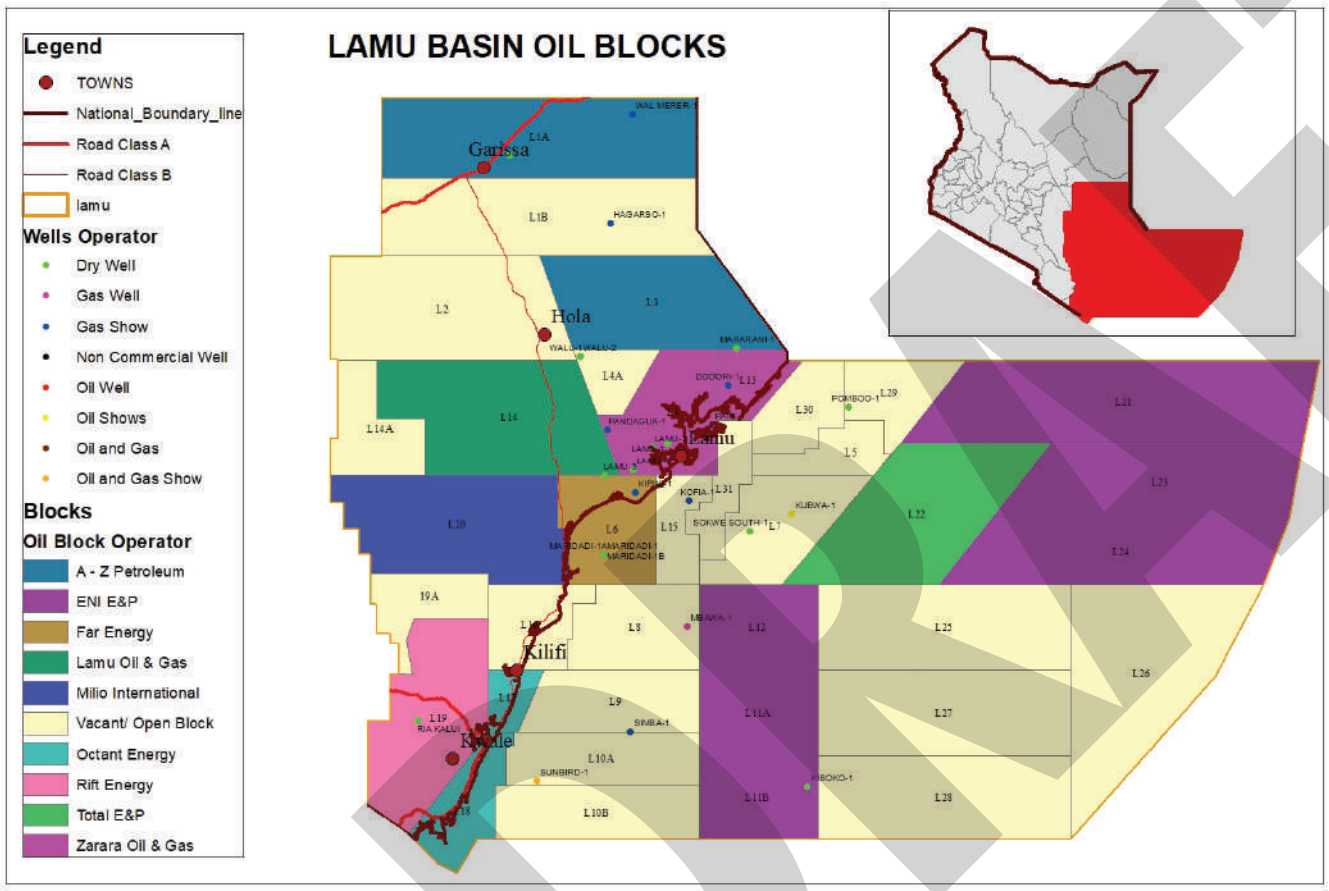


Figure 124: Lamu basin oil blocks

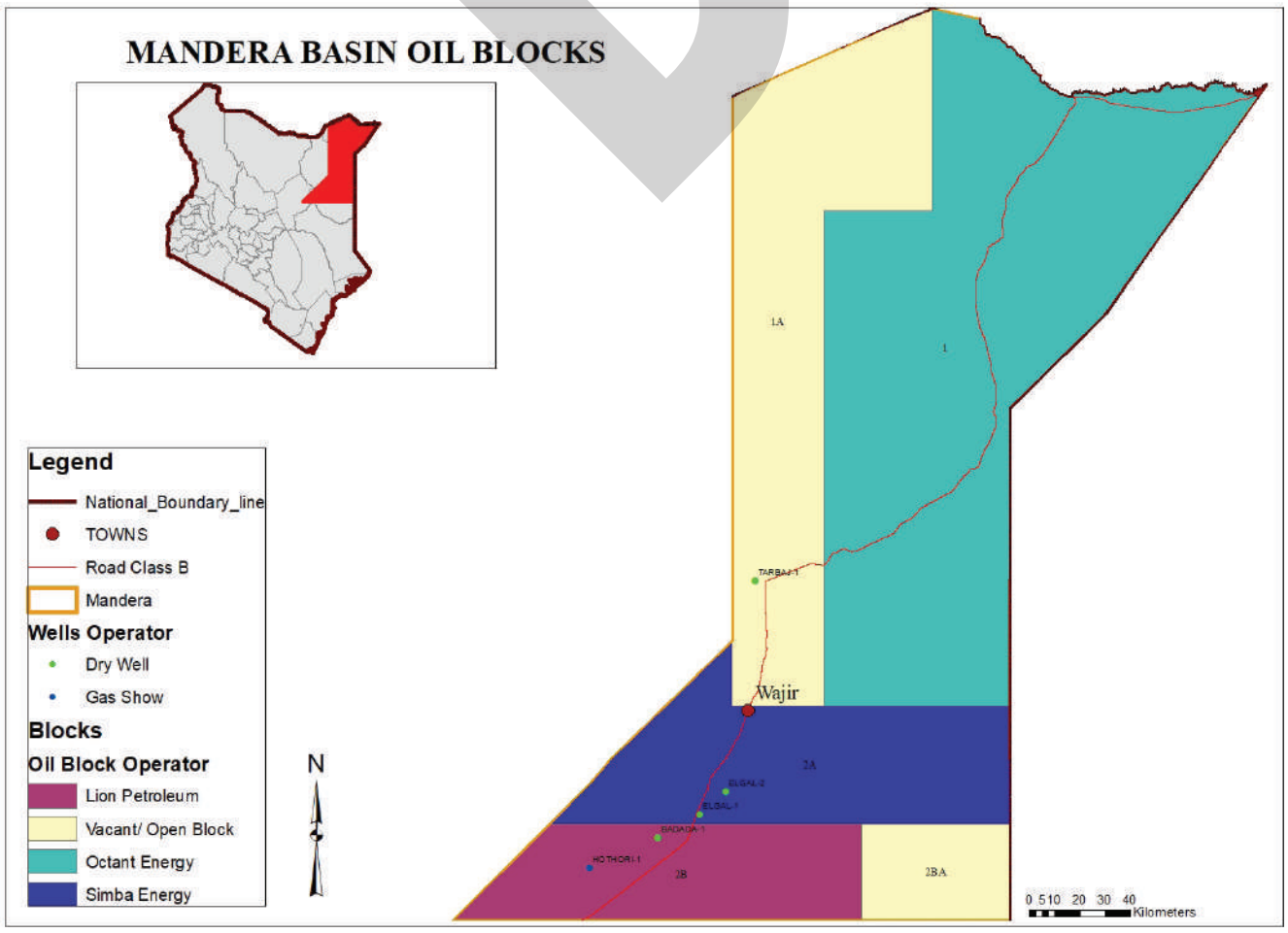


Figure 125: Mandera basins oil blocks

Distribution of Petroleum in Kenya (Blocks)

The oil basins forms the basis from which the oil blocks are distributed upon which extraction are implemented. The extraction is conducted by digging up of wells categorized by the operators.

Prospecting and Exploiting of Oil and Gas

Prospecting is the very first stage in the search for oil and gas fields, which tends to cover large areas in an attempt to ascertain if petroleum accumulations might be present. Prospecting typically includes desktop studies, land or sea floor sampling , geochemical and geophysical surveys

Once oil accumulations are identified, the exploitation of the resource is divided into three broad phases namely:

1. Upstream – comprising of Exploration, development, and production
2. Midstream – comprising of Storage, refining and transportation
3. Downstream – comprising of Supply and distribution

Table 52: *Types and description of the survey for prospecting oil and gas*

Types of survey	Description
Geochemical	This is sampling of rocks/stream sediments which are analyzed for chemical composition. e.g.
Geophysical	This kind of survey generate images of underground layers and structures and explore for spots that may contain hydrocarbon accumulations mainly utilizing sound waves (seismic and swath bathymetry surveys) that are shot into the ground and received using sophisticated equipment with the aim of mapping the underground layers in a bid to identify areas with petroleum accumulations, commonly referred as 'sweet spots'. Other types of geophysical surveys include: Full Tensor Gravity surveys which can be done by air or on land, Magnetic surveys and Resistivity surveys which measure the electrical conductivity of different rocks and the fluids within them to identify areas where certain rock types are present (source rock).
Land/ Seafloor sampling	
Desktop studies	

Table 53: *Distribution of minerals in Various Oil Blocks in Kenya*

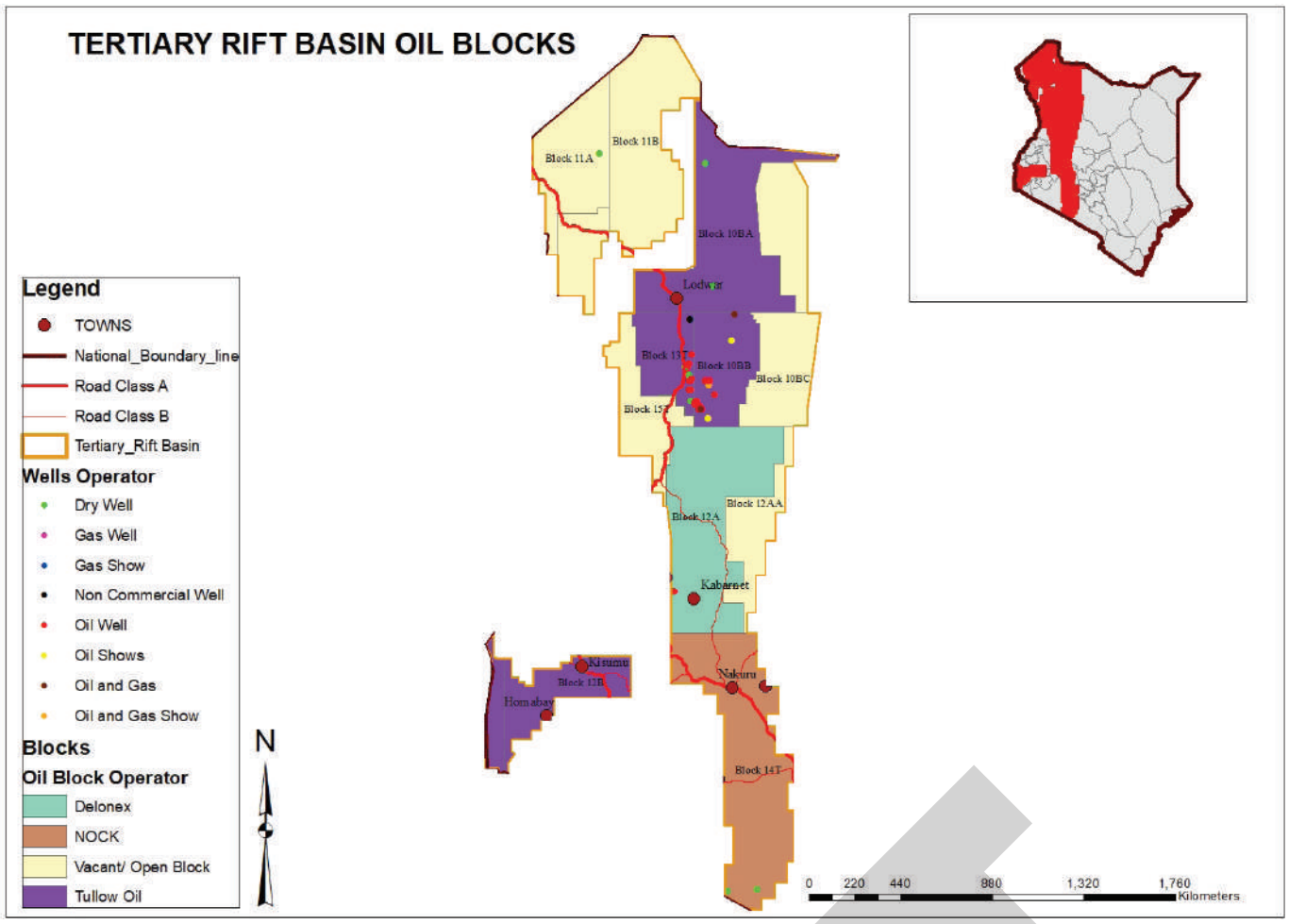


Figure 126: Tertiary rift basin oil blocks

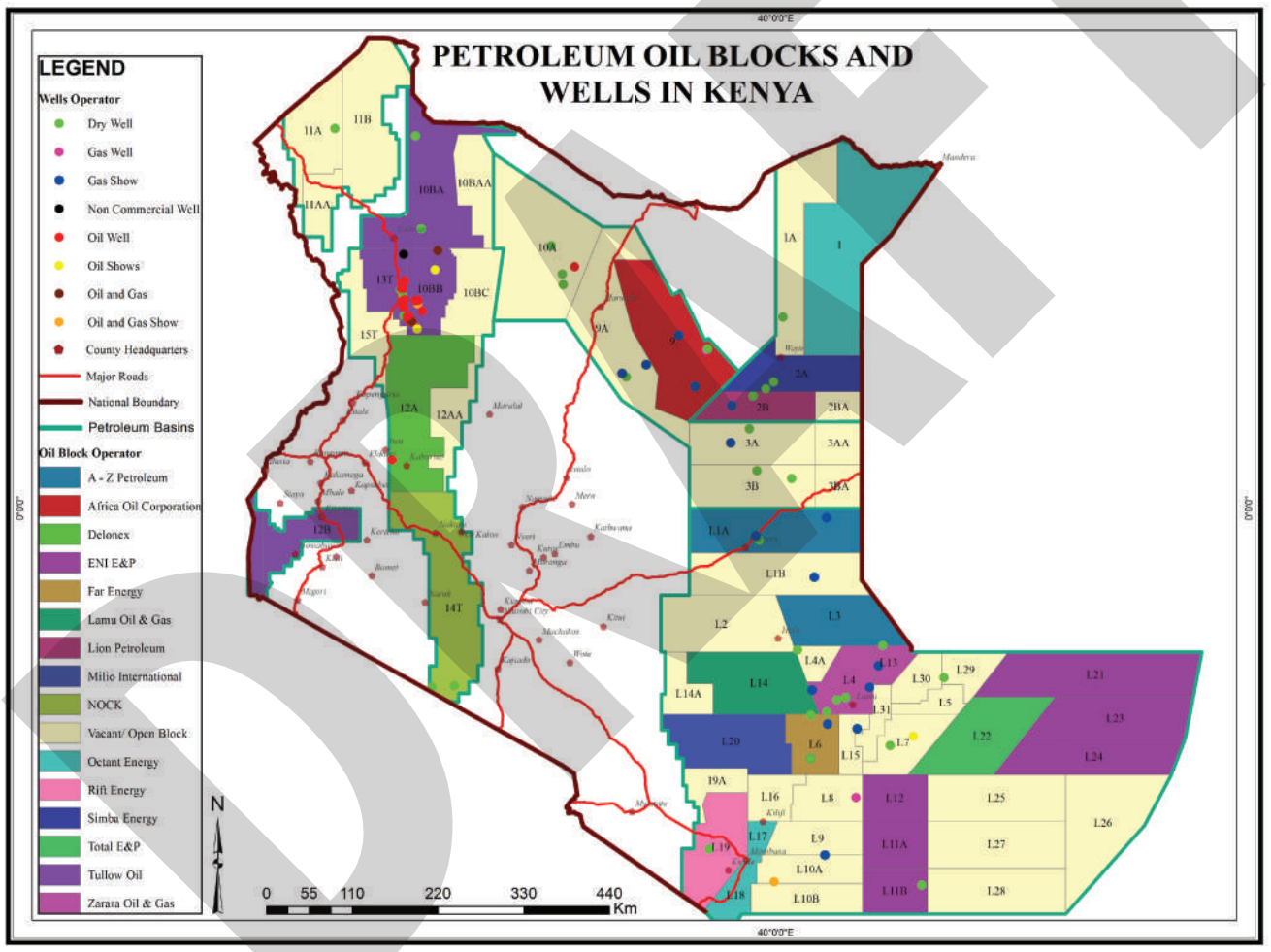


Figure 127: Petroleum oil blocks and wells in Kenya

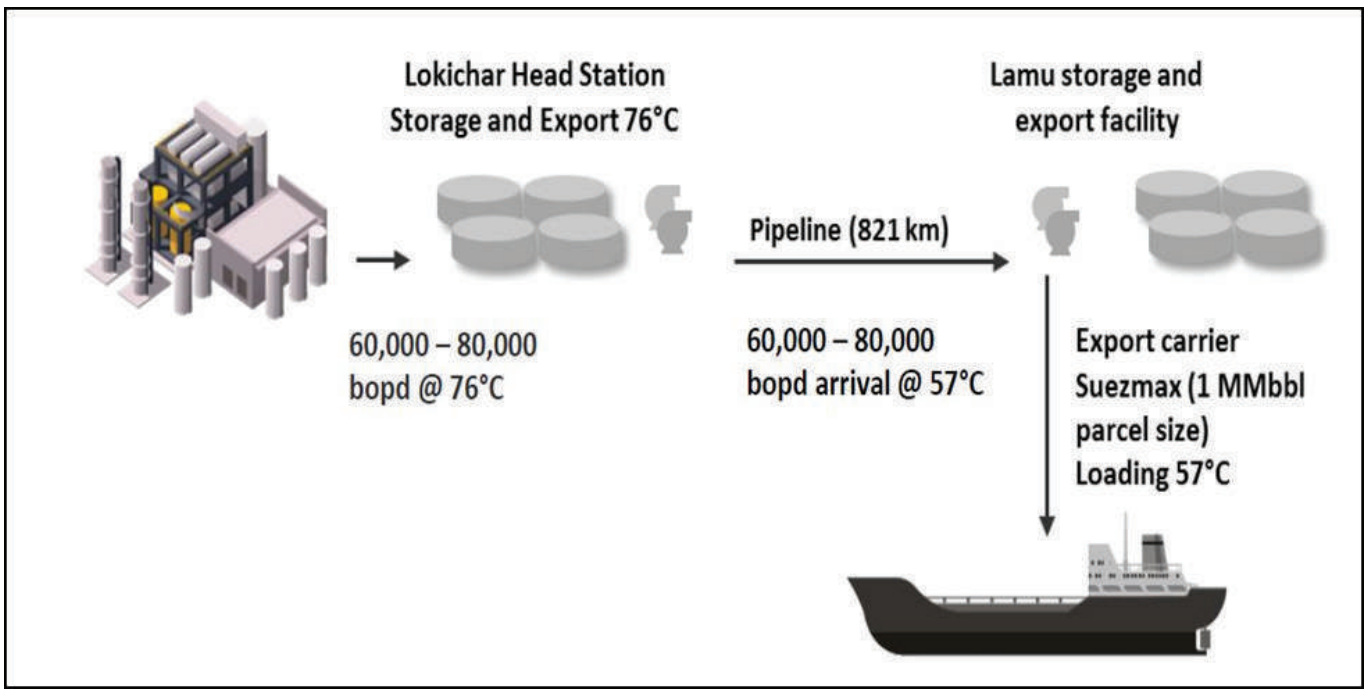


Figure 128: Upstream at Lokichar, Turkana; Midstream pipeline traversing through six counties of Turkana, Samburu, Isiolo, Meru, Garissa & Lamu; and Downstream distribution by the Suezmax carrier

Effects of Petroleum operations

Petroleum operations have both positive and negative impacts on people and the environment. On a positive note, the discovery of petroleum in Kenya is expected to pave way for employment and job creation especially for the Kenyan youth with an estimated 10,000 jobs which will bolster economic growth and GDP at the local, county, National and International scale:

However, petroleum operations, if not mitigated, may have huge negative and deleterious impacts on the people and the environment. For instance, concerns of air pollution through gas flaring, underground water pollution and associated health and safety issues have been raised by local communities in areas where petroleum operations are conducted.

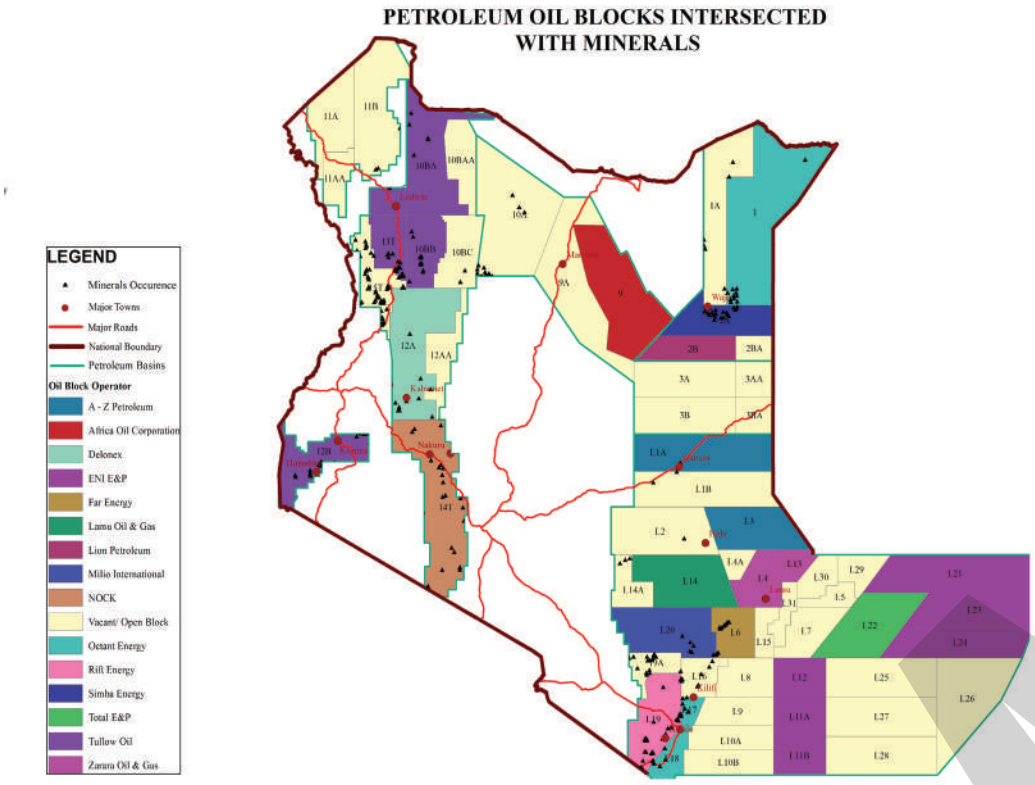


Figure 129: Petroleum oil blocks intersected with minerals

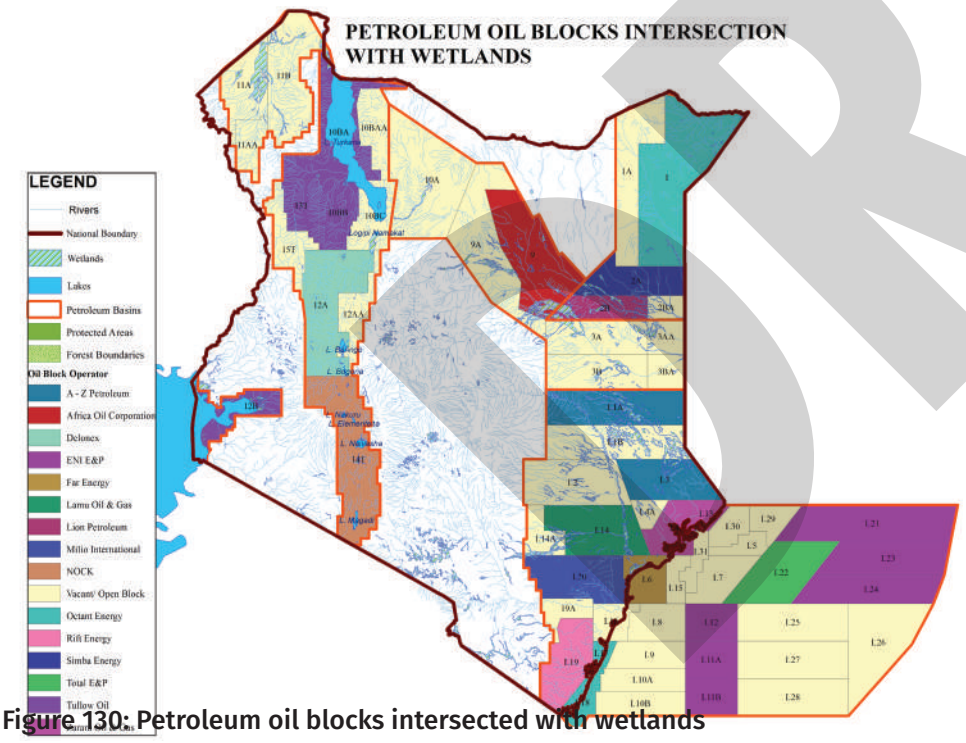


Figure 130: Petroleum oil blocks intersected with wetlands

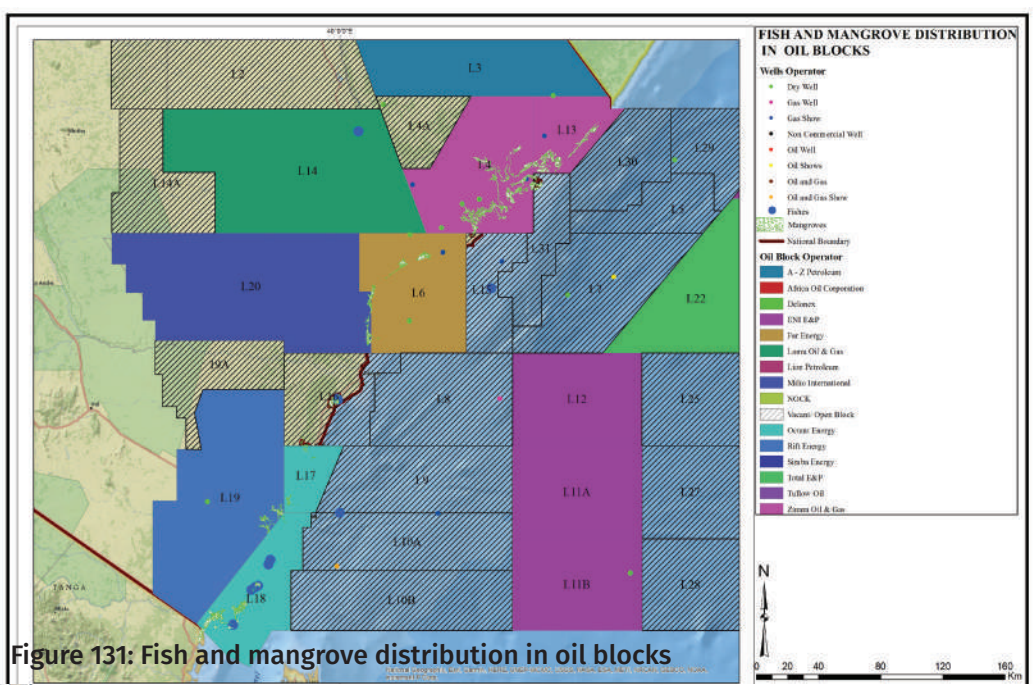


Figure 131: Fish and mangrove distribution in oil blocks

Over 1,286,295 hectares of wetlands might be affected by Oil Exploration processes which intrude on catchment areas especially in areas around Garissa, Isiolo and Wajir. Water is a critical component in petroleum operations needed to process the oil and for pressure maintenance. Drilling chemicals and acids need to be disposed of in an acceptable manner to avoid pollution of the water sources. Furthermore, Oil and Gas operations in Kenya take place in water-scarce areas hence the need to have proper water management mechanisms:

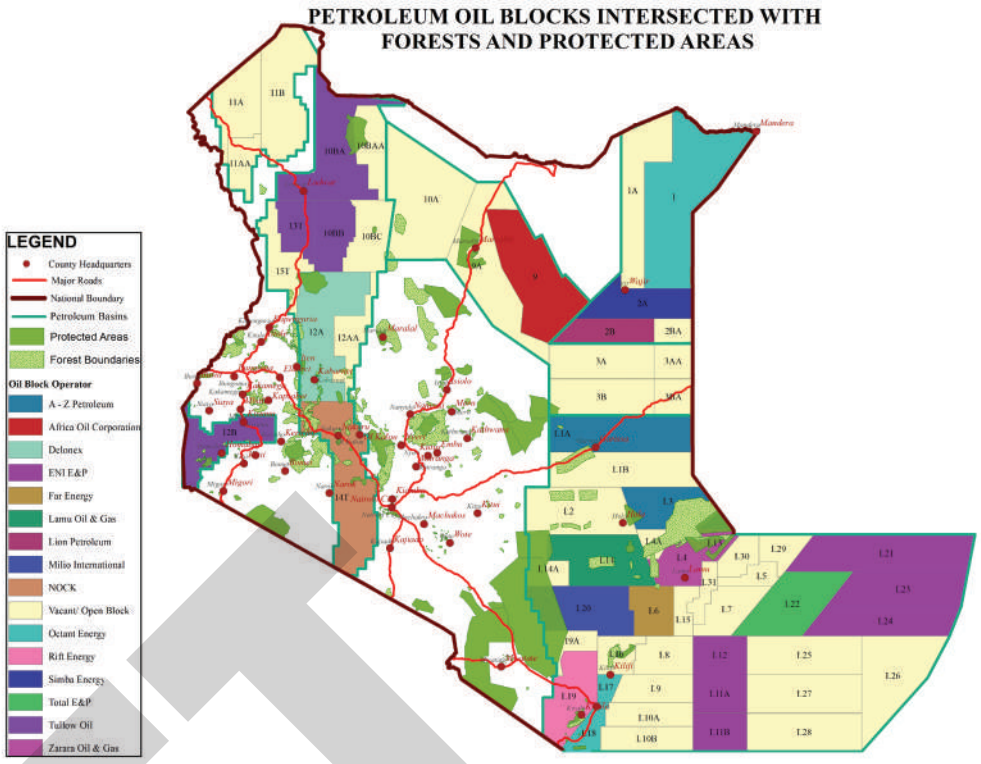


Figure 132: Petroleum oil blocks intersected with forests and protected areas

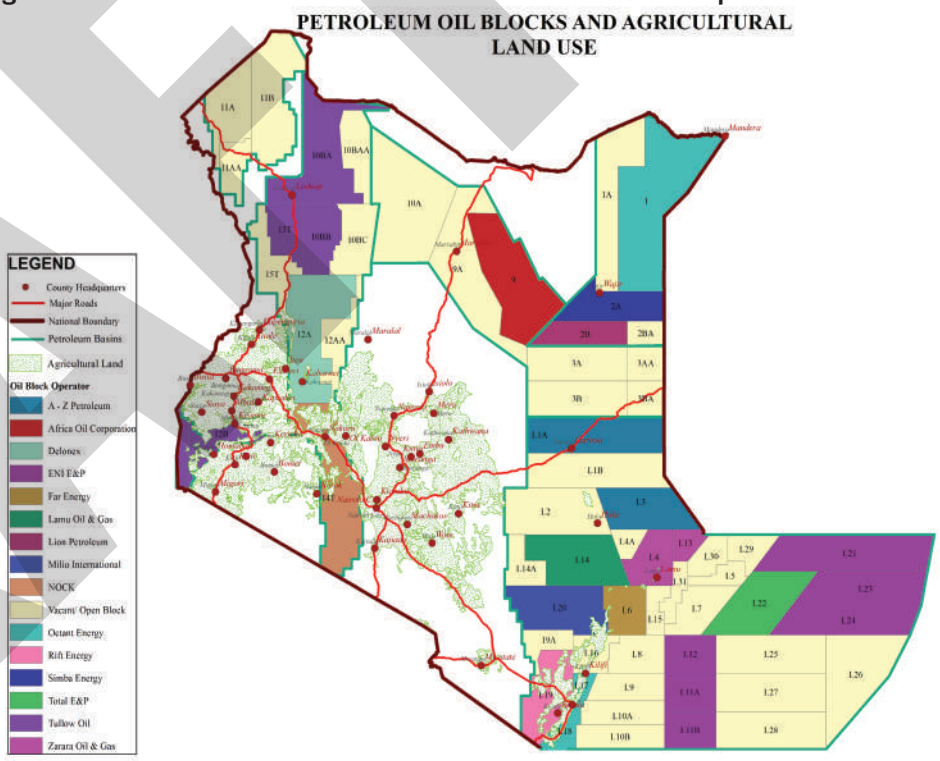


Figure 133: Petroleum oil blocks and agricultural land use`

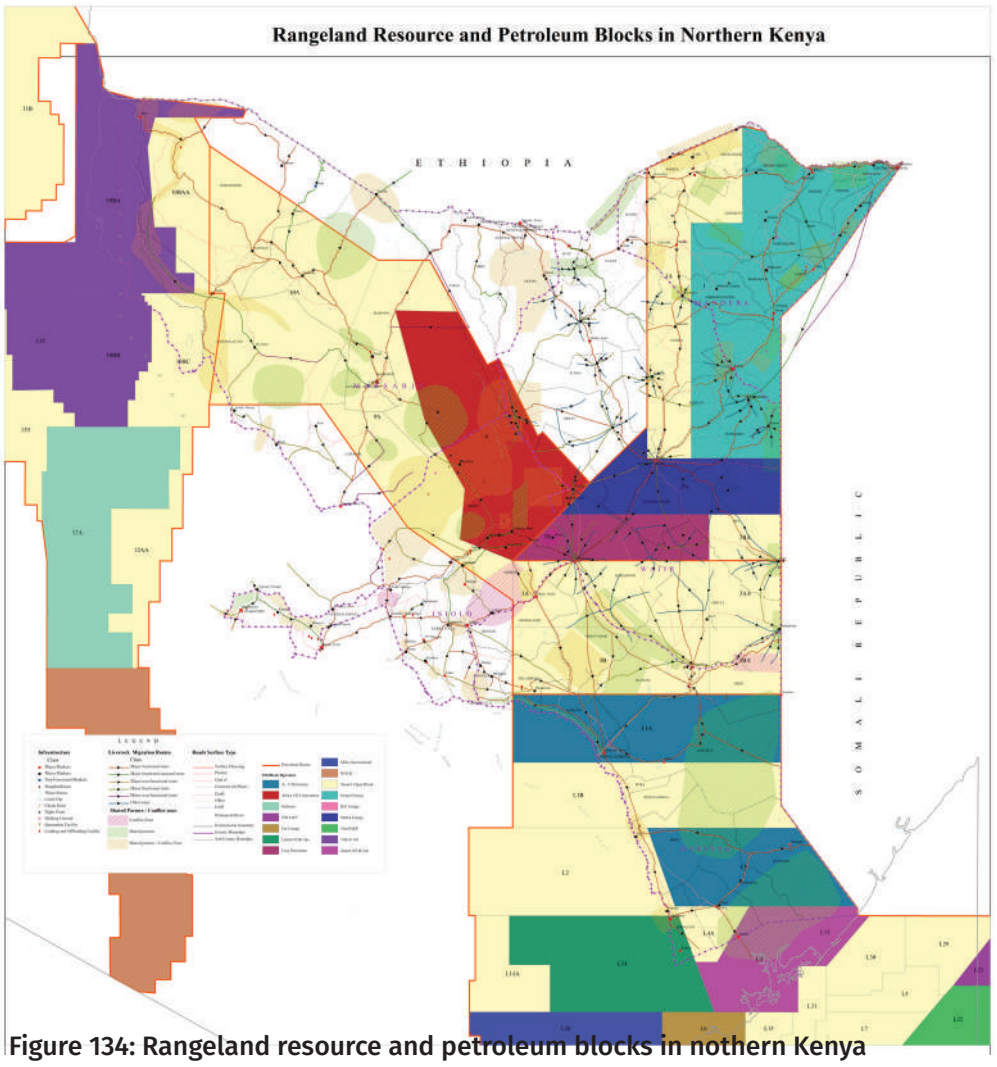


Figure 134: Rangeland resource and petroleum blocks in nothern Kenya

Challenges

1.Land Access

In Kenya, land is classified into three categories: Public, Private and Community. Exploitation of petroleum resources require land for establishing wells, pipelines, and associated facilities. This will, therefore, require the government to make sure that land is available for contractors charged with responsibility of exploitation and development of oil fields, especially upstream petroleum operations. While it is easier and straightforward to avail public land for government/public-led projects and initiatives such as development of oil and mineral resources, making private and community land available for public purposes, sometimes is faced with resistance relating to acquisition and / conversion. PART VIII of the Land Act 2012 provides the process on how land can be acquired and made available from community and private entities for public purposes. Despite the robust legislative framework, land acquisition and conversion for public projects has continued to receive immense pressure and resistance from project affected persons (PAPs).

2.Water Access for upstream petroleum operation

Water is a critical component in petroleum operations. These operations more often than not, take place in water-scarce areas hence the need to have proper water management mechanisms. Concerns and Conflicts over water for petroleum operations as well as for local communities have escalated in the recent past. There is need to strike balance and develop a water sharing mechanism so as to ensure flow regimes for other environmental services.

3.Dealing with Community expectations

The discovery of various natural resources in the country, particularly those related to the petroleum sector such as oil and gas, has resulted in high expectations, confrontations, and conflicts among communities where discoveries are made. Potential conflicts and social unrest associated with the exploitation of these resources results in costly delays in project implementation and operations. In some cases, these situations can lead to loss of lives and livelihoods among local populations, employees or contractors, and bring about profound developmental set-backs. It is therefore critical to ensure continuous engagement and accurate information flow across all levels of the various stakeholders including the communities.

4.Social Cultural issues

Petroleum development projects have various impacts on communities where the projects are implemented. Key among this is physical displacement of the people which can pose a potential negative impact on social, cultural or recreational life of communities such as loss of livelihood, change of lifestyle and erosion of family ties among others. The socio-cultural set up is affected by the projects during petroleum exploration, development, acquisition of way leaves during the construction of pipelines, acquisition of land for upstream and midstream operations. Hence, the need to exercise sensitivity to cultural dynamics while implementing such projects.

5.Revenue / benefit sharing

Constitutionally all natural resources are vested in the national government in trust for the people of Kenya, (Article 62 (3)). Similarly, Article 202 (1) states that revenue raised nationally shall be shared equitably among various levels of government. The International Oil Corporations have a provision to recover the costs used in exploration and development (known as cost oil) that is capped at 55% of the production in onshore resources and may go as high as 70% in offshore resources. It is only the remainder of the oil (known as profit oil) which is then divided between the Operator and the Government as per the percentages stipulated in the Production Sharing Contract's (PSC'source). Some of the benefits accruing from the exploitation of petroleum resources include profits, training, employment, technology transfer, and Corporate Social Responsibility (CSR) programs. Article 66(2) of the Constitution requires that investments in property shall benefit the local communities and their economies. There is however, an urgent need to fast-track revenue sharing mechanism for proceeds from oil development and exploitation.

6.Environmental issues

Petroleum resource management requires efficient use of technology to minimize wasteful practices which could impact negatively on the environment. Conservation measures have the potential to scale down capital investments needed to provide additional supplies and reduce overall resource misuse. Sustainable and efficient exploitation of petroleum resources reduces associated costs on waste, energy demand, improves energy security, improves competitiveness and helps to mitigate climate change by lowering Green House Gas (GHG) emissions. Petroleum contractor should put in place appropriate risk management measures during the span of the petroleum operations:

7.Boundaries

Petroleum blocks often rarely fall within administrative boundaries. There is therefore need to have mechanisms to address cross-border petroleum resources. Examples of cross-border resources include Trans-county boundaries of blocks; Trans-boundary reservoirs and Trans – country reservoirs. Where a petroleum deposit in a contract area extends beyond the said area, the same shall be developed under a unitization agreement as guided by the Petroleum Act.2019.

8.Local Content

This means the use of Kenyan local expertise, goods, and services, people, businesses and financing for the systematic development of national capacity and capabilities for the enhancement of the Kenyan economy (source). All petroleum resources found in Kenya belong to all citizens of the country and need to be exploited, developed and managed in a manner that benefits all Kenyans. In this regard, the government must endeavor to capture and retain value created from petroleum resources to stimulate employment, entrepreneurship, value addition, diversification, transfer of technology and knowledge across the value chain and economy.

9. Upstream High investment costs.

Upstream petroleum exploration is a high risk and capital intensive venture. The business is conducted by international companies with risk capital for exploration. Petroleum exploration is being undertaken both on-shore and off-shore in the country's four major sedimentary basins. The Government has taken the initiative to spearhead primary technical data acquisition in the exploration blocks in order to make them attractive to oil and gas exploration companies and by August 2018, there were a total of 90 exploratory wells, about 90,221 line km of two dimensional (2D) and more than 6,300 Km^2 of three dimensional (3D) seismic data (source).

10.Capacity Building

Research, Development, and Dissemination as well as human resource development are key in achieving the objectives of the Petroleum Policy. It is, therefore, necessary to establish a Petroleum Institute to undertake training, research, development, dissemination, nurture talent, innovation and to enhance capacity building in the sector. Investors will be required to develop capacity in their area of operation to have Kenyans replacing expatriates.

Geology and Mineral Resource potential of Kenya

Introduction

Mineral potential resources of a country are a function of its geology. Kenya's mineral endowment is directly related to its highly varied geology in terms of geochronology, tectonic history, geomorphological characteristic and geographical distribution of the constituent rock units. An overview of the geology and mineral resource potential of Kenya is presented in the following sections.

Geology of Kenya

The geology of Kenya may generally be grouped into the following five major geological successions: Archean (Nyanzian and Kavirondian), Proterozoic (Mozambique Belt and Bukoban), Palaeozoic/Mesozoic sediments, Tertiary/Quaternary volcanics and Tertiary/Quaternary sediments.

Quaternary

Soils, alluvial beach sands, evaporites, fossil coral reefs and sandstones at the coast: alluvial and lacustrine sediments of the Rift Valley. There are also volcanic rocks of the Rift Valley from the younger volcanoes. They include the gypsum beds of Kajiado and Garissa counties and the Kanjira beds of Homabay county. The Quaternary formations cover large swathes of Kenya including the Coast, Eastern, North Eastern and Rift Valley regions.

Tertiary

These consist of the Coastal sediments, Late Miocene and Pliocene volcanics, terrestrial and lacustrine inland sediments. There are early Tertiary formations which are not represented at surface. Included in this group of rocks are the Alkaline Complexes (including carbonatites) of Mrima, Buru, Homa, Ruri and Rangwa hills in Kwale, Kericho and Homabay counties respectively.

Plate 71: Tertiary volcanics being mined for aggregate and construction stone (M. Nyakinye, 2023

Palaeozoic/Mesozoic

The Karroo formations of the Kenyan coastal hinterland, mainly the Permo-Triassic Duruma sandstone Group of the Karoo Super Group, also including the basal sedimentary formations of north-east Kenya. The break up of the Paleozoic Gondwana continent resulted in the formation of an intracratonic basin, filled with continental permo-Triassic clastics which make up the Duruma Sandstone Group.

Proterozoic

The Kisii Group (Bukoban Super Group) consisting of volcanics with sediments. The volcanics mainly comprise of subaquatic and andesitic basalts, upper volcaniclastic beds of lapilli tuff and lahar conglomerates while sediments comprise lower detrital beds of siltite and local conglomerate, an arenitic formation of mature shallow water arenitic sediments with minor cinerite and chert as well as the Ikonge ignmbrite of rhyolitic igmbrite and minor andesite. The Kisii Group is an outlier covering most of Kisii and Nyamira counties in western Kenya that unconformably overlies the Archean Super Group.

The Mozambique Belt consist of quartzites, biotite/hornblende gneisses, schist, granitoid gneisses, amphibolites, and migmatites. These are rocks formed from magmatic underplating and a period of residence in the mid-lower crust followed by cooling between 830 and 520 million years ago. Almost all the constituent rocks of the Mozambique Belt attained at least upper amphibolite/granulite grade of metamorphism. According to current evidence it is suggested that low-grade ophiolitic/volcanosedimentary sequences are allochthonous and structurally emplaced over the higher-grade gneisses. Intrusives within the Mozambique Belt include mainly syntectonic granites. The Mozambique Belt rocks cover many counties in Coast, Eastern, Rift Valley and North Eastern regions of Kenya.

Archean

The Archean rocks of Kenya include the Kavirondian Super Group comprising mudstones, sandstones, conglomerates and granitic intrusions and the Nyanzian Super Group which comprises of shales, cherts, ironstones, pyroclastics, rhyolites, andesites and basalts. These rocks have been subjected to low-grade metamorphism of the greenschist level, leading to them being referred to as "greenstones". The Nyanzian Group greenstone rocks differ from many greenstone belts by the relatively large amounts of andesite and rhyolite present. The overlying Kavirondian Super Group succession is composed chiefly of greywacke-argillite, tuff, arkose, and conglomerate.

Segregated geology

The Nyanzian Shield

The Nyanzian and Kavirondian Super Groups forming the Nyanza Craton are the oldest rocks in the country with ages over 3,100 million years. The Nyanzian Super Group is mainly composed of lavas and pyroclastics with minor sediments and Banded Iron Formations (BIF). The Kavirondian, which rests uncomfortably on the Nyanzian, consists of grits, sandstones, greywackes and conglomerates. Both the Nyanzian and Kavirondian Super Groups are isoclinally folded about axes that have an east-westerly trend. The Kavirondian, is only slightly younger than the Nyanzian but folding in the two Super Groups has similar orientation. Numerous granitic bosses and batholiths have intruded the Nyanzian and Kavirondian rocks. The Kavirondian intrusions were more but the pre-Kavirondian were also widespread and the two successions are discernible.

Plate 72: Gold-bearing quartz vein within the Archean Greenstones of Western Kenya (M. Nyakinye, 2023)

Mozambique Belt

The Mozambique Belt is a structural unit within which a wide variety of meta-sedimentary and meta-igneous rocks are found showing a broad concordance of structural style and metamorphic history. In most of these rocks, the degree of deformation is intense and is of high metamorphic grades. They were thus referred to earlier in literature as the basement system rocks, due to high degree

of metamorphism and deformation.

Recent work on the Mozambique Belt has shown that the rocks can be sub-divided into groups of contrasting lithology, structure and composition of igneous rocks content. These groups are being studied in greater detail in order to come up with proper chronostratigraphic terminology.

Within the Mozambique Belt basic igneous complexes are found and range in size from bosses to small dykes. They occur both east and west of the Rift Valley. Some of the older basic intrusions have undergone deformation and metamorphism to give ortho- amphibolites and charnockitic gneisses.

Basic and granitic intrusions are known in the Mozambique Belt. The most characteristic feature of the Mozambique Belt is its structural trend which is more or less north-south in the entire belt.

Variations of the northerly trend are minor and when observed can be explained and are localised. The majority of Mozambique rocks have been placed in upper Precambrian (Proterozoic) Era.

Plate 73: Pegmatite dyke within the Mozambique Belt (M. Nyakinye, 2022)

Palaeozoic and Mesozoic Formations

Palaeozoic and Mesozoic formations in Kenya are found near the coast and in north- eastern Kenya. The earliest of these rocks are Permo-Carboniferous which are mostly sandstones and shales that form the Duruma series. This is equivalent to the Karroo Super Group in Southern Africa. The local formations are Taru, Maji-ya-Chumvi, Mariakani and the Mazeras. They extend for about 100 kilometres from Taru to Mazeras, west of Mombasa. The rocks dip very gently towards the ocean and are heavily faulted in places.

Mesozoic rocks occur in two separate areas, in the north-east part of Kenya and along the Coast belt. The stratigraphy and fossils in the two areas are very distinct and it is likely that the sedimentary basins in the two areas were connected. Revision mapping in the North Eastern region has come up with interesting lithological units that have revised lithological names.

Tertiary and Quaternary Volcanics

Volcanic rocks cover the central parts of the country from south to north, occurring in the floor of the Rift Valley and on the peneplains west and east of the valley. The oldest of the volcanics are of Lower Miocene age and comprise the eroded lavas and pyroclastic piles of South Nyanza. Late in Miocene times, Kapiti and Yatta phonolites were erupted and flowed to great lengths. Further eruptions accompanied by faulting persisted and also gave rise to the Rift Valley and the volcanic piles of Mounts Kenya, Elgon and Kilimanjaro.

Quaternary volcanism was mostly within the Rift Valley and has given rise to the craters and cinder cones that are found in the floor of the Rift Valley e.g. Longonot, Menengai and Suswa.

Tertiary and Quaternary Sediments

There are many sedimentary deposits of sediments of Tertiary and Quaternary ages in various parts of Kenya. They usually occur at the base of volcanic successions, intercalated with them or occurring in tectonic troughs. The repeated faulting of the Rift Valley floor and the numerous volcanic eruptions created many short-lived basins of internal drainage in which lacustrine and fluviatile sediments accumulated. Most of these sediments are unfossiliferous, but a few are of interest as they contain deposits that bear artefacts and interesting fossils that have been studied extensively.

Plate 74: Quarternary sediments on Lake Natron (M. Nyakinye, 2022)

The more important sediments of middle Pleistocene are the Olorgesaillie lakebeds (Rift Valley), a lacustrine series with much diatomite, mammalian fossils and artefacts. This is also comparable to the Kariandusi sediments near Gilgil (Rift Valley) and the Kanjira beds in the Kavirondo Gulf of Lake Victoria.

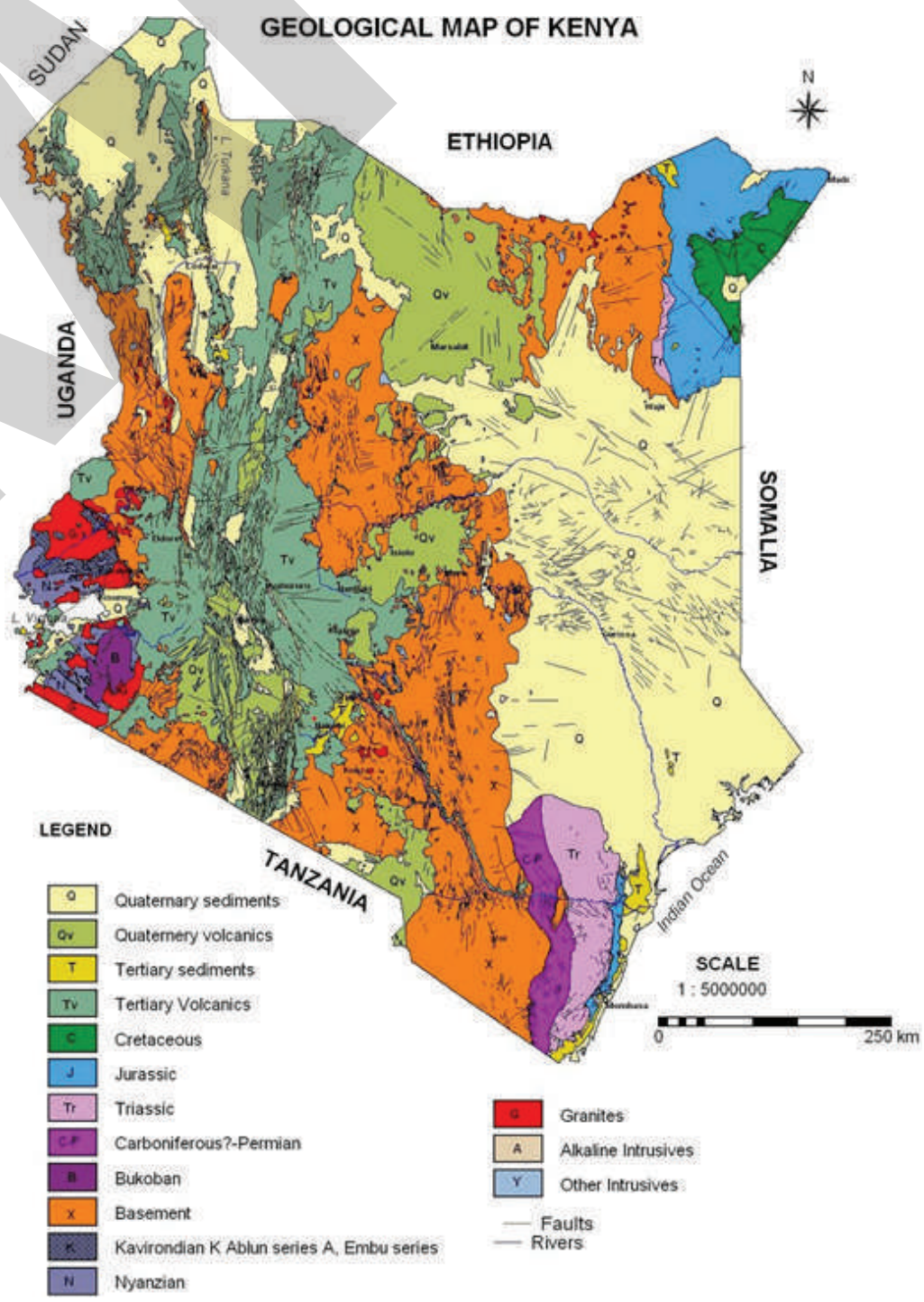


Plate 75: Fig Geological Map of Kenya (Source: Kenya Geological Survey)

Mineral resources

Kenya is endowed with a variety of mineral resources whose full potential is unknown and therefore untapped. With the the recently completed countrywide airborne geophysical survey, followed up by detailed geological investigations Kenya will uncover its mineral wealth. At present the mining sector's contribution to Kenya's economy is relatively small (0.8% of GDP) with mineral sands (~$150m/yr) and soda ash (~$50m/yr) forming a major part of total output by value. The sector contribution to the GDP is expected to increase to 10% by 2030 (Source: State Department for Mining-SDM). The Government of Kenya, through the Ministry of Mining, Blue Economy and Maritime Affairs, has already worked on formalizing and improving the mining sector, but in order to realize
the full potential the Ministry plans to focus on:

- Creating clarity around the geological potential of the country
- Improving the effectiveness of the institutional and social frame
- Ensuring a predictable and transparent set of policies and legislations
- Improving the overall attractiveness of the business environment

Based on the identified opportunities, the full potential of the sector could be up to $1.2bn annually in direct revenue, which corresponds to a total sector impact of up to $3bn.

Kenya's main minerals are categorized into five broad categories for purposes of mineral dealing, namely:

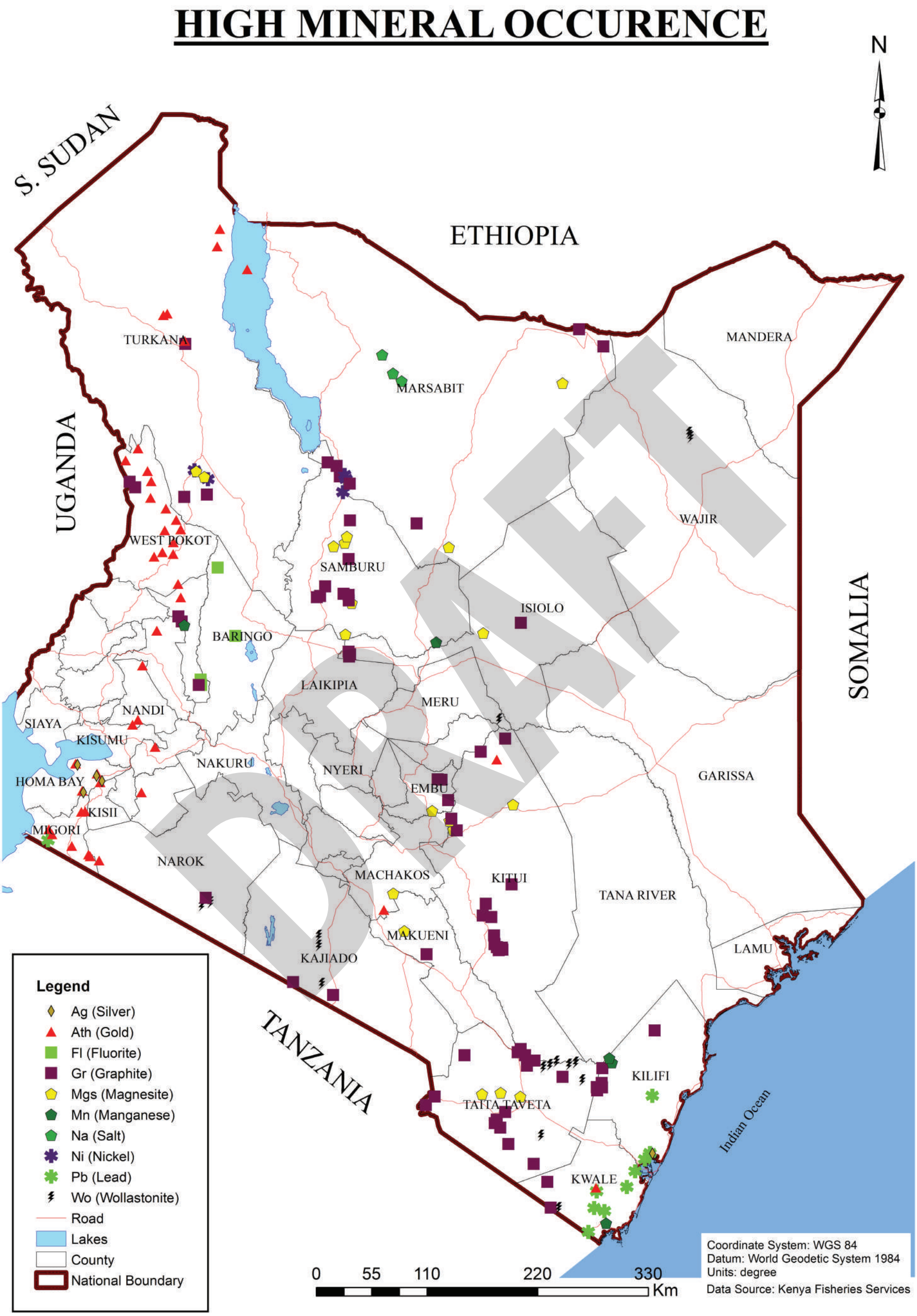
1. Construction and industrial minerals building stones and sand
2. Gemstones (precious and semi-precious stones)
3. Precious metals, e.g., gold, silver
4. Base metals e.g. copper, manganese
5. Diamond

Plate 76: Underground gold mining at the Kilimapesa gold mine in Transmara, Narok county (C. Odhiambo, 2021)

Table 54: *List and location of most common minerals in Kenya*

S/No	List of Minerals	Area found
1	Gold	Kakamega, Vihiga, Migori, Narok- Transmara, Siaya, Pokot, Turkana and Nandi.
2	Tanzanite	Taita Taveta, Baringo and Kwale counties
3	Graphite	Taita Taveta, Baringo and Kwale counties
4	Sand	Rivers, Coastal Areas, Kajiado, Marsabit, Machakos, Kitui and Isiolo counties
5	Marbles	Kilifi and Kajiado counties
6	Green Garnate	Taita Taveta and Kwale Counties
7	Coral Rocks	Along the Coastal Counties
8	Titanium	Kwale Malindi and Lamu
9	Trona (Soda ash)	Kilifi County Lake Magadi in Kajiado
10	Fluorspar	Elegeyo Marakwet at Kimwarer in Kerio Valley
11	Coal	Kitui (Mui Basin)
12	Iron Ore	Taita, TharakaNithi, Kitui, Kilifi and Kakamega.
13	Manganese	Kilifi and Mrima hill in Kwale
14	Diatomite	Nakuru at Kariandusi near Gilgil
15	Vermiculite	Machakos-Kinyiki Hill
16	Gypsum	Wajir at El Wak, Garissa, Tana River, Kajiado and Turkana
17	Natural carbon dioxide	Kereita in Kiambu
18	Limestone	Wajir at El Wak, Garissa, Tana River, Kajiado and Turkana
19	Niobium and Rare Earth Elements	Mrima Hills –Kwale
20	Soapstone	Kisii
21	Sapphire	Taita Taveta
22	Grosullar Garnets (green)	Rift valley
23	Corundum (ruby)	Taita Taveta
24	Tsavorite	Taita Taveta

Figure 138: Mineral occurence in Kenya



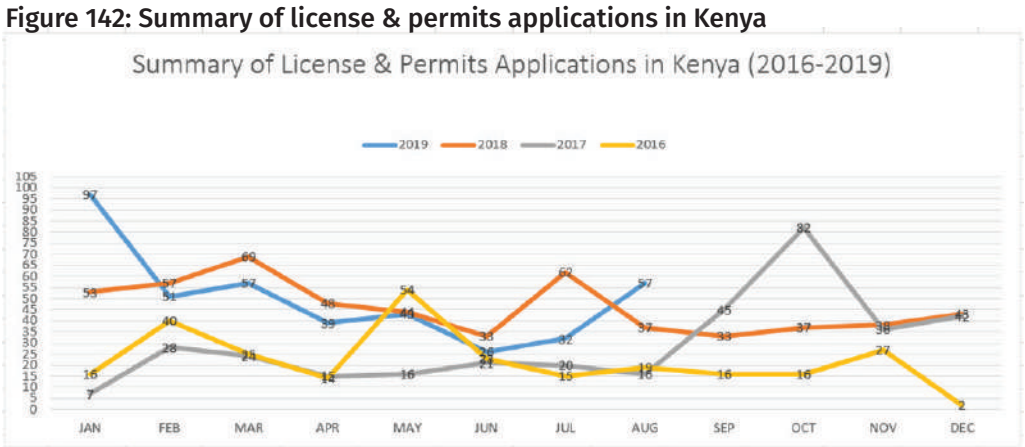
Mineral Occurrence in Parks, Forests and wetlands (Protected areas)

Kenyan parks, gazetted forests and also protected areas such as wetlands constitute some of the mineral-rich areas. In this regard, harmonization and coordination including establishment of requisite social and environmental safeguards are imperative. The mineral occurrence map in parks and protected areas reveal occurrence of important minerals in Tsavo East, Tsavo West, Maasai Mara, Shaba, Meru, and Amboseli national parks. Similarly, forest reserves also play host to a variety of minerals in Kenya. Such overlaps and intersections may aggravate conflicts between sectors. Thus, the need for cross-sectoral coordination and synergy building to provide direction and mitigation measures for potential negative threats to these environmentally sensitive ecosystems.

Figure 141: Mineral occurence in protected areas

Mineral Licensing And Concessions Management

Figure 142: Summary of license & permits applications in Kenya



All licensing for minerals Rights Applications are governed by the Kenya Mining Act 2016. Mining is done on large scale or small-scale operation. Table…. provides a summary of the various types of licenses and permits issued by the state department of mining. For major mining operations, licenses are required, while for small-scale operations, only permits are required

Royalty rates for various minerals

The Royalty Sharing Framework is stipulated under section 183 of the Mining Act 2016. It articulates how the Royalty shall be shared by the National, County, and Community (70%, 20%, and 10%) respectively. There are different royalty rates are chargeable in respect of the extracted minerals in Kenya. For instance, the royalty rate chargeable for diamond is 12% of the gross sale value

Table 55: *Royalty rates for various minerals*

Mineral	Royalty rates
Diamond	12 %of the gross sale value
Earth elements and radioactive minerals	10% of the gross sale value
Niobium	10% of the gross sale value
Titanium ores and zircon	10% of the gross sale value
Coal	8% of the gross sales value
Gemstone	5% of the gross sale value
Metallic ores, iron ore, manganese ore, Chromium, nickel ore, bauxite, and other ores	8% of the gross sale value
fluorspar, diatomite, natural carbon dioxide gas, and all other minerals	5% of the gross sale value
Industrial minerals including gypsum, limestone silica sand	1% gross sales
construction materials	2% of gross sales value

Table 56: *Licenses and permits categories for mineral operations in Kenya*

License Type	Description	Permit Type	Description
Reconnais-sance License	A reconnaissance license grants a qualifying person or company the right to carry out noninvasive investigations for minerals in or over the license area according to an approved reconnaissance license work programme. A reconnaissance license right is non-exclusive.	Reconnais-sance permit	Subject to Clause 111 of the Act, a reconnaissance permit grants a person or body corporate the non-exclusive right to carry out non-invasive investigations for minerals within the permit area.
Prospecting License	A prospecting license grants a qualifying person the right to prospect for a mineral or minerals in the license area according to an approved programme of prospecting operations. A prospecting license is an exclusive right.	Prospecting permit	Subject to Clause 132 of the Act, a prospecting permit grants a person or body corporate the exclusive right to prospect for a mineral or minerals in the permit area according to an approved programme for prospecting operations
Retention License	A retention license grants the holder of a prospecting license who has identified a mineral deposit which has potential economic significance but which is, in whole or in part, temporarily uneconomic, the exclusive right for a limited period and subject to continuous re-evaluation by the Mining Cadastre Office, to conduct prospecting and feasibility operations in the retention area and to apply for a mining license.	Mining permit	A mining permit grants an eligible person or body corporate the exclusive right to carry out small-scale mining operations in the permit area according to an approved mining permit programme.
Mining License	A mining license grants a qualifying person or company the exclusive right to develop a deposit, extract, process, beneficiate and dispose of a mineral or minerals, including from mine dump or mine waste and tailings and to conduct further exploration activities within the license area according to an approved programme for mining operations.	Artisanal min-ing permit	Pursuant to Clause 95 and the Second Schedule, Clause 2(b) of the Act an artisanal mining permit grants an eligible person, who shall be a resident of the County, the exclusive right to carry out prospecting and mining operations using traditional and customary methods in accordance with an approved artisanal mining programme

Regulation of commercial explosives

Commercial explosives are widely used in the mining industry, in addition to other sectors like construction entertainment, religious activities etc. In the mining sector explosives are used to break or loosen hard rock during exploration, mining or mine rehabilitation. The manufacture, importation, transportation and storage and use of commercial explosives is governed and regulated by the Explosives Act, Cap 115 of the Laws of Kenya. The manager of this Act is the Cabinet Secretary, for the time being, in charge of mining in Kenya.

The Explosives Act provides for the appointment and gazettement of Explosives Inspectors who are responsible, under the Director of Mines, for licensing, supervision and inspection of the use of commercial explosives. Licensing and permitting is done by the Explosive's Inspectors, who also ensure the explosives are manufactured, transported and used in strict adherence to the provisions of the Act and its regulations.

The table below shows the various fees charged for the various permits and licenses.

Table 57: *blasting explosives and fireworks licence/permit fees (Source: State Department for Mining)*

	Type of Licence/Permit		Prevailing Charges (Kshs)	Applicable Regulations
A: BLASTING EXPLOSIVES				
1.	Issue or renewal of licence to store up to 500kg per year or part thereof		250	Section 7 Rule 37 Second Schedule
2.	Issue or renewal of licence to store more than 500 kg but less than 1000 kg per year or part thereof		500	
3.	Issue or renewal of licence to store more than 1000 kg but less than 10,000kg per year or part thereof		500	
4.	Issue or renewal of licence to store more than 10,000 kg per year or part thereof		500	
5.	Transfer of storage licence		100	
6.	Issue of duplicate licence		-	Section 30(1)(l)
7.	Issue or renewal of Explosives Dealer's Licence		5,000	Section 8
8.	Issue or renewal of Blasting Contractors Certificate		-	Section 30(1)(l)
9.	Issue or renewal of permit to use blasting explosives per year or part thereof (individual)		50	Section 11
	Fees for the blaster's theory test		-	Section 11(2)
	Fees for the blaster's practical test		-	
10.	Issue of permit to purchase blasting explosives		-	Rule 72
11.	Issue of Import/Export/In-Transit Permit		-	Rule 18
12.	Verification of import/transit explosives/ fireworks		-	Rule 21
	Purchase of security seal		-	Rule 33(1)(dd)
13.	Issue or renewal of licence to manufacture explosives at a factory		2,000	Section 5
	Issue or renewal of licence for onsite mixing of explosives		2,000	Gazette Notice(26th January, 1965)
14.	Authority to use blasting explosives		-	Rule 78
15	Issue of Special/Continuous Transport Permit		-	Section 13
	Issue or Renewal of Explosives Transporter's Certificate	Small (up to 1000kg)	-	
		Medium (1001kg-10,000kg)	-	
		Large (above 10,000kg)	-	
B: FIREWORKS				
1.	Issue or Renewal of Fireworks Importer's Licence per year or part thereof		1,000	Section 10 Rules 6
	Issue of fireworks import permit		-	Rule 7
2.	Issue or renewal of Fireworks Dealer's Licence per year or part thereof		250	Rule 11(2)
	Issue or renewal of Licence to manufacture fireworks		2000	Section 30(1)(l)
3.	Issue of Special Import Permit		100	Rule 8(2)
4.	Application for fireworks event permit	Ground fireworks	-	Rule 8
		Aerial shells not more than 125mm caliber	-	
		Aerial shells of more than 125mm and up to 250mm caliber	-	
6.	Issue or renewal fireworks Contractor's Certificate		-	Section 30(1)(l)
7.	Fireworks display operator's Permit		-	Section 30(1)(l)
8.	Replacement of any License/Permit Document		-	Section 30(1)(l)

Impacts of mining

Socio-economic and environmental impacts

The State Department for Mining has set standard specifications for all stakeholders engaged in mining activities to mitigate any negative impacts of mining and to improve the safety standards of the miners. Artisanal and Small-scale mining (ASM) inherently impact environmental resources such soil, landscape, vegetation, the ecosystem and water among others. Additionally, human displacement sometimes occurs whenever there is expansion or new discovery of mines. This may also lead to in-migration into the mining areas. Mining areas also become hot spots of sexually transmitted disease prevalence. Other potential hazards include; fire eruption, flooding, emission of excess heat, emission of dangerous gases and fumes, site explosion and collapsing of the mines (HSE 2019). The Statement, in operationalizing the Mining Act 2016 and in close coordination with other relevant government agencies, has developed regulations to govern the operations of the all categories of mining operations in the county.

Plate 77: Open cast mining at Kilimapesa gold mine in Narok county (C. Odhiambo, 2022)

Energy Resources

Energy is one of the key enablers of Kenya's Vision 2030 and the Big 4 Agenda development programs. Kenya treats energy security as a matter of national priority. The Third Medium Plan 2017-2022 identifies energy as the country's driver into "a newly-industrializing, middle-income economy, providing a high quality of life to all its citizens in a clean and secure environment." Kenya considers access to competitively-priced, reliable, quality, safe and sustainable energy as an essential ingredient for the country's social –economic development

There is hydropower potential of 2,987MW along its major river basins; Lake Victoria basin, Rift Valley basin, Athi River basin, Tana River basin and Ewaso Ngiro North River basin. The Rift Valley has an estimated geothermal potential of between of 10,000 MW spread over 16 prospective sites of hot springs and geysers. Other locations with undetermined capacity include Homa Hills in Nyanza, Mwananyamala at the Coast and Nyambene Ridges. Preliminary wind resource assessments in areas such as Marsabit, Turkana and the Coastal region shows that these areas can support commercial electricity generation as they enjoy wind speeds ranging from 8 to 14 metres per second (m/s) (Kenya National Master Plan 2018-2035.

The country discovered coal deposits at Mui basin in Mwingi district, which covers an area of 400 Km^2. The coal has been analyzed and found to range in ranking from lignite to sub-bituminous with calorific values ranging from 16 to 27 MJ/kg.

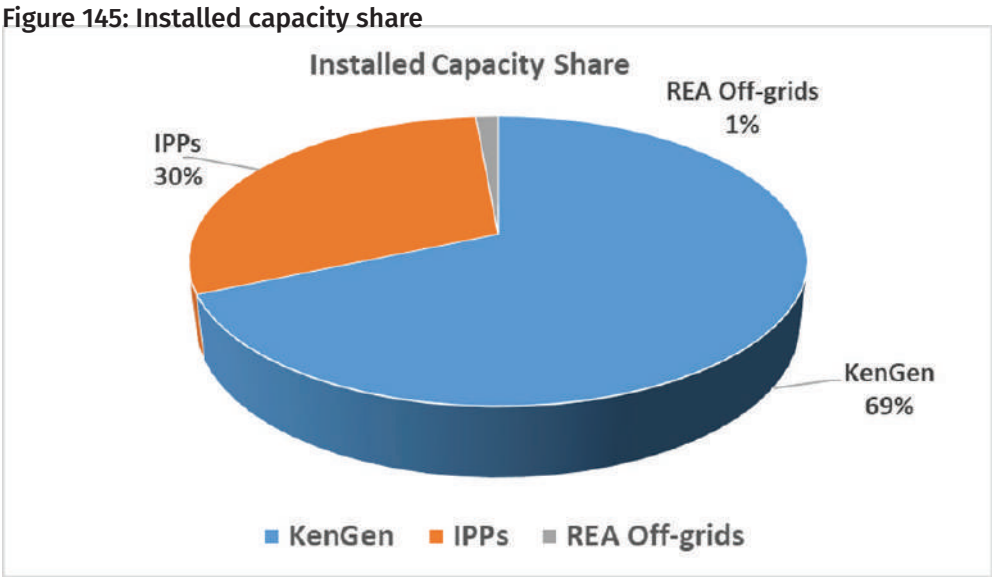
Electricity Supply

Installed capacity expanded by 28.53% or 663MW in the last five years from 2,327 MW in 2016 to 2,990MW in 2021 inclusive of off-grid capacity. The effective interconnected capacity increase from 2,236MW to 2,858MW over the same period. KenGen, the largest electricity generator in the country, accounts for 1,694MW or 60% of the effective generation capacity. Independent Power Producers (IPPs) constitute 1,037MW (38%) and Off-grid generation under the Government's Rural Electrification Programme (REP) implemented under REREC accounts for about 2%. Over the mid-term period, the demand is projected to rise from 1,859MW (2018) to 2,473(2023) in the reference scenario,the low scenario will see demand grow from 1,859MW (2018) to 2,257MW (2023) and the Vision scenario will see demand growing from 1,859MW (2018) to 2,952MW (2023).
(Source: LCPDP Mid Term Plan 2018-2023

Electric Power Transmission

The total length of the transmission and distribution network increased from 213,582 kilometers in 2016/17 to 255,581 kilometers in 2020/21. This growth is attributed to the sustained investments by the Government through KETRACO and KPLC to strengthen and expand the network to enhance electricity access. The total transmission network (400kV, 220kV, 132kV) as at June 2021 was 7,676 kilometers while the distribution network at the same period was 247,905 kilometers. The distribution network consists of 66 kV feeder lines and 33kV and 11kV medium-voltage lines and 415/240V LV lines distributed across the country. Efforts to increase the number of distribution lines across the country are underway with a goal of attaining universal electricity connections. In addition, the sector is implementing projects and programs aimed at reducing system losses and improving system reliability.

Figure 145: Installed capacity share



Sources of Energy in Kenya

The generation mix comprises of Hydro, Geothermal, Wind Thermal, Solar, Biomass and Off Grid as shown in Table 59 below

Table 59: *Sources of energy*

Capacity (MW) as at 30.06.2019		
	Installed	%
Hydro	826	30.46
Geothermal	663	24.44
Thermal	808	29.79
Cogeneration	28	1.03
Solar	50.94	1.88
Wind	336	12.39
Total	2712	100

Source : EPRA

Electricity market share

KenGen continues to dominate the market since most of its plants are either base load (for the case of Geothermal) or intermittent and therefore have a high availability factor. However, there is a small percentage of demand that is met through off grid plants and captive power generation. Figure 144 shows the market shares of the electricity sector

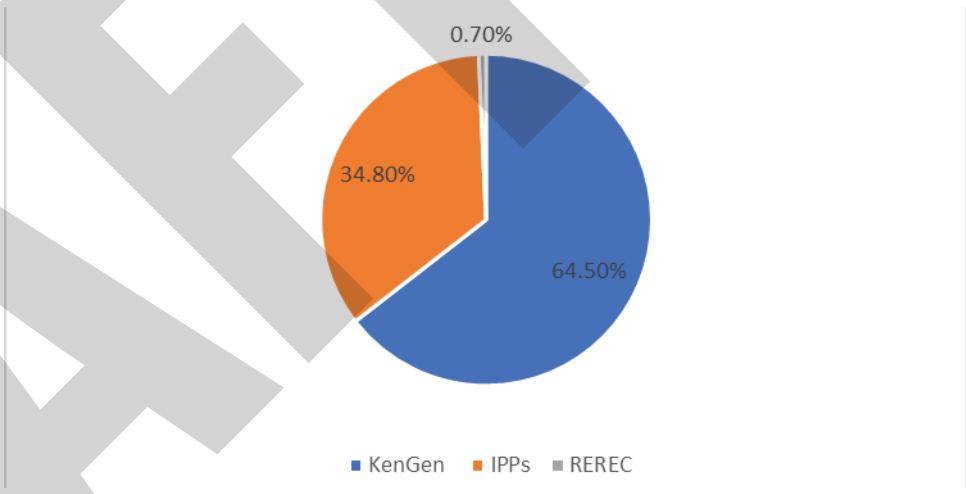


Figure 144: Electricity market share
Source: EPRA

Geothermal Energy

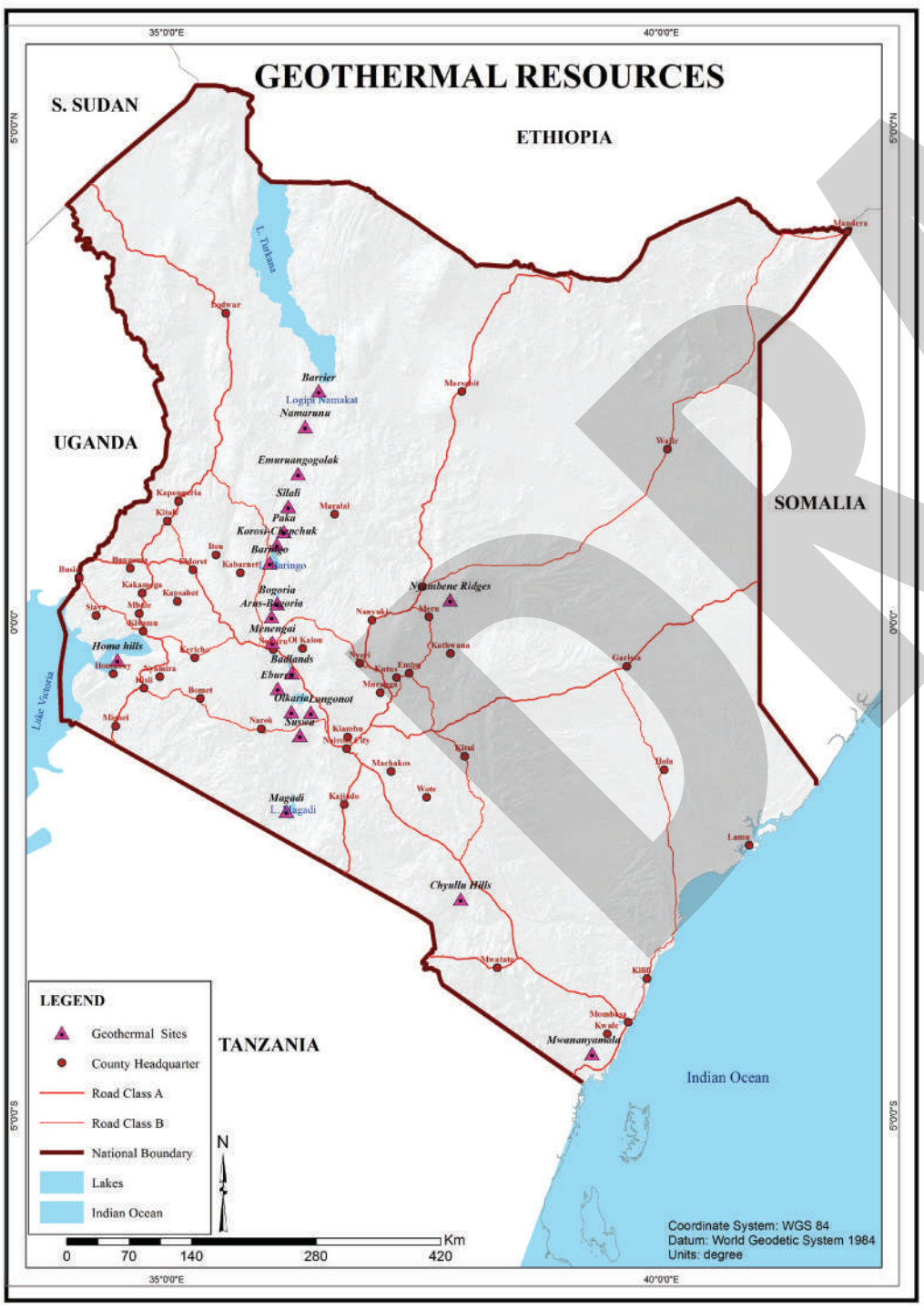
Geothermal installed capacity is at 863MW contributing for 42% of the total annual electricity supplied in the country (2020/21 KPLC annual report). Geothermalenergy has comparably Iow electricity production costs. Due to the low short-run marginal costs,geo-thenmal power plants generally run as base Ioad. Kenya geothenmal resource potential is estimated at 10,000 MW along the Kenyan Rift Valley

Currently geothenmal power is only being harnessed in the Olkaria, Menegai and Eburru fields. In the medium and long term new geothermal reservoirs, such as Suswa, Longonot, Akiira and Baringo Silali may be developed. Other potential geothermal prospects within the Kenya Rift Valley yet to be exploited include Emuruangogolak, Arus, Badlands, Namarunu, Chepchuk, and Magadi and Barrier.

Geothermal Development in Kenya

Exploration for geothermal resources in Kenya started in 1950's and gained momentum in the 1960's, when two wells were drilled at Olkaria. From 1967, the United Nations Development Programme (UNDP) in collaboration with the Kenya Government and the then East African Power and Lighting Company Ltd., conducted geological and geophysical surveys in the area between Lake Bogoria and Olkaria. The studies identified Olkaria as the most prospective area leading to the construction of the first geothermal power station between 1981 and 1984. (Source : KenGen, 2019)

Figure 146: Geothermal resources in Kenya



Solar Energy

Kenya's geographical location astride the equator gives it a unique opportunity for a vibrant solar energy market. The country receives good solar insolation all year round estimated at 4-6 kWh/m²/day.

There has been a significant growth in the utilization of solar photovoltaic (PV) systems in Kenya due to a global decline in the cost of these systems and the development and enforcement of facilitative regulations by the Authority. The installed solar systems include utility scale projects, commercial and industrial solar PV systems, mini grids, solar water pumping systems, solar streetlights, solar home systems and consumer devices.

Kenya has four (4) utility scale solar photovoltaic plants with a combined installed capacity of 170 MW. These are Garissa Solar Power (50MW), Selenkei solar (40MW), Cedate solar (40MW) and Malindi solar (40MW. Source : EPRA.

It is estimated that 200,000 photovoltaic solar home systems, most of which are rated between 10We and 20We estimated at a cost of KShs 1,000/We, are currently in use in Kenya and generate 9GWh of electricity annually, primarily for lighting and powering television sets for about 1.2% of households in Kenya. It is estimated that the rate of market penetration will increase considerably. Given that there are four million households in rural Kenya alone, the potential for photovoltaic solar home systems is virtually untapped. With the diversification of rural electrification strategies and the declining solar energy production costs, the number of installed solar systems will grow substantially, harnessed for electricity supply to households, water heating, and telecommunications facilities in isolated locations.. Source: LCDP 2022-2041.

With the enhanced State support, it is estimated that the rate of market penetration will improve considerably. Given that there are four million households in rural Kenya alone, the potential for photovoltaic solar home systems is virtually untapped. It is therefore expected that with the diversification of rural electrification strategies, the number of installed solar home systems will grow substantially. This can be hanessed for water heating, and electricity generation for households and telecommunications facilities in isolated locations.

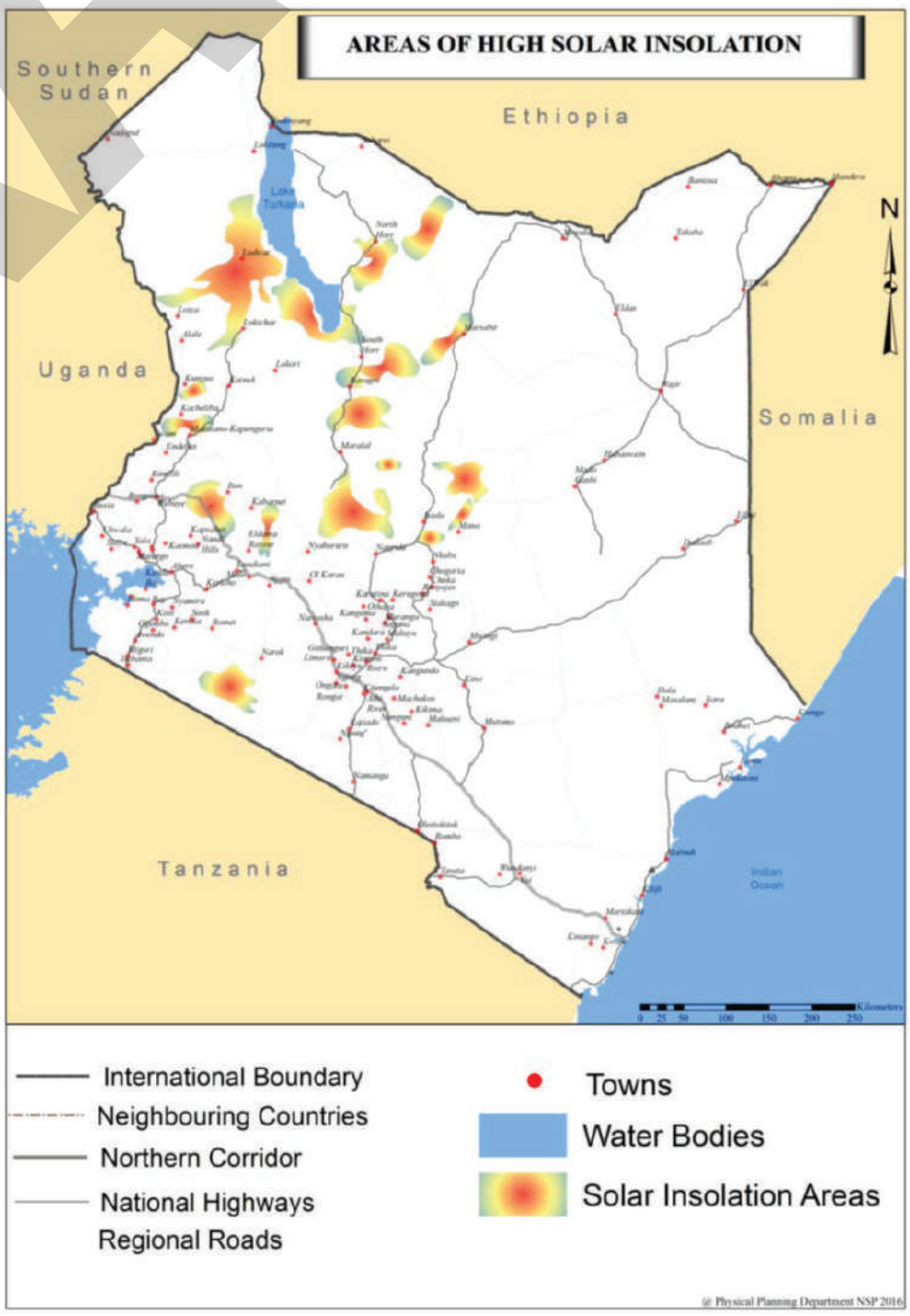


Figure 147: Areas of high solar insolation

Hydro Energy

Hydroelectric energy is one of the most commonly used forms of renewable energy in the world. This technology uses the power of moving water to generate electricity. Kenya has relied on hydropower for generations to support its growing economy

Beyond the existing schemes, Kenya still has substantial hydropower potential. This is reflected by current plans to develop large hydro projects in Karura and High Grand Falls (both in the Tana catchment area), Nandi Forest (in the Lake Victoria North catchment area) and Magwagwa (in the Lake Victoria South catchment area), and Arror (in the Rift Valley area). This development could lead to additional hydropower capacity of over 800 MW in the long term

Today, KenGen has an installed capacity of 818MW of hydroelectric power drawn from about nine large ((more than 10MW)) power stations and about five other small hydropower stations. Hydro accounts for about 30% of KenGen's total installed capacity.

The hydropower plants operated by KenGen include:Masinga (40MW), Kamburu (90MW), Gitaru (225MW), Kindaruma (72MW), Kiambere (168MW), Tana (20MW), Wanjii (7.40MW), Sagana (1.5MW) and Mesco (0.43MW), Sondu Miriu (60MW), Turkwel (106MW), Sangoro (21MW), Gogo (2MW) and Sosiani (0.4MW) (Source: KenGen, 2019).

Figure 148: Major hydropower dams

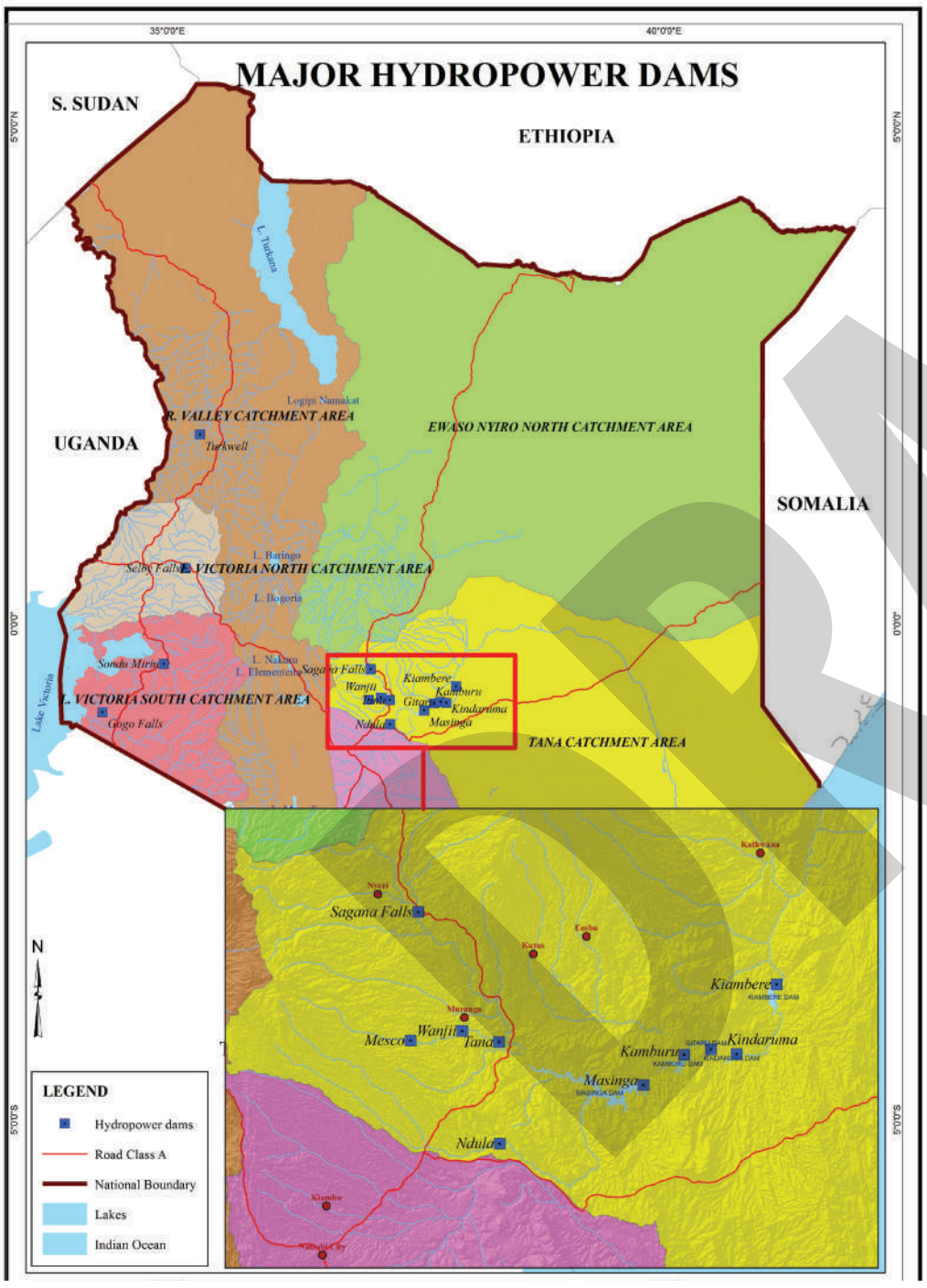


Table 60: *Hydropower potential by catchment areas*

Catchment area	Area (Km^2)	Identified Hydropower potential (MW)
Lake Victoria North	18,374	151
Lake Victoria South	31,734	178
Rift Valley	130,452	305
Tana	126,026	790
Athi	58,639	60
Ewaso Ng'iro North	210,226	Nil
TOTAL	575,451	1,484

Wind Energy

Wind power or wind energy is the use of air flow through wind turbines to generate electricity. Wind power is a sustani able and renewable energy and has become popular across the world over the recent years. Kenya is endowed with favorable wind speeds with 73% of the country experiencing wind speeds of 6 m/s or higher at a 100 meters above ground level. Of this, 28,228 sq.km experiences wind speeds of between7.5 – 8.5 m/s and 2,825 sq.km experiences wind speeds of between 8.5 – 9.5 m/s.

The country has an installed wind capacity of 435.5MW. Lake Turkana Wind Plant (310MW), Ngong Wind (25.5MW) and Kipeto Wind Farm (100MW) are the only wind plants connected to the grid. KenGen's wind farm in Ngong hills was the first one to be developed in East Africa. The Lake Turkana Wind Power Project and Kipeto Wind Farm has also installed 310MW and 100MW respectively of reliable, low cost wind power to the Kenya national grid.The wind famn site is located in Loiyangalani, Marsabit County.The Best wind sites in Kenya are located in Marsabit,Samburu,Laikipia,Meru,Nyeriand Nyandarua and Kajiado counties.Other areas of interest are Lamu,off shore Malindi, Loitokitok at the foot of Kilimanjaro and Narok plateau. On a v e r a g e t h e country has an area of close to 90,000 square kilometers with very excellent wind speeds of 6m/s and above.(Source: Ministry of Energy,2013)

The wind regimes in many parts of Kenya especially the norther and eastern regions such as Marsabit, Ngong and the Coastal region can support large scale utility electricity generation as these regions enjoy extremely good annual mean wind speeds in the range of 6-10 m/s throughout the year. At lOOm height, it is observed that Marsabit County has the largest potential area with a maximum of mean annual wind speed of 9.27m/s and minimum of mean annual wind speed of 5.32 m/s followed by similar wind speeds in Turkana County in Rift Valley province. Despite this enormous potential, wind resources have not been exploited and remain largely under-developed, yet it supports the energy needs ofthe people of Kenya.

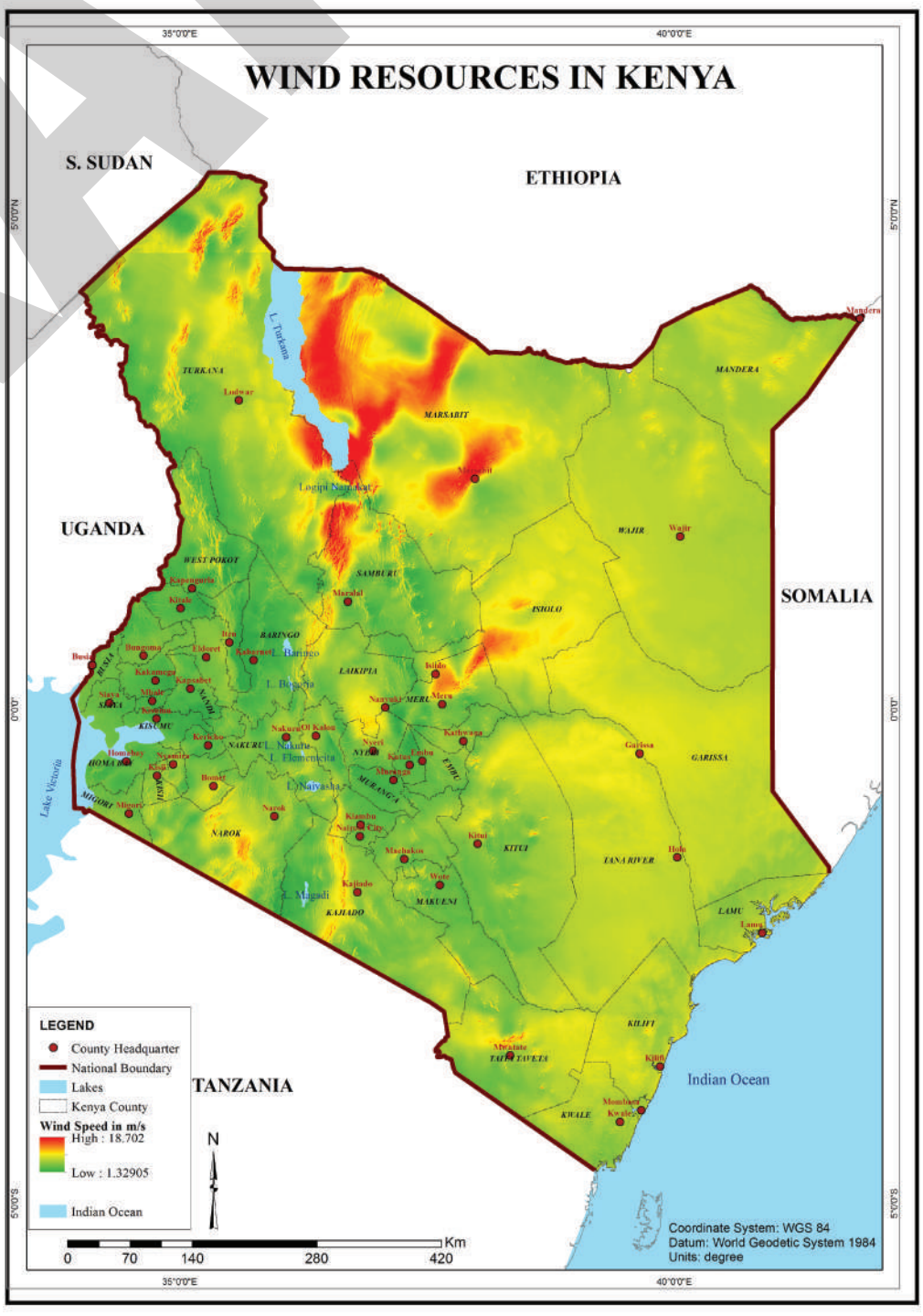


Figure 149: Wind resources in Kenya

Coal Energy

Coal has been the second most important fossil energy source in the world measured by energy content next to crude oil. It is extracted from geological formations beneath the earth's surface. Coal reserves are abundant whereby they are distributed relatively evenly among many countries. However, coal is faced by challenges in opposition of its use due to strong environmental impacts namely pollution due to emission of sulphur dioxide and release of heavy metals and production of greenhouse gases

In Kenya local coal reserves of a substantial depth of up to 27 meters has been discovered in the Mui Basin in Kitui County. The coal basin which stretches across an area of 500 square kilometers is divided into four blocks: A (Zombe – Kabati), B (Itiku – Mutitu), C (Yoonye – Kateiko) and D (Isekele – Karunga). 400 million tons of coal reserves were confirmed in Block C (Government of Kenya, 2018.).

Due to its widespread deposits, production experience as well as relatively low costs, coal is an important fuel option for expansion planning but the negative environmental impacts have to be factored in. The planned Lamu power plant would be the first coal power plant in Kenya.

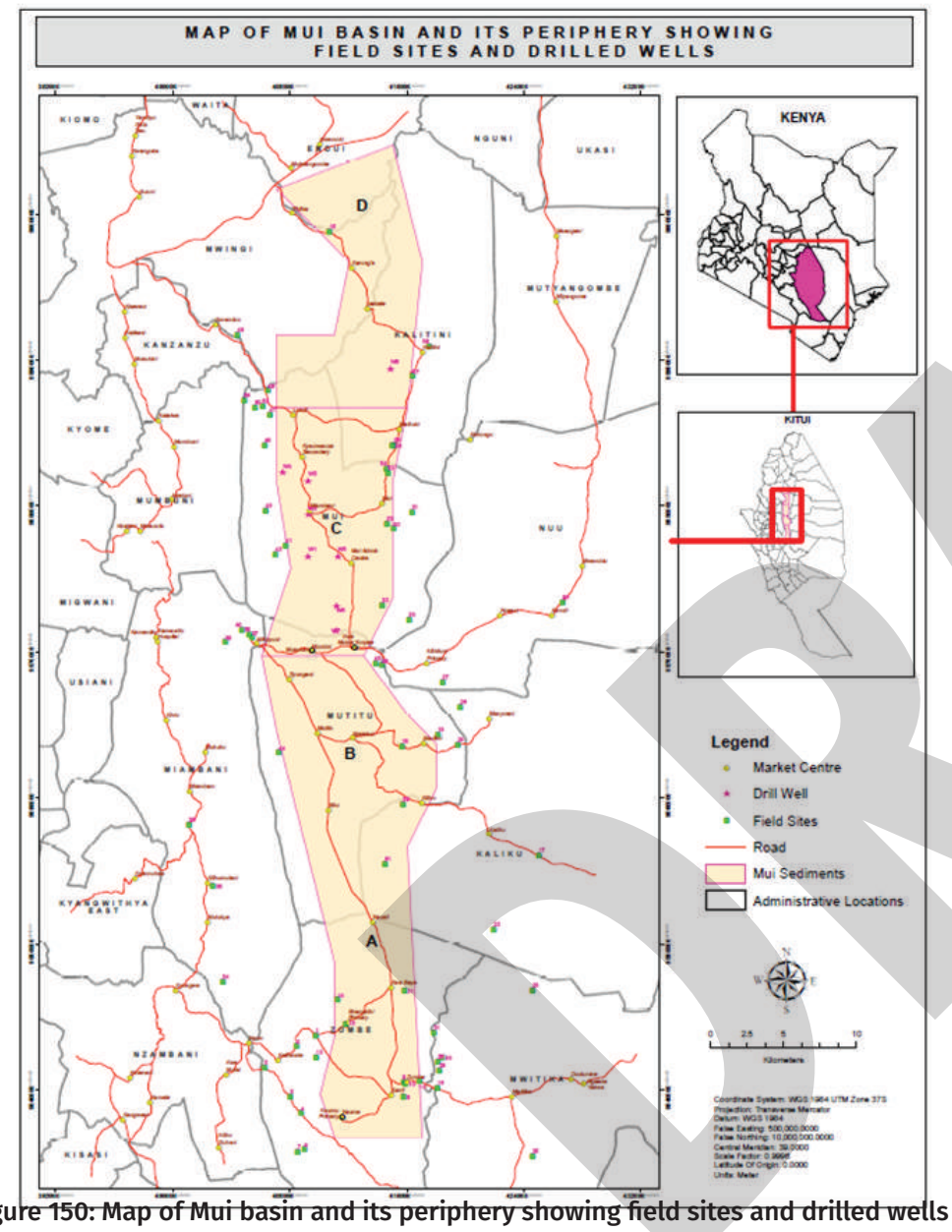


Figure 150: Map of Mui basin and its periphery showing field sites and drilled wells

Natural gas

Natural gas has been the third important energy source in the world measured by energy content, behind crude oil and coal. Africa Oil Corporation, a Canadian oil and gas exploration and production company, discovered natural gas onshore deposits in north-eastern Kenya. An appraisal plan to follow up the gas discovery is currently being evaluated in consultation with the Government of Kenya. In addition, the Africa Oil Corporation is considering drilling an appraisal well on the crest of the large Bogal structure to confirm the large potential gas

discovery which has closure over an area of up to 200 square kilometers. The gross best estimate of prospective resources for Bogal are 1.8 trillion cubic feet of gas based on a third-party independent resource assessment. Due to the early stage of exploration, it is assumed that domestic natural gas will not be a potential energy source for power generation in the medium term. Source LCDP 2022-2041

Liquefied natural gas (LNG)

Liquefied natural gas (LNG) is relatively new option for large-scale power generation. LNG is recommended as an alternative fuel option to allow for the diversification of fuels used in power generation and its environmental advantage compared to more harmful fossil fuels. The import of LNG would also provide economic benefits for other consumers, such as in the industry, households or transport sector. However, LNG is natural gas liquefied at the country of origin restricted by the available transport infrastructure which increases overall costs of imported LNG.

Given the restriction paused by required liquefaction and regasification facilities of LNG as well as competing demand on the world market, the Government of Kenya has been exploring opportunities for developing the domestic resource instead of importing. If domestic gas resources were available imported LNG would most probably not be a competitive source. Source LCDP 2022-2041

Biomass, biogas and waste-to-energy

Biomas are flexible renewable energy from sources such as wood and wood residues, agricultural crops and residues; and animal and human wastes. Biomass appears to have modest potential at present, but could increase significantly with the agro industrial development mainly through revamping sugar mills and future concentration of other agro industries.

Agricultural and agro-industrial residues and wastes have the potential to generate heat and/or power. The best example in several countries is power generation from bagasse. Presently, its use for power generation into the national electricity grid is being explored. Besides the sugar bagasse, there could be some potential in the tea industry as well, which could cogenerate about
1 MW in the 100 factories using their own wood plantations for drying.

Biogas is a mixture of methane and carbon dioxide with small amounts of other gases and needs a further cleaning step before it is usable. Biogas is similar to landfill gas, which is produced by the anaerobic decomposition of organic material in landfill sites.

Municipal Solid Wastes (MSW) constitute a potential source of material and energy as well. Because of its heterogeneous components, it is necessary to pretreat this waste (or collect it separated by source) before it can be used. The objective is to recycle as much as possible and use the remaining material with a high calorific value in an incinerator or gasification process to provide heat, electricity or syngas. The wet material can be used in a fermentation process to produce biogas. Source LCDP 2022-2041.

Energy: Legal and Regulatory Framework

The Energy Act, 2019 was enacted in response to calls to consolidate the laws relating to energy; promote renewable energy; promote exploration, recovery and commercial utilization of geothermal energy; regulate midstream and downstream petroleum and coal activities, among others. It is expected to create an enabling environment for the Government's Big Four Agenda.

It establishes the Rural Electrification and Renewable Energy Corporation ("REREC") as successor to the Rural Electrification Authority ("REA").

In addition to overseeing the implementation of the Rural Electrification Program, REREC's extended mandate includes developing and updating the renewable energy master plan; establishing energy centers in the Counties; developing, promoting and managing use of renewable energy (excluding geothermal); coordinating research in renewable energy; developing appropriate local capacity for renewable technologies; offering clean development mechanisms such as carbon credit trading, among others.

Specifically in relation to the energy sector, Part 1 of the Fourth Schedule provides that the National Government shall be responsible for:-

a. Protection of the environment and natural resources with a view to establishing a durable and sustainable system of development including water protection, securing sufficient residual water, hydraulic engineering and the safety of dams.
b. Energy policy including electricity and gas reticulation and energy regulation; and
c. Public investment.

In relation to the County Governments, Part 2 of the Fourth Schedule provides that they shall be responsible for county planning and development including electricity and gas reticulation and energy regulation.

- Lack of clear and agreeable formula for benefit sharing between the national government, county government and local community.
- Land access for the development of renewable energy and way leaves for the transmission lines
- High upfront investment costs in exploration and development of energy resources
- Relatively long lead time of between 5-7 years from conception to production of electricity
- Heavy investment in transmission and other support infrastructure due to long distances to existing load centres.
- Land and water use conflict.
- Climate change impacts on hydropower development
- Community conflict in terms of relocation and resettlement of affected persons to create room for the construction
- Weak enforcement of the legal and regulatory framework for sustainable production, distribution and marketing of biomass.
- Inadequate R&D in renewable energy technologies
- Lack of a framework for management of cross-county energy resource areas

CHAPTER

06

SOCIO-ECONOMIC LINKAGES AND EMERGING IMPERATIVES

Farming Communities

Agriculturalists including the Kikuyu, Meru, Embu, Pokomo, Kamba, Taita, Tharaka, Kisii, Kipsigis, Luo, Nandi, Teso and Luhya mainly live in high potential zones which support crop farming. These communities' concept of land 'ownership' and user rights shapes their governance of land and natural resources which revolves around securing land tenure to ensure crop production.

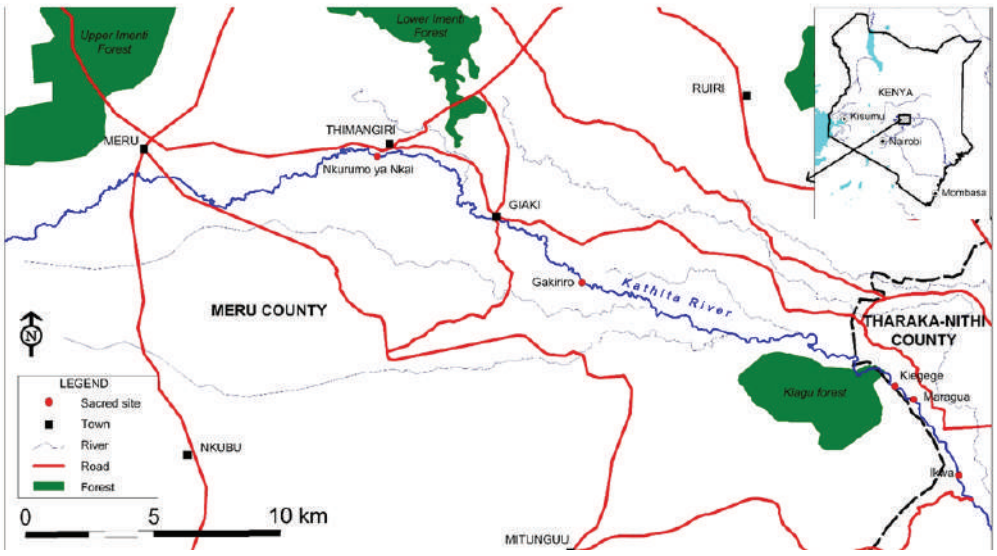


Figure 151: Farming communities in Meru county

Fishing communities

A number of communities in Kenya practice fishing, either as their major livelihood, or as a supplement to pastoralism and agriculture. Important coastal and lakeside fishing communities include the Bajuni, Somali, Kauma, Luo, Suba, Turkana and El Molo.

Coastal communities have over the centuries acquired a deep knowledge of the ocean's tides and seasons and developed productive fishing customs and technologies. Traditional fishing communities ensured conservation of fish, mangrove forests and reefs by limiting access to fish breeding sites some of which are considered sacred sites, and other key biodiversity areas. The communities also occasionally supplement fishing with small scale farming and trading.

Communities living around the lakes also have a long history of fishing, often supplementing agriculture, pastoralism and hunting practices. The El Molo, Turkana and Luo are the main lake fishing communities around Lake Turkana and Lake Victoria respectively.

Pastoralism and the rangelands

Kenya's rangelands are home to diverse communities including pastoralists, agro-pastoralists and hunter-gatherers including the Turkana, Gabbra, Boran, Rendille, El-Molo, Burji, Pokot, Somali, Garri, Maasai, Samburu, Waata, Saakuye, Daasanach and the Konso whose cultures are intertwined with the biodiversity. Majority of these communities occupy the Northern Kenya region that has a unique ecosystem and encompasses over 100,000 square Kilometers of arid and semi-arid lands. These communities by and large have collective land tenure systems managed through traditional institutions. Their cultural practices which include seasonally moving between pastures and water points as well as varying their herd compositions supports adaptation to the wet and dry periods. These practices contribute to higher production and resilience to prolonged droughts in this region. In more erratic environments, pastoralists including the Turkana have diversified their diet by fishing and occasionally growing hardy fast-growing arid-adapted crops such as sorghum and millet.

The Maasai are renowned for the elaborate understanding of their territories and their rich cultures. The country's major parks including the Maasai Mara, Amboseli and Tsavo National parks benefit from the communities' conservation efforts

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Natural Cultural Sites

Some of the best conserved natural areas in the country are natural cultural sites and landscapes which are recognized under the Heritage Act 2006. Sacred Natural Sites are critical places within ecosystems, such as forests, hills, mountains, rivers and sources of water, which are of ecological, cultural and spiritual importance, and exist as a network embedded within a territory.

Indigenous communities govern and protect their territories on their own terms according to their customary governance systems. Sacred/cultural sites represent different landscapes and places of spiritual importance to communities which are sources of beliefs, myths and legends. Some sites are unique habitats with rich biodiversity and/or species of social, cultural and economic importance.

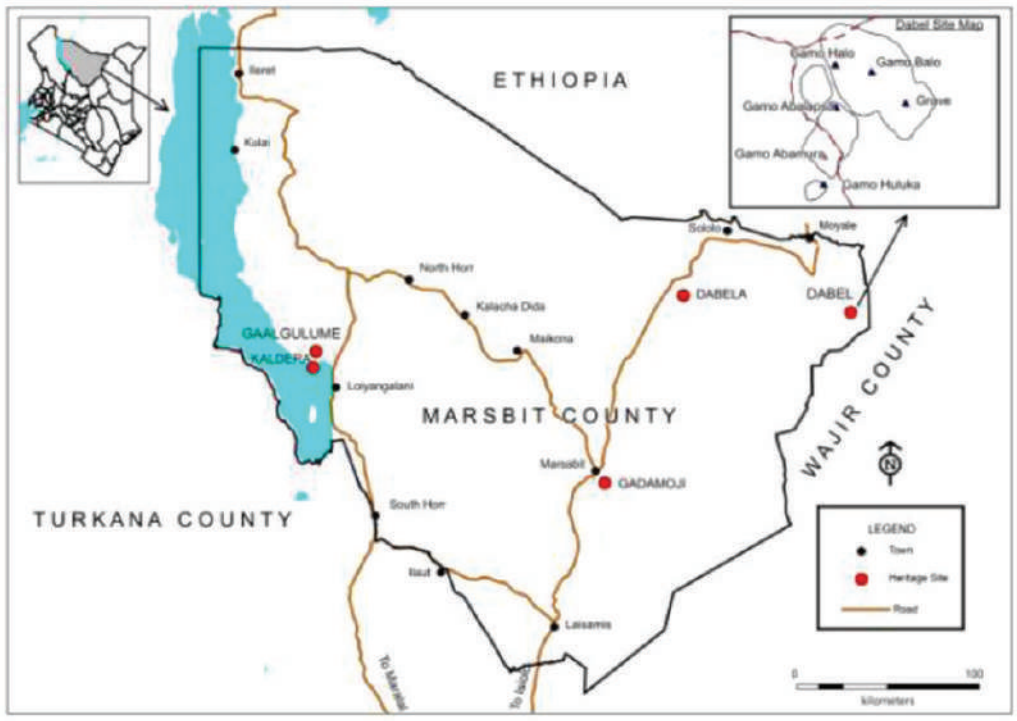
Some major cultural sites have attained national and international significance which reflects the universal value of Kenya's spectacular culture. Protection of cultural sites enables environmental conservation, strengthens social cohesion and provides a link to the spiritual world. Gazettement of sites and enlisting on the UNESCO World Heritage Sites enhances their protection.

Cultural Sites

The Sacred Mijikenda Kaya Forests

consists of 11 separate forest sites, spread over some 200 km along the coast. They contain the remains of numerous fortified villages, known as kayas, of the Mijikenda people. The kayas, created in the 16th century but abandoned by the 1940s, are now regarded as the abodes of ancestors, revered as sacred

Figure 152: Map of sacred sites in Marsabit County



sites and, as such, are maintained by councils of elders. These sites were inscribed to the list of UNESCO World Heritage Sites in 2008.

Forole Mountain

Forole is a sacred Mountain at the Kenya- Ethiopia border, in Moyale, Marsabit County. The traditional belief in the sanctity of the mountain and the cultural rituals practiced by the Galbo section of the Gabbra community has ensured the protection of its rich biodiversity. It is culturally forbidden to kill wildlife around the Mountains.

Hurri Hills sacred landscapes

Hurri Hills lie within North Horr Sub-County, Marsabit County. The hills have a unique ecosystem and are home to the Gabbra, Borana, Waayu and Konso communities. The hills commonly referred to as Badha Hurri, meaning mist forest, was according to oral history previously some large misty forest rich in wildlife. Most of the animal and plant species are now extinct in the area following poaching, overgrazing and growth in human settlement.
The traditional belief in the sanctity of the environment and cultural rituals practiced by the Gabbra community in the area makes conservation part of the community. It is for instance traditionally forbidden to cut trees other than for ceremonial purposes. Kaldera Island

The El Molo have their sacred sites on the Islands in Lake Turkana to the north west of El molo bay, in Loiyangalani, Marsabit County. The island is used as a prayer site during prolonged drought periods and most importantly, it is used as a fish source particularly for weaning ceremonies. The importance

and reverence of this site is underscored by the fact that the neighboring communities do not desecrate it even in times of conflict.

Lamu Old Town

Lamu Old Town is the oldest and best-preserved Swahili settlement in East Africa, retaining its traditional functions. Built in coral stone and mangrove timber, the town is characterized by the simplicity of structural forms, enriched by such features as inner courtyards, verandas, and elaborately carved wooden doors. Lamu has hosted major Muslim religious festivals since the 19th century, and has become a significant centre for the study of Islamic and Swahili cultures. Lamu old town has existed since the 19th Century and was enlisted in

the UNESCO World Heritage Sites in 2001..

Thimlich Ohinga archaeological site

This site gazetted as a national monument in 1982 and added to the UNESCO World Heritage Sites in 2018. Thimlich Ohinga refers to a “frightening dense forest” in Dholuo language, a Nilotic group who occupy the region. The stone structure enclosure has walls ranging from 1.0 to 4.2 meters in height, which were built of loose stones and blocks without any dressing or mortar.

Fort Jesus

Fort Jesus, an architectural masterpiece was built by the Portuguese at the end of the 16th century, and stands at the southern edge of Mombasa, over a spur of coral rock. It was kept under Portuguese control for one century, and is testimony to the first successful attempt by Western civilization to rule the Indian ocean trade routes – which, until then, had remained under Eastern influence. This historical site was inscribed to the UNESCO World Heritage list in 2011.

SOCIO-ECONOMIC LINKAGES AND EMERGING IMPERATIVES.

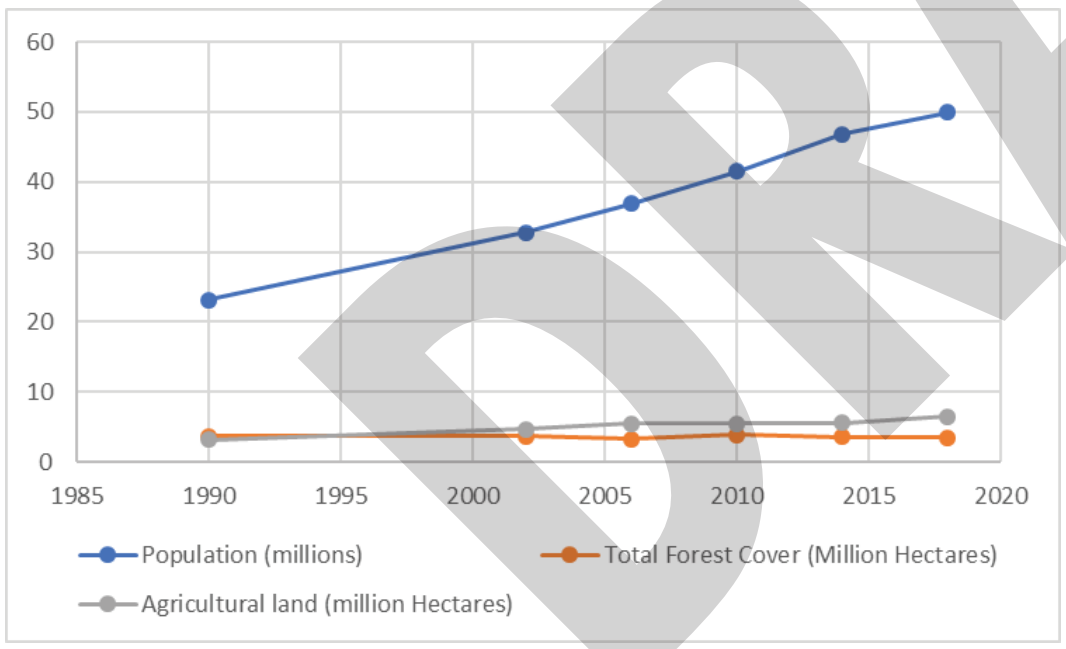
People's livelihood are intimately linked to the natural resources within territories and even beyond. Natural resources constitute a fundamental and integral beacon for people's survival and well-being, especially in the current context of changing climatic regimes. Socio-cultural practices, beliefs and traditional systems and knowledge contribute and are directly to natural capital. It is therefore important to establish and demonstrate such profound linkages.

In Kenya, there are 45 ethnic communities in the country (KNBS, 2019) whose distinct cultures are intimately tied to their lands and territories which form a fundamental part of their individual and social identity. Communities' indigenous knowledge about their natural environments is socially regulated through shared values and they practice complex resource management regimes to ensure the health of such territories. The various communities' land-use patterns vary with their local environments. This chapter focusses on the linkage between the socio-economic aspect and how they are linked to environmental stewardship and /or degradation, including the emerging imperatives that have become increasingly important due to changing circumstances the associated dynamics on land and people.

1. SOCIAL JUSTICE, EQUITY AND INCLUSION

There is an increasing trajectory regarding Kenya's population. As matter of fact, the Country is experiencing an inter-censual population growth rate of 1.99% which have direct implications on land use changes including natural resources (over)use, degradation and extinction of critical biodiversity as well as exacerbating pressures and threats to the limited natural resources. Equally, there are nexi between people's economic well-being and environmental degradation. Socio-economically disadvantaged communities/populations generally settle and occupy fragile and ecologically sensitive areas and, while at the same are more exposed to natural disasters. Poverty- environment-health linkages must be buttressed in the context of natural resource management agenda.

able xxxx: The relationship between population growth and land use



In terms of gender, Women constitute the majority of rural inhabitants unlike men who migrate to the cities (Hill, 2011). Evidently, women provide the biggest proportion of agricultural labour in Africa (world Bank 2009.), yet limited land ownership, access to and control of land resources hinder women from meaningful involvement in its management (Soita, 2007). Only about 1% of land is owned by women and 5-6% is co-owned by both men and women (Gaafar, 2014). In Kenya, a paltry 2% of women own land (KLA, report 2018), demonstrating urgent need for deliberate policy action in relation to social inclusion on maters and land and natural resources.

Kenya Population and Housing Census (2019) shows that the population of youth is 13,777,600, which accounts for 29% of the national population. Alarmingly, 5,341,182 or 38.9% of the Country's youth are employable (Alushual, 2020). Despite their numerical weight, the youths have not taken a keen interest on sustainable land and natural resources management. Their perceptions, behavior and inadequate participation in natural resources governance and management is critical. Perhaps, a paradigm shift is required to ensure meaningful inclusion and participation of the Kenyan youth, especially through the digital space and technologies. Broadly, there is an urgent need to embrace and mainstream gender equality and equity principles, inclusion of youth and persons living with disability, minorities and vulnerable members of society, including the elderly and children in sustainable land management and conservation practices.

2. CULTURAL TRADITIONS AND CUSTOMS

Cultural traditions and customs are often deeply ingrained in a community's identity and are seen as an important way of preserving and sharing the unique characteristics of a particular culture. They can also serve to reinforce social norms and values and provide a sense of continuity and connection between different generations of people within a community. The traditions are uniquely specialized and intimately related to their ecosystem.

In Kenya, Communities have had informal institutions including council of elders that provide leadership by guiding the social organization in terms of livelihoods and the management of natural resources including conflict resolution. Celebration during special events like Dowry, burial, Rites of passage and rainmaking that are directly linked to the utilization of the natural resources. Rituals performed often involve an array of symbolic actions like adornment in skin hides, twigs, sisal among others. Other communities use forests and the hills as shrines/ sacred areas and circumcision points. As such these resources were revered and protected for generations.

In the highland forests and the coastal lowlands of Kenya, several communities are known for their traditional and indigenous knowledge systems to protect forests and other critical resources. For instance, communities who living around gazzeted forests and water towers including Mt. Elgon, Mt. Kenya, Aberdare ranges and Mau Escarpment.

a) Cultural landscapes

Cultural landscapes reflect the values, beliefs, and practices of the people who create them and can provide important insights into their cultural, historical, and ecological contexts. Generally, cultural landscapes and structures are closely intertwined, with structures serving as the visible and tangible expressions of the larger cultural landscape.

Some of the best conserved natural areas in the country are natural cultural sites and landscapes which are recognized under the Heritage Act 2006. Sacred Natural Sites are critical places within ecosystems, such as forests, hills, mountains, rivers and sources of water, which are of ecological, cultural and spiritual importance, and exist as a network embedded within a territory.

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Some major cultural sites have attained national and international significance which reflects the universal value of Kenya's spectacular culture. Protection of cultural sites enables environmental conservation, strengthens social cohesion and provides a link to the spiritual world. Gazettement of sites and enlisting in the UNESCO World Heritage Sites enhances their protection.

Kenya's most notable cultural sites are spread throughout the country as indicated in the map below:

insert a map of cultural sites

Naibala, sacred site in Loita, Narok County. Photo courtesy of NMK

The Sacred Mijikenda Kaya Forests consists of 11 separate forest sites, spread over some 200km along the coast. They contain the remains of numerous fortified villages, known as kayas, of the Mijikenda people. The kayas, created in the 16th century but abandoned by the 1940s, are now regarded as the abodes of ancestors, revered as sacred sites and, as such, are maintained by councils of elders. These sites were inscribed to the list of UNESCO World Heritage Sites in 2008.

Plate 78: Kaya – Mijikenda Sacred Forest

Plate 79: Kaya Kambe Sacred Forest

Kaya Bomu Sacred Site

Plate 80: Kaya elder inspects memorial posts 'Vigango' at Kaya Kauma

Kaldera Island

The El Molo have their sacred sites on the Islands in Lake Turkana to the northwest of El Molo bay, in Loiyangalani, Marsabit County. The island is used as a prayer site during prolonged drought periods and most importantly, it is used as a fish source particularly for weaning ceremonies. The importance and reverence of this site is underscored by the fact that the neighbouring communities do not desecrate it even in times of conflict.

Plate 81: Kaldera Island on Lake Turkana.

Lamu Old Town is the oldest and best-preserved Swahili settlement in East Africa, retaining its traditional functions. Built-in coral stone and mangrove timber, the town is characterized by the simplicity of structural forms, enriched by such features as inner courtyards, verandas, and elaborately carved wooden doors. Lamu has hosted major Muslim religious festivals since the 19th century and has become a significant centre for the study of Islamic and Swahili cultures. Lamu's old town has existed since the 19th Century and was enlisted in the UNESCO World Heritage Sites in 2001.

Plate 82: Lamu Old town

Fort Jesus, an architectural masterpiece was built by the Portuguese at the end of the 16th century, and stands at the southern edge of Mombasa, over a spur of coral rock. It was kept under Portuguese control for one century and is testimony to the first successful attempt by Western civilization to rule the Indian ocean trade routes – which, until then, had remained under Eastern influence. This historical site was inscribed to the UNESCO World Heritage list in 2011.

Plate 83: Fort Jesus World Heritage Site

Thimlich Ohinga archaeological site was gazetted as a national monument in 1982 and added to the UNESCO World Heritage Sites in 2018. Thimlich Ohinga refers to a "frightening dense forest" in the Dholuo language, a Nilotic group who occupy the region. The stone structure enclosure has walls ranging from 1.0 to 4.2 meters in height, which were built of loose stones and blocks without any dressing or mortar.

Plate 84: Thimlich Ohinga archaeological site, a world heritage site

Threats to cultural resources

Contemporary communities have transformed the country's landscape, natural ecosystems and traditional lands. Several factors have led to the erosion of the customary governance systems of the sites' custodial communities. Mobile pastoralism has given way to sedentary ranching, smallholdings and dairy farms. The distinctive association between eco-climatic zones, plants, animals, livelihoods and culture are fast disappearing and giving way to plantations, greenhouses, irrigation, commercial farms and urban consumer societies. The survival of indigenous communities and their cultures is threatened by the dispossession of land. Sacred Natural Sites and Territories in Kenya are threatened with irreversible destruction from economic, social, political and religious developments.

EMERGING IMPERATIVES

Emerging imperatives refer to newly identified priorities or essential actions that have become increasingly important due to changing circumstances or trends. These include but not limited to: climate change, technological innovation, and migratory pests. As new challenges arise, it is necessary to identify and prioritize emerging imperatives in order to effectively address them in order to bolster peoples and landscapes resilience.

Climate Change and Environmental Stewardship

Kenya's resource base is increasingly under pressure from human activities and the effects of climate change resulting in environmental degradation and depletion. The region experiences frequent extreme climatic episodes such as frequent floods and droughts, which are exacerbated by the response to global warming that is currently being experienced world-wide (IPCC, 2013). In fact, the nexus between land and climate change is well articulated in the recent IPCC Report (2019). This clearly demonstrates the delicate connectivity between land and climate change as two mutually reinforcing variables. The country's emissions of greenhouse gases have been increasing by 44% per capita (Crippa et al., 2019), contributed majorly by anthropogenic factors such as forest degradation and deforestation, agricultural activities.

Arid and semi-arid lands (ASALs) are climate change hotspots, where climate change is already having significant and documented impacts, such as longer and more frequent droughts and unreliable rainfall. Recent assessment on the effects of drought in Kenya including loss of livelihoods, provide clear evidence on the impacts of climatic change both at the micro and meso-level. According to a Report published by United Nations Office for the Coordination of Humanitarian Affairs (2022), approximately 4.5 million Kenyans were in dire need of food and 2.5 million livestock had succumbed to an unprecedent drought that resulted from five consecutive below average rainy seasons that begun at the end of 2020.

Plate 86: Dead Giraffe in Lagboqol in Wajir County
Photo Credit: National Geographic

This photo shows KWS rangers preparing to move the body of a giraffe that died in its quest for water in an almost dried-up source in Lagboqol in Wajir County in November 2021.

Besides ASALs, other parts of the Country have also suffered a great deal due to losses and damages caused by changing climate e.g. rising water levels in lakes such as Baringo, Bogoria, Naivasha, Nakuru and Victoria. The emotional and psychological damage and trauma to such losses has been evident in the country (Plate 78)

Plate 85: Destruction of learning institutions - Submerged Nasoguro primary school in Marigat

Kenya has made significant efforts and progress towards addressing climate change by having in a robust regulatory framework both at the national and county levels. The Climate Change Act, 2016 is the main legislation guiding Kenya's climate change response through mainstreaming climate change into sector functions. Kenya has also developed a National Climate Change Adaption Plan, National Climate Change Response Strategy, National Adaptation Plan Kenya Smart Climate Change Policy, and National Climate Finance Policy among other sector plans and policies to address aspects of climate change.

Technological Advancement

Emerging technologies can predict, collect data and enhance surveillance of the status of the natural resources and further help in restoring degraded natural environments. Satellite imagery can be analyzed using machine vision to monitor natural resource quality and usage, informing decisions about resource management and sustainable policies and initiatives. These include technological aspect such as big data, robotics (artificial intelligence and machine learning), cloud and human-centred computing, and GIS and remote-sensing technologies.

Big data analytics can also be used to inform decision-making relating to the protection of natural resources. For example, in their study, Mzee Awuor and Opaa (2022) proposed a framework to monitor the encroachment and degradation of wetlands in Kenya. The proposed framework utilizes digital tools, which include mobile devices and support interactions using web and mobile apps, USSD and SMS, social media engagements, chatbots and call

centre agents to collect data (Mzee Awuor & Opaa, 2022).
Additionally, cloud computing can be used to make decisions relating to sustainable management of natural resources. In cloud computing, data is collected from multiple sources and stored in cloud servers where natural resources decision makers can access and analyze it to make decisions. Figure (...) depicts how cloud computing can work in natural resources management.

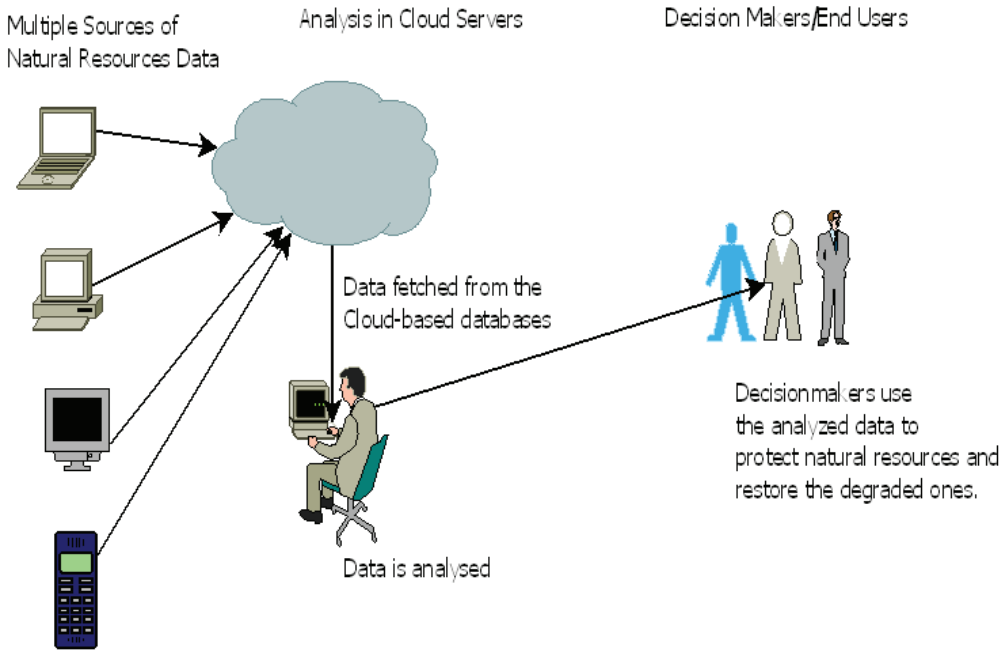

Figure 154: Cloud Computing Depiction in Natural Resources: Image Courtesy of NLC

Migratory Pests

Climate change has driven several insect species, whose geographical distribution was tropical, to expand and increase their geographic range. The fact that climate change impacts crop pests is empirically-proven (Schneider et al., 2022). According to Schneider et al. (2022), climate change favours the proliferation of pests all over the world, particularly, in temperate zones.
In the tropics such as Kenya, ***Schistocerca gregaria*** or the Desert Locust is an example of destructive migratory pest that threatened the stability of Kenya's natural resources in the recent past. Figure 154 shows the distribution and migratory path of the Desert Locust.

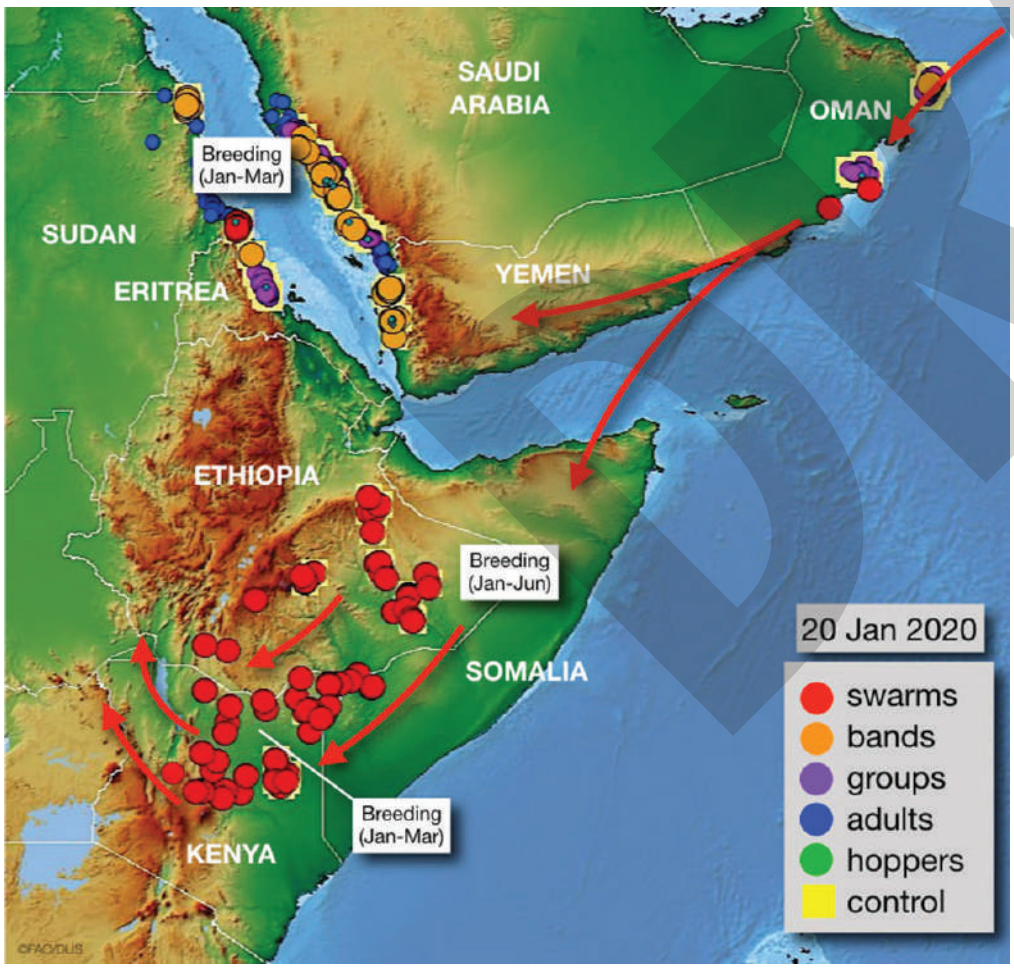

Figure 155: Desert Locusts Distribution and Migratory Path: Photo Courtesy of FAO (2021)

As the map shows, the locusts migrated into Kenya from Somalia and Ethiopia. These locusts were so many that FAO estimated that a single square kilometer of swarm could contain as many as 80 million adults (Food and Agriculture Organization, 2021). Also, it was estimated that in one day, these locusts could consume an equal amount of food as 35,000 people would (Food and Agriculture Organization, 2021). Such startling statistics explain why the locusts posed a significant threat to Kenya's food security.

Desert Locusts in invade plants and grazing land in Lokichar, Turkana County. Photo Courtesy of (FAO Mediabase, 2020)

Figure (XX) courtesy of FAO Mediabase (2020) shows the situation of desert locusts in Kenya as at June 2020. These locusts threatened food security and livelihood in Kenya.
Other examples of migratory pests in Kenya include ***Spodoptera frugiperda*** or fall army worms and red-billed quelea birds.

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