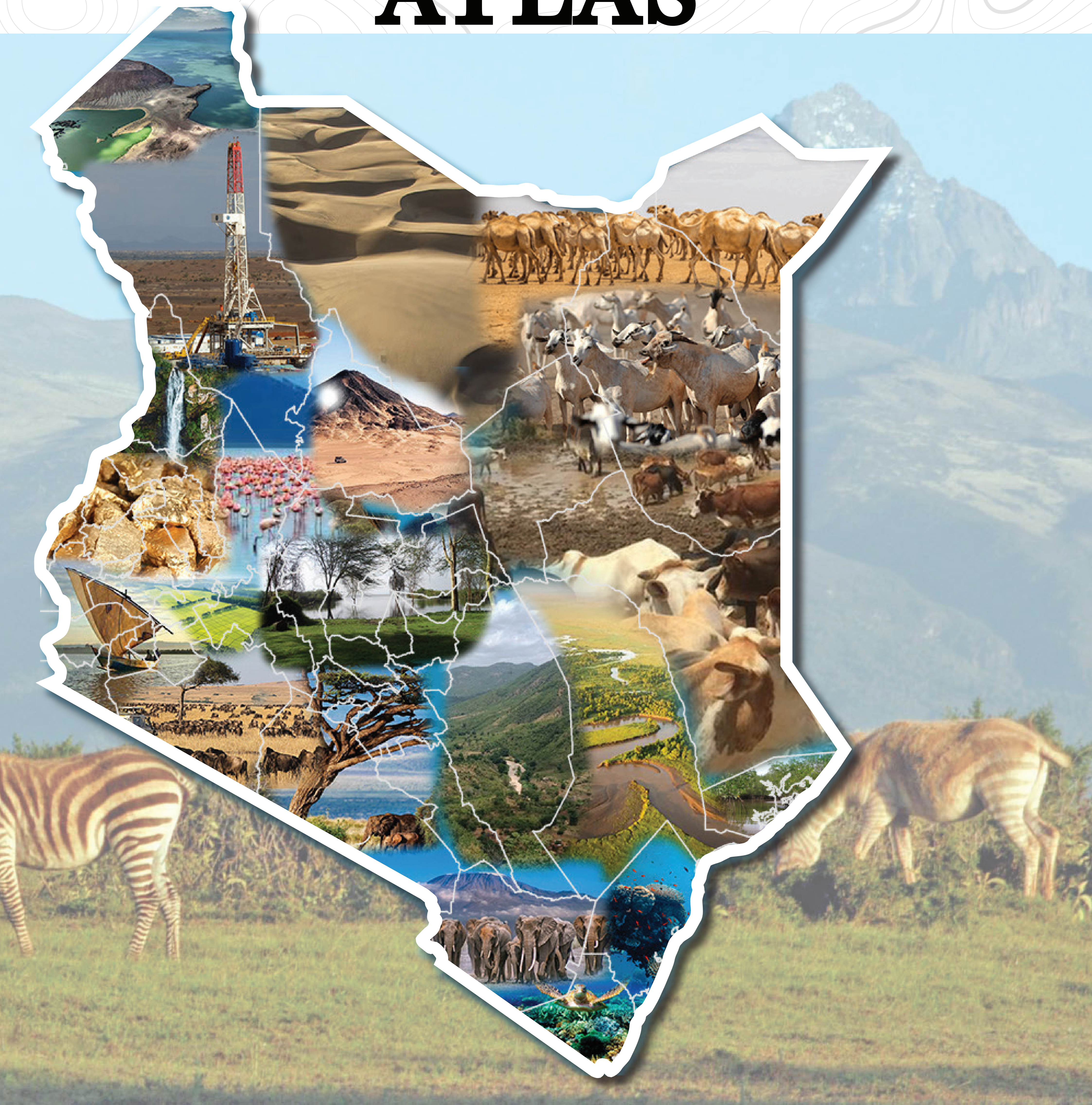
REPUBLIC OF KENYA

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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WILDLIFE RESEARCH & TRAINING INSTITUTE
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NATIONAL MUSEUMS OF KENYA
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nema

KSA

NuPEA
NUCLEAR POWER & ENERGY AGENCY

KENYA WILDLIFE SERVICE

KALRO
Kenya Agricultural & Livestock Research Organization

WRA
WATER RESOURCES AUTHORITY
Accounting for every Drop!

RCMRD

KenGen

University of Eldoret
flame of knowledge and innovatio

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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 which was adopted in 2006 has 5-year plans that were aligned towards achieving the out-phased Millennium Development Goals (MDG) which have since been succeeded by the United Nations General Assembly's 2015 Sustainable Development Goals (SDGs). Among the 17 SDGs, SDG 6 on clean water and sanitation aims to ensure sustainable access to safe drinking water and sanitation for all by 2030. This puts water and wetlands at the apex of the socio-economic development agenda of the country. Cognizant of the critical role the resources play in the country's development agenda, the Constitution of Kenya provides for sustainable management of Water and wetlands in Article 66 (1) which declares water resources and its catchments including wetlands as public land. Particularly, Article 62 (l) classifies rivers, lakes, other water bodies and their riparian as public land. Similarly, in the spirit of devolution, their management is a shared function between the National and County Governments with the National Lands Commission being the lead agency on land matters at the national level.

Water Resources

Generally, Kenya is categorized as a water scarce country with an annual per capita renewable freshwater availability below 1000 m^3. The country's land mass (more than 80%) is Arid and Semi-arid (ASAL). The mean annual precipitation varies from less than 250 mm in the ASALs to about 2000 mm in the highlands. The country's water resources mainly rely on little and fragile catchments covered by the montane forests in the country's highland areas with a humid climate with the five main water towers (i.e. Mt Kenya, Aberdare Ranges, Mau forest complex, Cherangany hills and Mt. Elgon) serving as the key catchments. The water resources constitute lakes, rivers, aquifers and other water bodies which are considered as a unit. The country adopted an integrated water resources management approach of managing water resources along the drainage system.

The Kenya's Basins

The management and administration of water resources is on the basis of hydrological systems (basins) rather than administrative boundaries. The basins are divided into six basin area i.e. Lake Victoria South (LVSBA); Lake Victoria North Basin Area (LVNBA); Rift Valley Basin Area (RVBA); Ewaso Nyiro North Basin Area (ENNBA); Tana Basin Area (TBA); and Athi Basin Area (ABA). The Basin Areas and major rivers in the country are shown in Figure 3. These basins contribute differently to freshwater water resources but largely independent of the landmass of the basin. For instance, ENNBA which is the largest by landmass, contributes 8% of the total water resources, while Lake Victoria South Basins, which is the smallest in size by landmass, contributes 23% of the water resources. ENNBA is largely ASAL which receives limited rainfall with the majority of the rivers being seasonal while LVNBA receives higher rainfall and is endowed with many permanent rivers, thus the contrast between the two basins. Figure 1 and Figure 2.

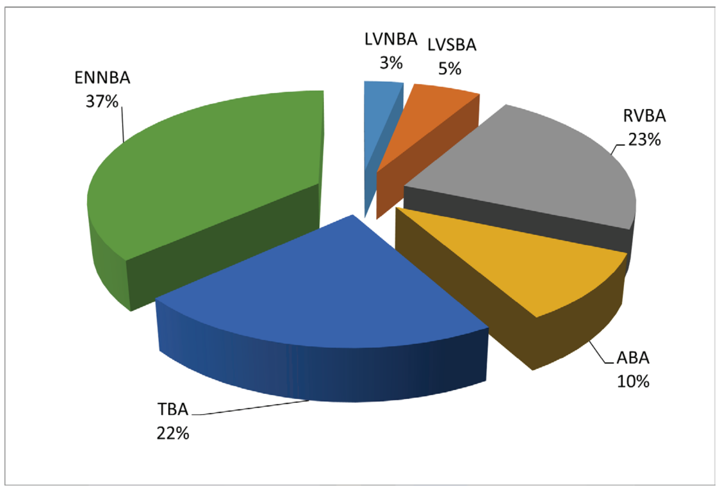

Figure 1: Proportion of Kenya land area (Sq km) by basin

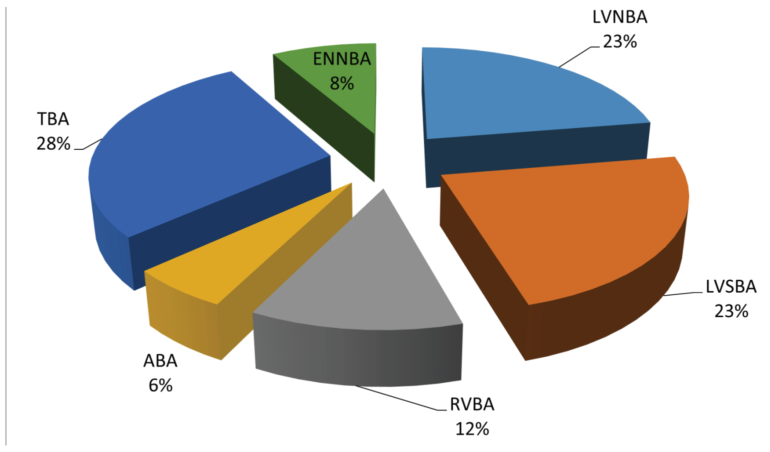

Figure 2: Contribution (%) of fresh water by basin

Plate 1: Wetland in Amboseli national park

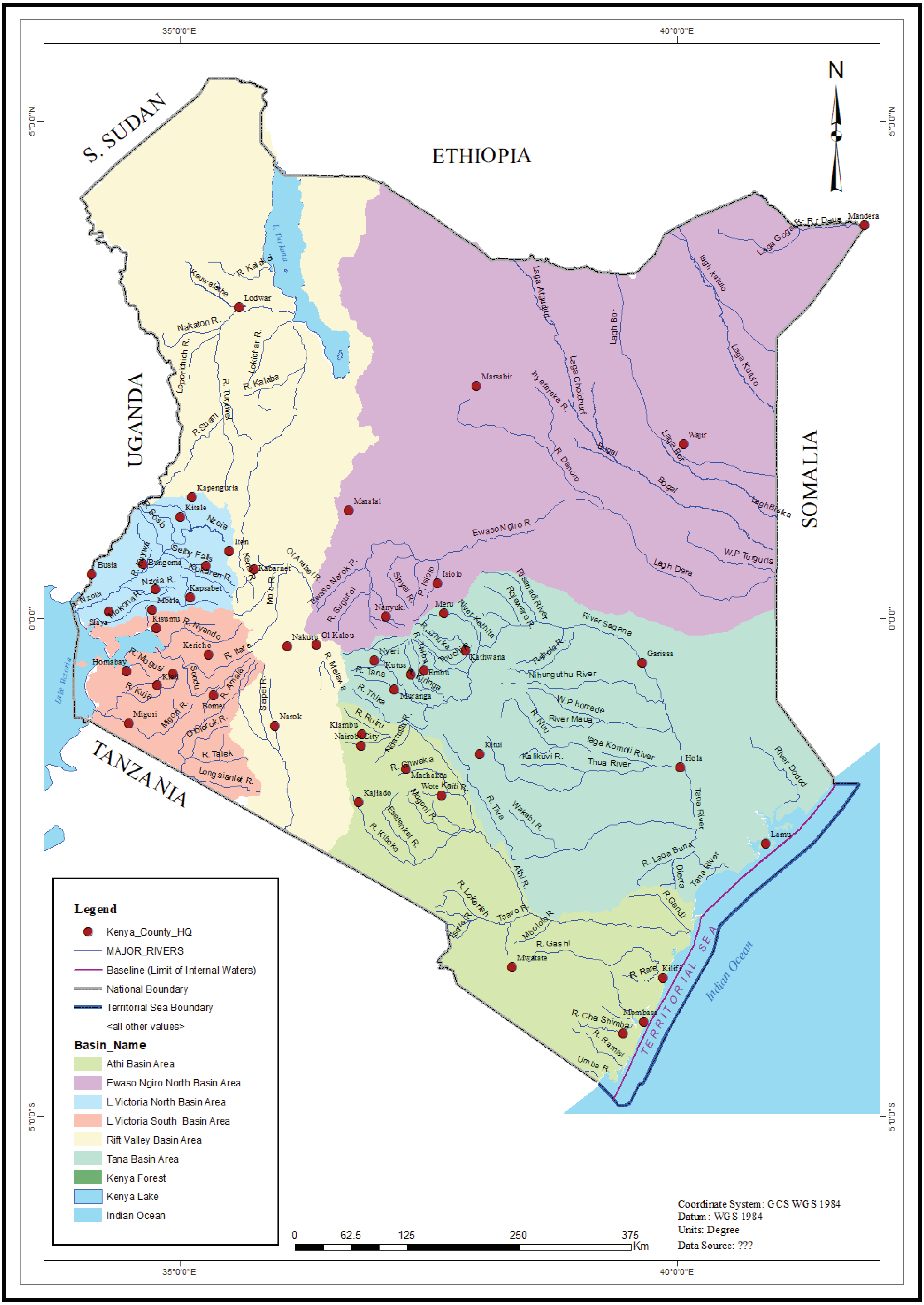

Figure 3: Map of Kenya drainage basins

Kenya's renewable water resources

Kenya's renewable water resources are classified into two distinct types; surface (lakes, reservoirs, rivers, swamps/wetlands, springs, dams, water pans) and groundwater resources (aquifers). The renewable water resources are rechargeable due to the hydrological cycle unless they are overexploited. The total renewable freshwater water resources is estimated at 76,610 MCM/year (2010) largely comprising groundwater Table 1 and is projected to reach 83,583 MCM/year in 2050 (NWMP 2030, 2013) Figure 4. The projection is based on the water resources development programs expected to be implemented by the government.

Table 1: *Kenya's renewable water resources (MCM/year)*

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

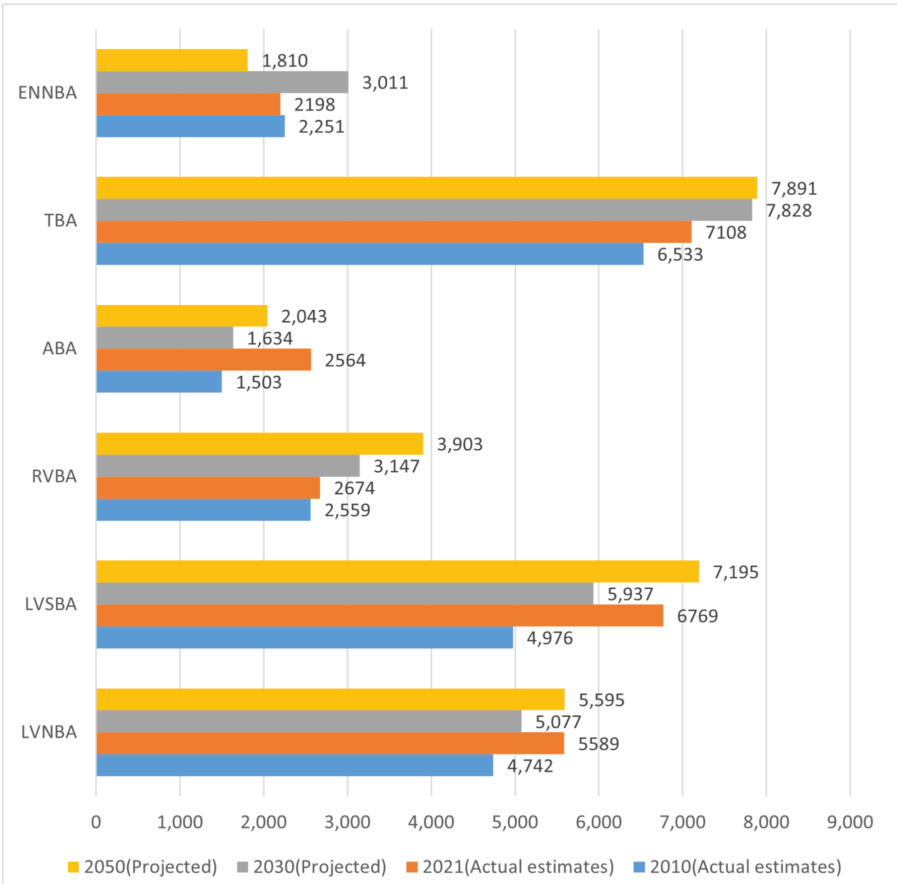

Figure 4: Projected water availability

Source: National Water Master Plan (NWMP 2030) and WRA monitoring data

Kenya's Rivers

The country has numerous rivers and watercourses, majority of which are seasonal. The few large perennial rivers mostly originate from the major water towers and highlands areas. These rivers' system are arranged by drainage basins.

Rivers of Lake Victoria South Basin

The Lake Victoria South Basin lies in the counties of Kisumu, Kericho, Bomet, Homabay, Migori, Kisii and Nyamira with a catchment area of about 26,900 km2. It comprises four main rivers – Nyando, Sondu, Kuja, Gucha-Migori and Mara which drain into Lake Victoria. The Mara River is a transboundary water resource shared between Kenya and Tanzania. Majority of these rivers originate from the Mau Forest Complex. The basin receives relatively high precipitation with an annual mean of 1,316 mm. Distribution of the rivers in the Basin (Figure 5)

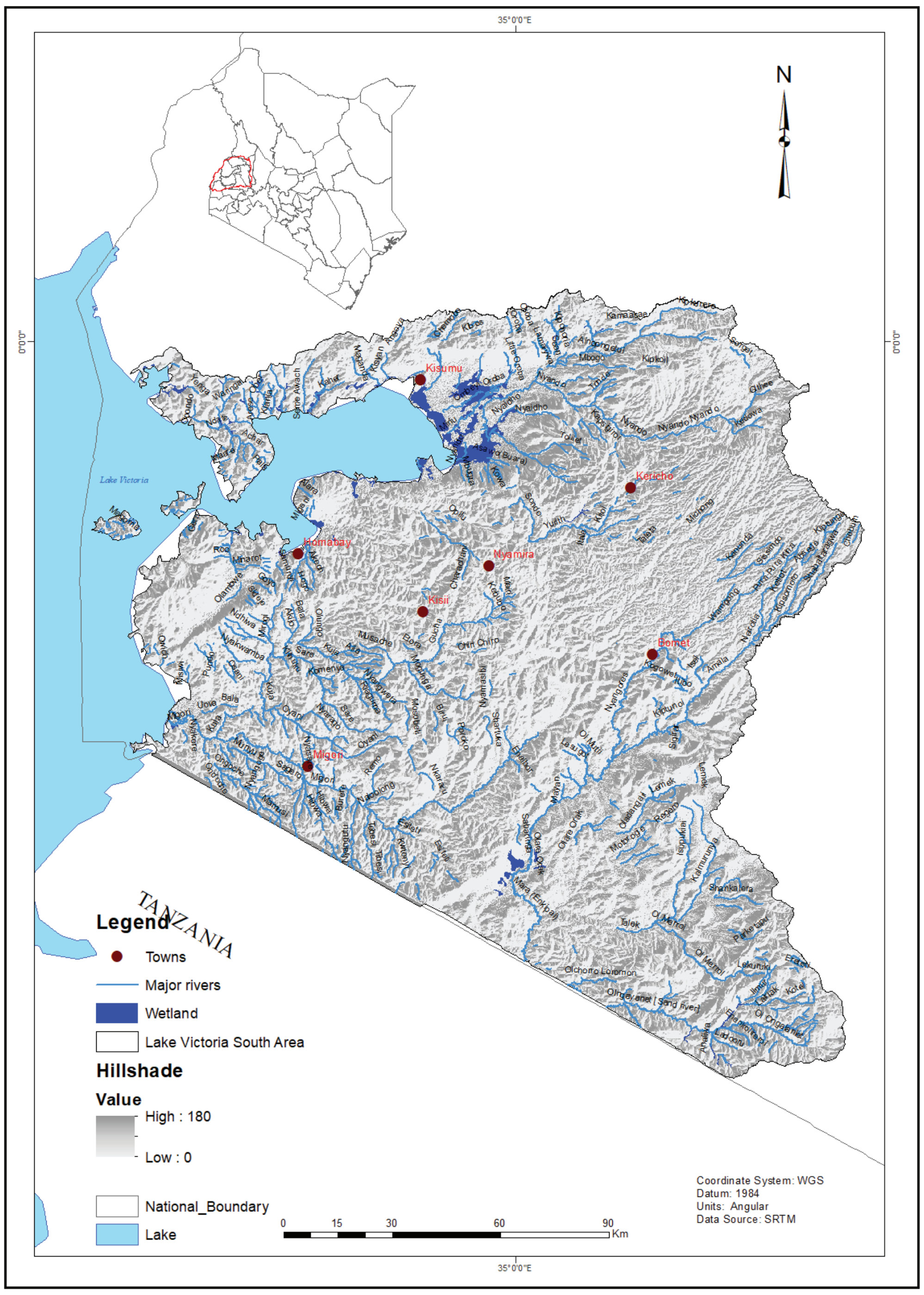

Figure 5: The river systems in Lake Victoria South Basin Area

Rivers of Lake Victoria North

The basin covers Siaya, Busia, Vihiga, Kakamega, Nandi, Bungoma, Uasin Gishu and Trans Nzoia counties with an area of 18,374 km2(National Environment Management Authority [NEMA], 2021). . The basin has four major rivers – Nzoia, Yala, Sio and Malakisi with R. Nzoia constituting about 70% catchment area. Notably, R. Sio and, R. Malakisi are Transboundary Rivers that flow through the Kenyan border into Uganda before draining into the Lake Victoria. The Mt. Elgon, Cherangani Hills and Nandi Escarpments form the main sources of the key rivers in the basin. The basin receives relatively high precipitation with the mean annual precipitation varying between about 1,000 mm to 1,900 mm. Figure 6 illustrates the drainage system of the Lake Victoria North Basin Area.

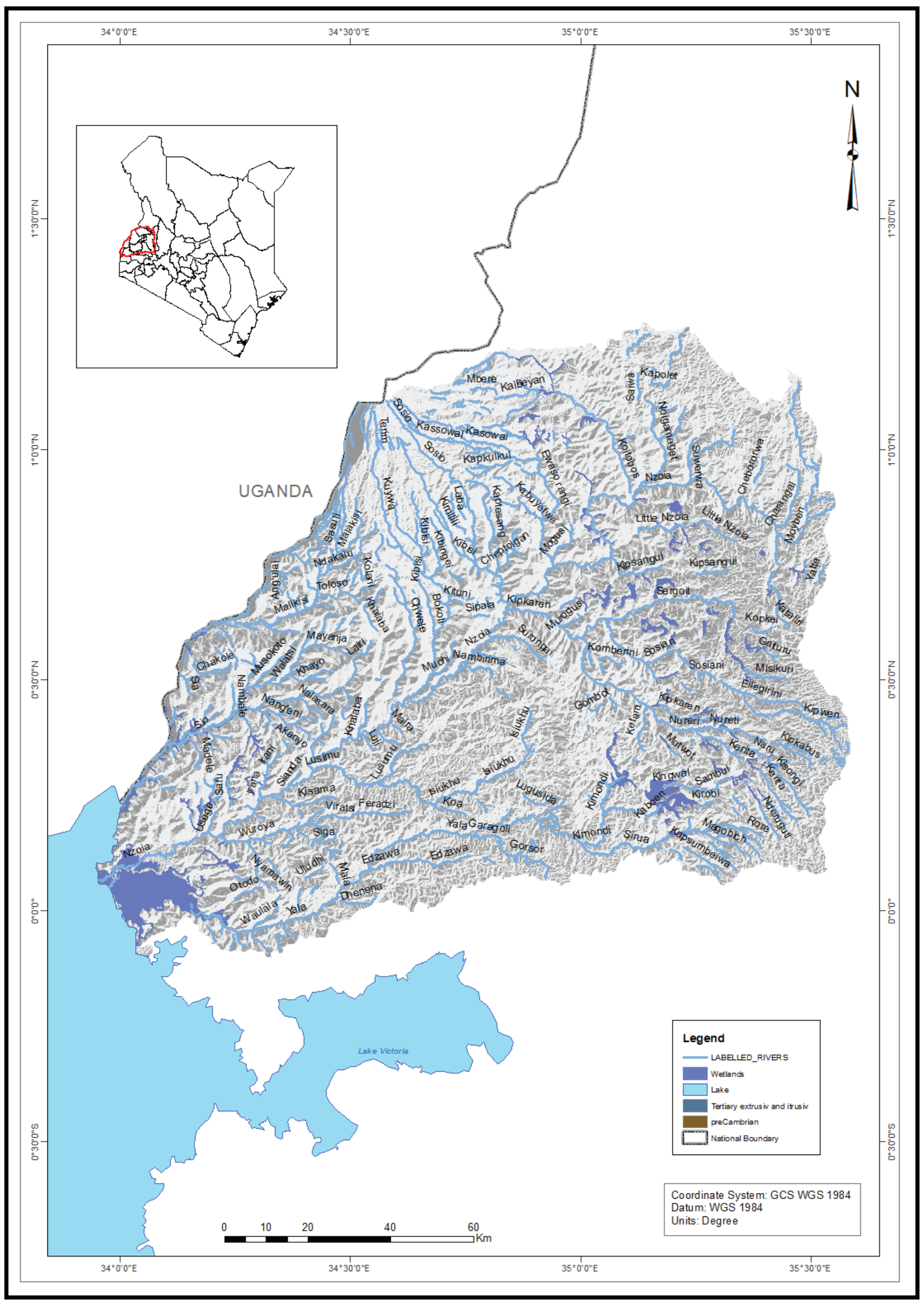

Figure 6: Drainage system of the L. Victoria North Basin Area

Rivers of Rift Valley Basin

Rift Valley Basin covers an area of 130,452 km^2 and borders South Sudan and Ethiopia in the north and Tanzania in the south. Its main rivers include Kerio, Turkwel (**Plate 2**), Ewaso Nyiro South, Molo and Perkerra among others (Figure 7). The rivers largely originate from Cherangani Hills, Mau Forest and the Aberdare Ranges. The northern part of the basin is generally arid land, forming one of the driest parts of the country. The mean annual precipitation varies from below 300 mm in the North to about 1,200 mm in the central areas. Administratively, the basin covers Narok, Nakuru, Baringo, Turkana, Nyandarua, West Pokot and Elgeyo Marakwet counties.

Plate 2: River Turkwel flowing up to Lake Turkana [photo courtesy of WRA, 2016]

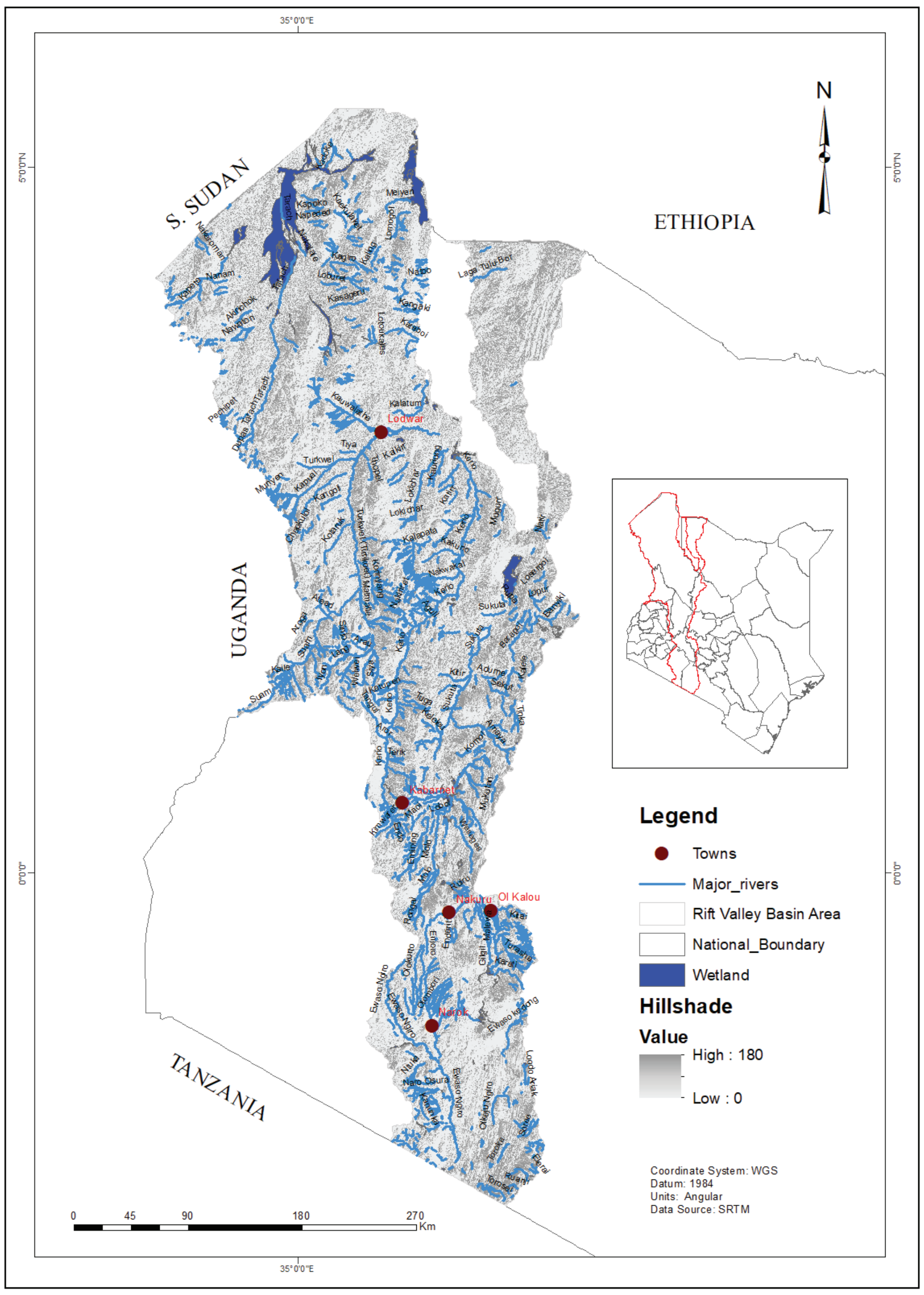

Figure 7: The drainage system of the Rift Valley Basin Area

Athi Basin Area

The Athi Basin has an area of 66,559 km^2 and hosts two most populated cities in the country – Nairobi and Mombasa. The basin is drained mainly by Athi-Galana-Sabaki River which drains about 57% of the basin. Additionally, it has two transboundary rivers i.e. R.Umba flows into the basin from the Usambara Mountains in Tanzania and R. Lumi which flows across the border into Tanzania. The river systems in the basin are shown in Figure 8. The basin receives a mean annual precipitation of 749 mm across the basin which varies between less than 500 mm to 1,400 mm. Administratively, the basin covers Kiambu, Nairobi, Machakos, Kajiado, Makueni, Taita Taveta, Kwale, Kilifi and Mombasa counties. Discharges of selected rivers in the basin are illustrated in Table 2.

Table 2: *Flow of selected rivers in Athi Basin Area at selected monitoring stations*

Station	2021 average (m3s-1)	Long Term Mean (m3s-1)	Maximum Recorded Value (m3s-1)	Minimum Recorded Value (m3s-1)
Athi (3DA2)	14.2	11.5	43.013	2.556
Ndarugu (3CB5)	2.223	1.686	7.671	0.004
Thiririka (3BD5)	1.62	1.197	6.549	0.025
Ruiru (3BC 8)	4.65	2.935	15.407	0.449
Kamiti (3BB12)	0.572	0.449	2.5	0.047
Athi Wamunyu (3DB01)	-	26.98	10.3	-
Umani Springs (3F04)	0.136	0.1745	0.9	0.6

Tana Basin Area

The Tana Basin drains an area of 126,208km2 with R. Tana River which constitutes the main river being the longest river in the country and drains 76% of the basin. The rivers originate mainly from the slopes of Aberdare ranges and Mt. Kenya. Some smaller rivers in the north-eastern part of the basin drain to Somalia. The precipitation in the area varies significantly with the mean annual precipitation ranging from less than 450 mm in the North-East to 1,900 in the highland areas. The Basin covers Muranga, Nyeri, Meru, Embu, Lamu, Kirinyaga, Kitui, Tana River, Tharaka Nithi and Garissa counties. The major rivers in the basin are shown in Fi 9 and flow trend (Table 3).

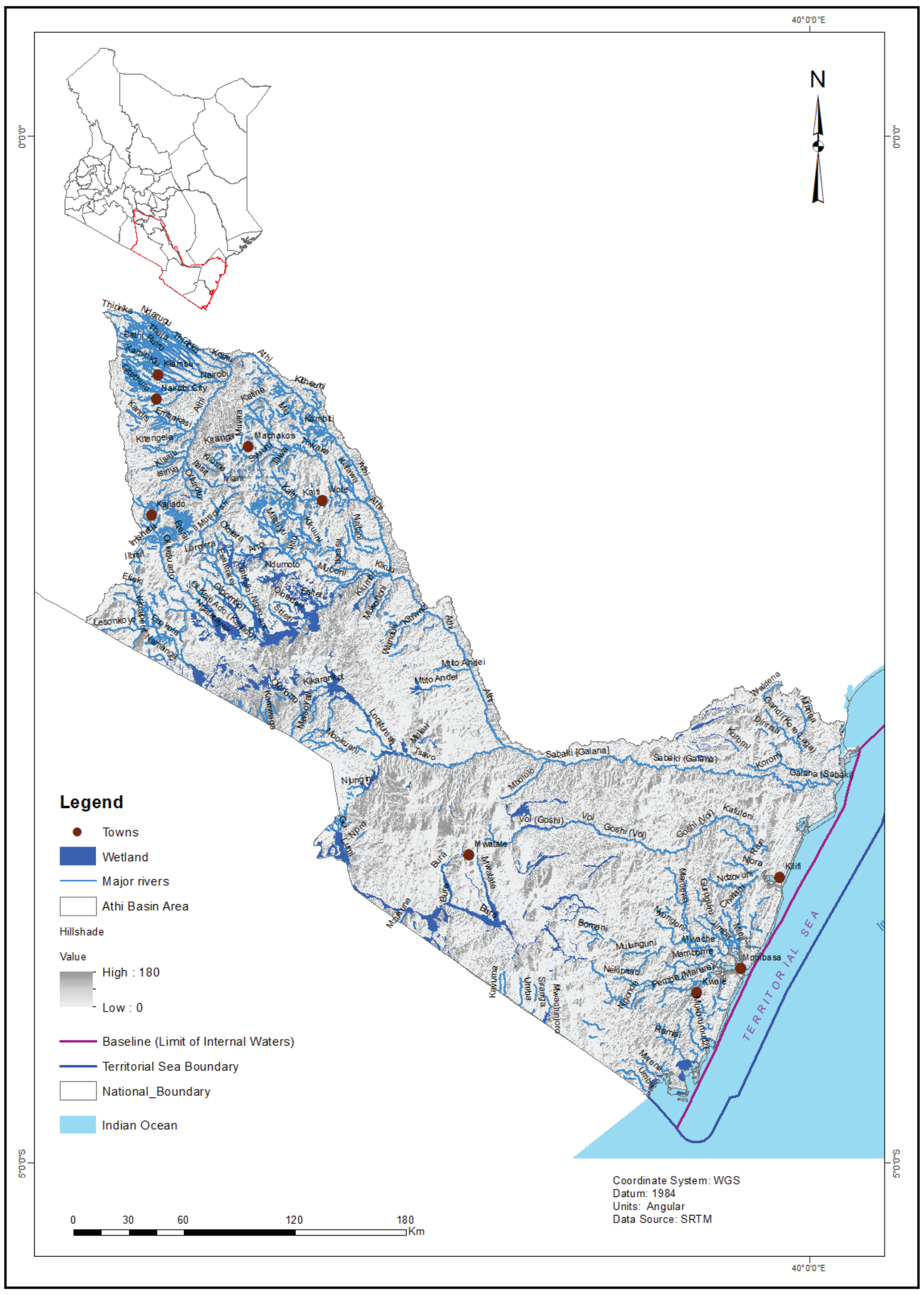

Figure 8: Drainage system of the Athi Basin

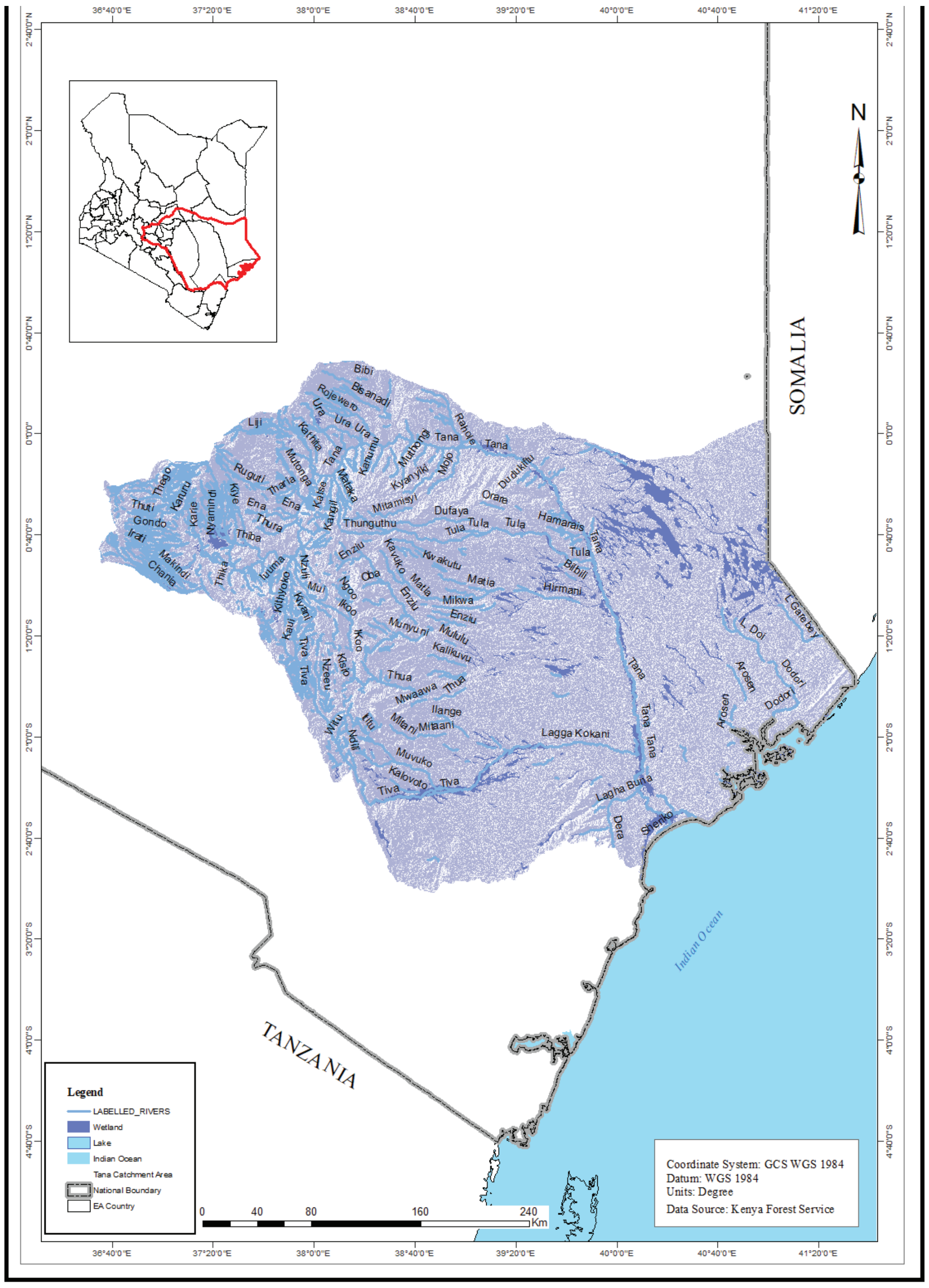

Figure 9: The drainage system of the Tana Basin Area

Table 3: *Long term trends water discharge for rivers in Tana Basin*

Station	Mean for Year 2021 (m3/s)	Long Term Mean (m3/s)	Maximum Recorded Value
Kapingazi(4DCII)	0.3849	0.317	0.3849
Rupingazi(DC03)	-	1.5708	2.5633
Kamweti(DA14)	0.6469	112,609	3.388
Thiba(DD02)	-	10.4165	25.179

Rivers of Ewaso Ng'iro North Basin

Ewaso Ng'iro North Basin constitutes the largest basin by land mass with an area of 210,000 km2, and is largely arid and semi-arid. Administratively, the basin covers Laikipia, Samburu, Isiolo, Mandera, Marsabit and Wajir counties. Its largest river –Ewaso Ng'iro forms about 39% of the basin. It has its source waters in Mount Kenya and flows across the border to eventually join the Jubba River in Somalia. The Daua River drains the north-eastern tip of the basin, and originates in the Ethiopian highlands. The average mean annual precipitation is approximately 430 mm across the basin but varies less than 300 to about 1,100 mm, which is considered low precipitation, hence majority of the rivers in the basin are seasonal. Fig 10 shows the major river systems in the basin.

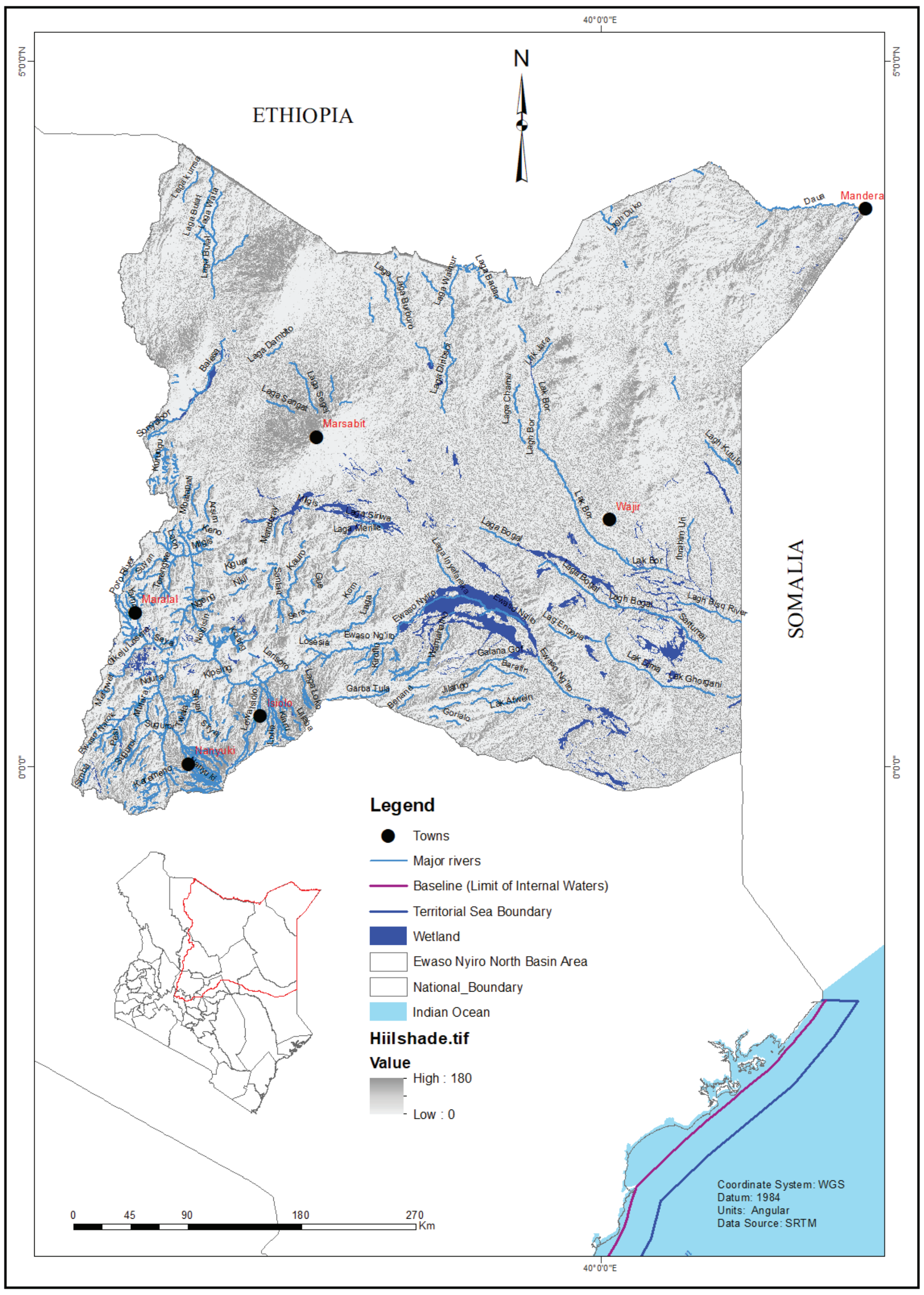

Figure 10: The drainage system of the Ewaso Ng'iro Basin Area

Lakes and Reservoirs in Kenya

Kenya is endowed with several lakes some of which are transboundary (e.g. L. Victoria). Globally, lakes are classified based on their origin, size, water quality, productivity (trophic levels), mixing of water and nature of inflow-outflow. Generally, the Kenyan lakes is estimated to cover a surface area of about 12,341 km2, 63% of which is salty (Table 4). In this Atlas, the lakes have been categorized into three main classes based on size i.e. Large (>100 km2), medium (1- 100 km2) and small (<1 km2) while water quality is categorized as either freshwater or Saline-Alkaline.

Table 4: *Freshwater and Salty Lakes of Kenya*

Category by Size	Surface Area (km2)	Freshwater (km2)	Saline-alkaline (km2)
Large	12,157	4,438	7,719
Medium	179.64	84.44	95.2
Small	5.09	4.16	0.93
Total	12,341.73	4,527	7,815

Large lakes

Seven lakes can be categorized as the large lakes (Table 5).

Table 5: *Large lakes*

Station	2021 average (m3s-1)	Long Term Mean (m3s-1)	Maximum Recorded Value (m3s-1)	Minimum Recorded Value (m3s-1)
Athi (3DA2)	14.2	11.5	43.013	2.556
Ndarugu (3CB5)	2.223	1.686	7.671	0.004
Thiririka (3BD5)	1.62	1.197	6.549	0.025
Ruiru (3BC 8)	4.65	2.935	15.407	0.449
Kamiti (3BB12)	0.572	0.449	2.5	0.047
Athi Wamunyu (3DB01)	-	26.98	10.3	-
Umani Springs (3F04)	0.136	0.1745	0.9	0.6

Medium Lakes

Twelve lakes are categorized as medium (Table 6).

Table 6: *Medium Lakes*

Name of lake	Basin	County	Surface Area (km2)	Quality
Nakuru	Rift Valley	Nakuru	40	Saline-alkaline
Olbolosat	Ewaso Ng'iro North	Nyandarua	43.3	Freshwater
Simbi Nyaima	Lake Victoria South	Homabay	3	Saline-alkaline
Kanyaboli	Lake Victoria North	Siaya	15	Freshwater
Lake Bob	Lake Victoria North	Siaya	2	Freshwater
Sare	Lake Victoria North	Siaya	5	Freshwater
Solai	Rift Valley	Nakuru	10	Saline-alkaline
Lake Lokipi	Rift Valley	Turkana	18	saline-alkaline
Elementaita	Rift Valley	Nakuru	20	Saline-alkaline
Lake Oloiden	Rift Valley	Nakuru	5	Freshwater
Lake Challa	Athi	Taita-Taveta	4.2	Saline-alkaline
Namboyo	Lake Victoria North	Siaya	14.14	Freshwater

Small lakes

Seventeen lakes can be classified as small (Table 7).

Table 7: *Small lakes*

Name	Basin	County	Surface Area (km2)	Quality
Lake Kamnarok	Rift Valley	Baringo	1	Freshwater
Lake 94	Rift Valley	Nakuru	0.3	Freshwater
Lake Sonachi	Rift Valley	Nakuru	0.3	Freshwater
Sokorte Dika	Tana Basin	Marsabit	0.24	Alkaline-saline
Amboseli	Tana Basin	Kajiado	0.13	Alkaline saline-
Shaka babo	Tana Basin	Tana River	0.24	Freshwater
Moa	Athi	Lamu	1	Fresh water
Lake Alice	Athi	Meru	0.2	Freshwater
Lake Michaelson	Athi	Meru	0.1	Freshwater
Lake Ellis	Athi	Meru	0.1	Freshwater
Lake Rutundu	Athi	Meru	0.1	Freshwater
Lake Nkunga (Sacred Heart)	Athi	Meru	0.39	Freshwater
Lake Narasha (Timboroa)	Rift Valley	Uasin Gishu	0.23	Freshwater
Lake Paradise	Ewaso Ng'iro North	Marsabit	0.56	
Lake Hotinel	Ewaso Ng'iro North	Meru	0.08	Freshwater
Lake Carr	Ewaso Ng'iro North	Meru	0.08	Freshwater
Lake Enchanted	Ewaso Ng'iro North	Meru	0.04	Freshwater

Profiles of selected rivers

Lake Victoria

Lake Victoria (Plate 3) is the largest tropical lake and second largest freshwater lake in the world with an estimated area of 68,000 km2 out of which 6% is in Kenya(Miriti, n.d.). Formed in the late Pleistocene (ca. 400,000 years ago but dried before refilling again 15,000 years ago (Johnson et al., 2000, Talbot & Laerdal 2000), the lake stretches 412 km from north to south and 355 km from west to east(Awange, 2020).. It is shared by three countries – Kenya, Uganda and Tanzania. Its over 193,000 km2 catchment covers Rwanda and Burundi(Awange, 2020).. The lake depression is 1,134 masl, between the west and east African rifts and its water balance is maintained by rainfall and evaporation rather than the inflows and outflows, (Spigel & Coulter 1996). The lake's residence time is 23 years (Cohen et al. 1996; Spigel & Coulter 1996).

More than 30 million people depend on the lake Basin ecosystem for their livelihoods which 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(Awange, 2006).. The Lake, its tributaries and related wetlands comprise an ecosystem with extraordinary biodiversity and ecosystem service values.

Plate 3: Lake Victoria (Anita Ritenour/Flickr0)

Lake Baringo

The lake is located in the Eastern Rift Valley and is one of the seven inland drainage lakes within the Rift Valley drainage basin. The lake has a surface area of about 100 km2 and a total drainage area of about 6,820 km2 (Plate 4)

Plate 4: Lake Baringo

Lake Nakuru

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

Plate 5: Lake Nakuru panoramic from Baboon Cliff (Source)

Plate 6: Lake Paradise - one of the beautiful crater lakes in Marsabit National Reserve
Photo courtesy of F. King Tours and Safaris - Day Tours

Reservoirs and Dams

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

In Kenya, dams and reservoirs have been developed in different regions for various uses including hydropower generation, irrigation, domestic and industrial water supply. There are about 3,050 reservoirs (dams) in Kenya majority (40%) of which are in Athi Basin Area (Table 8). Nine of major reservoirs provide the bulk (7,847 MCM) of the stored water. These major reservoirs are located in Tana Basin Area. The major reservoirs include Gitaru, Kiambere, Kiamburu, Kindaruma, Masinga, Mutonga, Thika/Ndakaini (all in TBA), Moiben and Luanda within Lake Victoria North Basin Area. The national distribution of dams /reservoirs in the country (Fig 11).

Table 8: *Distribution of dams in Kenya*

S/No.	Region	No.of dams	Class C	Class B	Class A
1.	Tana	164	10	15	20
2	Athi	1,209	13	43	75
3	Ewaso Ng'iro North	605	1	10	46
4	Lake Victoria South	451	5	2	16
5	Rift-valley	359	9	21	52
6	Lake Victoria North	262	3	12	10
	Total	3,050	41	103	219

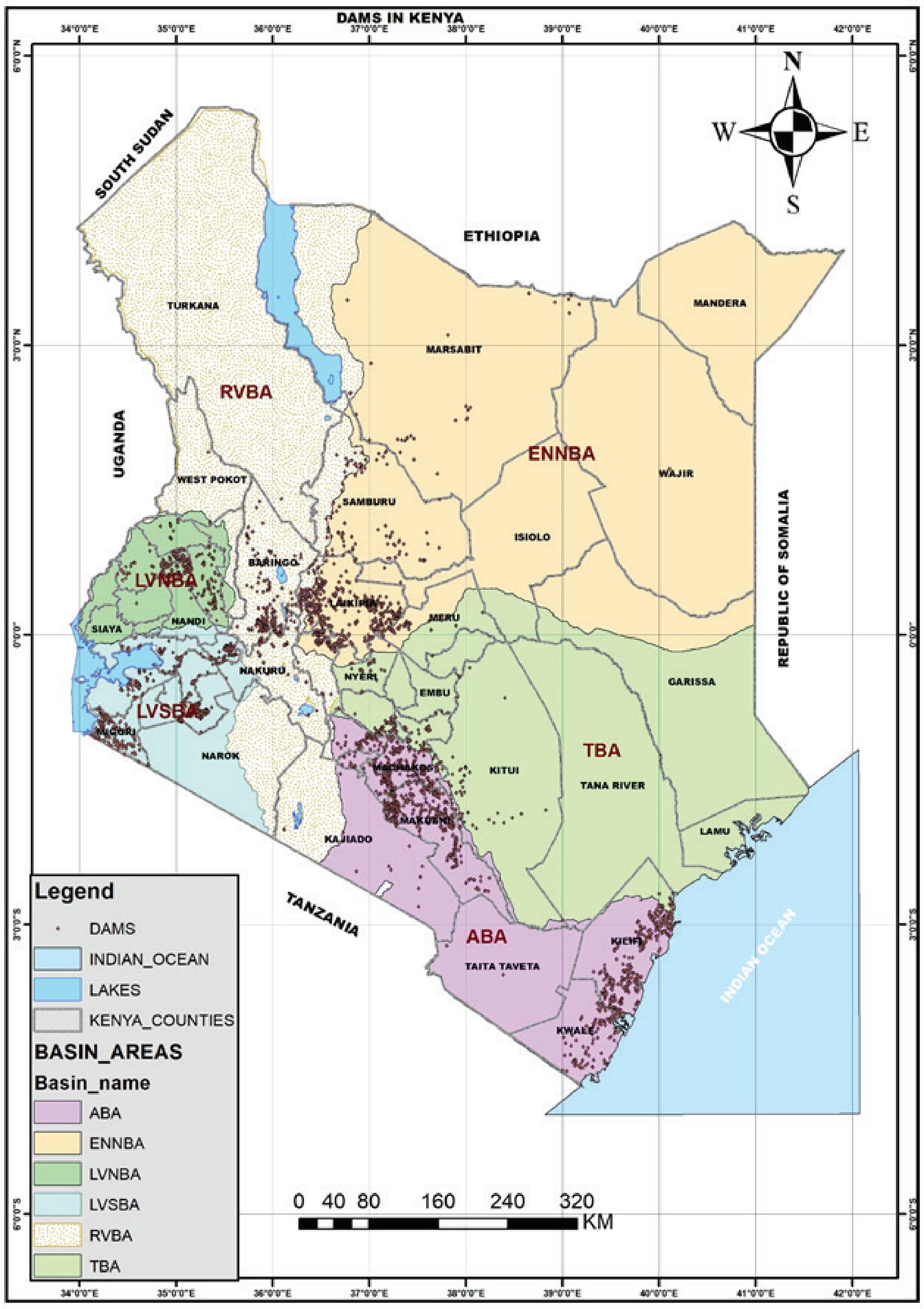

Figure 11: National distribution of dams (reservoirs) in the country

On matters pertaining dam utilization, the domestic use constitutes the highest (56%) use of the reservoirs while Hydropower & conservation, flood control and industrial use constitute both 1% (Fig. 12).

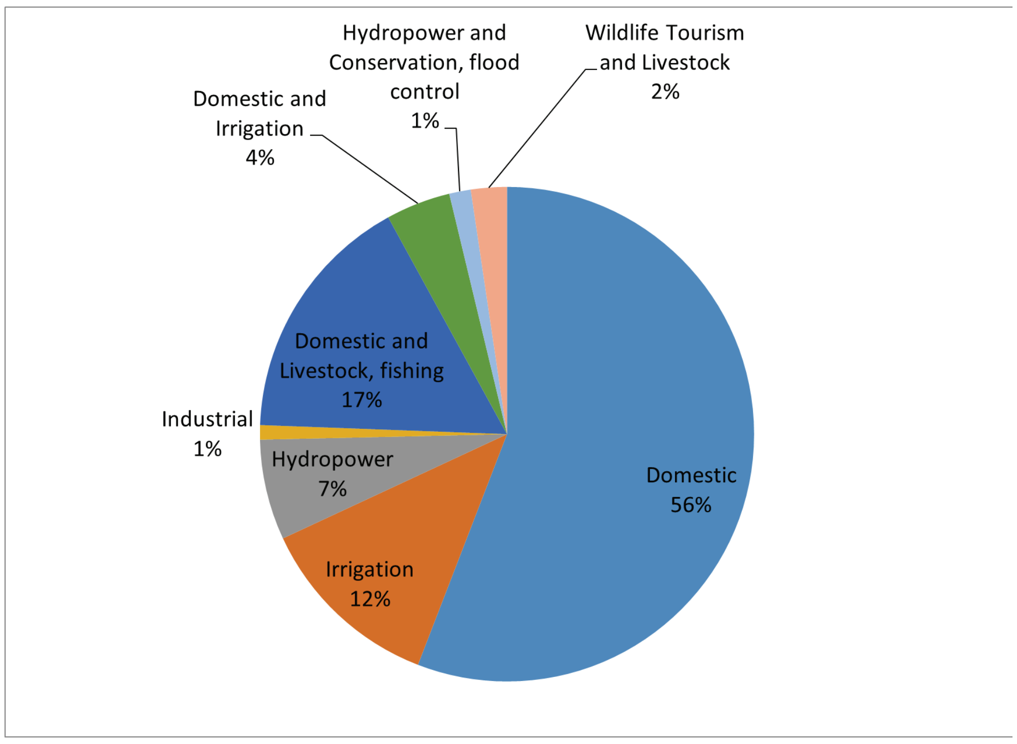

Figure 12: Non consumptive and consumptive use of the reservoirs.

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.

Groundwater Resources

Groundwater resources provide important water sources for both human consumption and environmental sustainability. The country has significant quantity of groundwater resources that is spread across different aquifers. The groundwater occurrence is determined by several factors including geological formations and climatic conditions, especially areas with predominantly pervious rocks and high precipitation are likely to have higher groundwater potential. Notably, groundwater available for use is about 10% of the groundwater recharge.

General geology of Kenya

The country comprises three main geological formations – the volcanic, sedimentary and basement systems (Fig 13). The volcanic system is spread within the East African Rift system and covers about 27.9% of the country land mass. It mainly comprises Basalt rocks which constitutes more than 50%, tuffs, phonolites, trachytes, and agglomerates. Volcanic rock formation favour high groundwater potential particularly when coupled with weathering, fracture zones and old land surfaces between successive flows. On the other hand, sedimentary systems constitutes the largest (41.6%) formation covering Eastern Kenya from Somali in the North to Tanzania in the South with some pockets in Western and Northern regions. They are both consolidated and non-consolidated including limestones, sandstones, shales, and sands. Additionally, they manifest varied varying hydraulic properties and geometry with aquifer thickness ranging between 2 to 50 m. The Basement system occupies about 30.5% of the country and includes the Archean and the Proterozoic formations which are common in Western Kenya and eastern side of the Rift Valley, respectively. Although the Basement system is associated with poor aquifers which is a characteristic of metamorphic rocks, areas with weathered and fractured zones, within the alluvial deposits controlled by drainage channels, and experiences high precipitation have good groundwater potential.

Classification of Kenya's ground water aquifers

The Kenyan aquifers are classified into five classes relative to their yields and national importance they include: strategic, major, minor, poor and special aquifers.

a. Strategic aquifers are used to supply significant amounts/proportions of water to an area where there are no alternatives, or where alternatives would take time and money to develop
b. Major aquifers are high-yielding aquifers with good quality water
c. Minor aquifers are moderate-yielding aquifers with variable water quality
d. Poor aquifers are low-yielding aquifers with poor to reasonable quality water
e. Special aquifers are aquifers or parts of aquifers designated 'special aquifers' by the WRA

Each of the classes are further defined in terms of its status (level of pressure, stress and threat). Three levels of status comprising of:

a. Satisfactory: no immediate stress, pressure or threat
b. Alert: stress, pressure or threat identified or anticipated
c. Alarm: water levels declining, water quality declining (stress, pressure or threat identified)

The different classes of aquifers and characterization (Fig 14 and Table 9) respectively. Notably, at least four aquifers are at an 'alarm' status while majority are at the 'alert' status.

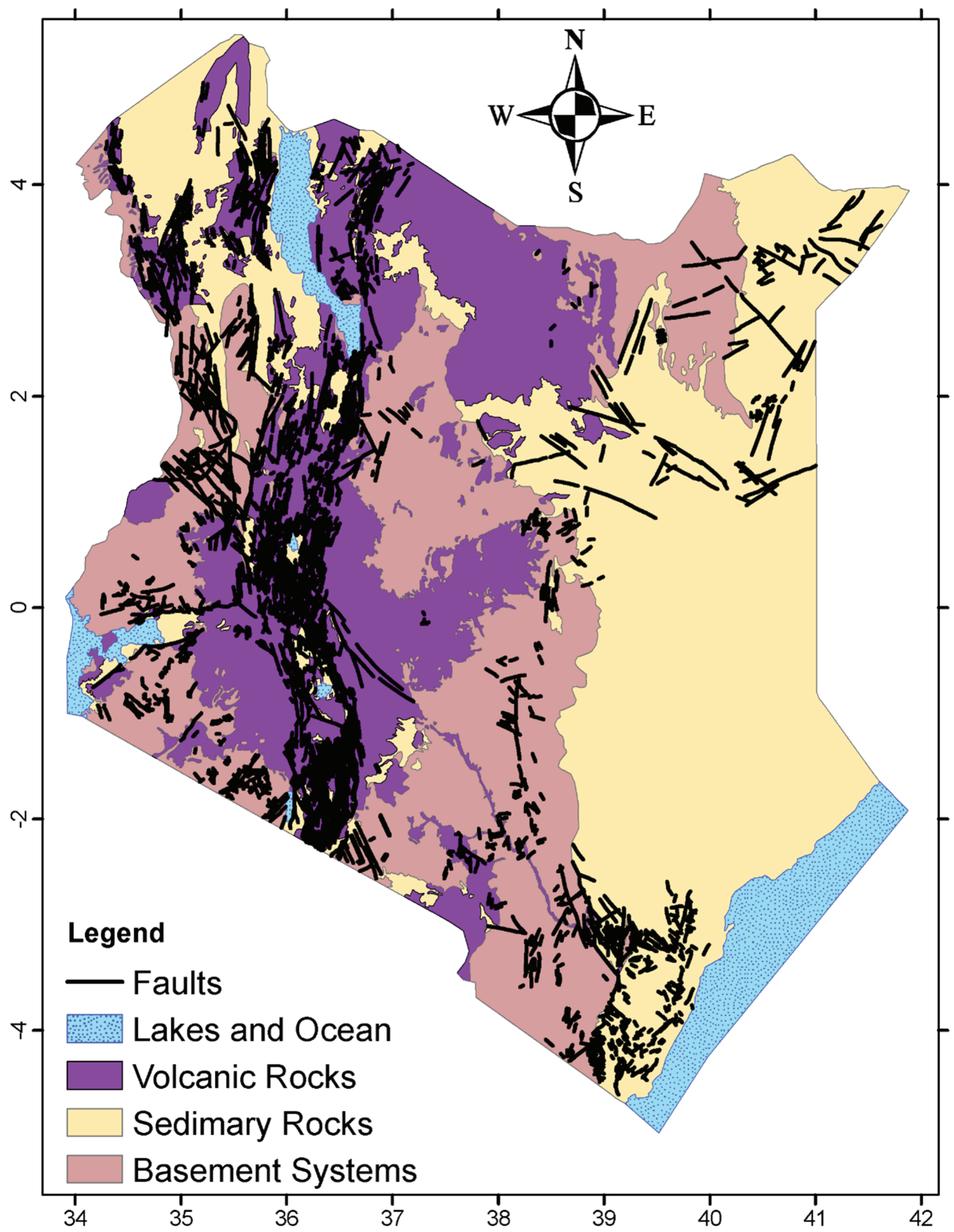

Figure 13: Simplified geology map of Kenya

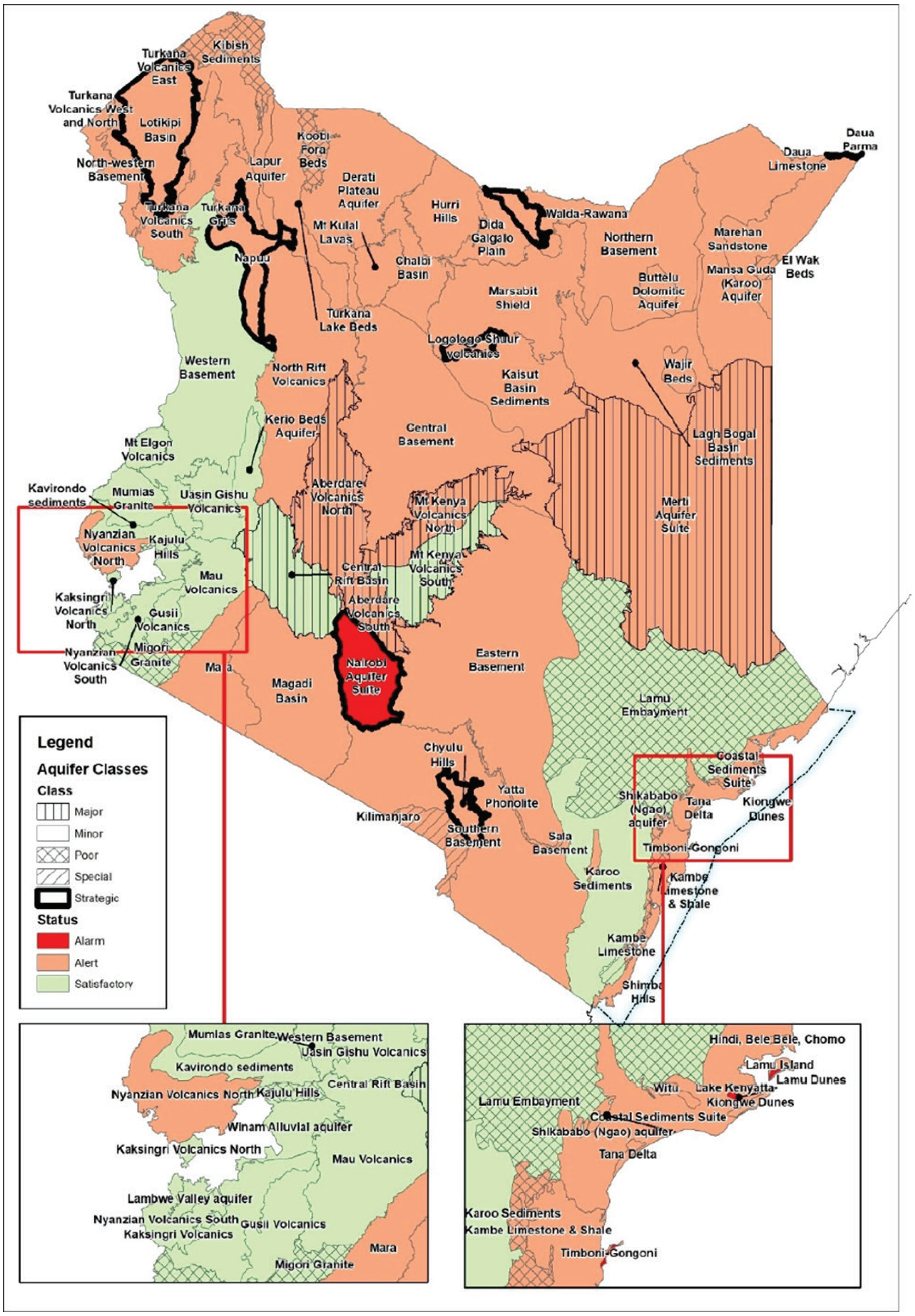

Figure 14: Map of Kenyan aquifers

Table 9: *Kenya Aquifers characterization*

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Mt Kenya Volcanics North	ENN	Comprise the Mt Kenya Volcanics and the Nyambene Volcanics which occur in the northern side of the aquifer. The Mt Kenya Volcanics on the northern side comprise mugearites, phonolites, basalts and trachytic tuffs. These units are interspersed by mudflows and lahars and other volcanic sediments. The Mt Kenya volcanics have a Pleistocene sedimentary member-- the Nanyuki Formation, which consists of sands, gravels and reworked tuff sediments. The Nyambeni Volcanics are chiefly olivine basalts and mugearites intercalated with basaltic agglomerates, volcanic breccias and lapilli-tuffs.	40- 120	Good to high (> 240 m3/ day)	NaHCO3; fresh water (EC<800 µS/cm)	Alert
Aberdare Volcanics South	ENN	The Aberdares volcanics comprise Miocene Simbara basalts in the upper reaches of the aquifer, known as Samburu basalts in the lower reaches. The aquifer has 3 lithologic provinces. On its upper reaches a thin layer of Pleistocene non-porphyritic basalts overlie the main Simbara series porphyritic basalts. A shallow inter-volcanic aquifer results. Within the Laikipia Plateau the aquifers are multi-layered, with two, sometimes three aquifers. On the western edge dropping into the Laikipia Escarpment a deeper aquifer exists, attributed to the fault swarms that transmit groundwater to deeper levels.	Simbara basalts aquifer < 100; Laikipia Plateau aquifers: 50-100 and up to 200; Laikipia escarpment: >250	Moderate to good (> 86)	NaHCO3; fresh water with variable fluoride (<0.5 to >5 mg/l)	Alert

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Aberdare Volcanics South	ENN	The Aberdares volcanics comprise Miocene Simbara basalts in the upper reaches of the aquifer, known as Samburu basalts in the lower reaches. The aquifer has 3 lithologic provinces. On its upper reaches a thin layer of Pleistocene non-porphyritic basalts overlie the main Simbara series porphyritic basalts. A shallow inter-volcanic aquifer results. Within the Laikipia Plateau the aquifers are multi-layered, with two, sometimes three aquifers. On the western edge dropping into the Laikipia Escarpment a deeper aquifer exists, attributed to the fault swarms that transmit groundwater to deeper levels.	Simbara basalts aquifer < 100; Laikipia Plateau aquifers: 50-100 and up to 200; Laikipia escarpment: >250	Moderate to good (> 86)	NaHCO3; fresh water with variable fluoride (<0.5 to >5 mg/l)	Alert
Merti Aquifer Suite	ENN	The Merti Beds Suite comprises Pliocene sediment aquifers of varying lithology and water quality. The sediments include coarse-textured continental fluvial to marine deposits, essentially sands, gravels, sandstone and conglomerates, interlayered with fine sediments. The Merti beds are at least 180m thick within the aquifer domain. The Central Merti Beds aquifer occurs along the Lorian Swamp-Lagh Dera axis along the centre of the sedimentary basin. It has coarser sediments and fresh water. Farther out (North and South Merti), the granulometry is finer and the sediments have more silt and clay content and very poor water quality.	<120 in Northern and Southern Merti; <180 in Central Merti	<240	EC<3000 ÂµS/cm in central Merti; fresh to brackish; EC>3000 in northern and southern Merti; brackish to saline	Alert
Aberdare Volcanics North	RV	The Aberdare volcanics comprise Miocene Simbara basalts in the upper reaches of the aquifer, known as Samburu basalts in the lower reaches, overlaid by Rumuruti phonolites.	Multi-layer, 50-200; 250 near rift escarpment	<240	EC<1000 ÂµS/cm	Alert
Central Rift Basin	RV	Central Rift Basin aquifer discharges into the Lake Bogoria, with local base levels and lakes Nakuru, Elmenteita and Naivasha. Dominant rock types include Tertiary phonolites and Quaternary basalts, trachytes, tuffs and pyroclastics	50-150; multi-layer	<240	EC<1500	Satisfactory
Mt Kenya Volcanics South	Tana	The uppermost units consist of ash accumulations, bedded deposits containing abundant lava and pumice inclusions of all sizes, with fragments of feldspars, nepheline and dark minerals, in a fine-grained matrix. These are underlain by micro porphyritic dark grey basalts, with sparse phenocrysts of deep green olivine. Older lavas consist of extensive flows of porphyritic phonolites that lie directly on Basement System gneisses. The phonolites are associated with bands of brecciated phonolite and phonolitic agglomerates and include kenyte, a glassy variety of porphyritic phonolite.	Multi-layered; at least two aquifers <120m	First aquifer<240; Second aquifer>240	EC<1500 ÂµS/cm	Satisfactory
Minor aquifers						
Coastal Sediments Suite	Athi	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Yatta Phonolite	Athi	The phonolite is a dense microcrystalline type with dark green to grey colours and porphyritic texture. It has a general thickness of 15m, occasionally thicker. It overlies a zone of en echelon faulting that was a precursor to the fissure eruptions that formed the lava flow. The elongated linear form of the Yatta Plateau is a direct result of erosion processes largely governed by fluctuating river action in geological periods when there was greater precipitation than at present. This evolution is noteworthy when looking for groundwater on the plateau.	<15	<86	EC<1500 ÂµS/cm	Alert
Sala Basement	Athi	Consists of gneiss, schists and granulites; metamorphosed psammitic and pelitic sediments; granitoid gneisses, with minor marble. The gneisses and schists are over 5000 meters thick. The country rock has a north-northwest regional strike, with a westerly dip of the foliation. Migmatites occur at a few locations presenting as biotite-hornblende banded and contorted gneiss.	<100	<86	EC>3000 ÂµS/cm	Alert
Coastal Sediments Suite	Athi	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Coastal Sediments Suite	Athi	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Southern Basement	Athi	Banded gneisses; Granitoid gneisses; Granulites, these being part of the Kurase-Kasigau group of metasediments. Mainly biotite-hornblende gneisses in the Kurase Group and quartz-felspar-biotite-hornblende gneiss in the Kasigau Group.	Generally <100m	<240	EC>3000 ÂµS/cm	Alert

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Coastal Sediments Suite	Athi	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Karoo Sediments	Athi	The suite comprises the Taru, Maji ya Chumvi and Mariakani formations. They comprise arkoses, sandstones, shales, and siltstones with minor conglomerates and limestones. Lithology od the Upper Taru Member is made up of arkoses, lacustrine shales and minor limestones. The Maji ya Chumvi Formation comprises 3 members in a sequence of lacustrine laminated shale, siltstone, and fine-grained sandstone overlain by a coarser lake-shoreline sandstone and minor shale/siltstone. The Mariakani Formation comprises a sequence of pale coloured, cross-bedded fluvial sandstones with shale/siltstone units, also in 3 members.	<100	<86	EC>3000 ÂµS/cm	Satisfactory
Daua Limestone	ENN	The Daua Limestone Series is divided into two groups- oolitic and non-oolitic. The former is represented by the Burmayo Limestones and the lower, non-oolitic are the Didimtu Beds. A thin marly horizon separates the two. Didimtu Beds overlie Basement rocks unconformably. The Burmayo Limestones are more varied in colour and nature of occurrence, with an estimated total thickness of the variants at 1,500m.	<100m in Didimtu Beds; >200m in Burmayo limestones	Low (<86)	High Cl-, low fluoride waters	Alert*
Daua Limestone	ENN	The Daua Limestone Series is divided into two groups- oolitic and non-oolitic. The former is represented by the Burmayo Limestones and the lower, non-oolitic are the Didimtu Beds. A thin marly horizon separates the two. Didimtu Beds overlie Basement rocks unconformably. The Burmayo Limestones are more varied in colour and nature of occurrence, with an estimated total thickness of the variants at 1,500m.	<100m in Didimtu Beds; >200m in Burmayo limestones	Low (<86)	High Cl-, low fluoride waters	Alert*
Hurri Hills	ENN	Quaternary basaltic lavas and pyroclastics form the central minor shield and are non-water bearing; the main shield-building volcanics are Tertiary-Quaternary flood lavas. The latter outcrop on the fringes and are the main aquifer unit in the area; the central Hurri Hills dome has no groundwater potential.	>200	Moderate (<240)	EC>1500	Alert*
Dida Galgalo Plain	ENN	Pleistocene olivine basalts that rest on the Basement System metamorphic rocks. Large thickness of the basalts laid on the Anza Graben continental sediments centred on the North Anza Basin.	>250	Moderate (<240)	Brackish; EC>2000 ÂµS/cm)	Alert*
Derati Plateau Aquifer	ENN	Fissure basalts of the Gombe Group and Hurran Hurra and the Bulal lavas; the Bulal lavas and the Gombe Group are plateau lavas erupted contemporaneously. The Bulal lavas are about 200m at theory thickest, with individual flow units attaining thickness of 60m. They have blocky bases and scoriaceous tops. The Gombe Group is also 200m thick, and have a thin, persistent sediment intercalation. In contrast, the Bulal lavas have no interbedded paleosols.	<100 in Gomber Group; 200 in the Bulal lavas	Moderate (<240m3/day)	EC>1000<3000 ÂµS/cm)	Alert*
Mansa Guda (Karoo) Aquifer	ENN	Mansa Guda Formation consists of sandstones, quartzites, grits and conglomerates of variable texture, belonging to the Karoo Series. It varies in thickness from as little as 6m to 600m.The lithological variations depending on the locality includes a sequence of grits, coarse conglomerates, quartzites, occasional fine-grained laminated sandstones; in places it comprises coarse sandstones and conglomerates.	<100	<86	Brackish (EC<3000 ÂµS/cm)	Alert*
Buttelu Dolomitic Aquifer	ENN	Crystalline limestones here are derived from metamorphism of calcareous sediments of varying composition. Initially highly dolomitic, differences in carbonate content, and non-calcareous impurities lead to a range of limestones including marble and impure types of various shades and texture.	<100m	Poor (<86)	CaHCO3; fresh hard water to brackish hard water	Alert
Marehan Sandstone	ENN	The Marehan Sandstone is the upper of the two members of the Marehan Series. Its lower member is the Danissa beds, composed of flaggy, fine-grained sandstones. The Marehan Sandstone consists of massive, cross-bedded, largely unfossiliferous sandstones, intercalated with flaggy sandstones and siltstones.	<120	<86	Brackish to saline (EC>3000 ÂµS/cm)	Alert*
Mt Kulal Lavas	ENN	The Kulal Shield comprises two main basalt units- Lower Kulal basalts and Upper Kulal basalts. The upper lavas are composed of coarsely porphyritic basalt.	<120	<240	EC<2000 ÂµS/cm	Alert*
Northern Basement	ENN	Varied lithology consists of granodiorites in the Moyale area, granites in Bamba Gurar- Malka Mari area and serpentine intrusives in the Dabel area. West of Moyale in the Sololo-Ambalo-Forole triangle the Northern Basement rock assemblage includes migmatites, biotite gneisses, biotite-hornblende gneisses and biotite-hornblende granites.	<100	<86	EC<3000 ÂµS/cm	Alert
Chalbi Basin	ENN	Up 200m of aeolian, lacustrine and alluvial deposits deposited since the Miocene under the Hedad Plain, resting on undifferentiated gneisses; toward the Chalbi playa, on the peripheral Karole Desert, scattered basalt-topped mesas are found.	<200	Low (<86)	Brackish; high Cl-	Alert*
Marsabit Shield	ENN	Comprises Late Miocene plateau basalts at the base, less than 30m thick, with individual flow units being 5-10m in thickness. They are strongly jointed, with scoriaceous bases and vesicular tops. Late Quaternary ultra-volcanism on Mt Marsabit resulted to maars with ash and cinder cones and thin olivine basalt flows building up to the total thickness of 1,200m.	<200	<240	Fresh (EC<2000 ÂµS/cm)	Alert*
Marsabit Shield	ENN	Comprises Late Miocene plateau basalts at the base, less than 30m thick, with individual flow units being 5-10m in thickness. They are strongly jointed, with scoriaceous bases and vesicular tops. Late Quaternary ultra-volcanism on Mt Marsabit resulted to maars with ash and cinder cones and thin olivine basalt flows building up to the total thickness of 1,200m.	<200	<240	Fresh (EC<2000 ÂµS/cm)	Alert*
Marehan Sandstone	ENN	The Marehan Sandstone is the upper of the two members of the Marehan Series. Its lower member is the Danissa beds, composed of flaggy, fine-grained sandstones. The Marehan Sandstone consists of massive, cross-bedded, largely unfossiliferous sandstones, intercalated with flaggy sandstones and siltstones.	<120	<86	Brackish to saline (EC>3000 ÂµS/cm)	Alert*

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Wajir Beds	ENN	The Wajir Beds are a succession of Pleistocene clays and sands, sandstone, impure limestone and gypsum. Limestone is a minor member, with gypsum and the sandstones being the thicker horizons. Sandstone layers consist of quartzitic or feldspathic sandstone cobbles and pebbles or partly indurated ferruginous sandstones.	<30	<86	Brackish (EC<3000 ÂµS/cm)	alert
Lagh Bogal Basin Sediments	ENN	The Lagh Bogal Basin is a subset of the Anza Graben and is filled with a complex sequence of sediments, deposited in diverse environments that range from shallow to deep marine, continental-fluvial, wind-blown and lacustrine.	200-250	<86	Brackish to saline, EC > 2,000; in places >10,000 ÂµS/cm	Alert*
Kaisut Basin Sediments	ENN	The basin is infilled with Quaternary and Tertiary sediments; sands or sandstones overlying alternating of deposits of silty and sandy clay, with recurring shale horizons.	<100	Low (<86)	EC>3000	Alert*
Central Basement	ENN	Basement rocks in the Samburu-Marsabit area comprises basal Mukogodo migmatites unconformably overlain by metasediments, including banded gneisses, meta-arkoses, meta-quartzites and manganiferous sandstones. The southern end of the Ol Donyo Lenkeyio Shear Zone is generally a non-aquifer area; except in areas where there is a thin volcanic layer over the Basement, there is just one aquifer unit. Occasional deeper aquifers occur in faulted and fractured zones but not exceeding 100m deep.	30-60	Low (<86)	Fresh; temporary hardness; Fl- < 3 mg/l	Alert
Western Basement	LVN	The Basement System rocks here do not show the diversity of high-grade regional metamorphic types, which characterize other areas of Basement System rocks in Kenya. They consist of schists, gneisses and migmatites derived from an original sedimentary succession, which has been transformed by regional metamorphism and recrystallization. Originally pure quartzose sandstones occur as granular quartzites, with small amounts of muscovite, and originally less pure sandstones are now represented by quartz-mica schists. Granitic sheet and vein intrusions and pegmatite veins are common. Some degree of granitization has affected all the Basement System rocks of the area, with the exception of the quartzites and related rocks.	<60	<86	Ec<1,500 ÂµS/cm	Satisfactory
Mumias Granite	LVN	The granite is an intrusive body into the rocks of the Kavirondian System and appears to be one large batholith. There are two types â€“ a finer-grained leucocratic type and the normal coarse-grained type. It lacks the strong vertical jointing of the Maroli Granite	<30	<86	Ec<1500 Âµs/cm	Satisfactory
Mumias Granite	LVN	The granite is an intrusive body into the rocks of the Kavirondian System and appears to be one large batholith. There are two types â€“ a finer-grained leucocratic type and the normal coarse-grained type. It lacks the strong vertical jointing of the Maroli Granite	<30	<86	Ec<1500 Âµs/cm	Satisfactory
Mt Elgon Volcanics	LVN	This aquifer consists almost entirely of agglomerate and breccia of which the main constituent is a mela-nephelinite lava. They have a phonolitic appearance due to the dark colour and the nepheline laths. Minor fine-grained tuffaceous bands occur. The agglomerate is largely uniform in appearance, containing boulders of various size. The rocks are horizontally bedded, perhaps reflecting the depositional nature of the volcanics, rather than lava flows	<100	<86	EC<1500 ÂµS/cm	Satisfactory
Mumias Granite	LVN	The granite is an intrusive body into the rocks of the Kavirondian System and appears to be one large batholith. There are two types â€“ a finer-grained leucocratic type and the normal coarse-grained type. It lacks the strong vertical jointing of the Maroli Granite	<30	<86	Ec<1500 Âµs/cm	Satisfactory
Western Basement	LVN	The Basement System rocks here do not show the diversity of high-grade regional metamorphic types, which characterize other areas of Basement System rocks in Kenya. They consist of schists, gneisses and migmatites derived from an original sedimentary succession, which has been transformed by regional metamorphism and recrystallization. Originally pure quartzose sandstones occur as granular quartzites, with small amounts of muscovite, and originally less pure sandstones are now represented by quartz-micaschists. Granitic sheet and vein intrusions and pegmatite veins are common. Some degree of granitization has affected all the Basement System rocks of the area, with the exception of the quartzites and related rocks.	<60	<86	Ec<1,500 ÂµS/cm	Satisfactory
Uasin Gishu Volcanics	LVN	The volcanic suite has a basal tuffaceous member comprising tuffs, tuffaceous grit and agglomeratic tuffs, overlaid by Lower and Upper Uasin Gishu Phonolites. These phonolites are somewhat similar to the Kapiti type. They are dense, black and heavy, with platy white felspar phenocrysts and yellowish rounded, resinous, nepheline phenocrysts. The lower of the two phonolites is distinguished by its sparsely porphyritic lava while upper contain abundant large nepheline and glassy feldspar phenocrysts.	50-100	<240	Varied; EC<1000 to EC>1500 ÂµS/cm	Satisfactory
Kavirondo sediments	LVN	The sediments consist of an Upper Division rich in feldspathic grits (arkose) with pebble bands containing slate at its base. The Middle Division has slates, rnudstones, and phyllites, with intercalated finer grits and siltstones. Its Lower Division is made up of conglomerates, breccias, siltstones, and feldspathic grits (arkose) containing pebble bands. The grits are highly angular being residuals from granite and other rocks rich in feldspar. The rocks suggest the rapid deposition in a large continental basin. The Lower Division has interstitial pyrite.	<30	<240	Ec<1500 Âµs/cm	Satisfactory
Nyanzian Volcanics North	LVS	The Nyanzian System is a suite comprising porphyritic andesites, andesitic tuffs, basalts, metabasalts with banded ironstones, rhyolites, greywackÃ©s and conglomerates. In the Nyanzian Volcanics North, the rhyolites and tuff are absent; porphyritic andestes are dominant, alongside basalts and dacite.	<50	<240	EC<1500ÂµS/cm	Alert
Kaksingri Volcanics North	LVS	Made up of the Kisingiri Volcanic Series that belongs to the Nyanzian System. They range from agglomerates and tuffaceous deposits to pyroclastics and reworked volcanic material. The reworked material and pyroclastics were deported as lake beds	<100	<240	EC<15000 ÂµS/cm	Satisfactory
Winam Alluvial aquifer	LVS	Medium to coarse grained alluvium from clastic sediments derived from hillwash of the Nyando Escarpment, silt and fine clayey alluvium in the lowest zones. Recent alluvial materials here consist of lateritised lava soils and red and grey soils.	<100	<240	EC<1500 ÂµS/cm	Satisfactory

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Lambwe Valley aquifer	LVS	Diatomitic lake beds, reworked volcanic sediments and alluvial deposited in the Lambwe Valley	<100	<240	EC<15000 ÂµS/cm	Satisfactory
Mau Volcanics	LVS	A volcanic succession of Kericho phonolites, phonolitic nephelinites and trachytic phonolites. The Kericho phonolites are the oldest member in the succession and make the main water-bearing unit in the Mau Volcanics. The series overlies undifferentiated Basement rocks and where a contact aquifer is encountered, it tends to be brackish.	Multi-layer; <100; <150; >200	<240	<1500 ÂµS/cm	Satisfactory
Kaksingri Volcanics	LVS	Made up of the Kisingiri Volcanic Series that belongs to the Nyanzian System. They range from agglomerates and tuffaceous deposits to pyroclastics and reworked volcanic material. The reworked material and pyroclastics were deported as lake beds	<100	<240	EC<15000 ÂµS/cm	Satisfactory
Nyanzian Volcanics South	LVS	The Nyanzian System is a suite comprising porphyritic andesites, andesitic tuffs, basalts, metabasalts with banded ironstones, rhyolites, greywackÃ©s and conglomerates. In the Nyanzian Volcanics North, the rhyolites and tuff are absent; porphyritic andestes are dominant, alongside basalts and dacite.	<50	<240	EC<1500ÂµS/cm	Satisfactory
Gusii Volcanics	LVS	Composed of rhyolitic tuffs with quartzites and cherts underneath; these rocks belong to the Bukoban System, which is characterised by a succession of basalts, quartzites and cherts. The latter tend to outcrop in valleys, while the higher areas are made up of rhyolites and rhyolitic tuffs.	<60	<240	EC<1500 ÂµS/cm	Satisfactory
Mara	LVS	The aquifer is a suite of volcanic and Basement rocks. The Basement rocks belong to the South-western Mozambican Belt System, which comprises gneisses, schists and amphiholites together with intercalated massive quartzites. The Tertiary volcanic rocks consist of phonolitic lava flows, being generally less than 60m thick and younger volcanic ashes and tuffs of Mau. Between the Mau Tuffs and the Mau Ashes, thin horizons of lapilli tuffs and agglomerates may be found.	Upper Mara- >200; Lower Mara-50-150	Upper Mara<240; Lower Mara>86	Upper Mara EC<1000 ÂµS/cm; Lower Mara EC<1500 ÂµS/cm	Alert
Turkana Volcanics North	RV	Olivine basalts are the bulk of the Turkana Volcanics West and North, with smaller outcrops in the east. They are coarsely porphyritic in texture and have relatively high resistance to weathering compared to the analcime basalts, which leads to steeper topography where they are found. The olivine basalts occasionally lie discordant with the older basalts, hence their contact is of interest to groundwater occurrence. There are occasional occurrences of andesites	>50	<240	EC<3000 ÂµS/cm	Alert
Lapur Aquifer	RV	A Jurassic sandstone aquifer (Lapur Sandstones) that underlie the younger volcanics. The sandstones are based out by Basement complex.	<50	<240	EC>1500 ÂµS/cm	Alert
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Turkana Volcanics West and North	RV	Olivine basalts are the bulk of the Turkana Volcanics West and North, with smaller outcrops in the east. They are coarsely porphyritic in texture and have relatively high resistance to weathering compared to the analcime basalts, which leads to steeper topography where they are found. The olivine basalts occasionally lie discordant with the older basalts, hence their contact is of interest to groundwater occurrence. There are occasional occurrences of andesites	>50	<240	EC<3000 ÂµS/cm	Alert
Nakalale and Gatome	RV	The composition of the sediments suggests that they are derived from Turkana Grits. Superficial sediments consist of sandy mixed sediments, with rounded pebbles and reworked volcanic sediments, lava fragments. In certain areas nodular pea-sized kunkar limestone of varying shades of off-white have developed.	<50	<86	EC>3000 ÂµS/cm	Alert
Nakalale and Gatome	RV	The composition of the sediments suggests that they are derived from Turkana Grits. Superficial sediments consist of sandy mixed sediments, with rounded pebbles and reworked volcanic sediments, lava fragments. In certain areas nodular pea-sized kunkar limestone of varying shades of off-white have developed.	<50	<86	EC>3000 ÂµS/cm	Alert
Turkana Volcanics East	RV	These are Tertiary volcanics, which include, in succession, augite and analcime basalts, phonolites and nephelinites, olivine basalts and the younger rhyolites. Analcime basalts are mainly found in the Turkana Volcanics East, on the Pelekech, Lapur Range, Kalimapus and Murua Dou hills. They are thoroughly jointed and fractured and affected by numerous faults. Consequently, there are more easily weathered compared to the other lava flows. The analcime basalts reach a maximum of 1,200m thickness.	>50	<240	EC<3000 ÂµS/cm	Alert
North-western Basement	RV	The rocks comprise coarse-grained migmatitic gneisses and granitoid gneisses, often leucocratic and pink, grey or buff in colour. The rocks are psammitic in composition. They lack the diversity of high-grade regional metamorphic types which characterize Basement System rocks in other parts of the country. The gneisses have variable amounts of biotite or hornblende with locally abundant epidote, and more rarely, garnet.	<100	<86	EC>1000 ÂµS/cm	Alert
Lapur Aquifer	RV	A Jurassic sandstone aquifer (Lapur Sandstones) that underlie the younger volcanics. The sandstones are based out by Basement complex.	<50	<240	EC>1500 ÂµS/cm	Alert
Turkana Volcanics South	RV	Consists of rhyolites directly overlying Basement rocks, with intercalated andesites. The rhyolites include bedded pyroclastic horizons, composed of angular fragments of pumiceous tuff.	<100	<240	EC<1500 ÂµS/cm	Alert
Turkana Lake Beds	RV	The aquifer material consists of deposits of grey, reddish or yellowish calcareous grits. There are horizons of sub-rounded to rounded pebbles derived from Basement System rocks, in a clayey calcareous matrix.	<120	<240	Chloride rich; low fluoride	Alert
North Rift Volcanics	RV	The Suguta Trough is the central feature of this aquifer. It comprises Upper Miocene and Pliocene phonolites, trachytes and olivine basalts overlaid by Pleistocene trachytes, basalts and pyroclastics	<50	<86	EC>1500 ÂµS/cm	Alert

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Kerio Beds Aquifer	RV	The western escarpment aquifer boundary runs on hornblende gneisses and hornblende-garnet gneisses, overlain by Kerio Valley Beds in the valley bottom. On the eastern scarp the aquifer rises from the valley bottom into Kabarnet trachytes. These are underlain by the Eron basalts and Ewalel phonolites, all part of the Tugen Hills Group. A shallow valley bottom aquifer in the Kerio Beds is a product of hill wash made up of a mixture of Basement and volcanic material.	50-100	<86	EC<1500 ÂµS/cm; high fluoride	Satisfactory
Magadi Basin	RV	Comprises Quaternary and Tertiary volcanics from Mau and Suswa deposited into the Magadi Trough. Younger Quaternary volcanics consist of Suswa Phonolites, Longonot Trachyte and Kedong Valley flood deposits. Older Quaternary volcanics include Mau Ashes, Lower sequence of Longonot volcanics, Legemunge Beds, Magadi Trachytes and Limuru Trachytes among others. Deeper aquifers are made up of Tertiary volcanics- Olorgesailie volcanics, Mau tuffs and Ol Esayeti basalts	70-160; 250-300 near rift escarpment	<240	EC>1500 ÂµS/cm	Alert
Hindi, Bele Bele, Chomo	Tana	Shallow aquifers (freshwater zone<20m deep); medium to fine calcareous sands. Other lithologies include lagoonal clayey sands, fossil dune sands, raised coral reefs and coquinas.	<20	Hindi <86; Belebele >240; Chomo>240	EC<1000 ÂµS/cm	Alert
Lamu Dunes	Tana	Shallow aquifer with freshwater zone <20m deep; consists of medium to fine sand, intercakated with horizons of broken shells (coquina)	<15	<86	EC<1000 ÂµS.cm	Alarm
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Mapenya Aquifer	Tana					Alert
Witu	Tana					Alert
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
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Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
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Lake Kenyatta	Tana	Fossilised coral limestone, with sand lenses and cavities overlaid by recent unconsolidated sands and sandy clays	<20	<86	EC<1000 ÂµS/cm	Alarm
Kiongwe Dunes	Tana	Very fine, fine and medium graind Holocene shoreline dune sands	<10	<86	EC<1000 ÂµS/cm	Alert
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Shikababo (Ngao) aquifer	Tana					Alert
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Tana Delta	Tana	Very fine, fine and medium graind Holocene shoreline dune sands	<10	<86	EC<1000 ÂµS/cm	Alert
Coastal Sediments Suite	Tana	Members include the Pliocene Magarini Formation, pale cream to red-brown fine to coarse sands, though clays, silts and occasionally weakly-cemented sandstones are present. The Pleistocene Kilindini Formation comprises an heterogeneous mix of clays, silts, sands, coral blocks and breccia, with occasional calcareous sandstones laid down under lagoonal conditions behind a fringing reef. Also included is the Pleistocene fossil coral reef formed contemporaneously with the Kilindini sands, and the two formations are inter-fingered. Usually present as a massive and compact fossil limestone with well-preserved coral fossils with sandy bands. It is the highest yielding of the Coastal Sediments Suite. Recent material (alluvium) is not extensive; typically quite thin (<15m), fine to coarse sands occasionally form a useful but low-yielding aquifer.	Sands- <25m; coral breccia- <70m;	>860	EC<1500 ÂµS/cm in the South Coast; EC>1500 ÂµS/cm in the North Coast	Alert
Eastern Basement	Tana	Banded biotite/muscovite/hornblende gneisses; hornblende schists, granitoid gneisses. The gneisses and schists are of semi-pelitic and pelitic origin. Bands of crystalline limestone and calc-silicate gneisses occur; high-grade metamorphism has resulted to migmatization in places, with amphibolite schlieren.	50-100	<86	EC>1000 ÂµS/cm	Alert
Timboni-Gongoni	Tana	Shallow aquifer (freshwater zone <10m deep); Holocene shoreline sediment series made up of medium to corase sand, with imited gravels and clay	<10	<86	EC<1000 ÂµS/cm	Alarm
Poor aquifers						
Kambe Limestone	Athi	Kambe Formation comprises dark grey, dense, oolitic, coralliferous/reefal and dark bluish limestones with interbedded shales. The formation has three distinct limestone facies, including the Rare Limestone, the Pangani Limestone and the Mwachi Limestone Members, named after their type localities. The aquifer also includes the Mtomkuu Formation, mainly shales with subordinate sandstones, limestones, marls and siltstones. The Mtomkuu Formation is subdivided into three members.	<100	<86	EC<3000 ÂµS/cm	Alert
Kambe Limestone	Athi	Kambe Formation comprises dark grey, dense, oolitic, coralliferous/reefal and dark bluish limestones with interbedded shales. The formation has three distinct limestone facies, including the Rare Limestone, the Pangani Limestone and the Mwachi Limestone Members, named after their type localities. The aquifer also includes the Mtomkuu Formation, mainly shales with subordinate sandstones, limestones, marls and siltstones. The Mtomkuu Formation is subdivided into three members.	<100	<86	EC<3000 ÂµS/cm	Alert
Kambe Limestone & Shale	Athi	Kambe Formation comprises dark grey, dense, oolitic, coralliferous/reefal and dark bluish limestones with interbedded shales. The formation has three distinct limestone facies, including the Rare Limestone, the Pangani Limestone and the Mwachi Limestone Members, named after their type localities. The aquifer also includes the Mtomkuu Formation, mainly shales with subordinate sandstones, limestones, marls and siltstones. The Mtomkuu Formation is subdivided into three members.	<100	<86	EC<3000 ÂµS/cm	Alert
Kambe Limestone	Athi	Kambe Formation comprises dark grey, dense, oolitic, coralliferous/reefal and dark bluish limestones with interbedded shales. The formation has three distinct limestone facies, including the Rare Limestone, the Pangani Limestone and the Mwachi Limestone Members, named after their type localities. The aquifer also includes the Mtomkuu Formation, mainly shales with subordinate sandstones, limestones, marls and siltstones. The Mtomkuu Formation is subdivided into three members.	<100	<86	EC<3000 ÂµS/cm	Alert
Kajulu Hills	LVS	The aquifer is distinguished by the Maragoli granites bedrock. It is coarse and well-jointed, forming large tors which dominate the Nyando Escarpment on top of which the Kajulu Hills is situated. The granite is heterogeneous, varying from syenite to granodiorite and typical granite. It is predominantly porphyritic	<50	<86	EC<1500 ÂµS/cm	Satisfactory
Migori Granite	LVS	As the names suggests, a granite bedrock aquifer; the unit belongs to the Kavirondo Series. There are several varieties of granite â€" a grey to pink generally fine non-porphyritic, a porphyritic type and the coarse tor-forming granite.	<60	<86	EC<1500 ÂµS/cm	Satisfactory
Kibish Sediments	RV	Mainly Plio-Pleistocene unconsolidated sands, with some gravels and clays. These are lacustrine and fluviatile deposits that are related in origin to the proto Omo delta and Lake Turkana. In places the sediments thin down over the Basement rocks.	<50?	<86?	Brackish	Alert
Koobi Fora Beds	RV	The Koobi Fora formation is a Pliocene to Pleistocene sedimentary sequence deposited by fluvial activity in the East Turkana Basin. It is made up of lacustrine and fluvio-deltaic sediments. It has 8 members divided by persistent tuff beds identified by their chemical compositions. Basal members are Lonyumun, Loiti, Lokochot, Tulu Bor and Bulgi. These were previously referred to as the Lower Koobi Fora. The three upper members are KBS, Okote and Chari (Upper Koobi Fora Formation).	60-100	<86	EC>1000 ÂµS/cm; Fl- >10 mg/l	Alert
Turkana Grits	RV	The grits are Jurassic similar to the Lapur Sandstone; their typical occurrence is at Muruanachok Hills northwest of Lodwar	<100	<240	EC<1500 ÂµS/cm	Alert*
Lamu Embayment	Tana	The aquifer is made up of poorly consolidated sands and sandstones with kaolinitic clays.	>150	<86	EC>6000 ÂµS.cm	Satisfactory
Lamu Embayment	Tana	The aquifer is made up of poorly consolidated sands and sandstones with kaolinitic clays.	>150	<86	EC>6000 ÂµS.cm	Satisfactory

Name	Basin Area	Description	Depth_(m)	Yield m3pd	Water quality	Status
		Strategic aquifers				
Kilimanjaro	Athi	The aquifer is comprised of olivine basalt, phonolites, rhomb porphyries lavas and pyroclastics from the Kibo Stage of Mt Kilimanjaro vulcanicity. Lava flows average 3m in thickness, with generally 1m of flow breccia at the base of each flow.	100-200	<860	EC<2000 ÂµS/cm	Alert
Shimba Hills	Athi	The aquifer is made up of the Shimba Grits which is the upper member of the Mazeras Formation and the youngest in the Karoo System. Due to its higher groundwater potential, this unit of the Karoo is designated a separate aquifer unit. The rocks are coarse sandstones with pebbly horizons; the pebbly facies being much coarser, thicker and better developed in the Shimba Hills.	<100	<860	EC<1500 ÂµS/cm	Satisfactory
El Wak Beds	ENN	The El Wak Beds is a kunkar limestone and Gypsite unit that outcrops within the Marehan sandstone. The gypsum is microcrystalline and mixed with small amounts of calcareous clay.	<30	Low (<86)	CaSO4 waters; brackish	Alert*
Strategic aquifers						
Nairobi Aquifer Suite	Athi	Nairobi Aquifer Suite (NAS) is a multilayer volcanic aquifer that comprises aquifer units composed of volcanic flows from different ages. The principal lavas are trachytic and are divided into 3 units: the Upper Trachyte Division, the Middle Trachyte Division and the Lower Trachyte Division. The Middle Trachyte Division comprises Tigoni, Karura, Kabete and Ruiru Dam Trachytes and the Kerichwa Valley Tuffs, with the tuffs being the main aquifer. Rocks of the Lower Trachyte Division include the Nairobi Trachyte, Nairobi Phonolite, Mbagathi Phonolitic Trachyte, Athi Tuffs and Lake Beds sediments and Kapiti Phonolite. Rocks of the Upper and Middle Trachyte Divisions, along with the Mbagathi Phonolitic Trachyte in the Lower Division, make the Upper Athi Series Aquifer (UAS). The Lower Athi Series Aquifer (LAS) includes reworked tuffs, Lake Beds and Kapiti Phonolite. Erosional surfaces occurring between the lava flows and commonly referred to as 'old land surface' provide intergranular flow.	UAS-200; LAS-400	UAS->860; LAS-<240	UAS-200; LAS-400; EC<1500 mg/l Variable fluoride; UAS-<5mg/l Fl- ; LAS->1.5 mg/l Fl-	Alarm
Chyulu Hills	Athi	Overlain by a succession of young (<26,000yrs) basaltic and pahoehoe lavas, agglomerates, volcanic cones and ash deposits, to a maximum thickness of 1,150m at the crest. Includes the Mzima Springs sediments (calcareous fossiliferous silts; lacustrine/depositional). The exact make-up of the material hosting the aquifer is uncertain.	<100	<860	EC<1000 ÂµS/cm	Alert
Daua Parma	ENN	Composed of sandy alluvial sediments and gravels derived from Basement gneisses in upper reaches of River Daua.	<30	Good (<860 m3/day)	Fresh water; NaCl-type	Alert*
Walda-Rawana	ENN	Pleistocene olivine basalts that rest on the Basement System metamorphic rocks. Large thickness of the basalts laid on the continental sediments deposited in the North Anza Basin.	<100	>240	EC <2000 ÂµS/cm	Alert
Logologo-Shuur volcanics	ENN	Comprises Pleistocene olivine basalts, overlain by younger olivine-augite basalts. Late Miocene blocky and fractured/brecciated plateau basalts occur on the eastern extent of the aquifer	<100	<240	Fresh (EC<1,500 ÂµS/cm)	Alert*
Lotikipi Basin	RV	The aquifer is made up of a series of sediments, including alluvial sands, clays and gravels â€“ detritus derived from undifferentiated Basement	Multilayer; <100 to >200	>240	EC>3000 ÂµS/cm	Alert
Napuu	RV	The Napuu aquifer is located along the Turkwel River valley, within the Lodwar Trough, which is one arm of the Lodwar-Loperot Trough. The aquifer is a water body within the Turkana Lake Beds aquifer. It comprises alluvial sands and gravels, in a paleochannel of Turkwel River	30-70	>864	EC>1500 ÂµS/cm	Alert

Transboundary aquifers

Some of the aquifers are transboundary resources (Table 10).

Table 10: *Transboundary aquifers*

Aquifer	Shared Country	Area (km2)
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

Sourcen et al., 2018; Abiye2010)

Groundwater recharge

Groundwater recharge is critical for ensuring water availability through aquifer replenishment and sustainable exploitation of groundwater resources. It is a complex process that involves several hydrogeologic processes that differ from area to area. Actual infiltration into an aquifer only occurs after a certain rainfall threshold has been surpassed within a specific time period. Areas with low groundwater recharge may experience low yields and huge drawdowns during production/pumping which may also increase the cost of borehole development. The national groundwater recharge is estimated to range between 2.135 to 214.4 mm year-1 (Fig 15). The high altitude areas which also coincide with high precipitation such as the water Mau Forest Complex, the Aberdare Ranges and Mt. Kenya have high recharge level. However, this reduces gradually towards the low altitude areas particularly the ASALs.

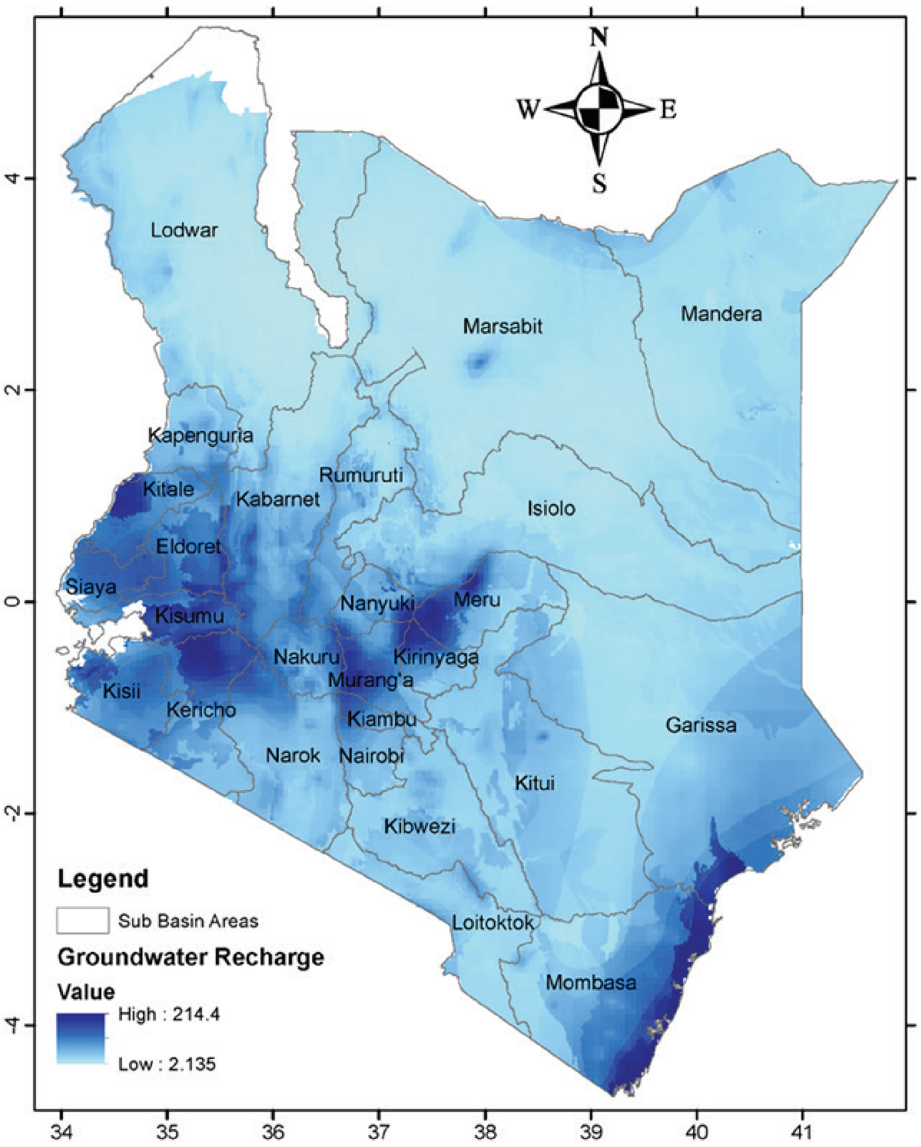


Figure 15: Groundwater Recharge (mm year-1) map with an overlay of Sub Basin Areas

Groundwater potential

The groundwater potential is an indicator of an area's capability to provide groundwater sources. The estimated national groundwater potential ranges between 0.11 to about 74 mm year-1 (Fig 16). Similar to the recharge pattern, the high altitude areas have high potential when compared to the low altitude areas, which may have implication on groundwater exploitation and development. Moreover, groundwater potential information is critical for development planning and provides guidance on how much water can be allocated for use.

Groundwater development and abstraction

Over the years, there has been increased water demand driven by the rapidly growing population that has created a lot of pressure on national resources to satisfy its socio-economic needs. Coupled with the negative impact of climate change, the pressure on the available water resources can't be overemphasized. To meet the increasing water demand, focus has been shifting towards groundwater exploitation to supplement the rapidly diminishing surface water resources. Consequently, Kenya has experienced exponential growth in groundwater development (Fig.17).

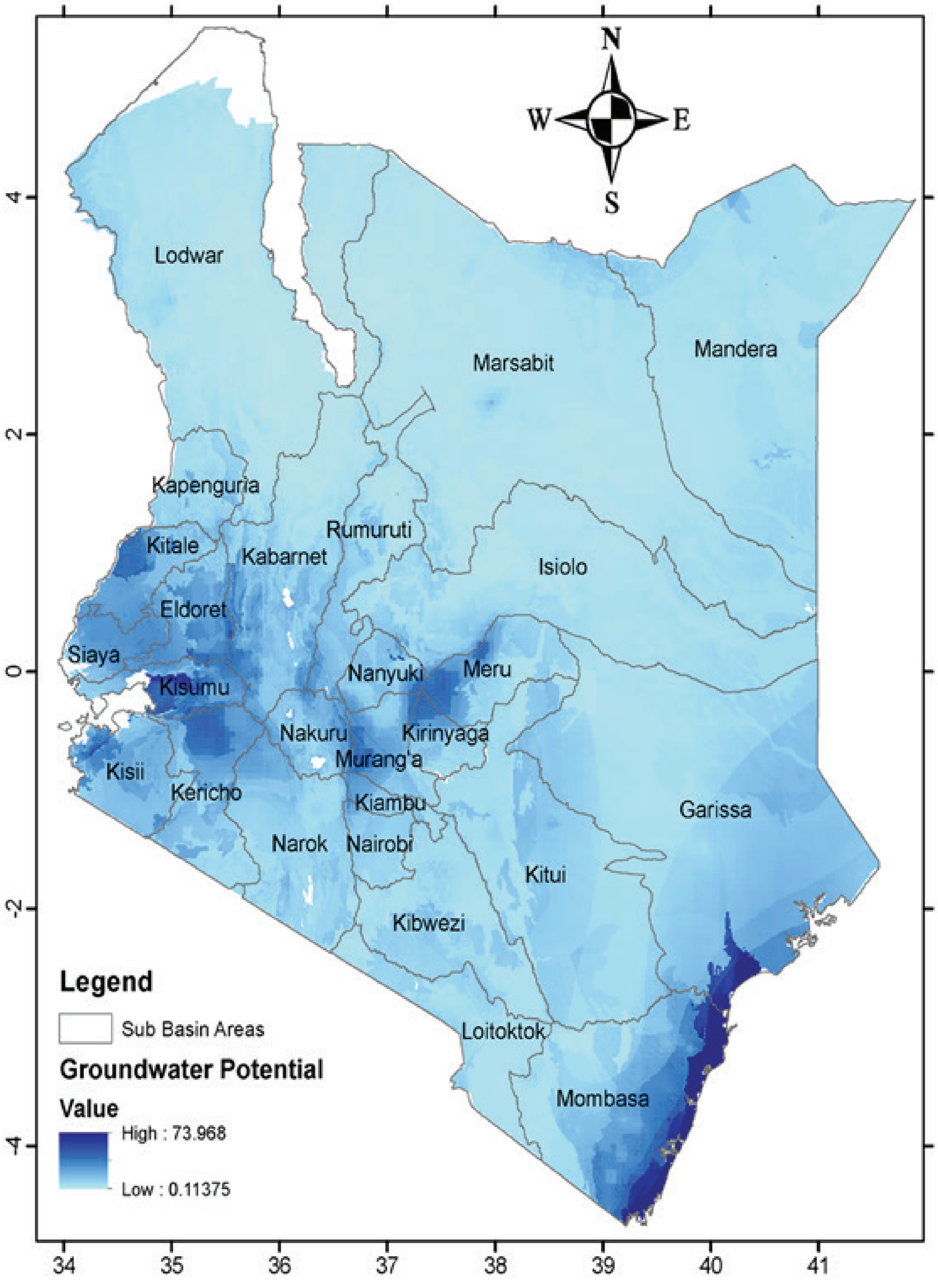


Figure 16: Groundwater potential (mm year-1) map of Kenya with an overlay of Sub Basin Areas

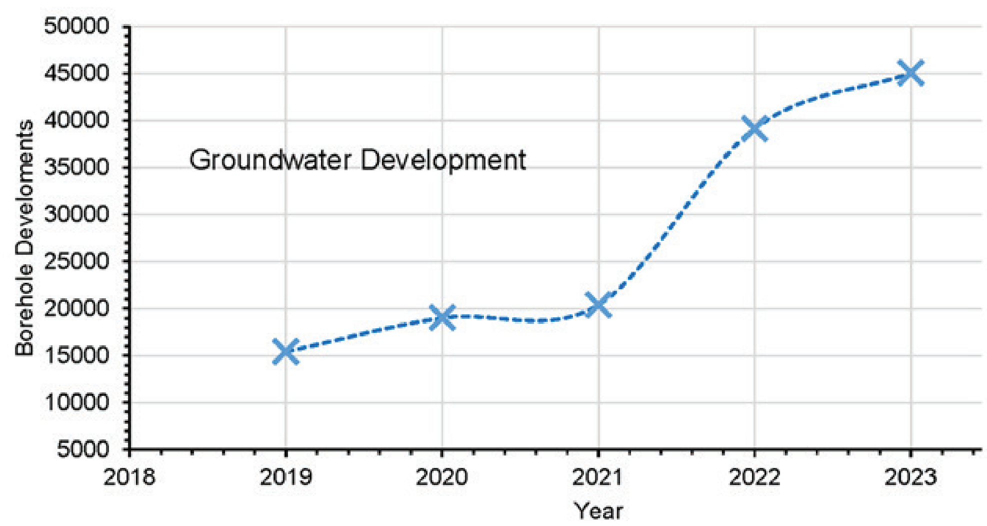


Figure 17: Groundwater development trends from 2019 – 2023

The high water demand has seen significant increase in groundwater abstraction, particularly, in high potential areas with high population. This is evident in the national borehole distribution pattern (Fig. 18) where there is high borehole density in the areas on Nairobi, Machakos, Kiambu, Mombasa and Nakuru counties among others.

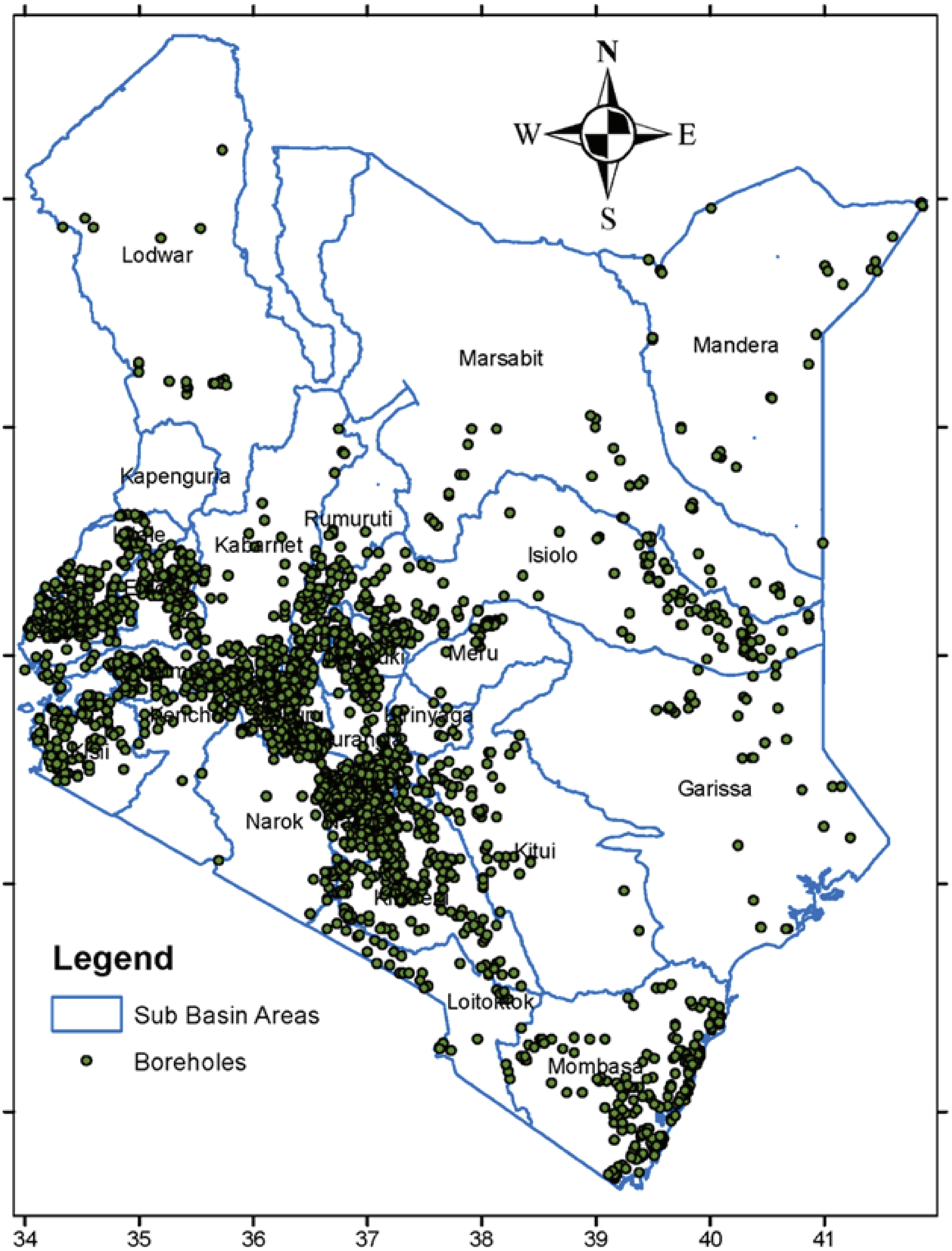


Figure 18: Map of boreholes spatial distribution and sub basin delineations across the country

Groundwater balance

Understanding of groundwater balance is important for sustainable management of water resources. The groundwater balance is the difference between the inflows into and outflows from an aquifer which informs on water that could be available for allocation. Areas with low groundwater balance are at high risk of depletion resulting from over exploitation. The areas with high borehole density show negative groundwater balance (Fig. 19). Nonetheless, the coastal areas along the shoreline, sections of upper Athi, upper Tana and L. Victoria region show positive balance. In the areas, with negative balance, managed aquifer recharge could be sustainable solution to address depletion.

Groundwater Quality

Groundwater quality is influenced by hydrogeological processes, climatic conditions, the nature of the groundwater aquifer, land use (anthropogenic activities), and physical-chemical characteristics of contaminants. Through surface water-groundwater interactions, contaminants arising from anthropogenic activities are introduced into the aquifers. Whereas elevated levels of groundwater quality elements resulting from natural processes are difficult to control in situ, pollution emanating from anthropogenic activities is manageable through various pollution control interventions. Notably, water quality parameters are several, thus often challenging to present in a single map, for example, although use of indices is becoming a viable presentation option. Standards to determine suitability of water depends on the targeted use of the water. Groundwater quality based on selected parameters such as Total Dissolved Solids (TDS), Fluoride, Iron and Chloride (Fig. 20)

Total Dissolved Solids is an indicator for the level of dissolved elements (salts) in groundwater. For example, groundwater with high concentration may manifest salty taste. ASAL areas seem to have higher TDS level partly because of the high evaporation rate among other factors in such regions. Elevated level of fluoride is evident mostly in areas dominated by volcanic formations. Particular 'hotspots' are the Nairobi Aquifer Suite, the Naivasha volcanoclastic aquifer and parts of Nakuru, Baringo and Laikipia Counties. Consumption of water with excessive fluoride concentration (>1.5 mg L-1) is linked to dental and skeletal fluorosis. Indeed, high prevalence of dental fluorosis has been reported in the areas of Naivasha and Nakuru where groundwater contains elevated level of fluoride. Though a water quality parameters, Chloride level can be used as an indicator for salt intrusion along the coastal regions.

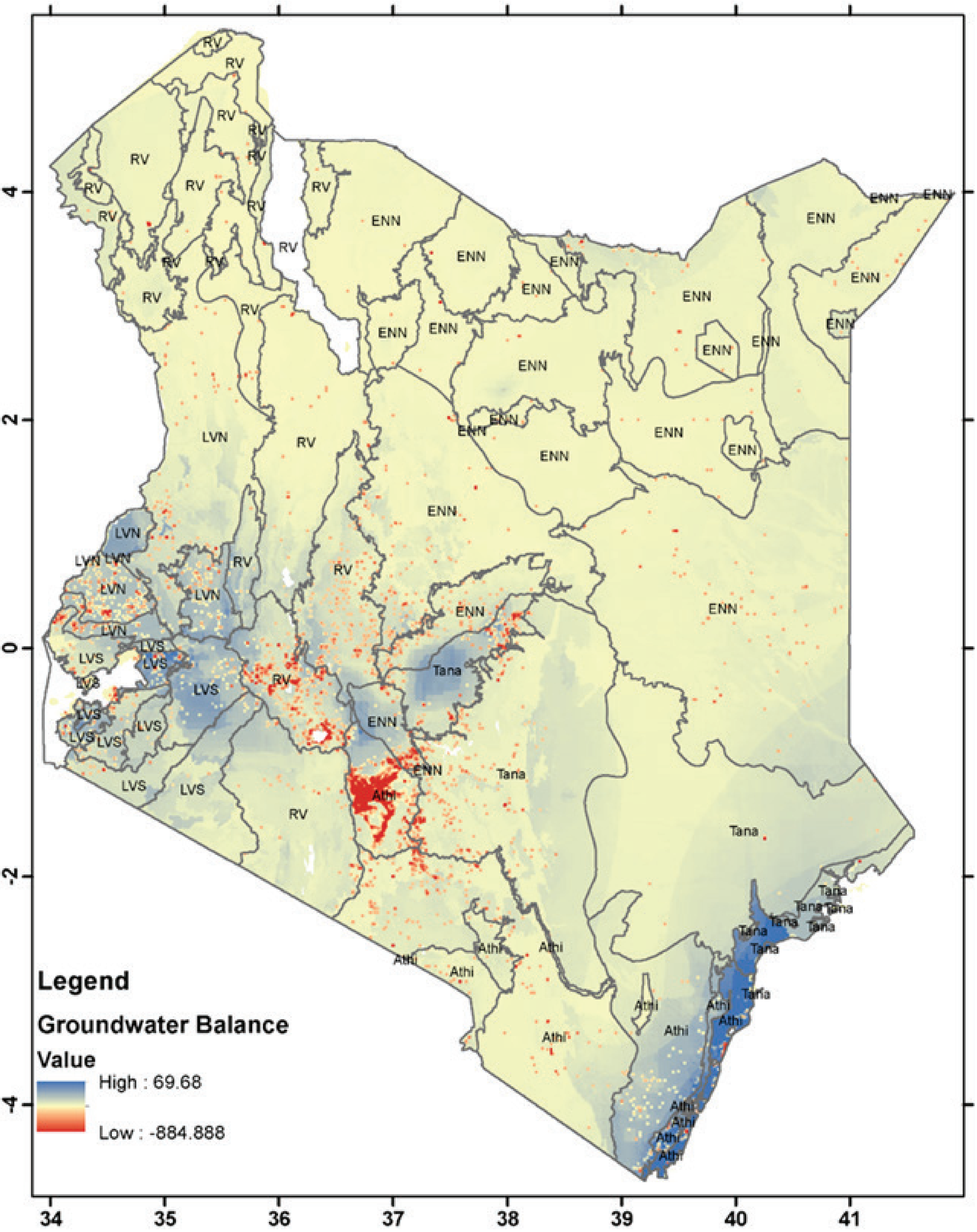


Figure 19: Groundwater balance map of Kenya with an overlay of aquifer boundaries

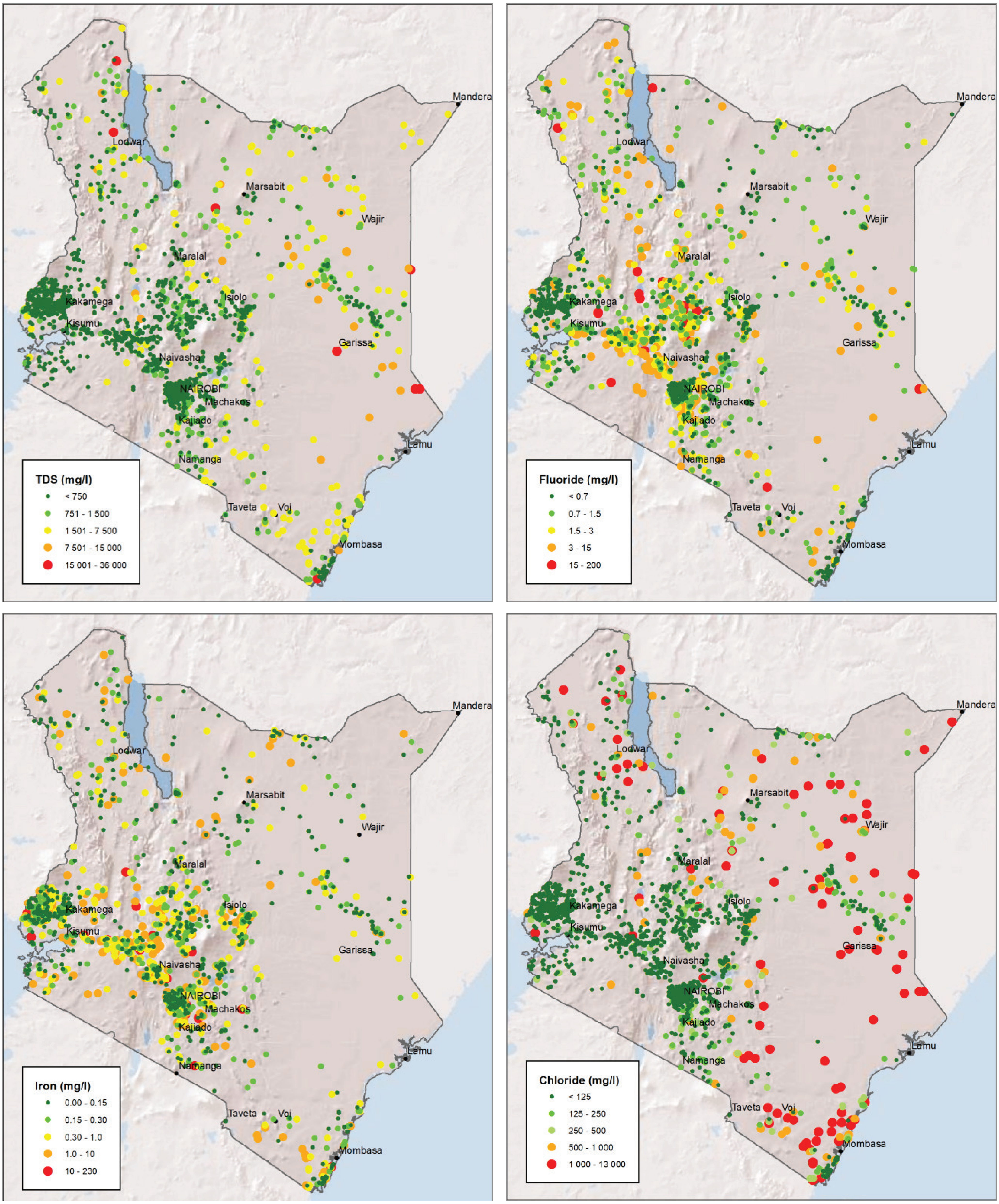


Figure 20: Distribution of selected water quality parameters (Total Dissolved Solids [TDS], Fluoride, Iron and Chloride) in groundwater

Water demand

The population growth immensley affects water demand. Therefore, conservation of the available water resources for sustainable development is imperative. The estimated and projected water demand between 2010 and 2050 (Table 11)

Table 11: *Actual and projected water demands*

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

The power usage of water constitutes the highest proportion, followed by irrigation, public supply and domestic (Table 12). However, it should be noted that hydropower generation is a non-consumptive water usage.

Table 12: *Volume of water by category of water use up to June 2021 (x 1000 m3/ day). The data reflects permitted abstractions*

Basin	Public		Domestic		Livestock		Irrigation		Industrial		Power		Others	
LVNBA	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
LVNBA	88.15	0.92	10.04	16.29	2.03	0.23	11.1	0.29	123.3	0.23	411.5	-	12.4	0.18
LVSBA	104.75	0.23	6.64	6.04	0.012	0.08	17.14	0.12	24.12	0.31	2646.5	0.01	1.9	0.09
RVBA	8.61	64.5	5.75	22.8	3.6	1.9	55.04	202.24	0.47	3.24	1657.9	0.32	6.18	8
ABA	84.2	60	12	102.33	0.16	2.44	288.14	31.16	38.33	31.4	0.07	1.48	1.06	1.75
TBA	407.8	10.7	488.2	10.7	3.7	1.8	934.9	1.9	12.1	0.14	80628	-	60.1	1.1
ENNBA	30.6	2.23	45.3	8.7	6.5	0.99	101.9	22 4.4	0.71	0.18	0.07	4.4	0.165	-

KEY MESSAGE

Kenya boasts of an array of water resources both surface water and groundwater although the country is a water scarce. The resources are disproportionately distributed spatially and temporally. Yet, the rapidly increasing population growth, climate change impact and pollution puts a lot of pressure on the water resource. Therefore, there is need for adequate investments in water resources development, conservation and efficient usage technologies in various sectors particularly irrigation. Moreover, efficient, effective, and adequate enforcement of regulations is paramount

Wetland Resources

In Kenya, definition of wetlands is provided in the EMCA 1999, Wetlands, Riverbanks, Lakeshores and Seashores Management Regulations 2009 and the Water Resources Regulations 2021. EMCA (Wetlands, River Banks, Lake Shores and Sea Shore Management) Regulation, 2009 defines wetland as "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 of rivers, vegetation, areas of impeded drainage or brackish, salt or alkaline; including areas of marine water the depth of which at low tide does not exceed 6 maters", while Water Resources Regulations 2021 defines wetlands as an area where plants and animals have become adapted to temporary or permanent flooding by saline, brackish or fresh water.

The country has variety of wetlands which cover about 3-4% (14,000 km²) total land mass (Ramsar Convention Secretariat 2006) which are spatially distributed (Fig. 21).(Ministry of Environment Water and Natural Resources, 2014)

Classification of Wetlands

Wetlands are categorised into five types

a. Marine: occur in coastal areas and are exposed to the waves and currents of the open ocean. They include coastal lagoons, rocky shores, and coral reefs.

b. Estuarine: occur where fresh and salty water mix and include deltas, tidal marshes, and mangrove swamps.

c. Lacustrine: occur in and around lakes (whether freshwater or saline.

d. Riverine: occur along rivers and streams.

e. Palustrine: occur in "marshy" areas and include marshes, swamps and bogs.

However, the Ramsar Convention recognizes 42 types of wetlands which are further classified into three broad categories – inland, marine and coastal, and human-made. The human-made wetlands are any type of wetland constructed or maintained by humans for water storage, irrigation, and aquaculture. Detailed information on Kenyan wetlands can also be found in the Kenya Wetlands Atlas, 2012.

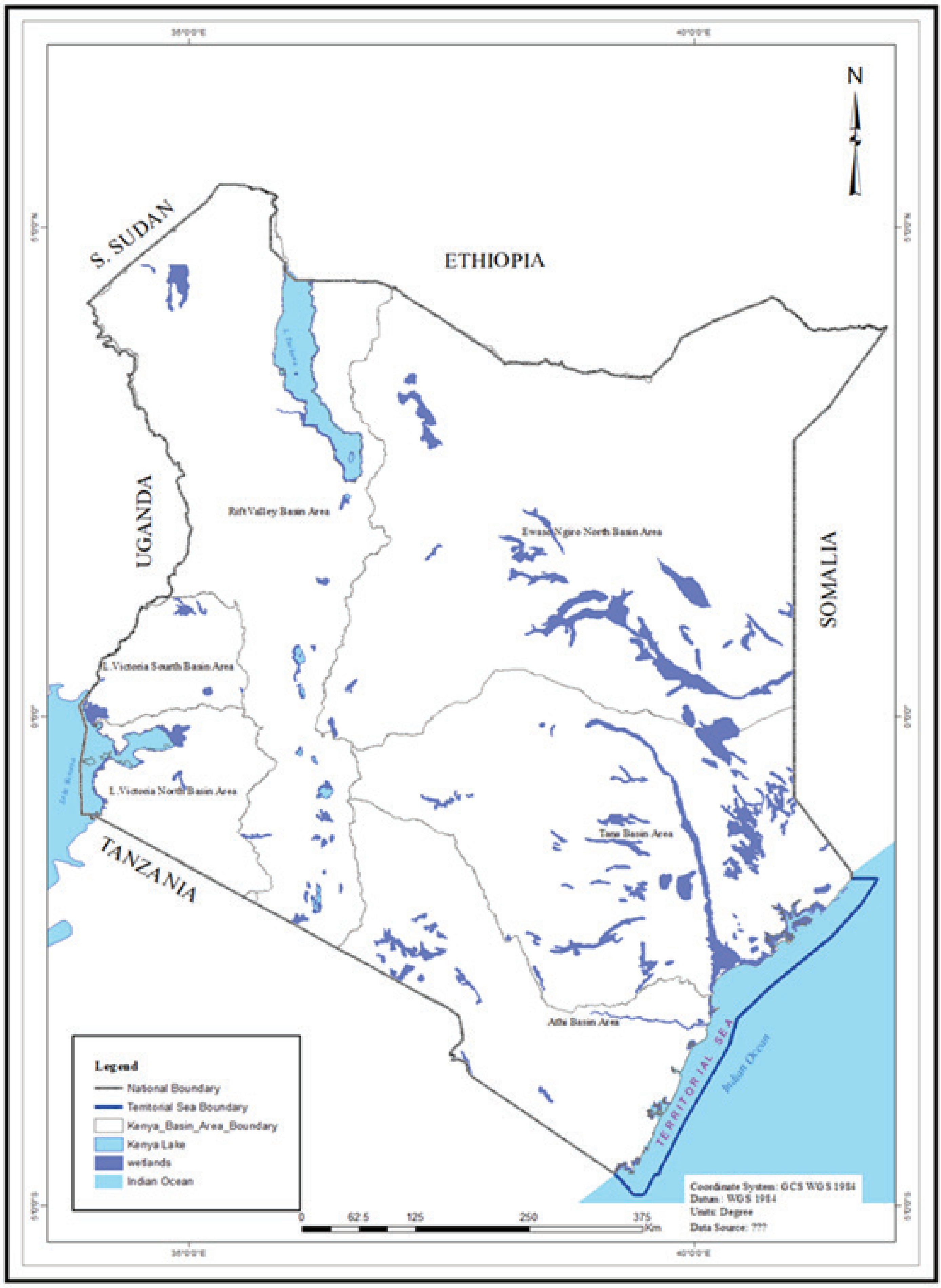


Figure 21: Distribution of Wetlands within the Basin Areas

Lake Victoria North Basin Area

Wetlands are both natural and Human made. There are three types of natural wetlands including riverine, lacustrine and palustrin. Human-made wetlands are evident in the agricultural, aquaculture and sewerage works sectors can be recognized in the lake Victoria North Basins. The wetlands include Kingwal, Sergoit, Saiwa, Yala, Nzoia, Sio-Siteko (Plate 7) and Lake Kanyaboli. Yala Swamp, which is located at the mouth of River Yala covering an area of about 175 km2, is the largest in the basin. Though not designated as protected area, the ecosystem provides major ecological and hydrological functions as well as a major source of livelihood for the surrounding communities (Table 13) within the LVNBA.

Table 13: *Attributes of the wetlands fond in Lake Victoria North Basin Area*

Forma-tion	Sys-tem	Sub System	Description/Names of Wetland	Catch-ment 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	

Plate 7: Sio Siteko wetland (Source: Wetland without border team, 2019). Sio-Siteko wetland is a transboundary wetland shared between Kenya and Uganda and provides valuable ecosystem services.

Ewaso Nyiro North Basin

The basin has several natural and human-made wetland formations ranging from the rivarine, lacustrine and palustrine inland wetlands systems (Table 14). The main wetlands are Lake Ol'Bolosat and Lorian swamp. Lake Ol'Bolosat, located in Nyandarua County, is a high altitude and the only lake around the Mt. Kenya region. It is a 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. However, between 189 and 2010, the lake area under the water has shrunk by 68% (Okumu, 2017).

Table 14: *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 basin being under the sea influence has both inland and marine wetland systems (Table 15 and Plate 8-11) The Tana Delta is the largest wetland in the basin being about 163,600-hectare. It is also second most important river mouth wetland in East Africa after the Rufiji Delta in neighboring Tanzania. The delta supports a variety of ecosystems, providing a habitat for many endangered and protected plant and animal species, and is also a source of livelihood for surrounding communities.

Table 15: *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	

Plate 8: Lake Paradise on mount Marsabit (Courtesy of Alamy Stock)

Plate 10: Lake Alice on Mount Kenya

Plate 9: Lake Ellis on Mount Kenya

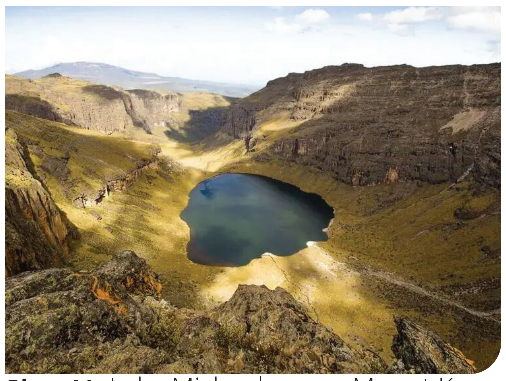


Plate 11: Lake Michaelson on Mount Kenya. Photo courtesy of Nomadic by Nature

Rift Valley Basin

Rift Valley Basin Area is predominated by lacustrine wetland types. They are compost of seven major wetlands around Lakes Turkana, Baringo, Bogoria, Nakuru, Elementaita, Naivasha and Magadi (Table 16).

Table 16: *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

Like TBA, Athi Basin area comprises both inland and marine wetlands. The marine wetlands are distributed along the coastal areas of the basin such as Kilifi. Table 17 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 ABA, namely Lake Jipe and Lake Chala. 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 17: *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	
			Marine	Areas along the coastal area	
	Human made		Aquiculture	Fish ponds	
			Agriculture	Irrigated fields –	
			Urban and Industrial	Sewerage and treatment works	
				Reservoirs	

Lake Victoria South Basin Area

The Lake Victoria South catchment area covering approximately 31,734 km2 .The main riverine 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 18 and Plate 12).

Table 18: *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	

Plate 12: Lake Simbi Nyaima (Source Daily Nation, June 14, 2019 courtesy of Barack Oduor, Nation Media group)

Kenyan wetlands of international significance (Ramsar Sites)

Kenya has six wetlands that have been declared as of international importance under the Ramsar site, thus requires special protection (Table 19). The wetlands play critical role in biodiversity conservation and host a rich diversity of birds and wildlife, some of which are endangered or rare species.

Table 19: *Wetlands of International Importance (Ramsar site)*

Wetland	Importance
Tana River Delta	Habitat for diverse marine and estuarine species
Lake Nakuru	Diversity of birds and wildlife
Lake Naivasha	Diversity of birds and wildlife
Lake Elementaita	Habitat for birds and wildlife
Lake Bogoria	Habitat for birds and other wildlife
Lake Baringo	Habitat for birds and other wildlife

Importance of the Kenyan wetlands

Wetlands play an important role in the Kenyan socio-economic development space in ensuring environmental sustainability. All the wetlands provide similar ecosystem services although the magnitude and diversity varies from one to the other. The major services provided by the wetlands include source of water and rivers, groundwater recharge zones, source of food security, habitats for diverse species of aquatic and terrestrial animals, flood protection, natural water quality improvement, tourist attraction sites such as bird watchers, source of natural products (medicinal plants), erosion protection and recreational sites among others. Thus, wetlands are critical natural resources that need to be harnessed, protected and exploited sustainably for environmental, social and economic development.

Springs

The Water Act 2016 defines springs as "water emerging from beneath of the surface of the ground other than as a result of drilling or excavation operation". Just like wetlands, springs, are sources of many rivers as well as source of water for various uses including domestic and agricultural applications. Springs of various sizes and capacities are wide spread across the country. However, a comprehensive database of the spring is yet to be developed. Mzima Springs in Taita Taveta and Kikuyu Springs in Kikuyu and Umani in Makueni are some of the major springs in the country. Mzima Springs is located in the Tsavo National Park and a main source of water supply to Mombasa and other coastal towns. Further, it plays host to several wildlife species, thus, a popular attraction site for tourists. Similarly, the Kikuyu Spring is an important source of water supply to the Nairobi City County producing an estimated 6,000 m3day-1(Nairobi City Water and Sewerage Company, 2023).

Legal and policy framework

Water and wetlands resources are governed by different pieces of national legislation, regulations and policies. Additionally, international conventions, particularly the Ramsar Convention and Convention on Biodiversity, have been ratified in Kenya and form the legal frameworks for water and wetlands resources management. At the national level, the water Act 2016 provides for the regulation, management and development of water resources, water and sewerage services. The Act establishes the Water Resources Authority (WRA) whose core mandate is to regulate the management and use of water resources in the country including declaring particular areas as protected water conservation areas. On the other hand, the Environmental Management Coordination Act 1999 (EMCA, Amended 2015) has several general provisions for sustainable management and exploitation of wetlands. Specifically, Section 42 of the EMCA proscribes certain activities from wetlands, empowers the Minister responsible for environment to declare wetlands as protected areas and issue specific orders and standards for sustainable management of wetlands. The two anchor laws are complemented by other related legislations including the Forests Act, 2005, Kenya Maritime Authority Act, 2006, Physical land use and Planning Act 2019, National Land Commission Act, 2012, Land Registration Act, 2012 and Land Act, 2012.

The Acts are further strengthened by various regulations particularly the Water Resources Regulations 2021 and Wetlands, River Banks, Lake Shores and Sea Shores Regulation, 2009 (also called Wetlands Regulations). The Water Resources Regulations actualizes the provisions of the Water Act 2016, giving in detail how the management and use of water resources is regulated. On the other hand, the Wetlands Regulations provides for, interalia, the conservation and sustainable use of wetlands and their resources, their protection as habitats for floral and faunal species, prevention of their pollution and siltation and a framework for public participation in their management.

In addition to the legislations and regulations, water and wetland resources management and use is guided by various policies. These include the National Water Policy, 2021 (Sessional Paper No.1 of 2021) which provides a framework for sustainable management and financing of water resources; water harvesting and storage; and for equitable, efficient, and universal access to water supply and reasonable standards of sanitation, for domestic, economic use and ecosystem sustenance. The National Wetlands Conservation and Management Policy, 2014 (Sessional Paper No.12 of 2014) goal is to ensure wise use and sustainable management of wetlands in order to enhance sustenance of their ecological and socio-economic functions for the present and future generations of Kenya.

WATER RESOURCES & WETLANDS THREATS AND CHALLENGES

The 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. Some of the threats and challenges are discussed below:

Water pollution

Water and wetlands resources are facing pollution from both point and non-point sources. Point sources include industrial effluent discharges, sewage discharges from treatment facilities, burst and overflowing sewers among other, while non-point sources are mainly diffuse in nature such as surface runoff from agricultural farmlands. The pollutants are biological, physical and chemical. Despite the conventional contaminants which have been known over the years, a new class of contaminants have emerged in the recent years. Popularly referred to as "contaminants of emerging contaminants, CECs", these contaminants are largely unregulated but have emerged as a threat for both human health and environmental sustainability. CECs include, interalia, pharmaceuticals, personal care products, new generation pesticides, hormonal products and Per- and Polyfluorinated Substances (PFAS). Recently, some CECs have been detected in some of the Kenyan rivers (Figure 22)(Plate 13). Considering the surface water and groundwater interactions, the pollutants infiltrate into the aquifers, thus compromising their sustainability.

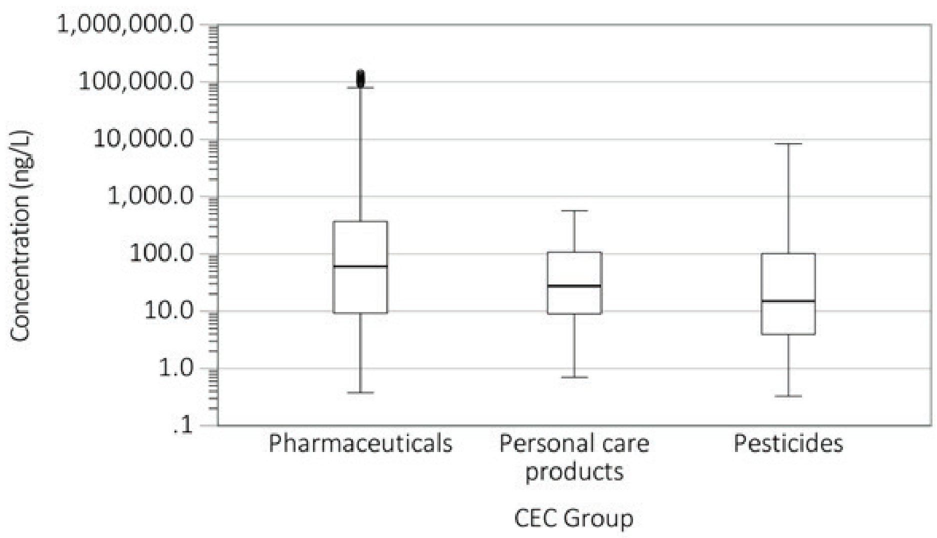


Figure 22: Concentration of pharmaceuticals, personal care products and pesticides in Athi Basin Area Source K'oreje et al., 2022

Plate 13: Section of River Ng'ong at the Kibera informal settlements illustrating pollution level

Encroachment of riparian and wetland areas

The increasing demand for land has seen local communities encroach riparian areas for agricultural activities and settlement (Plate 14). Despite the existence of laws that regulate activities that can be carried out in riparian and wetlands, enforcement challenges have hampered adequate execution of the laws. As a consequence of encroachment, some riparian areas have been reclaimed thereby diminishing the resources. For example, between 1989 and 2010, the farmland and built-up area in Lake Ol'Bolosat increased by 31% and 33%, respectively while area under water reduced by 68%.

Plate 14: Settlement in River Ng'ong riparian

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. The rising levels have been attributed to impacts of climate change, anthropogenic activities and geological processes. The lakes include Nakuru, Bogoria, Baringo, Naivasha and Turkana. Beside the Rift Valley lakes, Lake Victoria and Simbi Nyaima in (Lake Victoria basin) have recorded unprecedented rising levels within the same period. The rising levels caused destruction of investments around the lakes after homes and farms were submerged (plate 15) . Fig 23 and 24 Illustrate the extent to which lakes in the Rift Valley rose during the period between 2013 and 2020.

Plate 15: Effects of rising water level of L. Nakuru. Photo courtesy of Willis Memo

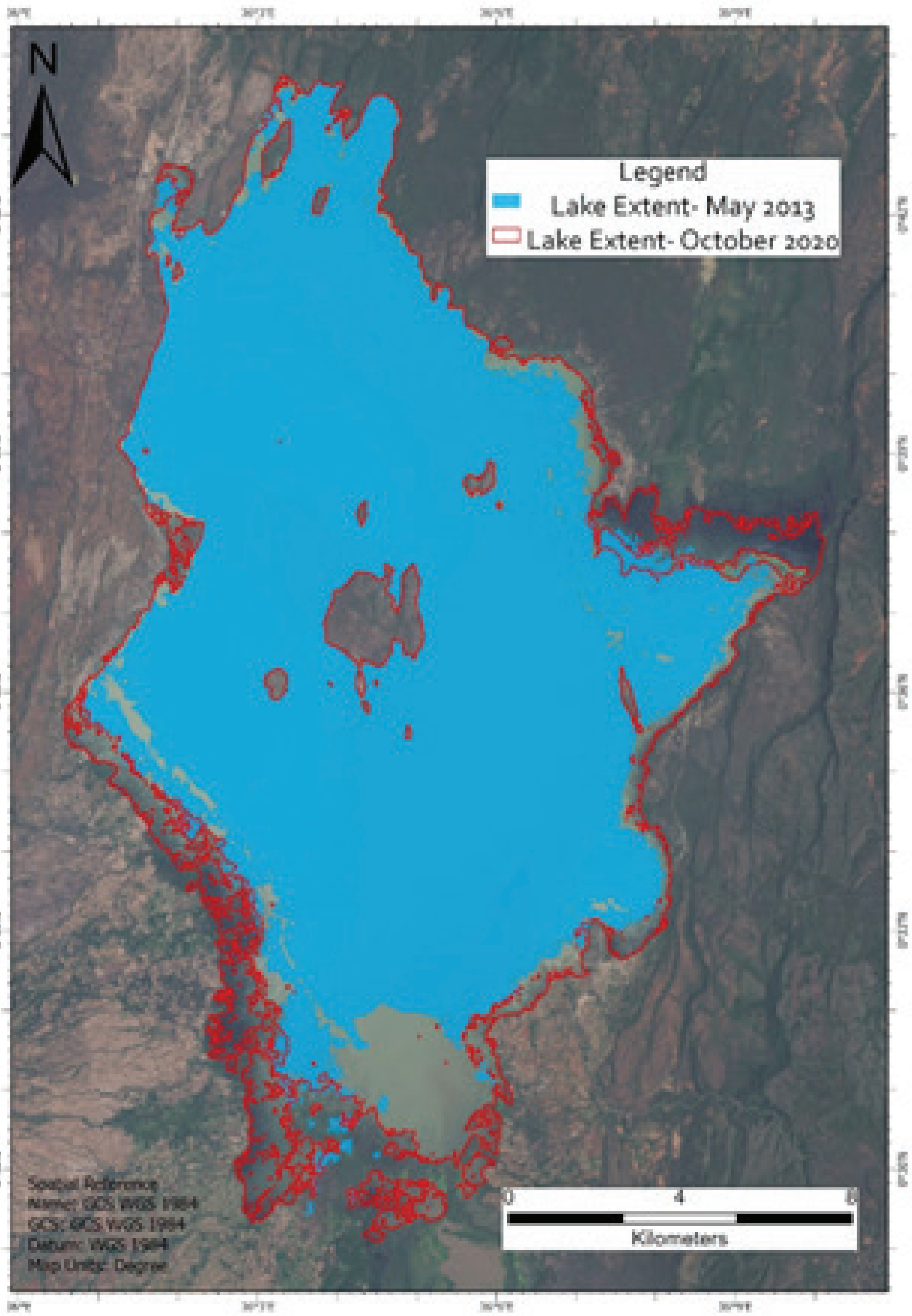


Figure 23: Illustration of the water level changes in Lake Baringo between 2013 and 2020 (RCMRD, 2021)

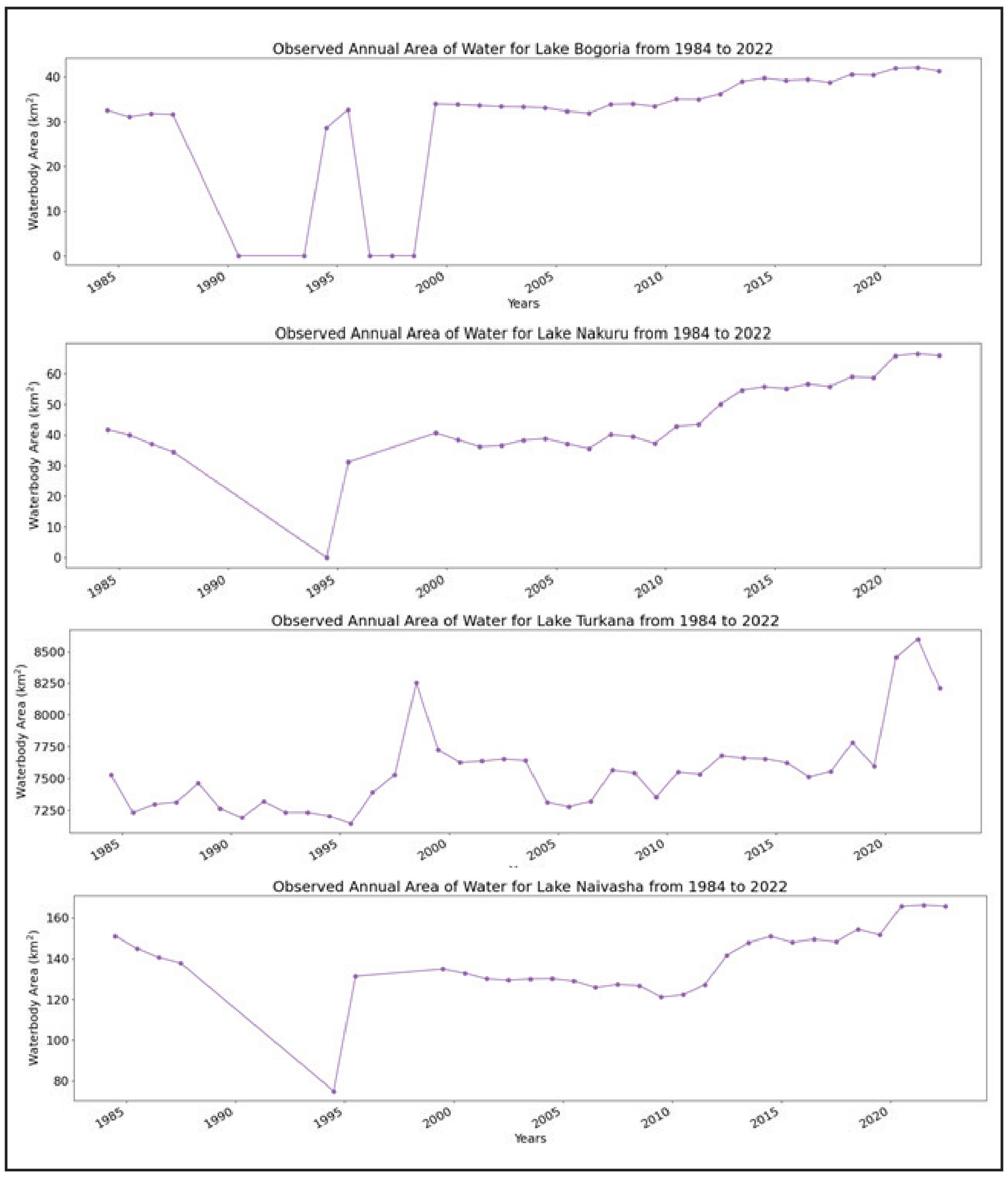


Figure 24: Illustration of the rising levels of Rift Valley Lakes.

Catchment degradation

Major catchments suffer significant degradation arising from encroachment and deforestation as communities invest in sources of livelihoods. There is rampant clearance of trees to create farmlands, wood fuel and charcoal production. Moreover, overgrazing particularly in the rangelands is a key driver of catchment degradation. Consequently, there is increased soil erosion in these catchments leading to siltation of rivers, lakes, wetlands and reservoirs. Severe siltation may results into frequent flooding and short lifespan of reservoirs. Additionally, degraded catchments impair water quality, hence high cost of production for drinking water.

Overexploitation of water resources

As the demand for water resources increases, abstraction of water has been in the upward trend. With the uncertainties surrounding availability of surface water, people are turning to groundwater to meet water needs. Consequently, some areas like the Nairobi Aquifer suite is experiencing negative groundwater balance. In many instances, areas facing limited availability of water resources experience water use related conflicts especially during long droughts.

Climate change effects

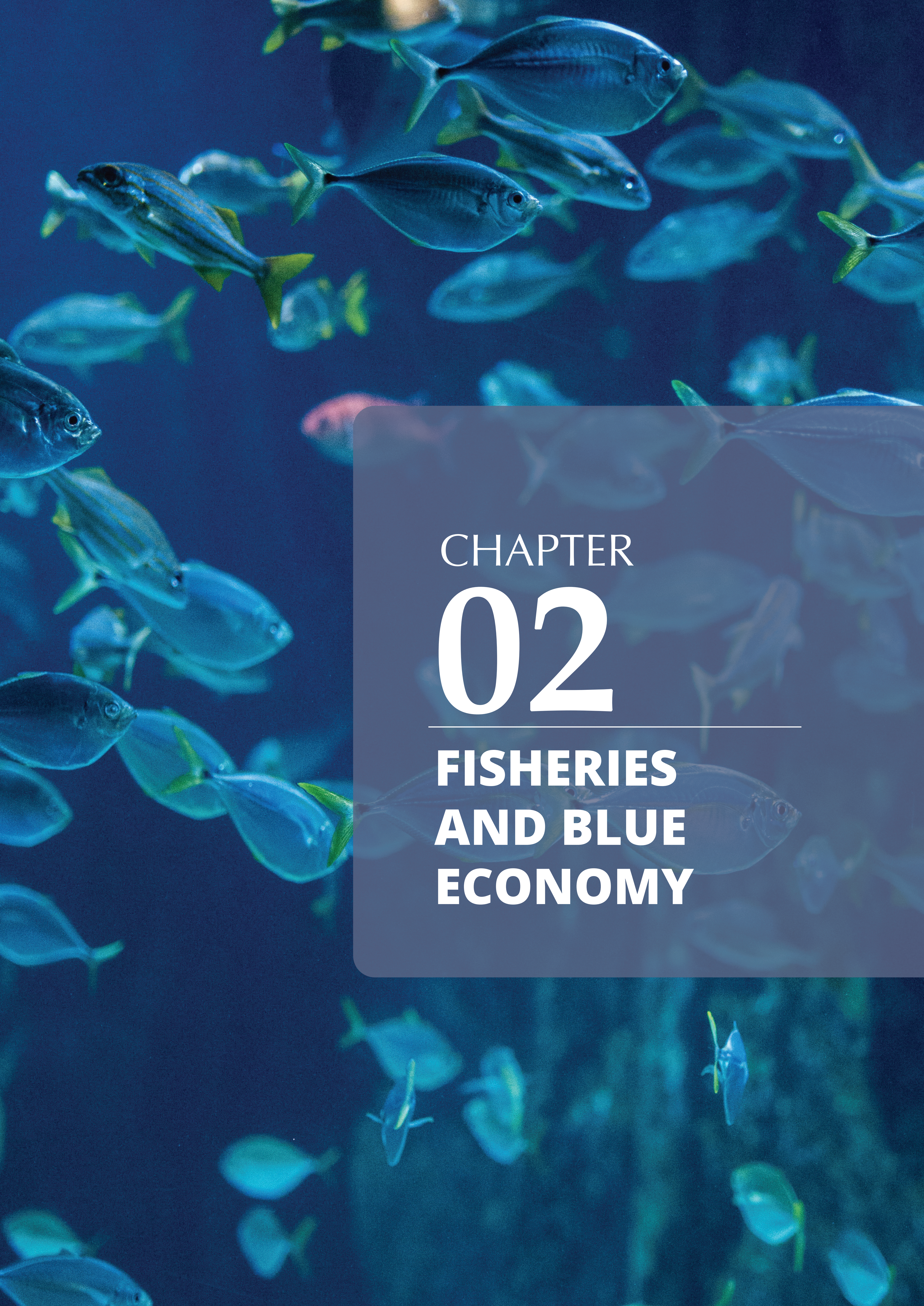
Uncertainties related to the vagaries of climate change implies that weather patterns are increasingly becoming more challenging to predict. The recent increasing lake levels have been partly attributed to climate change. There's also severe drought instances, thus receding often lakes and wetlands experience reducing water levels. In extreme cases, some wetlands may dry.

Invasive species

In some water resources such as lake Victoria, invasive plant species have invaded the ecosystems to an extent that indigenous species are not able to survive. Such species have been out competed, thus loss of biodiversity and source of livelihood.

KEY MESSAGE

Kenya has several wetland resources that significantly contribute to the environmental, social and economic sustainability of the nation. They are not only for socio-economic use and sources of livelihood but also important groundwater recharge systems (zones). However, there existence is severely threatened by anthropogenic activities including overexploitation, encroachment, and deforestation. This calls for a concerted collaborative effort among all the relevant stakeholders and government agencies to protect these vital resources. Moreover, humanization of the relevant laws which exhibit overlaps or conflict is necessary to improve efficiency in implementation of conservation measures.



CHAPTER

02

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.

Blue economy components

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

6. Provide social and economic benefits for current and future generations;
7. Restore, protect, and maintain the diversity, productivity, resilience, core functions, and intrinsic value of marine ecosystems; and
8. 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 20.

Table 20: *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 16) facilitate extraction of fisheries resources to landing sites.

Plate 16: Sindo landing site in Homa Bay county, Kenya; Source: KEMFRI

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 km2), Lake Victoria-Kenyan side (6% of the whole lake - 4,128 km2), Naivasha (210 km2), Baringo (129 km2) and Lake Jipe (39 km2). Major rivers include Tana (700 km), Athi/Galana/Sabaki (530 km), Ewaso-Nyiro North (520 km), Kerio (350 km), Suam-Turkwel (350 km2), 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 km2 while the Kenyan EEZ is 142,400 km2. Kenya also lays claim to extended EEZ, reaching 350 km with an extra area of approximately 103,320 km2. The total area for exploitation by the country is a massive 255,420 km2 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 21 shows an analysis of key statistics in the fisheries sub-sector.

Table 21: *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)

Fisheries Management Measures

According to the Fisheries Management and Development Act 2016 (currently under review), and in accordance with the best scientific advice and such other relevant information as may be available, with the approval of the Cabinet Secretary, by notice in the Gazette, the Director General may impose, inter alia, any of the following measures for the conservation and management of any fishery:

1. Closed seasons and or areas for species of fish or methods of fishing, provided that customary fishing rights are protected;
2. Prohibited fishing areas for all or designated species of fish or methods of fishing;
3. Limitations on the types of gear, including mesh sizes of nets, that may be used for fishing;
4. Limitations on the types and/or number of fishing vessels permitted to engage in fishing, provided that customary fishing rights are protected;
5. Limitations on the amount, size, age and other characteristics and species or composition of species of fish that may be caught, landed or traded;
6. Regulate the landing of fish and provide for the management of fishing ports, including fish landing stations;
7. Control of the introduction into, harvesting or removal from Kenyan fishery waters of any species of fish, including aquatic plants;
8. Define and identify fragile aquatic ecosystems and provide structures to enable collaborative protection;
9. Regulate trade in endangered species of fish and fish products;
10. Prohibit the possession, trade in or manufacture of prohibited gear in a specified area or areas; and
11. Any other measures consistent with the objective and principles of the Act.

In the Act, fish landing site is used interchangeably with fish landing station and is defined as a point on the shore of any waters or coastline, of which the Director General has, by notice in the Gazette designated a point to land fish. The Act stipulates that no person other than a sport fisherman shall land any fish at any point except at a fish landing station or port. There are more than 600 landing sites/stations along the shore of the waters and/or coastline of Kenya with most of the sites having been gazetted and a few are awaiting formal recognition. However, a majority of the sites, gazetted or otherwise, lack title deeds or any form of documentation. As such, opportunistic grabbers have taken advantage of this vacuum and taken illegal possession of some of the landing sites that are now under private ownership. Many factors have contributed to fish landing sites being grabbed: indifferent and unenthusiastic fisheries department, poor documentation at the land offices, and the absence of any progressive or corrective mechanisms to provide for alternative sites when fishermen had to concede landing sites for other public projects.

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 25). 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).

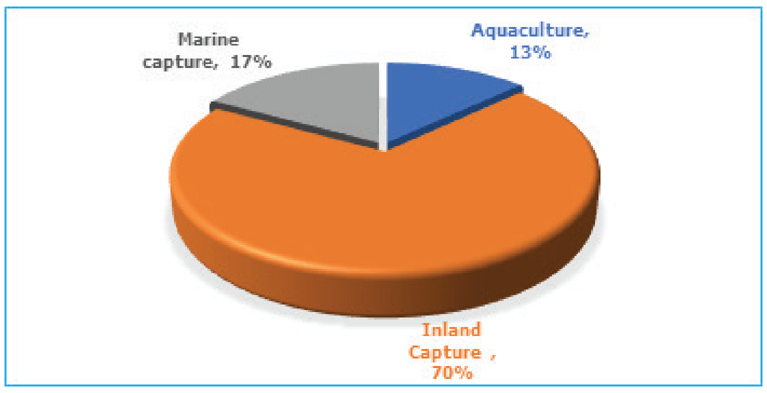


Figure 25: Pie chart showing the proportions of the major types of Fishery in the country

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 22.

Table 22: *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)	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.
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	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.
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 23. 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.

Table 23: *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: LVFO Frame survey, 2000 - 2020)

Lake Victoria's Fishery accounted for 94,349 mt (Table 23) 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 (Dagaa/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 26).

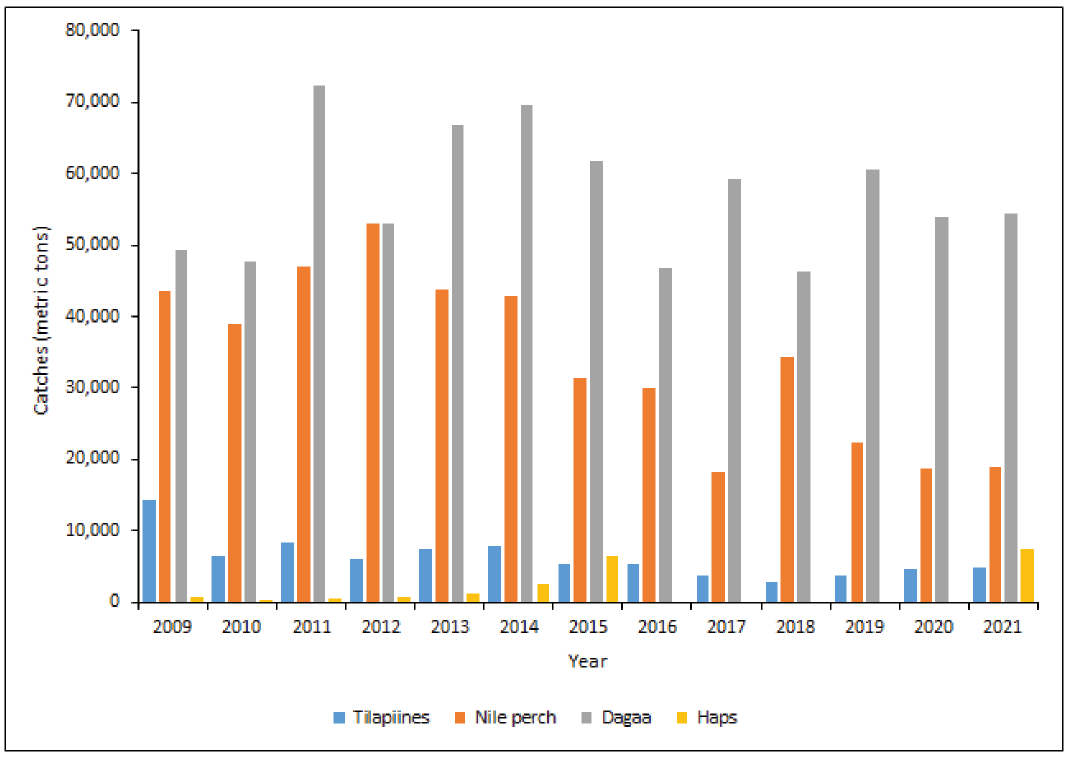


Figure 26: Fish landing in Lake Victoria, Kenya 2009-2021 (KeFS)

Resource-Use Conflicts in Lake Victoria, Kenya

Prominent conflicts in Lake Victoria, Kenya are presented in Figure 27. 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 is 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.

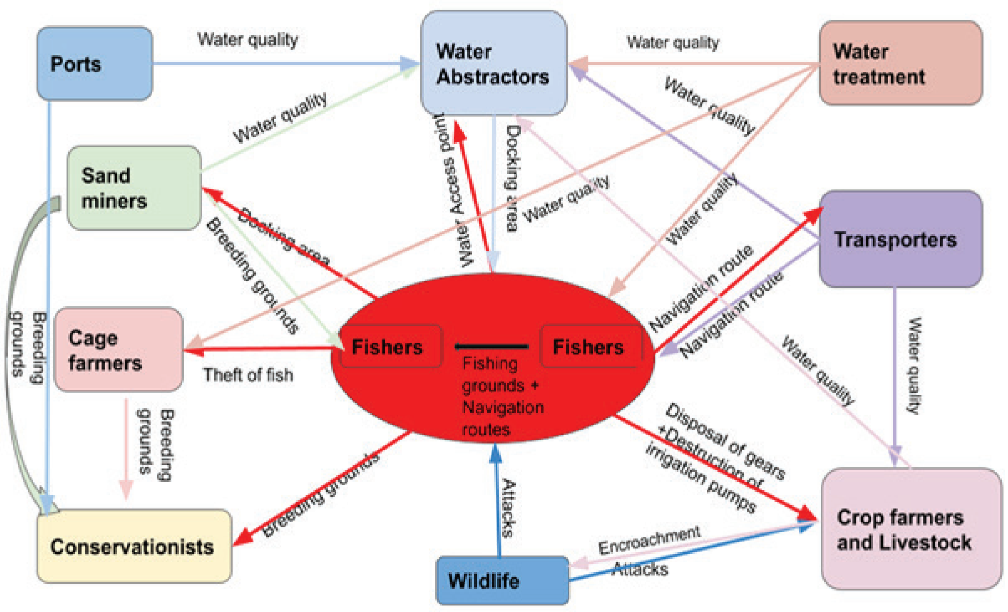


Figure 27: Resource-Use Conflicts in Lake Victoria, Kenya. Red = Dominant Lake user conflicting with many other lake users. Arrows point to the lake user being affected with the different colors representing who is affecting the other. (Adapted from Awuor et al., 2022).

Demarcation of fishbreeding sites

Fish breeding grounds are identified and demarcated to inform protection and conservation. In Lake Victoria, the breeding grounds are also influenced by water hyacinth. Figure 28 shows the water hyacinth distribution and demarcated fish breeding grounds in Lake Victorian. The blockage of river mouths and ongoing loss of floodplain, which are preferred areas for the feeding and breeding of many riverine fish species significantly reduce their long-term viability. Pollution from industrial effluents and agricultural chemicals is a growing concern. Furthermore, increased deforestation in the upper catchment basins of rivers draining into the lake is having an adverse effect on water quality through increased siltation and alteration of river regimes with increased runoff during the rains and reduced flow during drier periods. It is therefore, important to continue monitoring and regulation of upstream human activities to match the temporal and spatial dynamics to ensure protection of this critical habitats (Nyamweya et al., 2012).

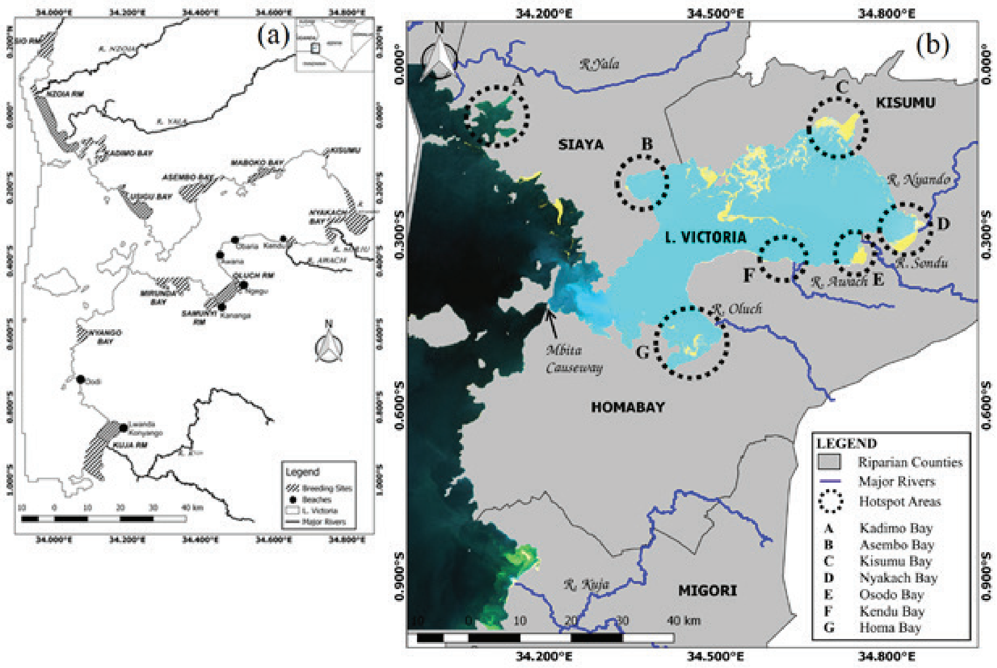


Figure 28: Fish breeding sites (potential areas for protection) (a) and water hyacinth hotspots (b) of Lake Victoria, Kenya (Adapted and modified from Ongore et al., 2018 and Aura et al., 2018b).

Demarcation of a buffer from the highest water around Lake Victoria Kenya

The demarcation of a 200-meter contour line around Lake Victoria, as depicted in Figure 6, is a crucial step in promoting sustainable management of the lake's shoreline. This boundary, established by referencing the highest watermark, serves to guide and regulate human activities along the lakefront. Its primary objectives are to protect the delicate ecosystem and aquatic life within Lake Victoria while also ensuring the well-being of communities reliant on its resources. This delineation aims to facilitate a harmonious coexistence between responsible development and conservation efforts, fostering a balanced approach to environmental stewardship and regional economic growth. It's important to note that while the buffer is conceptually defined, the physical pegging of these points remains pending and requires official determination.

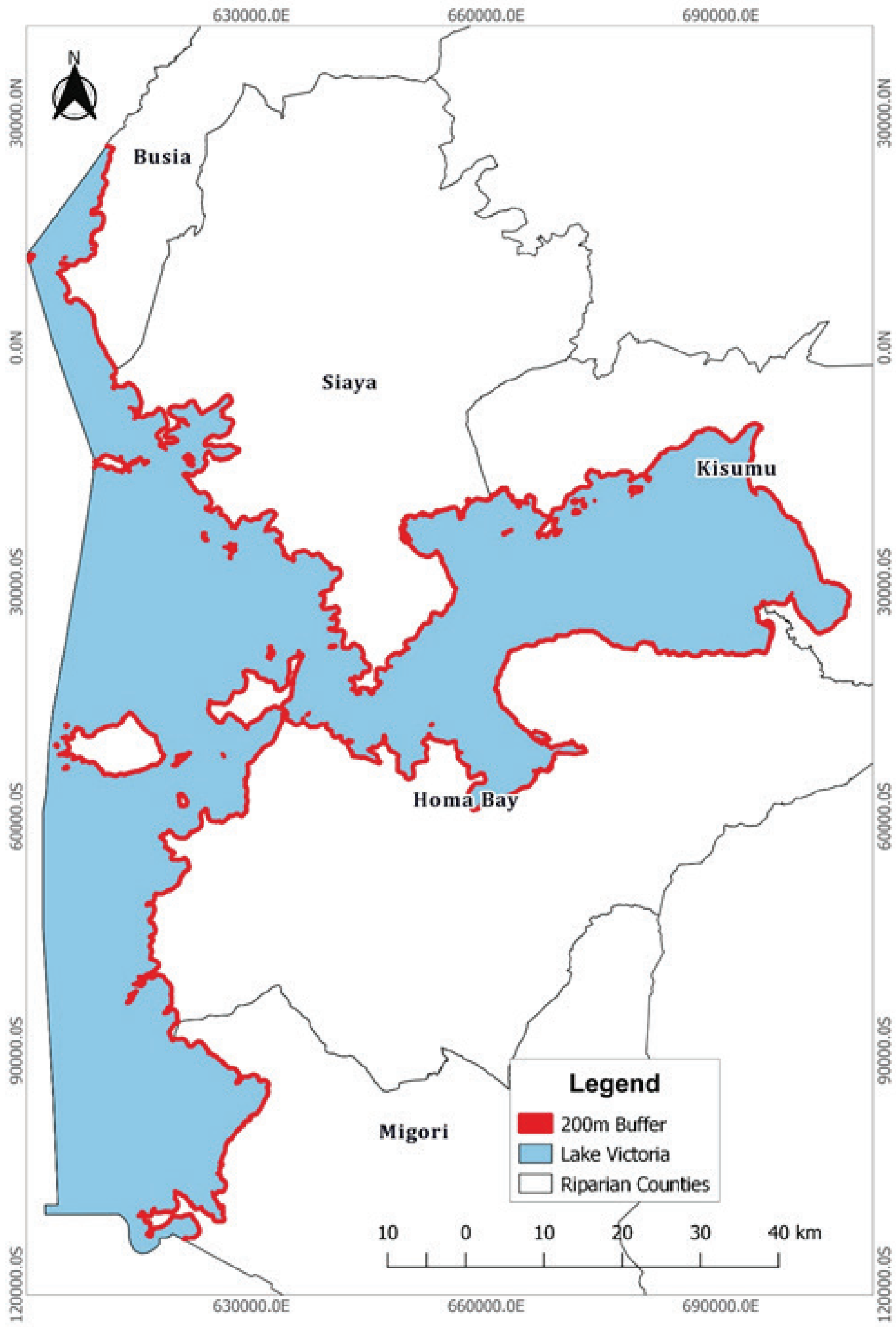


Figure 29: Demarcation of the Lake Victoria contour line (200m) to guide the extent of human activities around the lake front based on the highest watermark

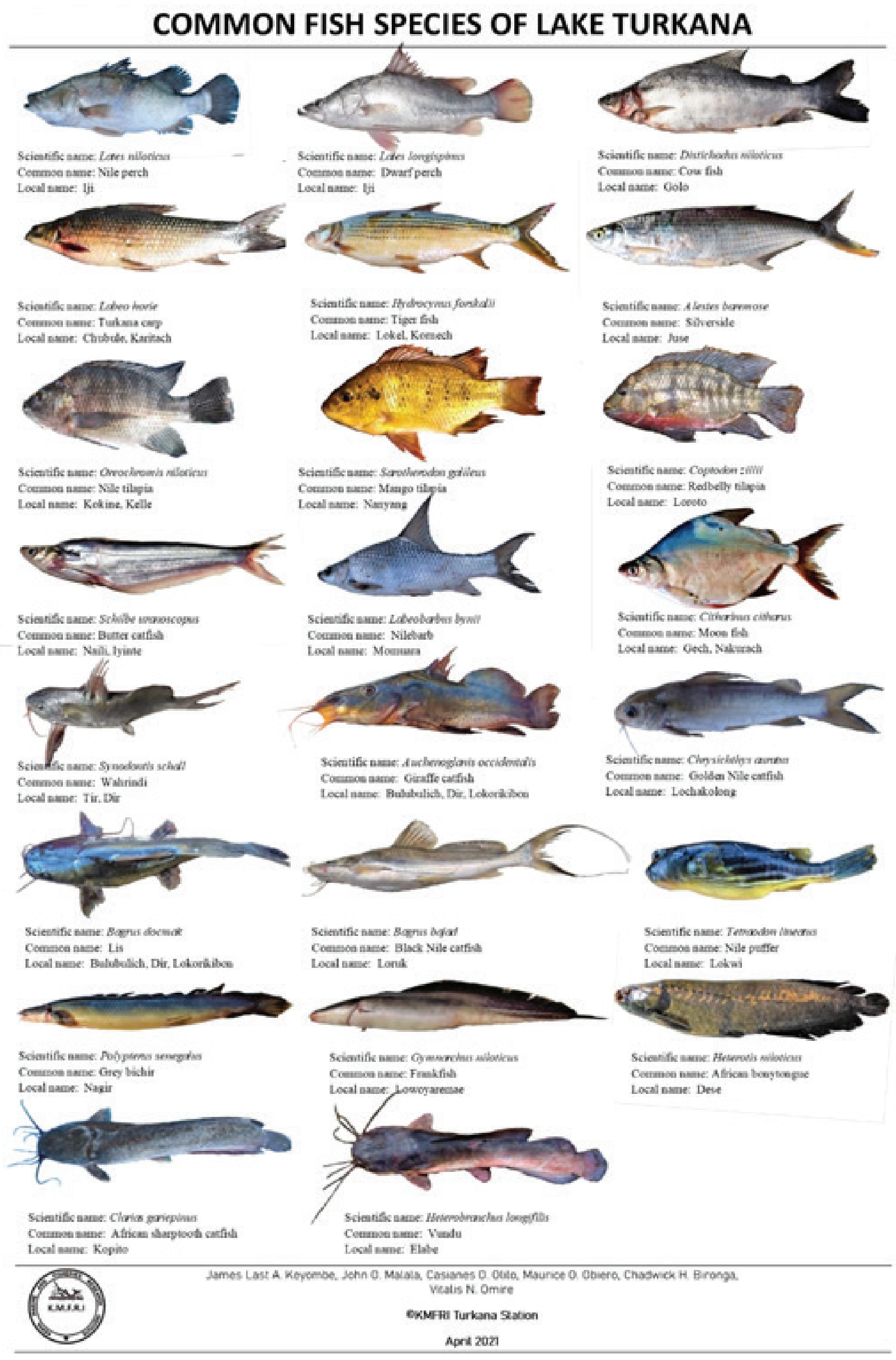


Plate 17: Common fish species of Lake Turkana (Scientific, common and local names)

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* (Plate 17). 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 22). 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 31). 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).

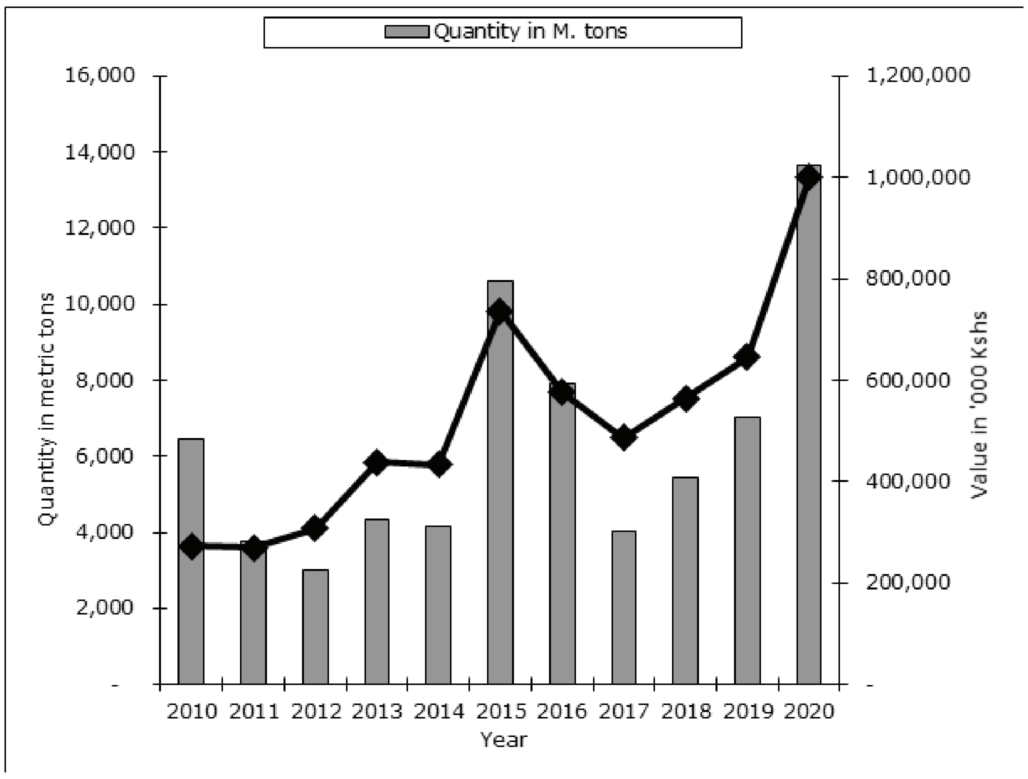


Figure 30: Trends in annual fish landings from Lake Turkana fishery 2010-2020; (Source: KeFS, 2021)

Lake Turkana Fishery Value chain

Starting from the initial landing, the harvested fish is directed to aggregators, who subsequently distribute the fish to regional and local markets. These local markets primarily serve Lodwar, Kakuma, Nyanza, and the Western region, with limited fish supply reaching Nairobi. Each of these areas receives various forms of fish products tailored to local preferences. Regional traders, primarily operating from Kalokol, Busia, and the Uganda-based Kalokol/Longech, play a critical role in this chain. They further extend the reach of Lake Turkana's fish to the Democratic Republic of Congo through three distinct routes, as illustrated in Fig. 32.

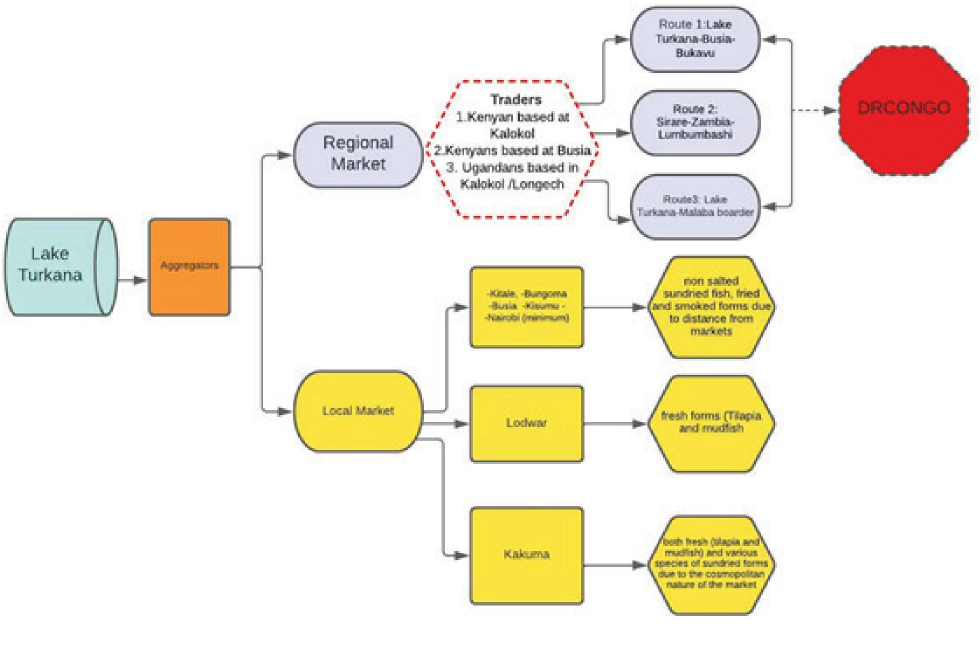


Figure 31: Lake Turkana Fish Value chain

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 32). This excessive fishing effort has had consequent impact on the fishery with decline in catches in two consecutive years (2020 and 2021).

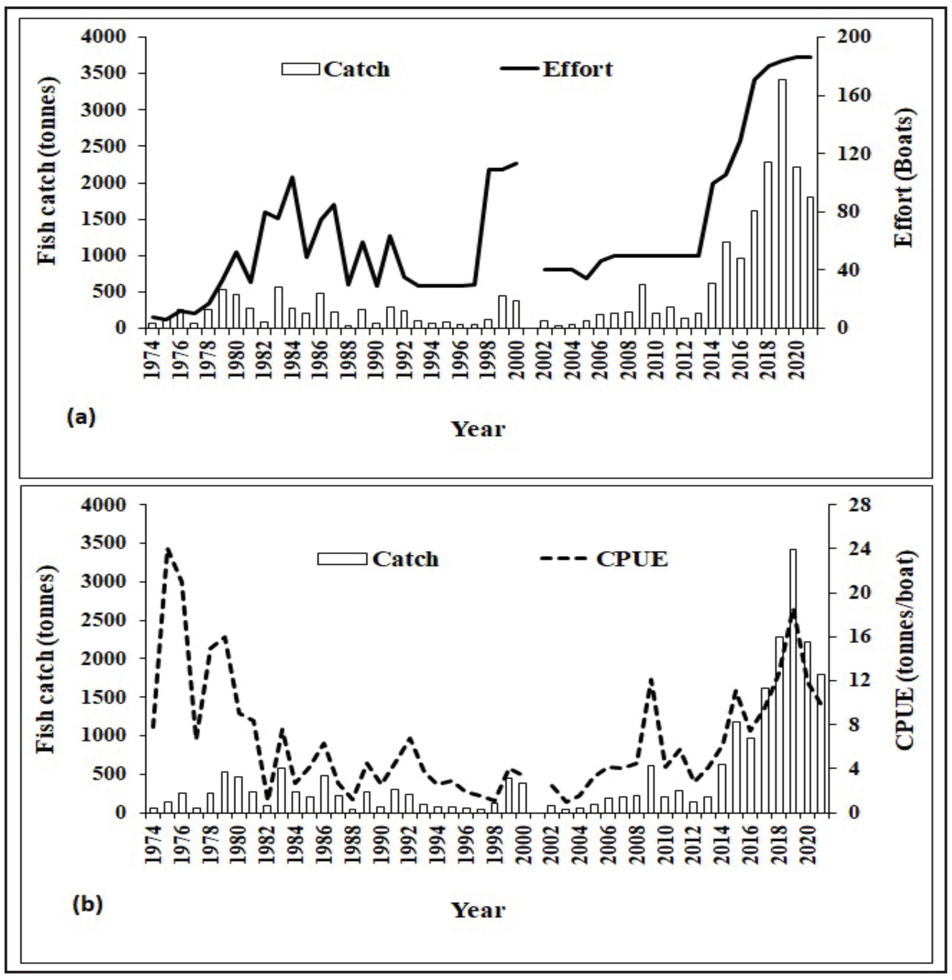


Figure 32: Trends in annual fish landings from Lake Naivasha fishery (1974-2020) in relation to: (a) fishing effort and (b) catch per unit effort (CPUE).

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 33). 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.

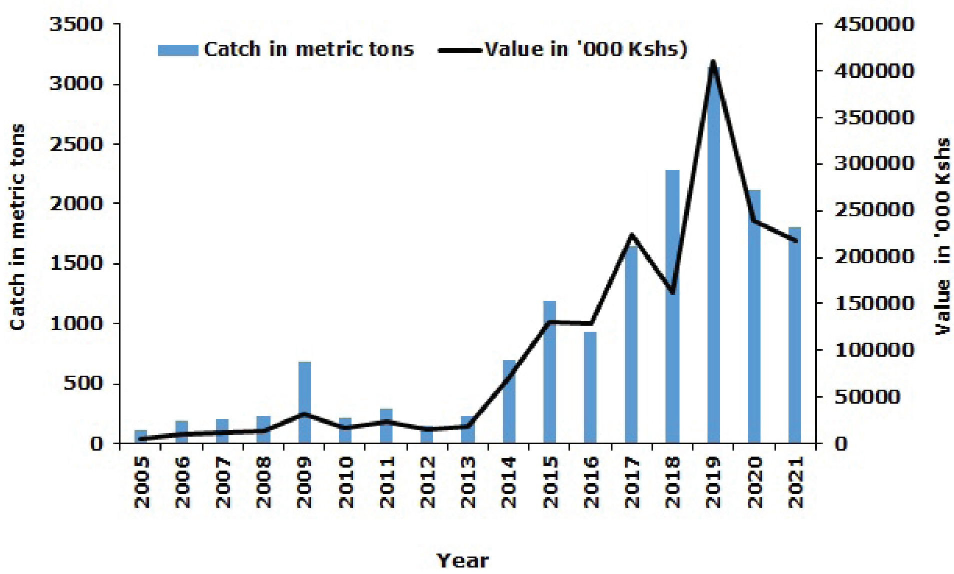


Figure 33: Trends in annual fish landings from Lake Naivasha fishery and value (2005-2021).

Lake Baringo

Lake Baringo is a shallow freshwater in the eastern Rift Valley of Kenya, with a surface area of more than 130 km2 and mean depth of approximately 9.5 m in 2020 (Walumona et al. 2021). The lake is designated as a Ramsar site (Ramsar, 2002) and lies at 0°36´N, 36°04´E, and approximately 60 km north of the equator at an altitude of 975 m above mean sea level. Despite being a Ramsar site, the pressures on the lake's ecosystem is considerable. The fish community of Lake Baringo comprises only a few species. Originally the endemic Tilapia (Oreochromis niloticus Baringoensis) was the only cichlid fish in the lake in 1931 (Worthington et al. 1936). The low fish diversity in the lake is thought to be due to overfishing and limnological changes (Hickley et al., 2004). By 1998 introduced species; the marbled lungfish (Protopterus aethiopicus/ "Kamongo"), catfish (Clarias gariepinus/ "Singiri"), Labeobarbus intermedius and Labeo (Labeo cylindricus) were recorded to be increasing in fishers' catches. The Lake has three commercially important fish species namely: Protopterus aethiopicus, Oreochromis niloticus and Clarias gariepinus, with Labeobarbus intermedius/ "Lebile" and Labeo cylindricus/ "Ningu" occasionally recorded in the landings. P. aethiopicus

(Pa) is the most abundant fish landed in Lake Baringo constituting 47.7% in 2020 and 66% in 2021 followed by C. gariepinus (Cg) at 29.8%, in 2020 and 7% in 2021, O. niloticus (On) at 12% in 2020 and 24% in 2021 and L. intermedius (Li) at 11% in 2020 and 3% in 2021as depicted in Figure 34. Nevertheless, it's important to note that the lake experiences high changing species ratio.

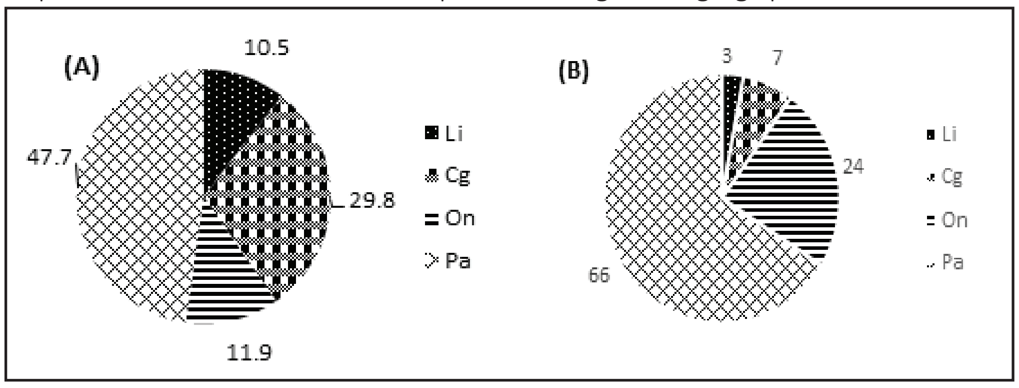


Figure 34: Percentage catch composition of commercially important fish species in 2020 (A) and 2021 (B). Pa (P. aethiopicus), Cg (C. gariepinus), Li (L. intermedius), On (O. niloticus)

The reported yield of Lake Baringo's fisheries has fluctuated greatly since the early 1990's (Figure 35). Generally, the bulk of the fish landings are being contributed by lungfish Protopterus aethiopicus and Cat fish, Clarias gariepinus. Historical landings from the lake over the last 30 years (Figure 13) has recorded as high as 465 tons in the year 2000 and 452tons in 2014 after El Nino rains of 1997/98 and heavy rains in 2013. A similar trend was observed in 2021 where 400 tons of fish was landed following the risen lake level that was recorded in all Rift Valley lakes in 2020. This as will be discussed in the section 4.0 was accredited to increased habitats which acted as refuge and suitable breeding areas among others. Presently and specifically by March, 2023, the O. niloticus baringoensis (listed as endangered in the IUCN Red List) was leading in terms of daily landing from the Lake.

Besides, the fisheries production data reported for Lake Baringo is still grossly under-reported owing to the fact that many of the active fishermen are unlicensed and sell their fish under cahoots as well as due insecurity in the North Eastern and Northern parts of the lake which aren't accessible by relevant government agencies engaged in data collection. However, it is believed that should proper documentation be done, the lake would be contributing more than is quantified towards alleviating poverty and fight against malnutrition that is rampant in Baringo County.

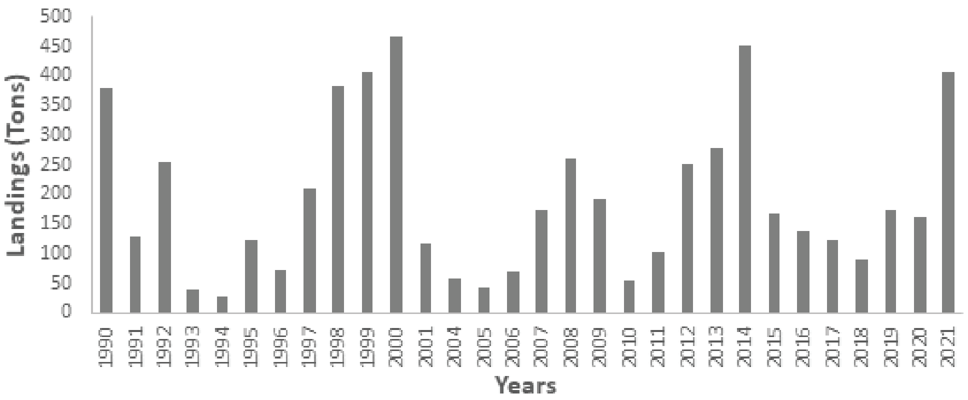


Figure 35: Fish yield (landings) for Lake Baringo over the last 30 years (1990- 2021)

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 36). Aquaculture is practiced in fresh, brackish and marine waters, with production limited to a smaller number of fish species compared to capture fisheries.

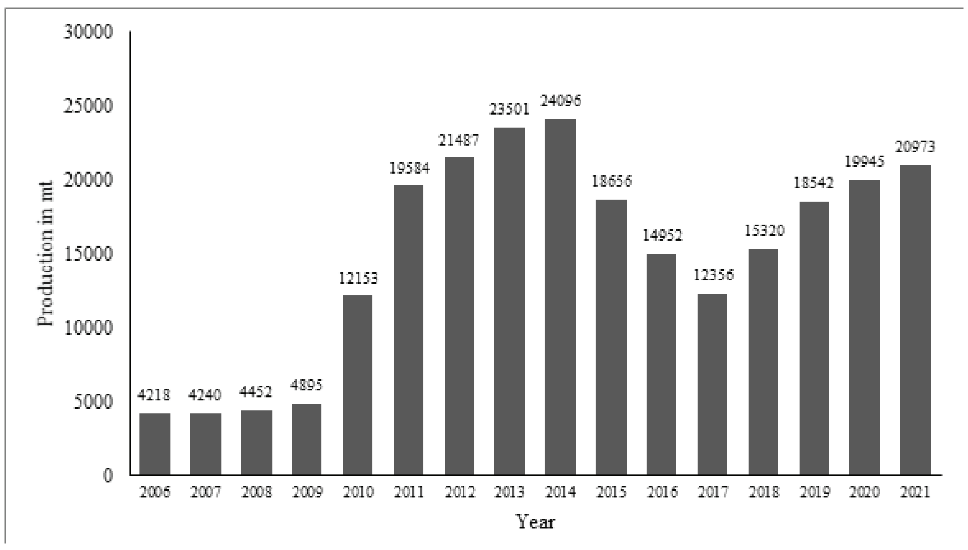


Figure 36: Trends in aquaculture production in Kenya 2006 – 2021; Source: (KNBS, 2022)

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 24). 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 24: *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 37). 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 18: 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 37 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).

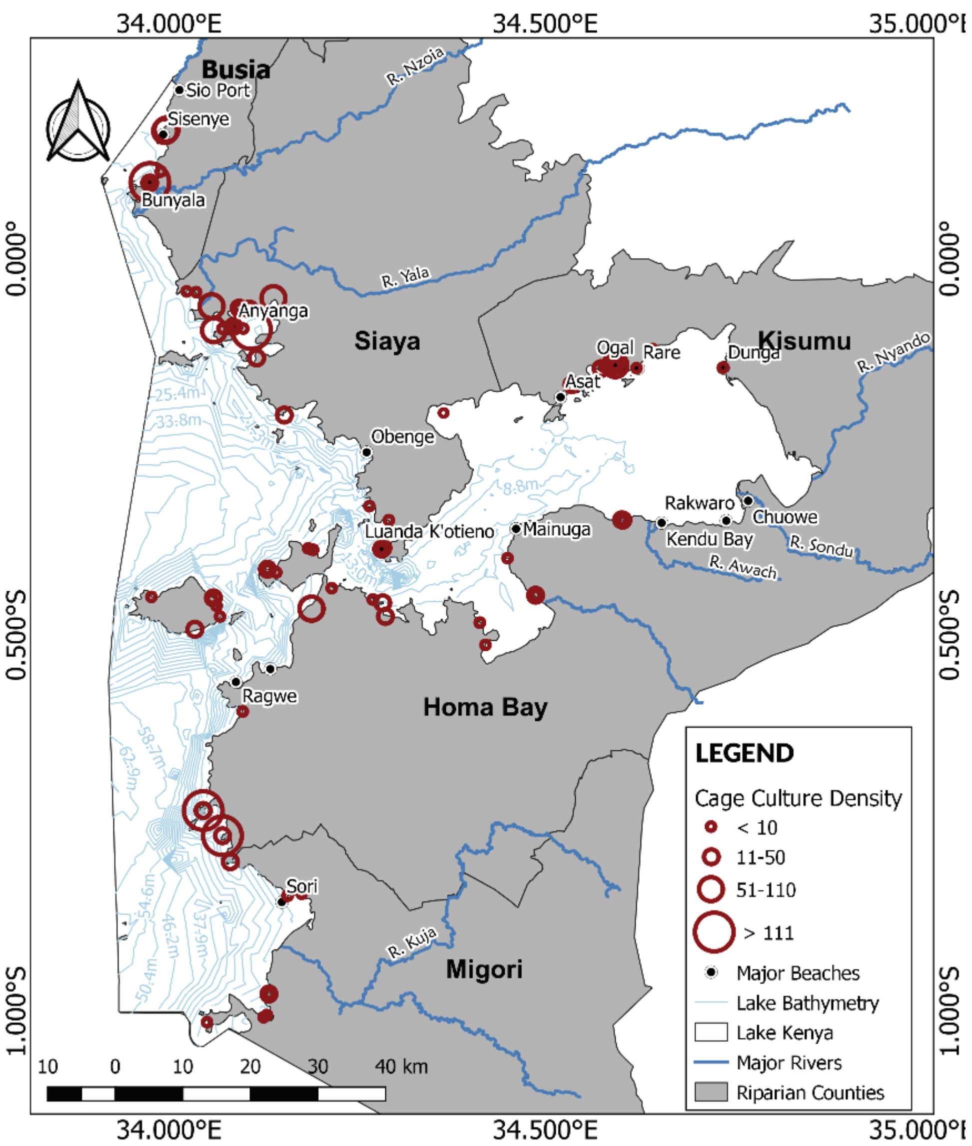


Figure 37: Distribution of cages in Lake Victoria, Kenya as per March 2022

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 25).

Table 25: *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

a. Initial cage culture setup and siting

There are statutory requirements for cage culture setup in the Kenyan waters (Table 26). Inshore Aquaculture

Table 26: *A summary of statutory cage culture setup requirements*

Best Management Practice	Description	Frequency	By Whom	Government Agency Check
Cage Location and Siting	Choose suitable locations for cage placement in Lake Victoria, considering factors such as water quality, depth, and current patterns. Avoid areas with heavy pollution, high sedimentation, or strong wave action.	As needed, during initial setup and periodically during operation	Fish farmer/ site manager	1. Ministry responsible for Fisheries and Aquaculture Development 2. National Environmental Management Authority (NEMA)-EIA/ESIA 3. Kenya Marine and Fisheries Research Institute (KMFRI)-Statutory institution on suitability 4. Kenya Fisheries Service (KeFS)-Permit 5. County Fisheries Government- no objection letter 6. Beach Management Unit (BMU)-Memorandum of Understanding 7. National Lands Commission (NLC) Concession letter

b. Inshore and offshore cage culture

The inshore suitable areas 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 (Fig. 38). 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. These cage culture suitability maps are subject to change given the dynamic nature of the lake ecosystem.

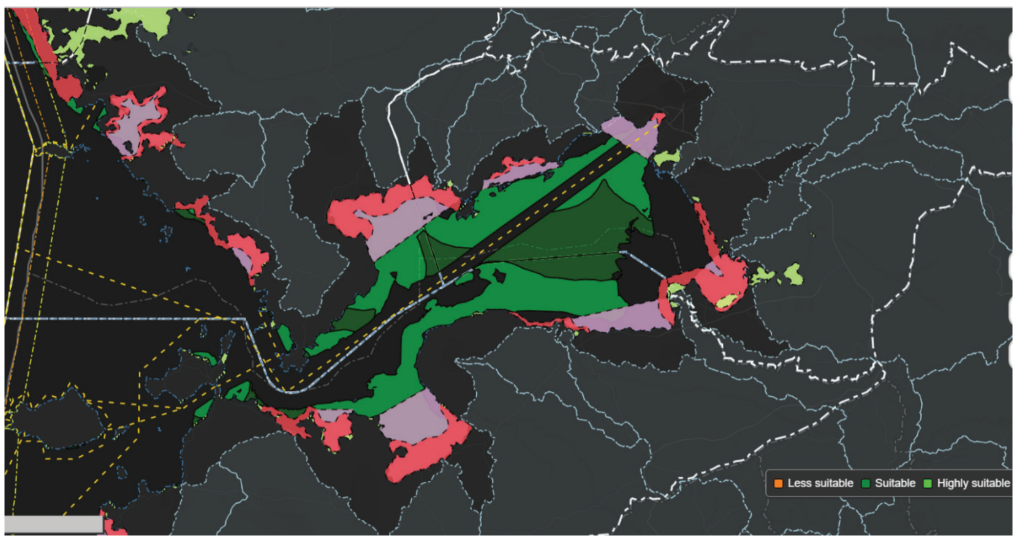


Figure 38: Inshore maximum area for aquaculture in Lake Victoria, Kenya

The offshore suitable areas 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 (Fig. 39). Such installations require firm anchorage to withstand strong currents and could be mainly for capital intensive farms.

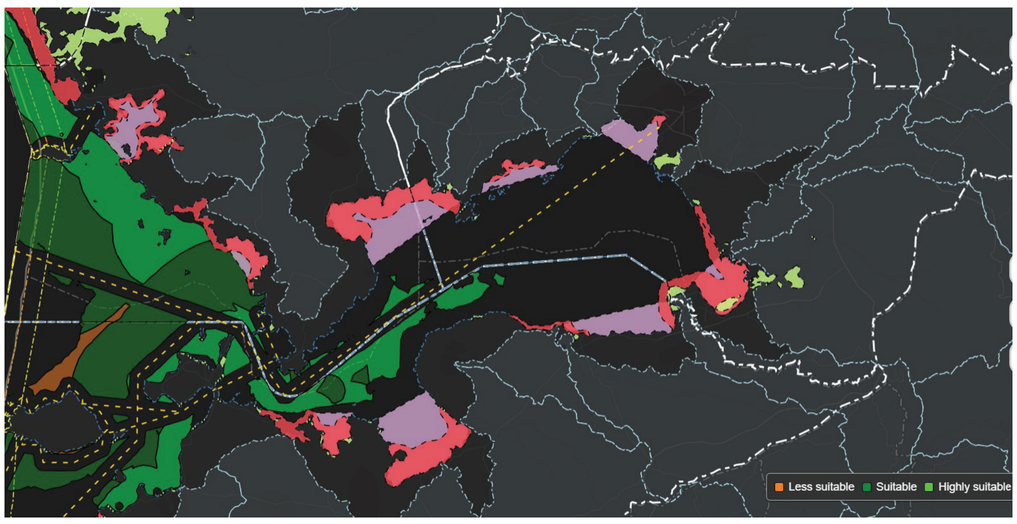


Figure 39: Offshore maximum area for aquaculture in Lake Victoria, Kenya

Aquaculture in Small Water Bodies (SWBs)

Recent studies on restocking and aquaculture expansion in Small Water Bodies (SWBs) have shown their potential in promoting fisheries and aquaculture in Kenya (Aura et al., 2023), for instance, 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 (Fig. 40). 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).

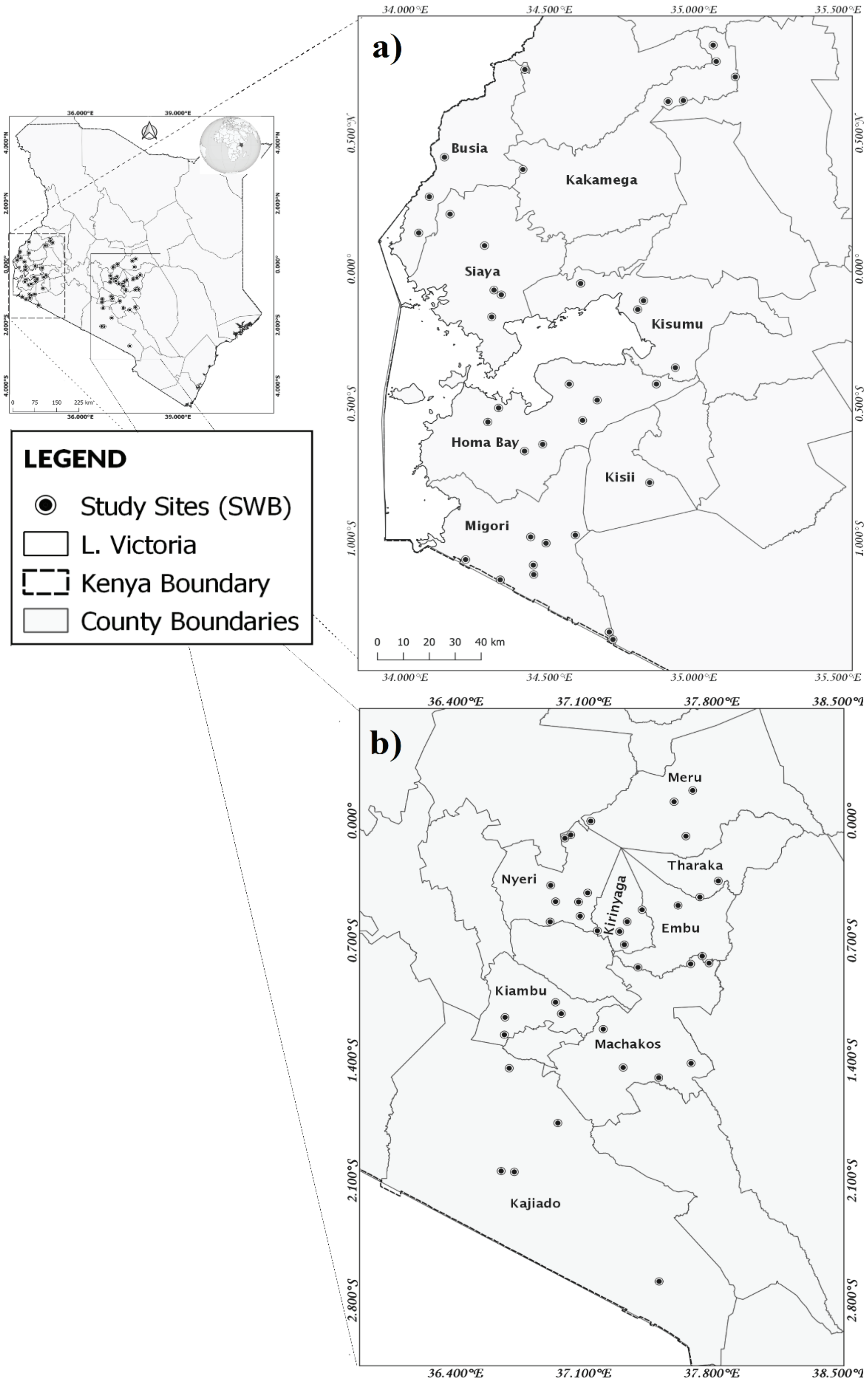


Figure 40: About 74 SWBs in a) western, and b) central regions of Kenya whose aquaculture and restocking potential has been identified (Source: Aura et al., 2022)

Coastal and Marine Fisheries of Kenya

Marine Capture fisheries

Marine capture fisheries include small-scale, semi-industrial, industrial, aquarium and recreational fisheries taking place in Kenya's territorial waters (Fig 41). Artisanal and semi-industrial fisheries are exploited by the coastal local communities, while the industrial fisheries are exploited by foreign fishing (KMFRI Report 2018). The inshore waters which are fishing grounds for artisanal fishers are over-exploited and degraded. The artisanal and semi-industrial catches are landed at an estimated 197 fish landing sites along the coast. Great potential exists in the exploitation of the Kenyan EEZ (Figure 19 and 20) where estimates done in 1975-1980 indicate potential of 100,000 to 150,000 metric tonnes annually (FAO, 1980) and more recent estimates indicate potential of 300,000 metric tonnes (Kimani et al., 2018).

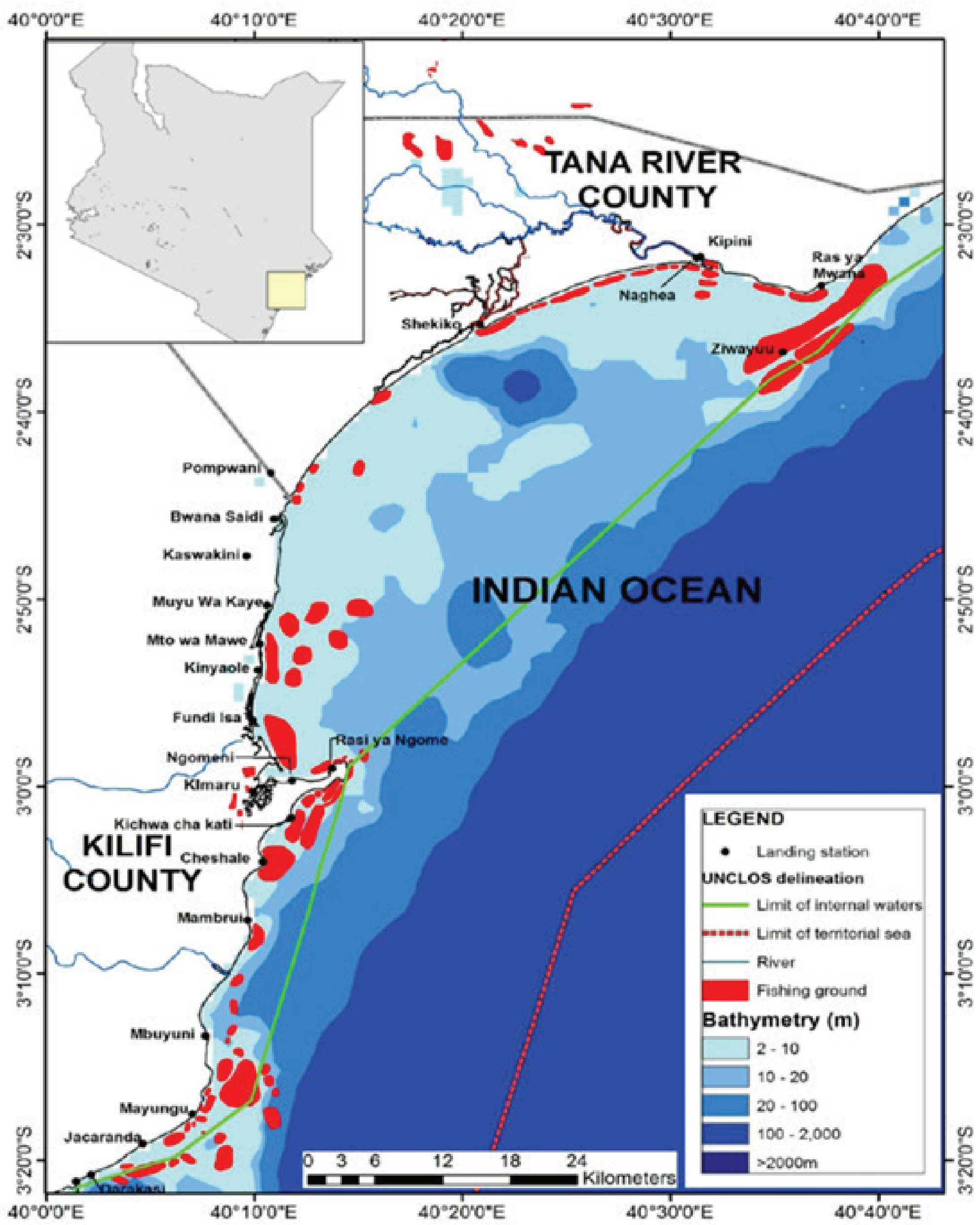


Figure 41: Major fish landing and fishing grounds within the Kenyan territorial waters (Source KMFRI, 2018)

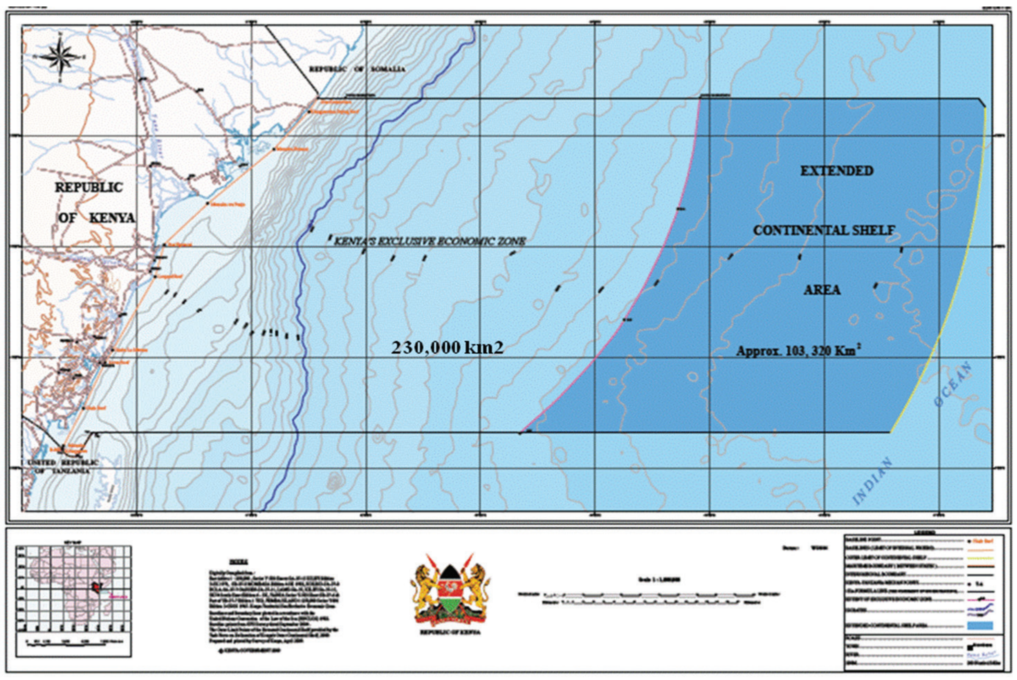


Figure 42: Kenya's oceanic exclusive economic zone

Marine artisanal Fisheries

Marine fish species commonly exploited along the Kenyan coast and whose stock assessment in undertake are shown in plate 19. 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 22). 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 43).

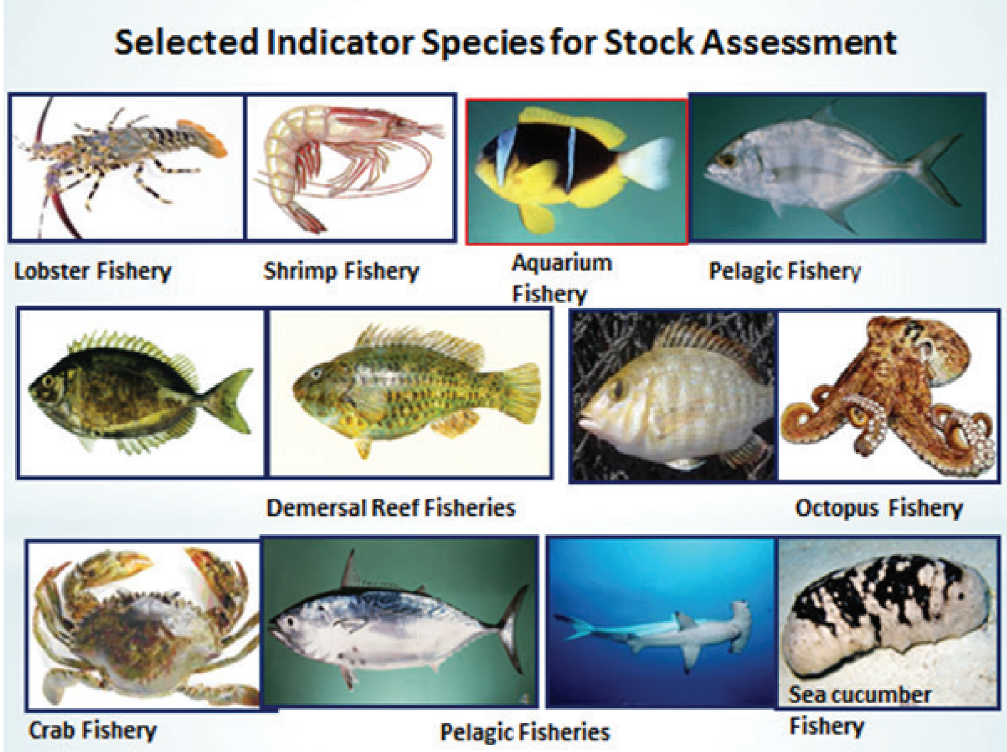


Plate 19: Selected indicator species for stock assessment commonly exploited from the Kenyan coast.

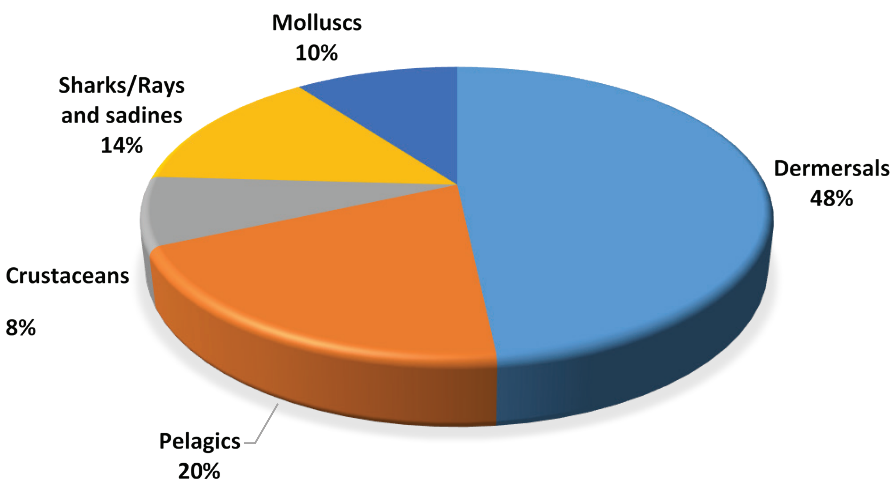


Figure 43: Percentage contribution of marine fish species groups by 2021

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 44). 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).

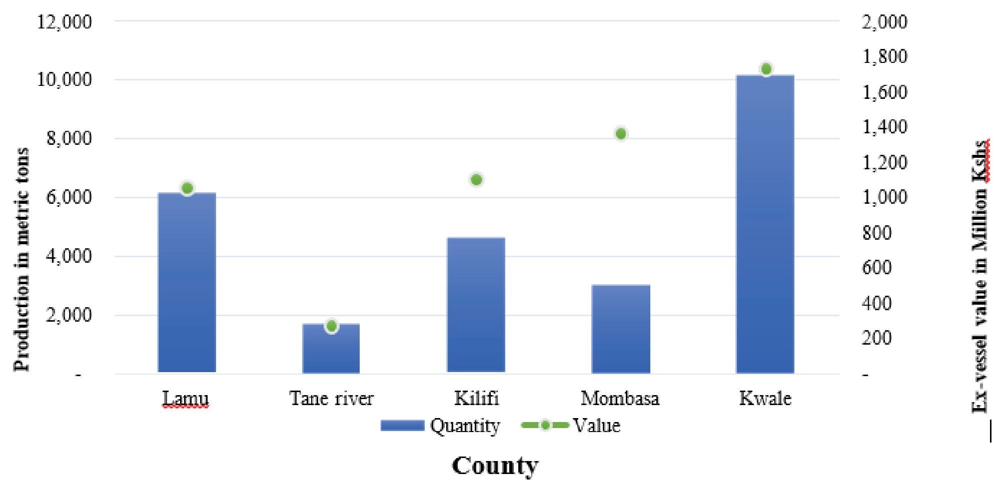


Figure 44: Marine fish production by Quantity, and Value by Counties by 2021

Industrial and semi-industrial Fishing

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 45). 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 (targeting a wide range of species majorly the tunas, the billfishes striped marlin and short bill spearfish) is mainly observed in the Kenyan EEZ, Tanzanian EEZ and to some extent in the high seas. Trawling by foreigners is undertaken in Kenyan deep sea between November and March during the peak. Their targets are tuna, shellfish and prawns. There was no activity observed in the area next to the Somali EEZ. The situation is similar to the year 2021 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).

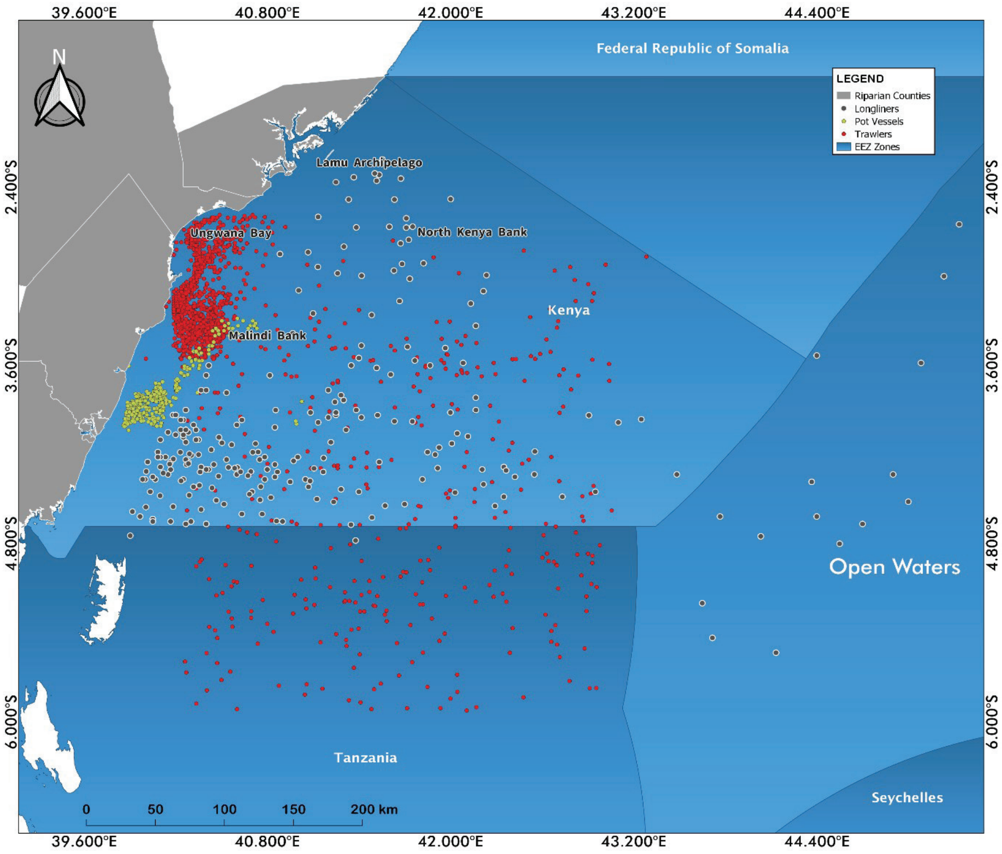


Figure 45: Map showing the Kenyan coastline, riparian counties and fishing ground data for the year 2021

Marine culture status

Coastal aquaculture development in Kenya can be traced back to the early 1980s mainly through mariculture initiatives by community groups (Mirera, 2011). Most of these groups mainly began with a conservation focus but deviated to different forms mariculture. Target species for culture have been milkfish, mullet, mad crab, prawns, artemia and seaweeds (plate 20). The main challenge faced in finfish culture include inadequate seeds, seasonal availability of seeds and inadequate extension services among others. These issues are being addressed with the investment on development of a marine hatchery by the Kenya government at Shimoni and small private investors in Kilifi County.

Plate 20: Target species for marine culture in Kenya: A= milkfish; B= mullet; C= mad crab; D= prawns; E= artemia; and F= seaweeds (Source KMFRI).

Milkfish has been fronted as one of the key culture species because of its faster growth, tolerant to high fluctuation in salinity and temperature and availability of the seed. Mullet has similar characteristics but grows at a slower rate in the local conditions and thus not preferred by farmers. Shellfish culture in coastal Kenya has mainly focused on the culture of mud crabs, prawns and artemia which to date have attained different levels of production. Seaweed farming was introduced in the south coast of Kenya to improve the wellbeing of communities initially with one village (Kibuyuni) but has currently spread to five other villages. The main seaweed species farmed commercially is Eucheuma denticulatum commonly known as "spinosum" while Kappaphycus alvarezzi commonly known as "cottonii" is farmed at experimental scale using different methods.

Marine cage culture suitability

Cage culture suitability and exploitation in the ocean has 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 hydrological 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 (Fig. 26).

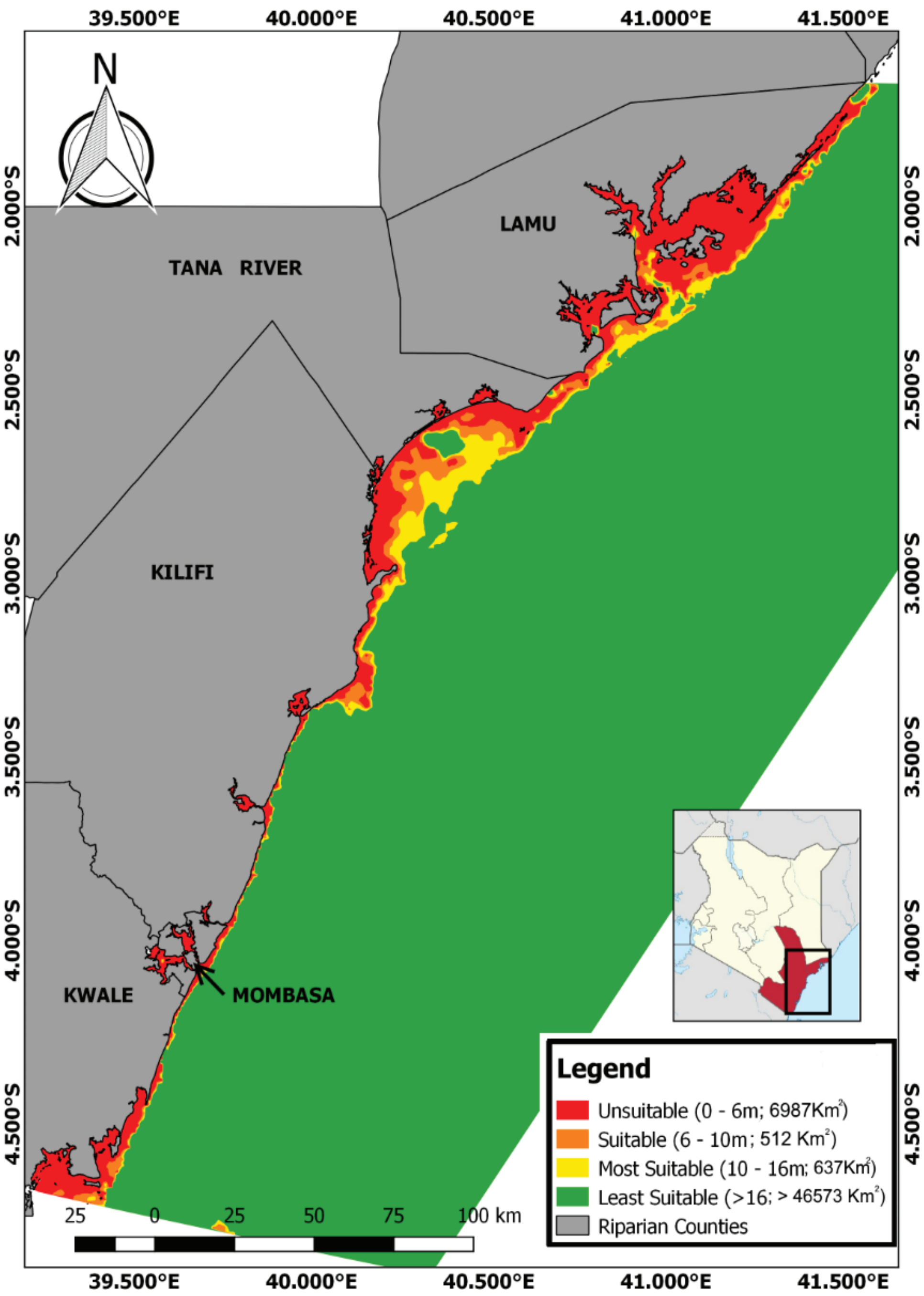


Figure 46: Proposed preliminary potential of cage culture suitability in Kenyan marine waters.

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:

i. Illegal Unreported and Unregulated (IUU) fishing

The Illegal Unreported and Unregulated (IUU) activities remains one of the greatest threats to aquatic ecosystems due to its potent ability to undermine national efforts to manage fisheries sustainably as well as endeavours to conserve aquatic biodiversity. In particular, weak management regimes in developing nations like Kenya, which lack the capacity and resources for efficient monitoring, control, and surveillance (MCS), are exploited by IUU fishing. It affects all facets and stages from fish harvesting/capture to utilization, and it may sometimes be associated with organised crime. It occurs in all types and dimensions of fisheries, on the high seas as well as in areas within national jurisdiction. Fisheries resources available to bona fide fishers are removed by IUU fishing, which can lead to the collapse of local fisheries, with small-scale fisheries in developing countries proving particularly vulnerable. This calls for enhanced sustainable management of the fishery through: empowering and enforcement of fisheries regulations by Fisheries department, Coast guard and BMU among other measures.

ii. 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, environmental degradation and inadequate enforcement of regulations. Reducing the fishing effort would allow biological processes to reverse the declining fish stocks seen in inland and inshore water bodies on Kenya.

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.

The waste removal capacities of rivers and wetlands has dwindled and dilution is no longer the solution to pollution. Most of the water quality problems are revealed in the impacts they cause, especially in the vulnerable environments; lakes, degrading wetlands, arid and semi-arid watersheds and coastal environments the world over. The aquatic waste sources can be classified into, Solid wastes and liquid wastes. The wastes are being disposed or flushed into the aquatic ecosystem from agricultural, commercial and private activities. They include: heavy metals, pesticides, agrichemicals, Nutrients and Synthetic organic among others. Synthetic organic wastes including microplastic are in recent years, more present than ever in the aquatic environment. It affects the entire food chain and even humans who eat seafood.

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. The aforementioned Fisheries Management and Development Act 2016 is currently under review i.e. The Fisheries Management and Development Bill 2023. The principal of objective of the Bill is to provide a comprehensive legislative framework for the development, governance and investments of the oceans and fisheries resources; in line with the national development policy objectives envisaged in the vision 20230. The Bill seeks to align the governance of fisheries sector to the constitution of Kenya 2010 which calls for sustainable use of natural resources for the benefit of the people of Kenya and governance at the county and national levels.

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.

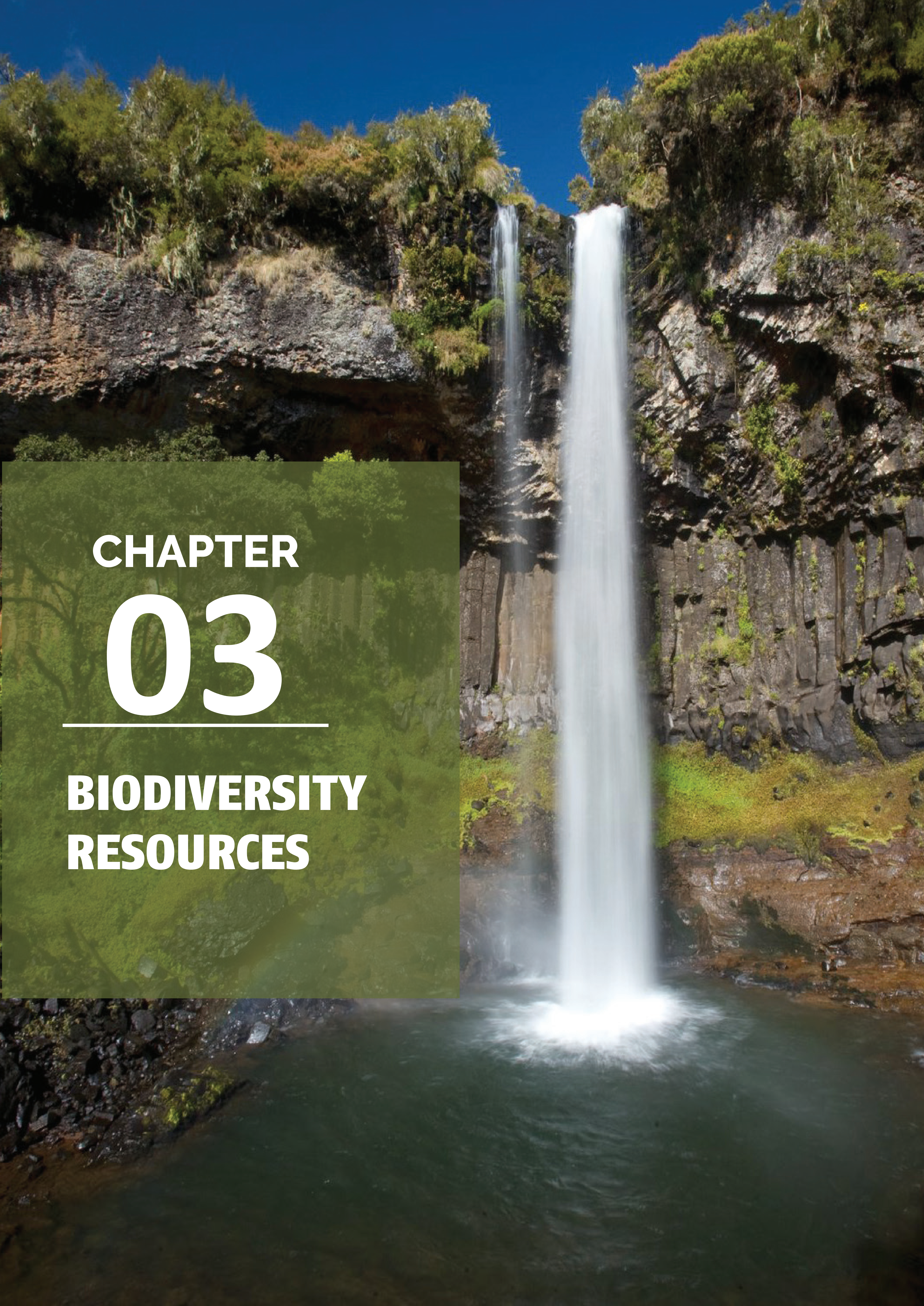
Climate Change

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.

Recommendations

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



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.

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(Figure 54). 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 Natural forests and Plantations

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 29: Closed canopy Natural forest within Mt. Kenya Forest Ecosystem

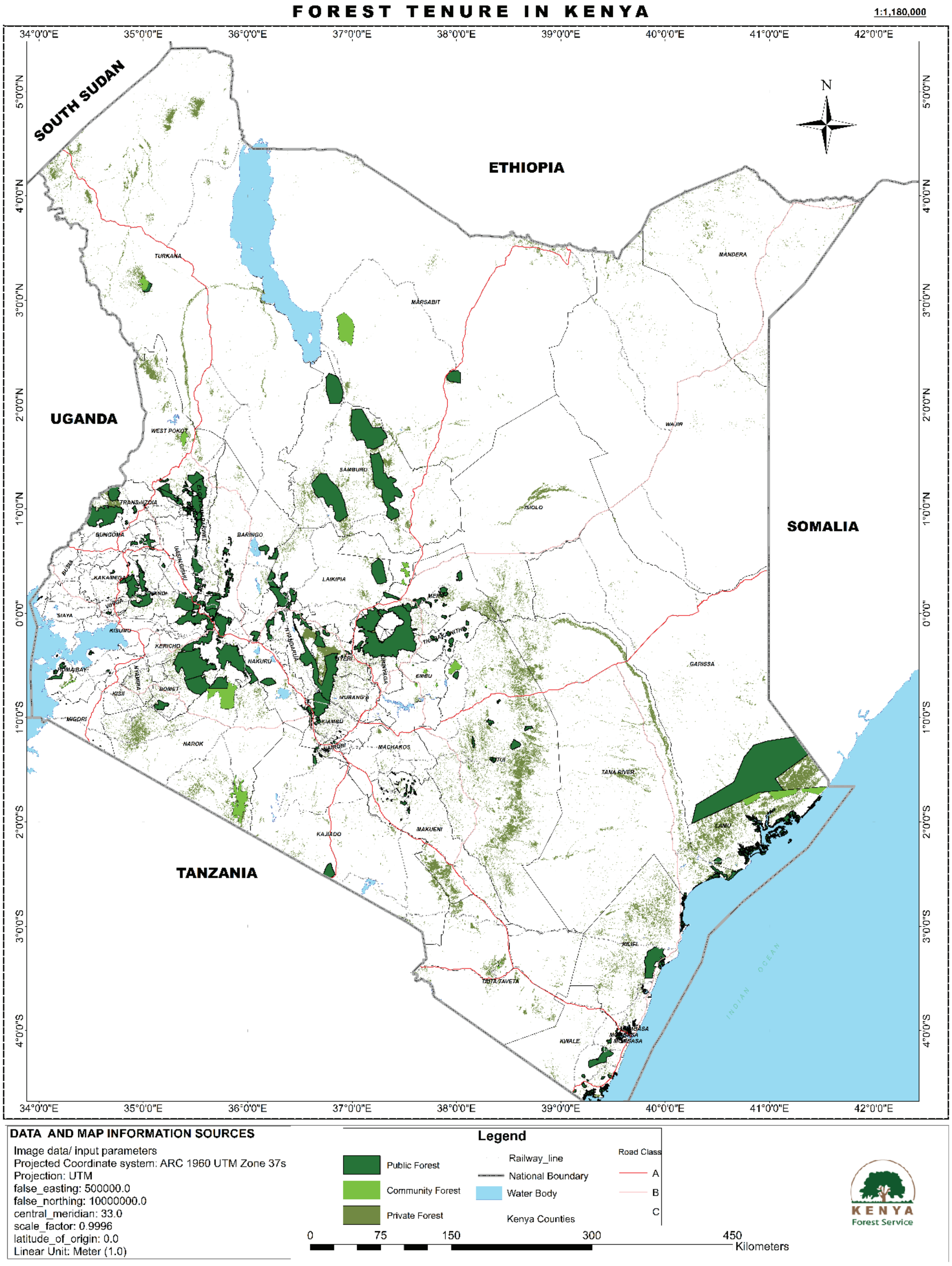


Figure 54: Forest Classes based on land tenure

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 30: Industrial forest plantations within the Mau Forest Ecosystem

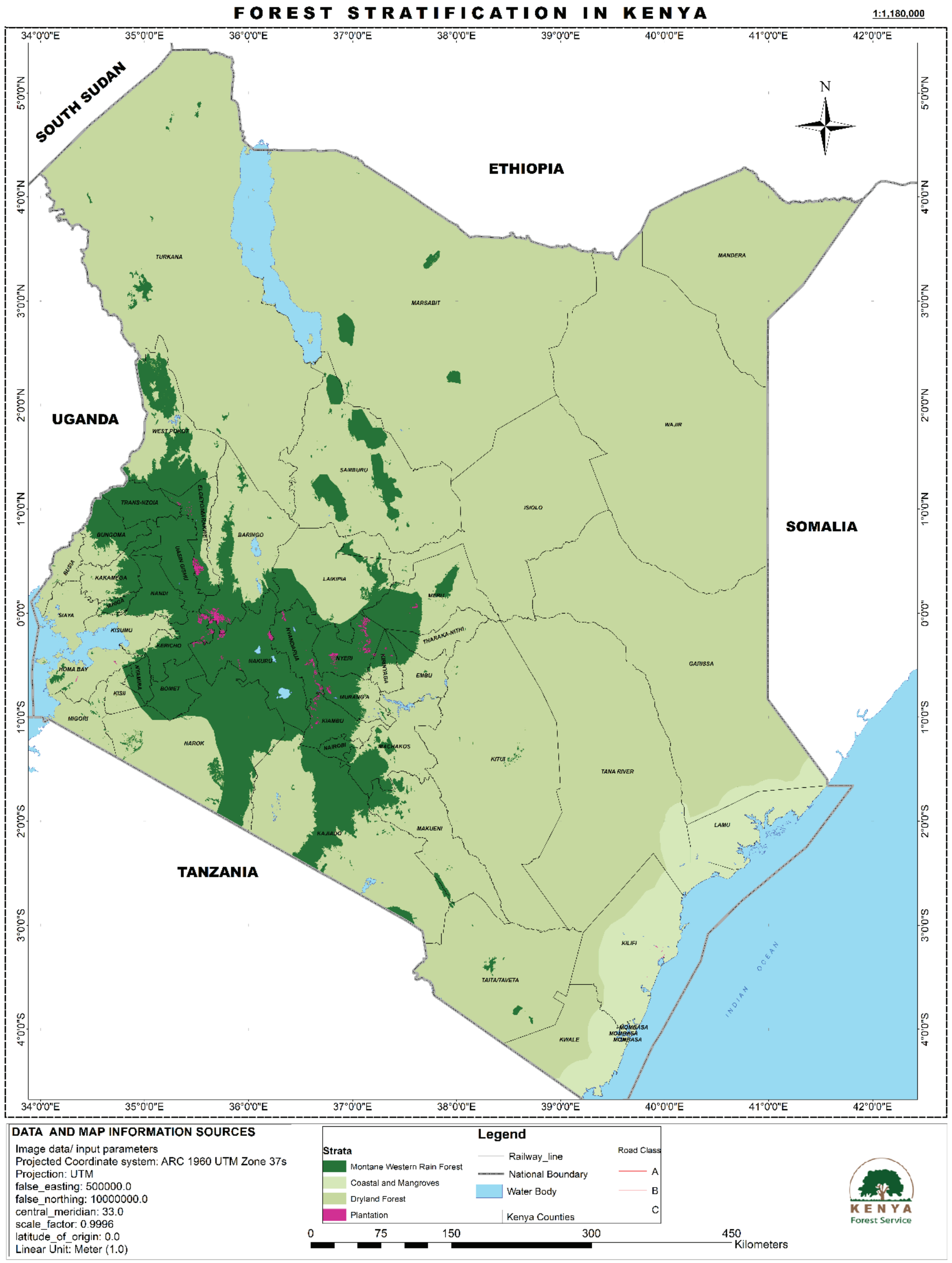


Figure 55: Forest Strata in Kenya

Figure 56: Forest Classes based on land tenure

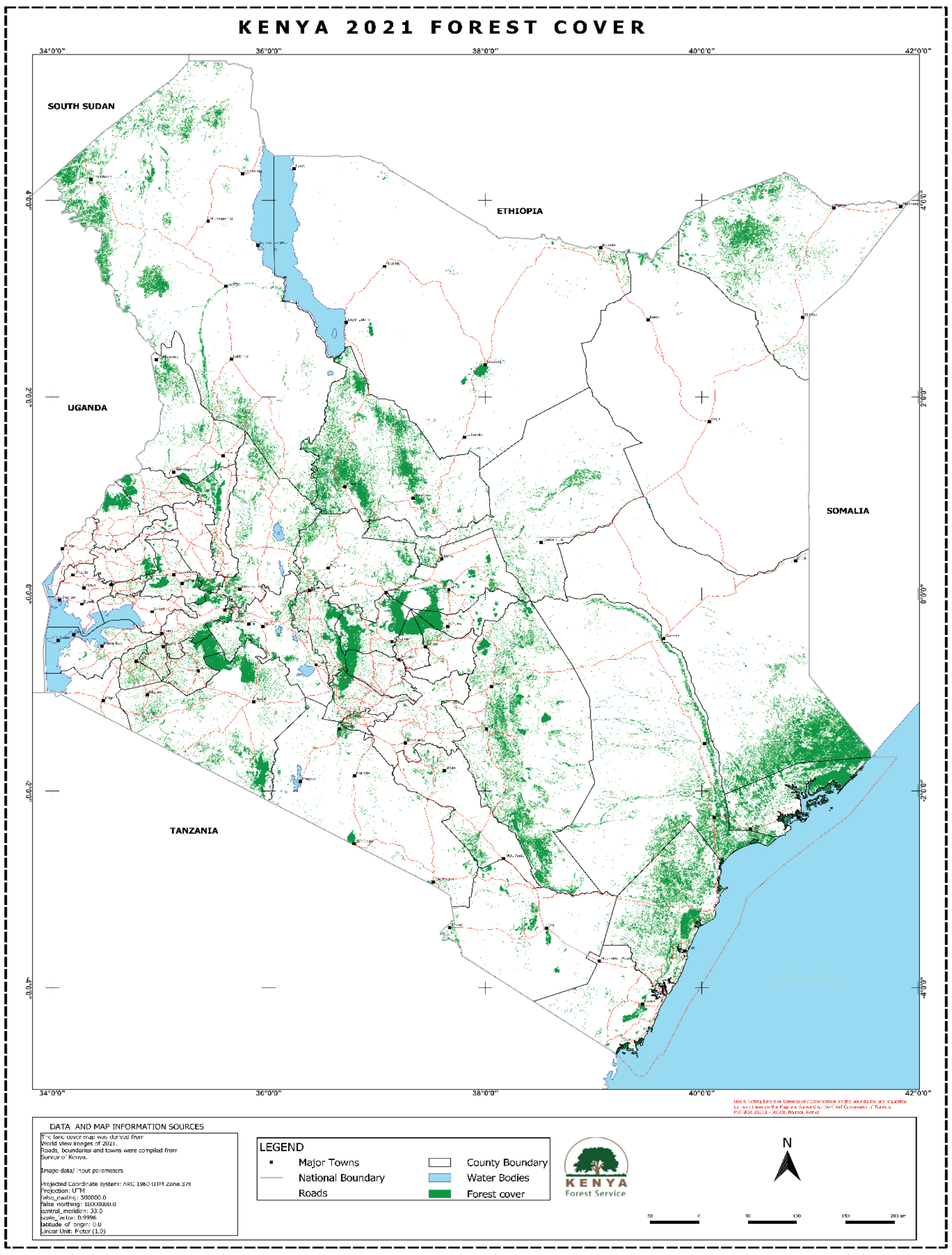


Figure 58: National Forest Cover as at 2021

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).

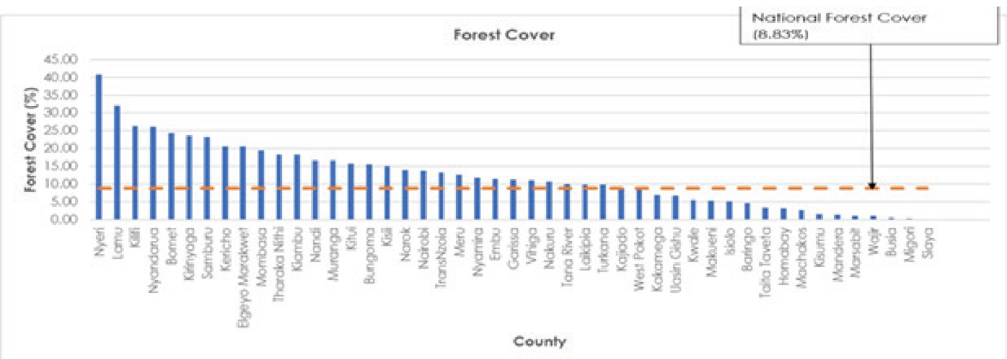


Figure 57: Forest cover (8.83%) by counties. ,Nyeri 40.89 Highest, Siaya 0.23 Least

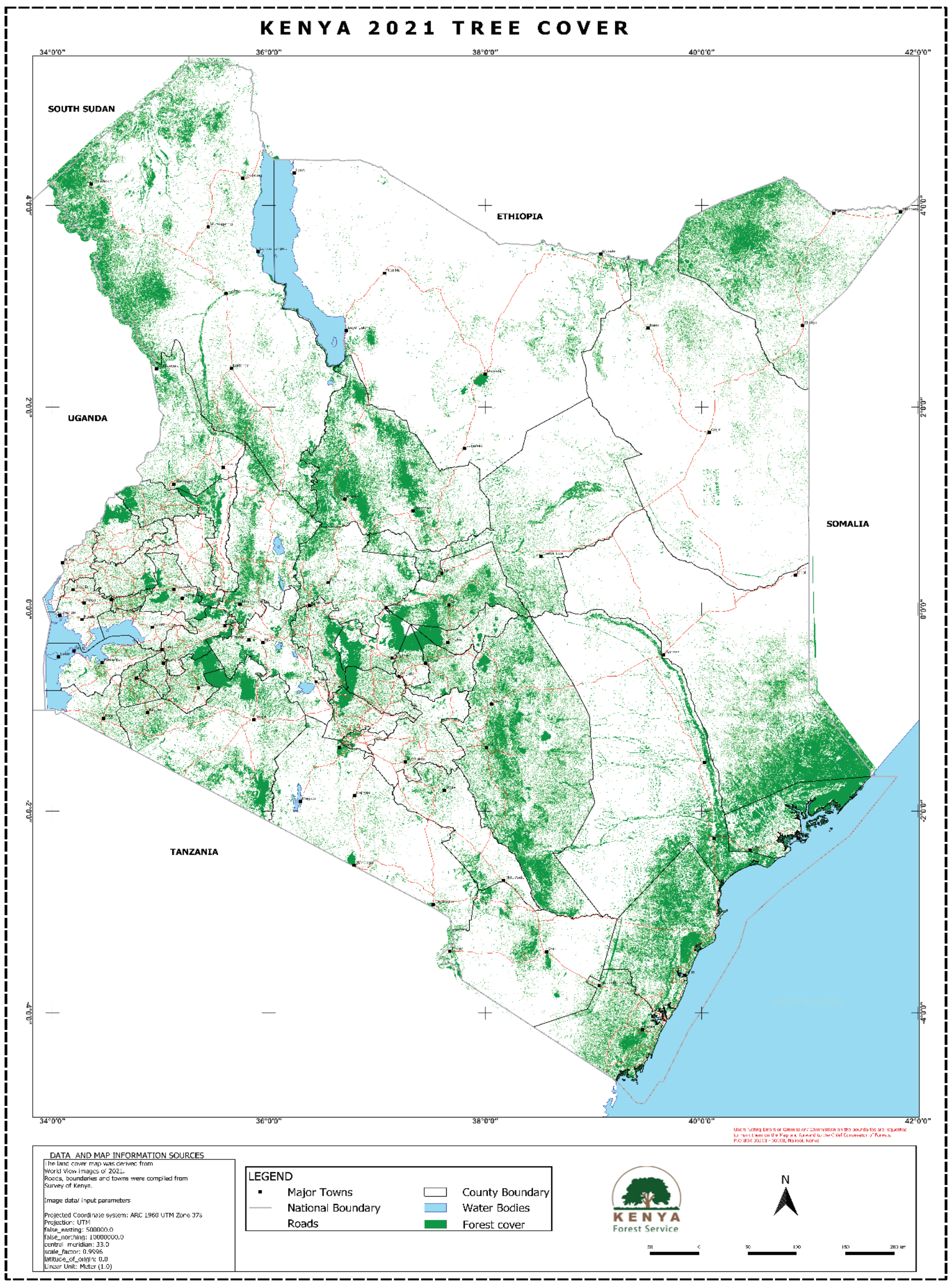


Figure 59: National Tree Cover as at 2021

National Tree Cover

The National Tree and Forest Resource Assessment of 2021, has established national tree cover at 12.13%. This is the first-time tree cover assessment conducted in Kenya. (Figure 57 and 58) the distribution of the tree cover across the country and by counties respectively.Kenya has a total of 7,180,000.66 Ha (71,800 Km2) of Tree cover which translates to 12.13% of the total land area (Fig. 59 and 60). The county with the highest tree cover is Nyeri at 45.17% while the lowest is Marsabit at 2.06%.

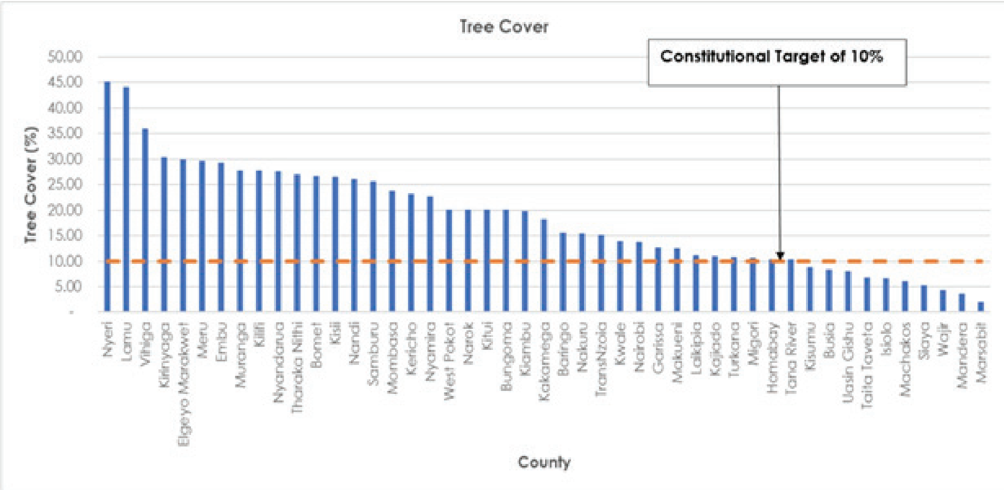


Figure 60: Distribution of 12.13% tree cover by counties

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 (Table 1) With accelerated corrective efforts however, the trend has been changing between 2018- 2021 (Fig 61 – Fig. 65). 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.

Table 37: *forest cover and canopy distribution between 2002 -2018*

Land Use Strata	2002		2006		2010		2014		2018		2021	
Year/ Species	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

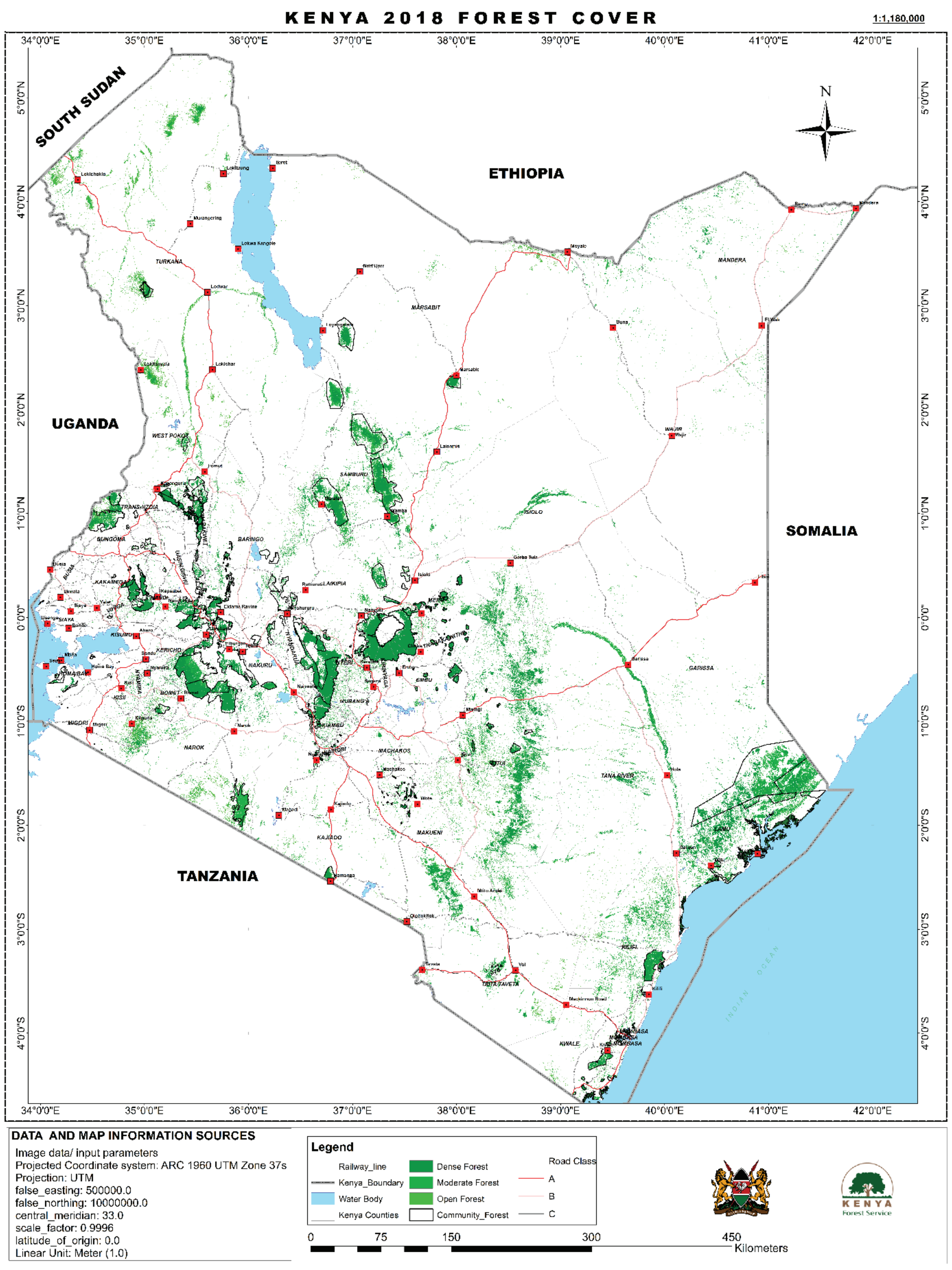


Figure 61: Forest cover map 2018

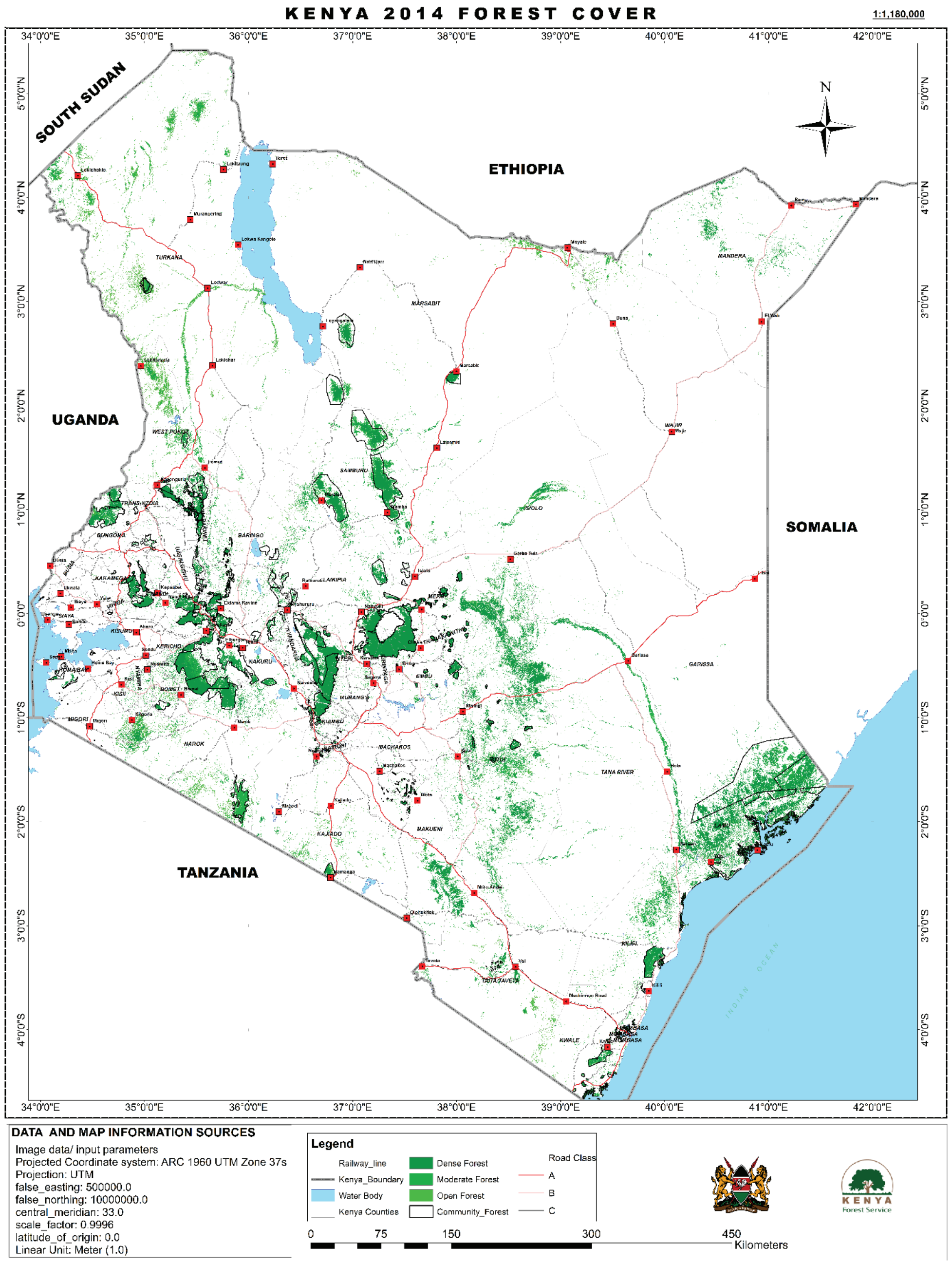


Figure 62: National forest cover 2014

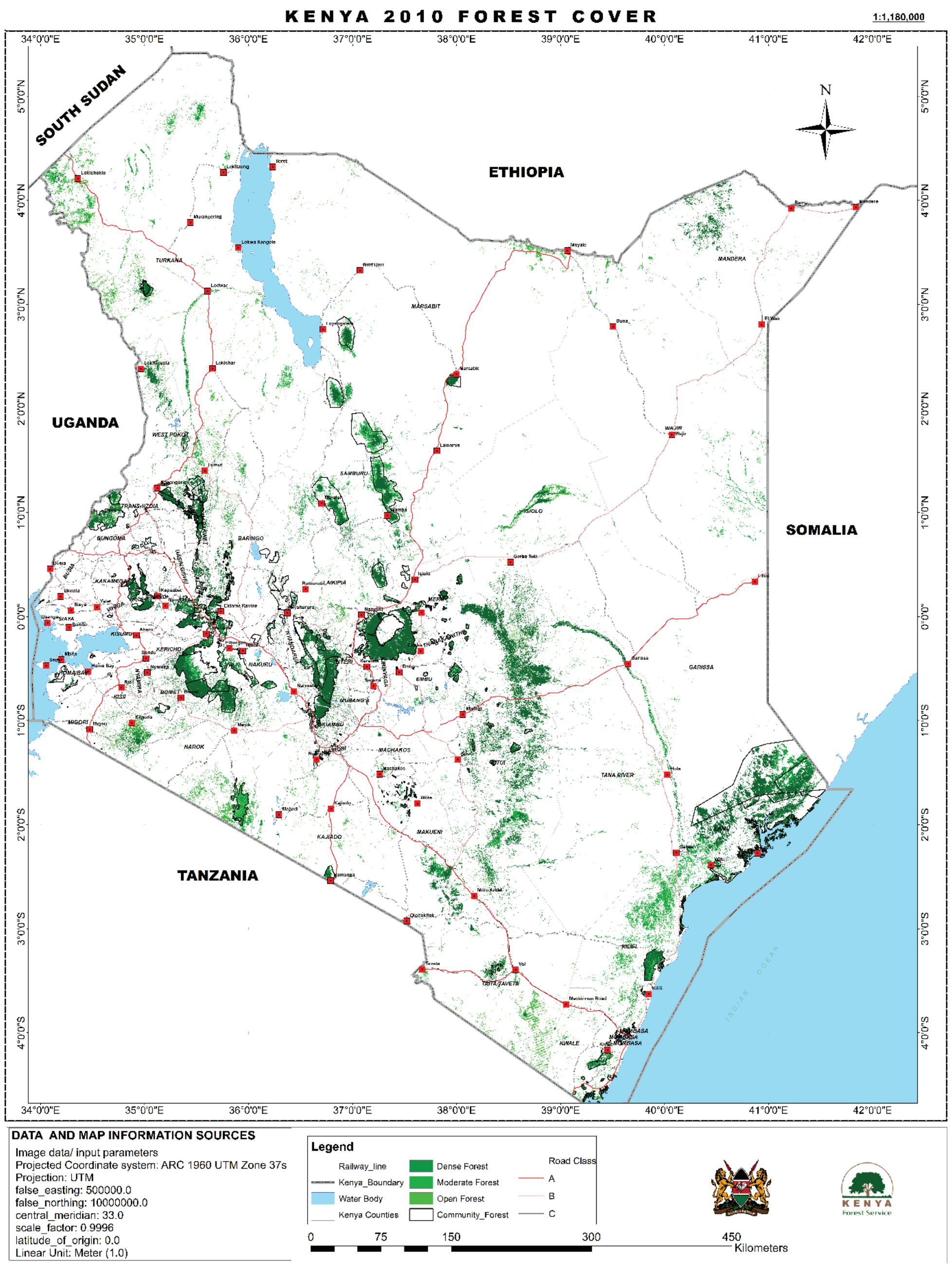


Figure 63: Forest Cover Map 2010

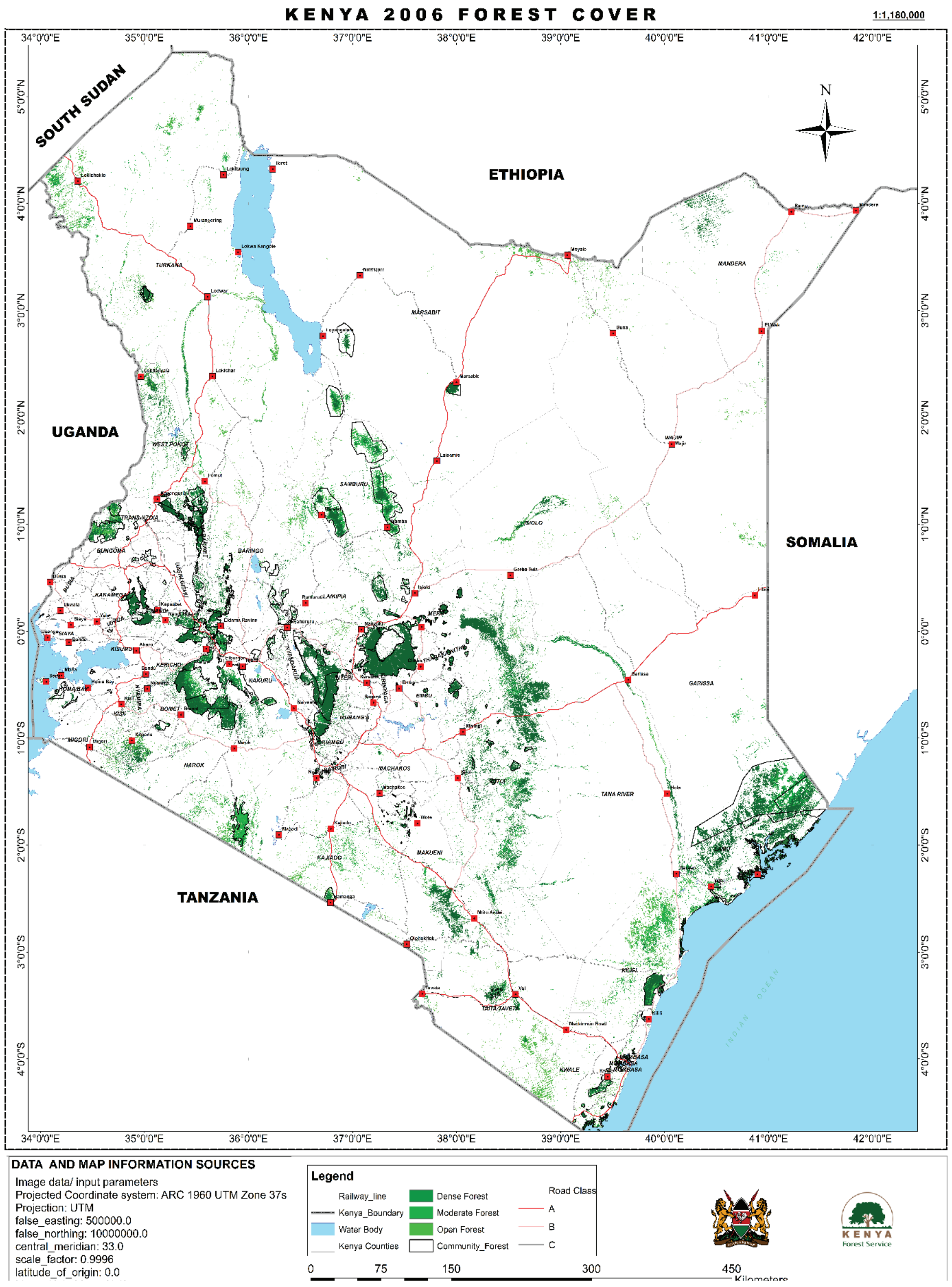


Figure 64: Forest Cover Map 2006

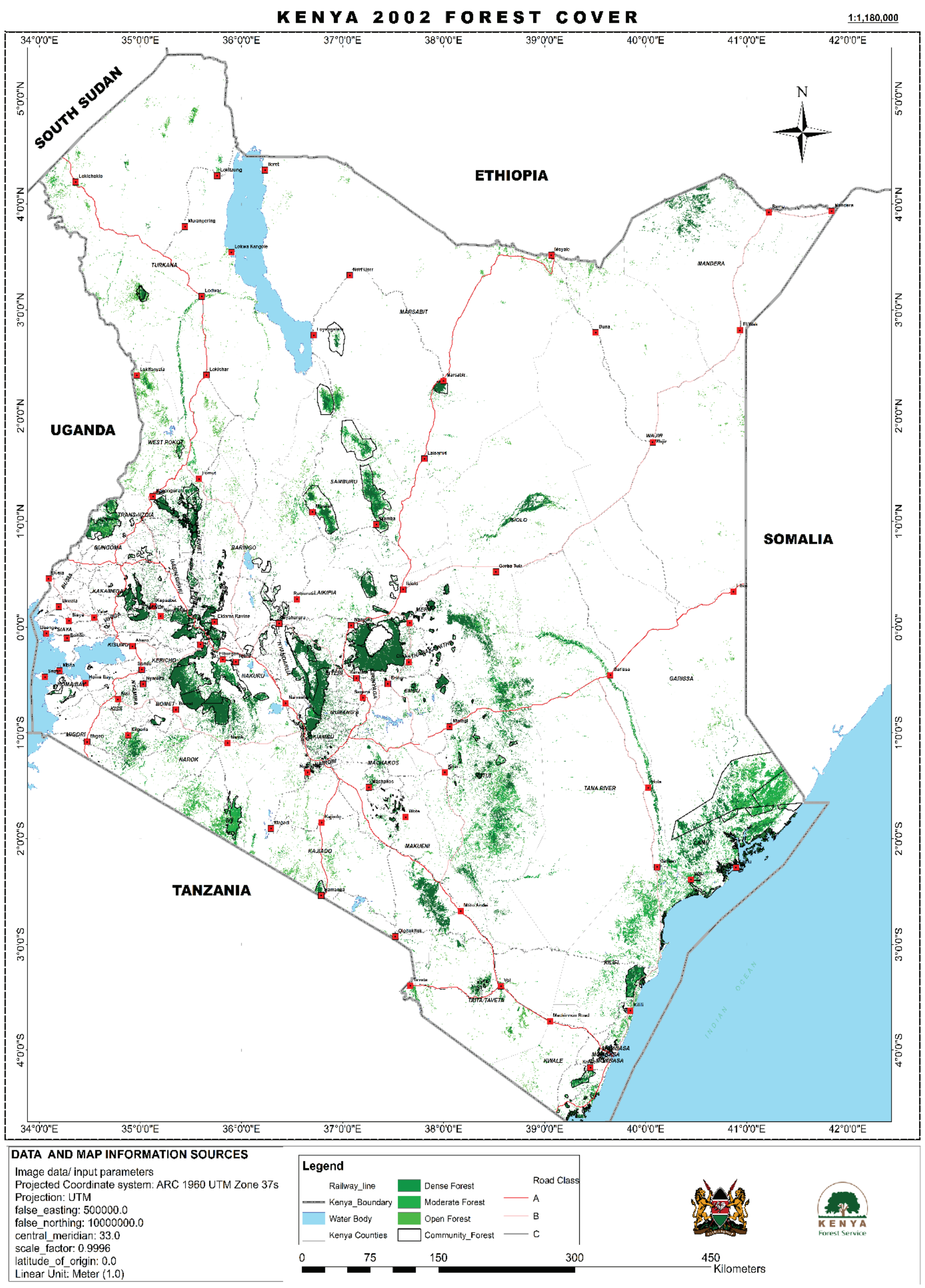


Figure 65: Forest Cover Map 2002

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 66: Wooded grasslands in Wajir County

Kirisia Forest

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 (plate 31), 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 31: Forest Rangers on routine patrol

Legal, Policy Considerations and Institutional framework for Forestry Resource Management

Over the last 20 years the Kenya's forest sector has experienced a series of government-led reforms through enactment of the Forest Act 2005 (now repealed by the Forest Conservation and Management Act 2016) and promulgation of the Constitution in 2010. The following are the key forest sector reforms:-

1. Establishment of Kenya Forest Service as a semiautonomous agency governed by an independent board, with better resource allocation and enhanced capacity.
2. Introduction of Participatory Forest Management (PFM) approach in management of public and community forest resources. This has led to establishment of 250 Community Forest Association (CFAs) around public forests and 290 Charcoal Producer Associations (CPAs) for regulation of charcoal production from community forests.
3. Decentralization of forest governance through establishment of forest Conservation Committee
4. Devolution of forestry functions to county governments established by the Constitution of Kenya, 2010. The conservation and management of forest resources on community land and private lands were decentralized to county governments. While KFS is assigned the responsibility of managing public forests as well as capacity building of county governments on devolved forestry functions
5. Strengthened governance of water towers through the creation of the Kenya Water Towers Agency
6. Strengthened forest research capacity in terms of infrastructure and human capacity. g) Promotion of private sector investments. h) Review of Environmental Management and Conservation Act that contributed to strengthening of forest sector governance and dispute resolution. i) Development of National Land and Land Use Policy and laws that gave recognition and enhanced tenure security of natural resources on community lands.

The Devolved Forest Functions

Forestry is a devolved function as set out in the fourth schedule of the Constitution of Kenya 2010, making county governments' key stakeholders in forest management and development. This is further strengthened by the Section 21 of Forest Conservation and Management Act No. 34, 2016, which mandates the county governments to:-

1. Implement national policies on forest management and conservation;
2. Manage all forests on public land defined under article 62(2) of the constitution;
3. Prepare an annual report, with the approval of the county assembly, for the service on the activities of the county government in relation to this act and any national policies on forest management and conservation;

4. Promote afforestation activities in the county;
5. Advice and assist communities and individuals in the management of community forests or private forests; and
6. May enter into joint management agreements with communities or individuals for the management of community forests or private forests.

Therefore, county governments have the responsibility of implementing specific national government policies on natural resources and environmental conservation as specified in the Gazette Supplement No. 116 of 9th August 2013.

Further, the forest functions have been unbundled and Transition Implementation Plans (TIPs) prepared for all 47 counties in 2016 with an expiring date of 2021. However, to date about 10 Counties have never signed their TIPs while a majority of those who signed have not fully implemented the actions in the implementation plan. The main challenge has been capacity and resource allocation to forestry functions. However, about 18 Counties have now established forestry departments with relevant personnel. Counties have a major responsibility in contributing to the achievement of the national target of 30% forest cover by raising their individual forest cover. This can only be achieved through proper resourcing and capacity building.

A challenge to the above is the empowering county governments to carry out new responsibilities in a competent and informed manner, while observing national laws and policy guidelines. The bottom line is that devolution as a concept has the potential to bring citizens and the government closer together, providing better informed and effective governance. This in turn could spur bottom-up economic development model, social transformation and environmental conservation.

For the achievement of sustainable forestry development and achievement of the National 30% tree cover strategy, the following legislations and policy frameworks have been considered:-

1. The Constitution of Kenya: The Constitution requires the Country to increase and maintain tree cover at a minimum 10% of the total land area. Article 69 (1) (b) emphasizes the need to "work to achieve and maintain a tree cover of at least ten per cent of the land area of Kenya".
2. The Kenya Vision 2030: The Vision places the environmental sector in the social pillar and emphasizes the need to conserve natural resources to support economic growth. For forests, the goal is to increase the area under forest to 10% by 2030 and sustainably manage natural forest resources for environmental protection and enhanced economic growth
3. Medium Term Plan III (2018-2022): Under the Medium Term III, the government has committed to protect natural forests in the water towers and continued rehabilitation of landscapes to increase and sustain water flow and ecological integrity.
4. The National Forest Policy, 2014: The policy aimed at increasing and maintaining tree and forest cover of at least ten percent of the land area of Kenya. The Policy requires every County Government to establish and maintain arboreta, green zones or recreational parks for use by persons residing within its area of jurisdiction.
5. The National Environment Policy, 2013: This policy outlines guidelines for the rehabilitation and restoration of environmentally degraded areas including hilltops in water towers. It recognizes the critical role played by the country's forests and water towers in biodiversity conservation as they provide habitats for unique assemblages of plants and animals, including endemic species.
6. Sessional Paper No. 3 of 2009 on National Land Policy: The land policy responds to manifestations of the land question, which include rapid population growth, breakdown in land administration and land delivery procedures, and inadequate participation by communities in the governance and management of land and natural resources.
7. Sessional Paper Number 1 of 2017 on National Land Use Policy: The policy offers a framework to guide action on the problem of haphazard land use practices and approaches. It calls for maintenance of land use systems that provide for land use planning, resource allocation and management for sustainable development, including within water towers to promote public good and general welfare.
8. The National Wildlife and Conservation Policy, 2017: The goal of this policy is to provide a framework for sustainable management of Kenya's wildlife resources through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures
9. The National Climate Change Action Plan (2018-2022). The Plan is a guide to Kenya's climate change actions, including the reduction of greenhouse gas emissions, built on the progress achieved during the implementation of NCCAP 2013-2017.
10. Kenya ASAL Policy-Sessional Paper No. 8 of 2012: This Policy has five key elements among them affirmative action that equitable development needs the support of all Kenyans; an enabling environment for accelerated investment in 'foundations' to reduce poverty and build resilience and growth; a responsive government to the uniqueness of arid lands which include ecology, mobility, population distribution, economy and social systems.
11. Forest Conservation and Management Act 2016: Section 6(3)(a)(iii) highlights the need to develop "programmes for achievement and maintenance of tree cover of at least 10% of the land area of Kenya". Section 37(1) requires every County Government to establish and maintain arboreta, green zones or recreational parks for use by persons residing within its area of jurisdiction. In this regard, every County shall cause housing estate developers within its jurisdiction to make provision for the establishment of green zones at the rate of at least 5% of the total land area of any housing estate intended to be developed.
12. Environmental Management and Coordination CAP 387 and (Amendment) Act, 2015: The Act Provides for protection of forests and environmental impact assessments of forest-related developments. Section 9(2)(r) of the Act requires NEMA to work with other lead agencies to issue guidelines and prescribe measures to achieve and maintain a tree cover of at least 10% of the land area of Kenya. Section 44 of the Act requires that NEMA in consultation with other relevant lead agencies, develop, issue and implement regulations, procedures, 18 guidelines and measures for sustainable management of hilltops, hillsides and wetlands.
13. Agriculture (Farm Forestry) Rules 2009: These Rules shall apply for the purposes of promoting and maintaining farm forest cover of at least 10% of every agricultural land holding and to preserve and sustain the environment in combating climate change and global warming. Part II Section 6 of the Rules specifically deals with the maintenance of 10% tree cover.

International Conventions and Obligations

Kenya is committed to global initiatives and Multilateral Environmental Agreements (MEAs) notably;

1. Restoration of 5.1 million Ha by 2030 of degraded landscapes as part of its contribution to the Africa Forest Restoration Initiative (AFR100) and the Bonn challenge, which contribute to the Paris Agreement goals and the United Nations declaration of forests
2. Reduction of 11 million tons of greenhouse gas emissions every year up to 2030 from the forest sector as an obligation to the Paris Climate Change Agreement. This will require huge investments in restoration of degraded landscapes and new afforestation and reforestation programmes.
3. Land Degradation Neutrality (LDN) by 2030 as its contribution to the United Nations Conference to Combat desertification (UNCCD).
4. A UN Decade of Ecosystem Restoration 2021-2030 preventing, halting and reversing degradation of ecosystem of every continent and every ocean.
5. The High Ambition Coalition (HAC) aimed at championing a global deal for nature and people with the central goal of protecting at least 30 percent of the world's land and ocean by 2030. The 30 by 30 target is a global target which aims to halt the accelerating loss of species and protect vital ecosystems that are the source of our economic security.
6. Glasgow Leaders Commitment at UNFCCC COP 26 to halt and reverse forest loss and land degradation.

7. Forest and Climate Leaders Partnership to strengthen commitments to the Glasgow Leaders declaration (UNFCCC COP

Kenya has also ratified the following MEAs:-

a. Convention on Biological Diversity (CBD) in relation to biodiversity and the Nagoya Protocol on access to generic resources and benefit sharing (ABS) most of which resources in Kenya occur in forests
b. United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement identifies forestry as a key vehicle for delivering global climate change goals. Under the obligation Kenya has developed; the climate change policy and Act, and the National Climate Change Action Plan. The implementation of the action plan will contribute to the achievement of the 10% tree cover
c. United Nations Convention to Combat Desertification (UNCCD) recognizes afforestation as key in arresting the spread of deserts. Kenya has committed to land degradation neutrality by 2030. National action plan for restoration of degraded sites in ASALs, and Climate Smart Agriculture Strategy exist to support the national efforts;
d. United Nations Forum on Forests (UNFF) which has developed a Strategic Plan for Forests (2017-2030) that operationalizes the Global Forest Goals on sustainable management of all forests and trees outside forests;
e. Convention on International Trade in Endangered Species (CITES). Forest provides habitat for a wide verity of endangered species of fauna and flora.
f. Convention for the protection of world cultural and natural heritage (UNESCO). Forests, because species diversity harbor most of the country's natural and cultural heritage, such as Kayas, indigenous resources and knowledge.
g. Forests and SDGs: Sustainable forest management positively impacts on several SDGs: SDG 1 (poverty eradication) by forests providing income to fight poverty; SDG 2 (zero hunger) through the provision of fruits, employment, reducing soil erosion, dry season grazing lands; SDG 3 (good health and wellbeing) through the provision of medicinal plants, ; SDG 6 (clean water and sanitation) through the provision of fresh water for drinking and irrigation; SDG 13 (climate action) through carbon capture and storage (CCS) and SDG 15 through contributions to biodiversity.

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 (Figure 67) 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 time series land cover data. For the purpose of this work, remote sensing data at 4 year interval covering 2002, 2006, 2010, 2014 and 2018 was used to generate land cover maps and 5 broad land cover classes (Forestland, Grassland, Cropland, Wetland and Otherland) considered to show habitat diversity within 8 conservation areas in Kenya. The conservation areas include; Central Rift(Fig 68), Coast (Fig 70), Mountain (Fig 72), Northern (Fig 74), Southern (Fig 76), Tsavo (Fig 78), Western (Fig 80) and Eastern conservation areas (Fig 82).

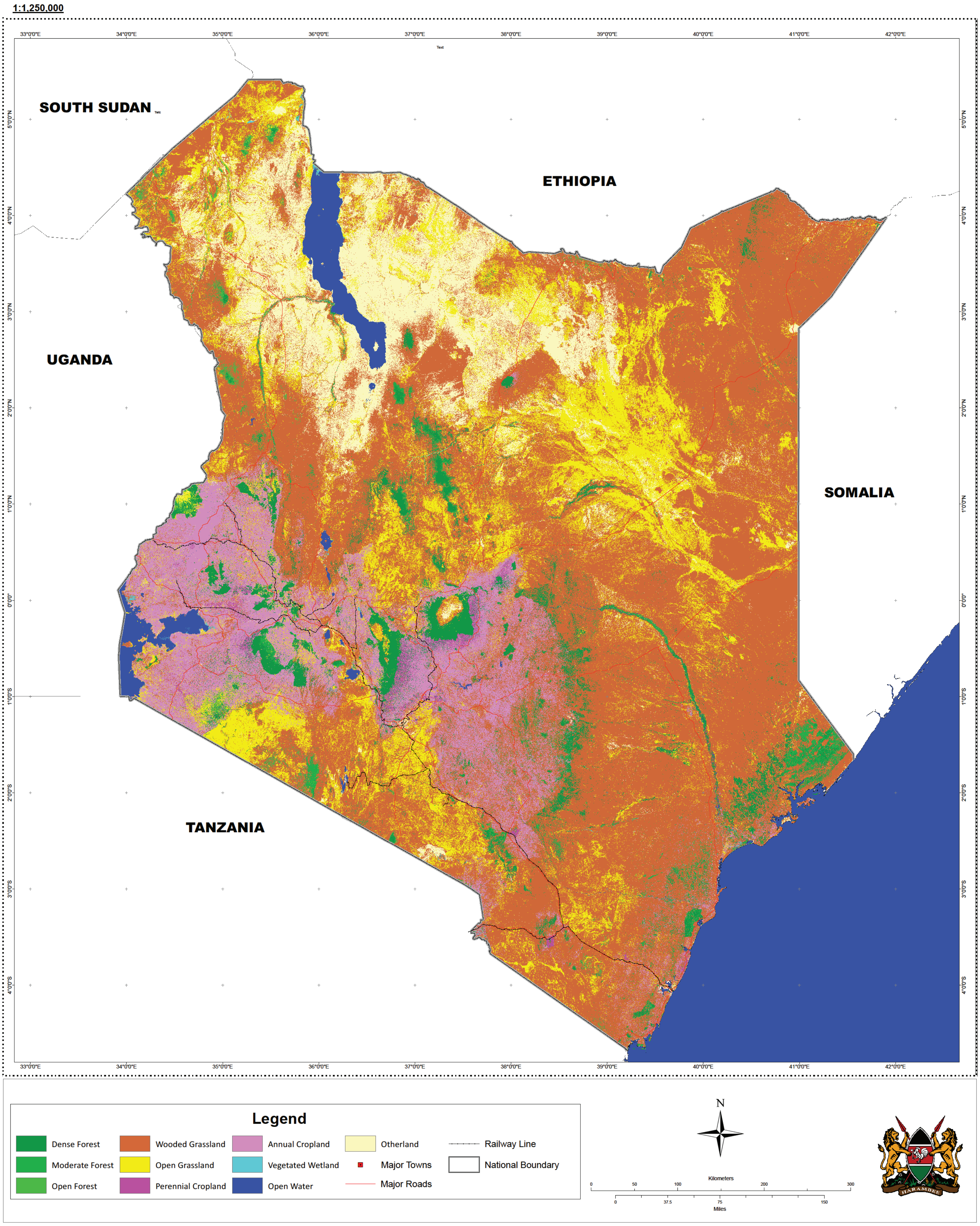


Figure 67: Spatial Distribution of Land Cover Types in Kenya in 2018

Source: DRSRS, 2018

TREND IN LAND COVER FOR EIGHT CONSERVATION AREAS IN KENYA (2002 – 2018)

Central Rift Conservation Area

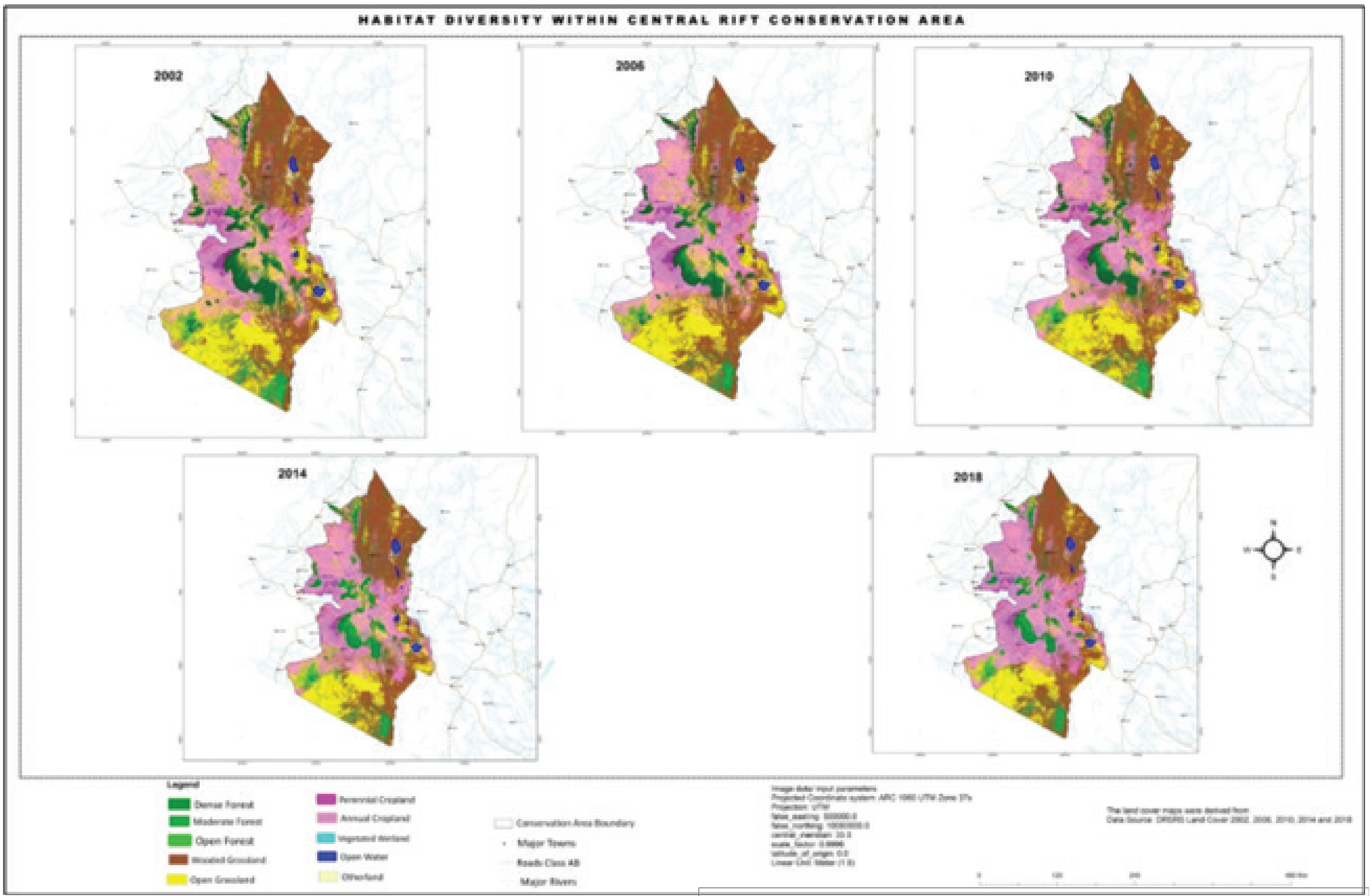


Figure 68: Habitat Diversity in Central Rift Conservation Area

Table 38: *Trend for major land cover types within Central Rift Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	531409.9	10.50	435874.9	8.61	452986.7	8.95	480192.5	9.49	412402.2	8.15
Moderate Forest	150144.5	2.97	120180.2	2.37	112359.5	2.22	123504.7	2.44	96744.9	1.91
Open Forest	90214.8	1.78	81248.2	1.61	116122.9	2.29	68232.2	1.35	72176.3	1.43
Forestland	771769.2	15.25	637303.3	12.59	681469.1	13.46	671929.4	13.28	581323.4	11.49
Wooded Grassland	1758929.1	34.76	1839047.8	36.34	1868811.0	36.93	1861408.9	36.78	1767240.4	34.92
Open Grassland	1226970.3	24.24	1119029.8	22.11	1062642.7	21.00	994960.3	19.66	855266.2	16.90
Grassland	2985899.4	59.00	2958077.6	58.45	2931453.7	57.93	2856369.2	56.44	2622506.6	51.82
Perennial Crops	47678.6	0.94	49011.9	0.97	49254.3	0.97	41834.3	0.83	53508.7	1.06
Annual Crops	1183684.2	23.39	1347773.3	26.63	1337424.5	26.43	1411400.3	27.89	1727127.0	34.13
Cropland	1231362.8	24.33	1396785.2	27.6	1386678.8	27.4	1453234.6	28.72	1780635.7	35.19
Vegetated Wetland	2556.4	0.05	3206.3	0.06	1290.3	0.03	3844.5	0.08	2224.3	0.04
Open Water	35677.7	0.70	35319.1	0.70	35418.0	0.70	48984.0	0.97	46308.7	0.92
Wetland	38234.1	0.75	38525.4	0.76	36708.3	0.73	52828.5	1.05	48533	0.96
Otherland	33541.4	0.66	30115.4	0.60	24497.0	0.48	26445.2	0.52	27808.2	0.55
Total	5060806.8	100.00	5060806.8	100.00	5060806.8	100.00	5060806.8	100.00	5060806.8	100.00

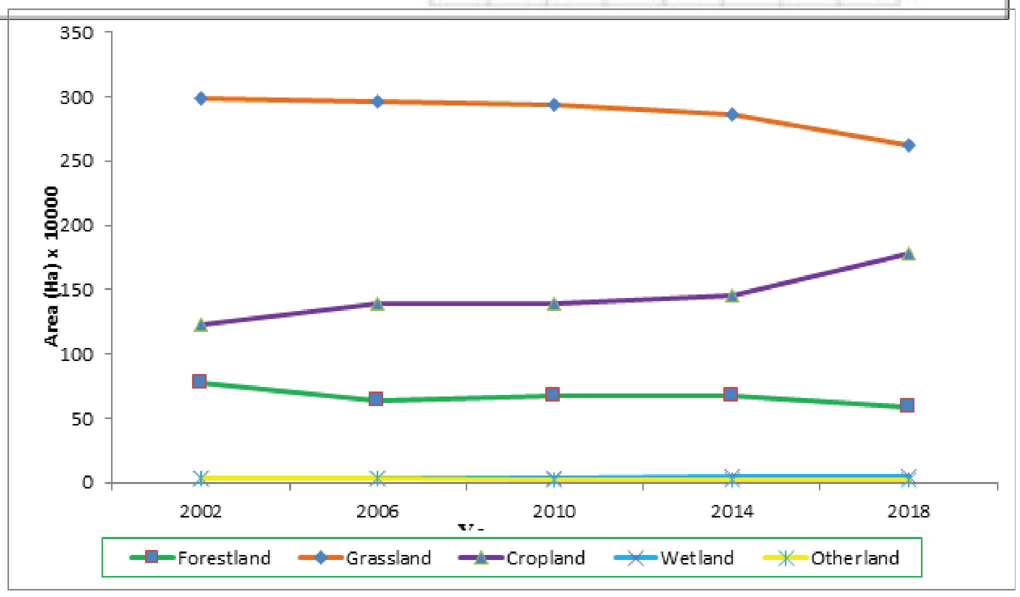


Figure 69: Trend for major land cover types within Central Rift Conservation Area

Central Rift was dominated by Grassland (Wooded and Open Grass) accounting for 59% of the total land cover in 2002, this reduced significantly to 52% during the mapping period. The second dominant land cover was cropland (Annual and Perennial Crops) occupying 24% of the conservation area in 2002, this increased steadily to 35% in 2018. Forestland (Dense, Moderate and Open) which is a key habitat for biodiversity occupied 15% of the conservation area in 2002. This reduced to 11.5% in the 16 year mapping period. The respective reduction in forest and grassland from 771, 769ha and 2,985,899 ha in 2002 to 581,323ha and 2,622,507 ha in 2018 was as a result of expansion of cropland (annual and perennial crops) which increased from 1,231,363 ha to 1,780,636 ha during the same period. Wetland (vegetated and open water) and otherland kept fluctuating during the entire mapping period (Fig 69 and Table 38).

Coast Conservation Area

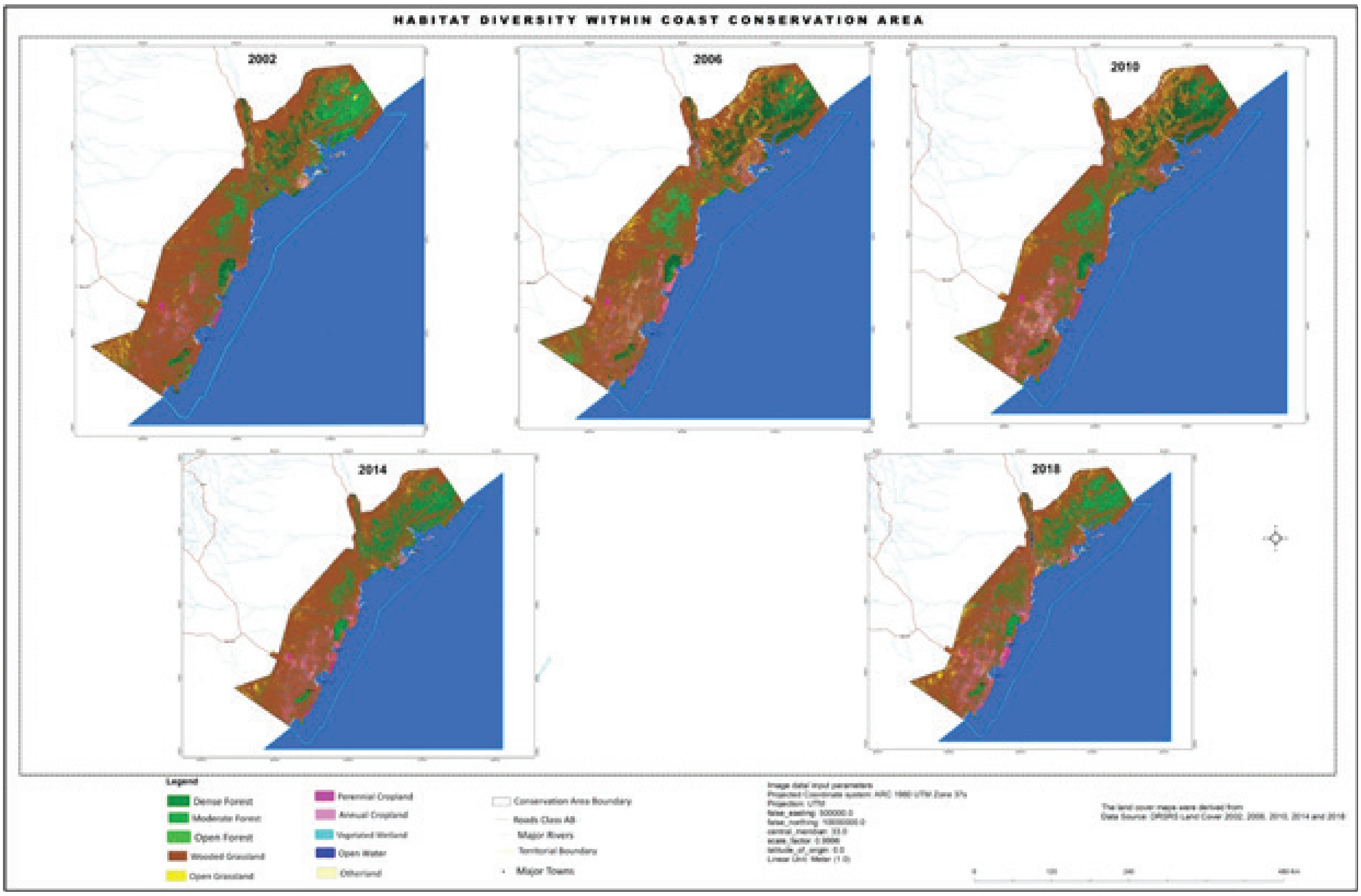


Figure 70: Habitat diversity within coast conservation area

Table 39: *Trend for major land cover types within Coast Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	204036.6	5.46	367154.1	9.83	394306.7	10.56	515277.6	13.80	331132.4	8.87
Moderate Forest	441480.3	11.82	184697.01	4.94	320401.4	8.58	158580.5	4.25	302681.0	8.10
Open Forest	60879.4	1.63	117251.37	3.14	35184.8	0.94	15050.9	0.40	26534.0	0.71
Forestland	706396.32	18.91	669102.48	17.91	749892.78	20.08	688909.05	18.44	660347.37	17.68
Wooded Grassland	2856683.1	76.48	2775244.86	74.30	2709731.9	72.55	2808281.6	75.18	2708825.3	72.52
Open Grassland	78141.2	2.09	131204.79	3.51	121248.5	3.25	69946.5	1.87	115271.4	3.09
Grassland	2934824.31	78.57	2906449.65	77.81	2830980.42	75.79	2878228.08	77.06	2824096.68	75.61
Perennial Crops	13959.8	0.37	6254.01	0.17	7573.4	0.20	9898.4	0.27	10669.2	0.29
Annual Crops	49778.7	1.33	84122.55	2.25	93731.3	2.51	125212.2	3.35	202325.2	5.42
Cropland	63738.54	1.71	90376.56	2.42	101304.72	2.71	135110.61	3.62	212994.45	5.70
Vegetated Wetland	1324.7	0.04	182.7	0.00	10.4	0.00	2286.8	0.06	3886.2	0.10
Open Water	10116.4	0.27	8286.57	0.22	11517.2	0.31	8430.5	0.23	15334.6	0.41
Wetland	11441.07	0.31	8469.27	0.23	11527.65	0.31	10717.29	0.29	19220.76	0.51
Otherland	18826.0	0.50	60828.3	1.63	41520.7	1.11	22261.2	0.60	18567.0	0.50
Total	3735226.3	100.00	3735226.3	100.00	3735226.3	100.00	3735226.3	100.00	3735226.3	100.00

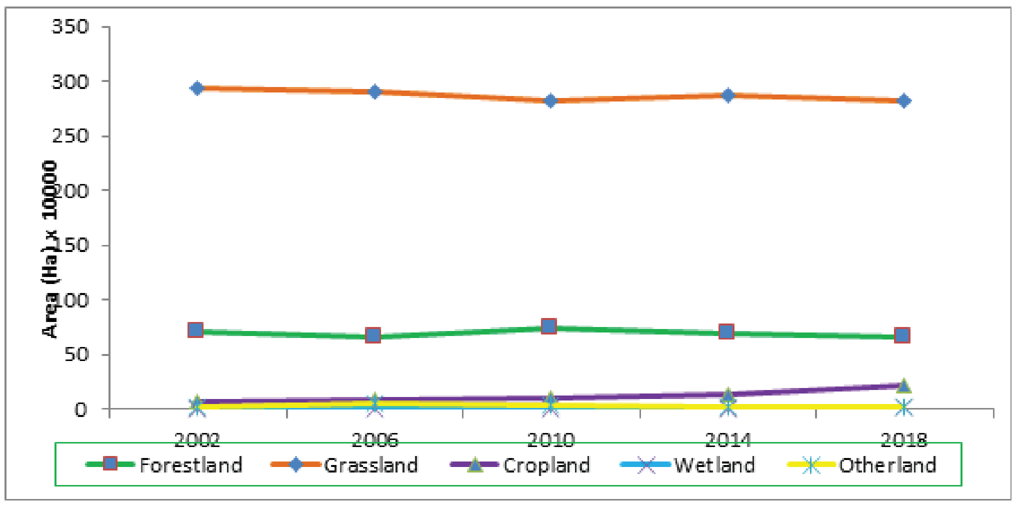


Figure 71: Trend of major land cover types in Coast Conservation Area (2002 – 2018)

The dominant land cover types at the coast conservation area were grassland and forestland occupying respective area of 79% and 19% in 2002. The two land cover classes reduced to 76% and 18% respectively in the year 2018. During the same mapping period, cropland class which occupied 2% of total land cover in 2002 increased significantly to 6% in 2018. The expansion of cropland was under expense of both grassland and forestland which recorded decrease during the same period. Wetland and otherland classes remained fluctuating throughout the entire mapping period (Fig 71 and Table 39).

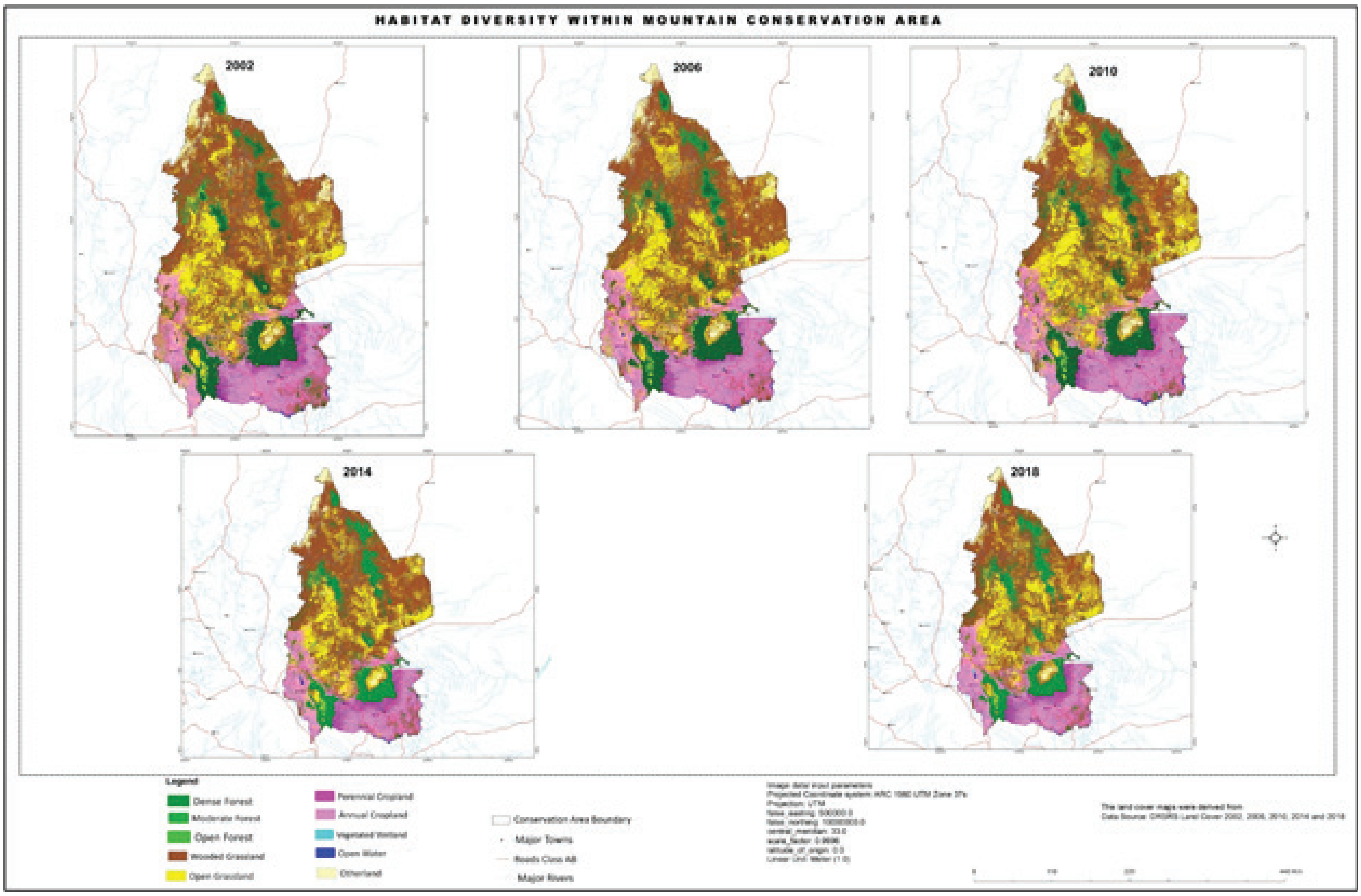


Figure 72: Habitat diversity within mountain conservation area

Table 40: *Trend for major land cover types within Mountain Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	489854.9	9.99	462524.4	9.44	501002.6	10.22	552679.1	11.28	574619.6	11.72
Moderate Forest	110715.9	2.26	128353.5	2.62	157330.5	3.21	125867.6	2.57	126378.7	2.58
Open Forest	38101.0	0.78	30582.8	0.62	19341.1	0.39	3970.9	0.08	25589.3	0.52
Forestland	638671.8	13.03	621460.7	12.68	677674.2	13.82	682517.6	13.93	726587.6	14.82
Wooded Grassland	2427680.4	49.53	2385631.3	48.67	2115755.3	43.17	2381194.8	48.58	2204977.1	44.99
Open Grassland	838234.0	17.10	849190.2	17.33	977588.0	19.95	817368.9	16.68	879873.6	17.95
Grassland	3904586.2	66.63	3234821.5	66	3093343.3	63.12	3198563.7	65.26	3084850.7	62.94
Perennial Crops	65169.0	1.33	52196.9	1.06	67898.5	1.39	103253.4	2.11	96223.7	1.96
Annual Crops	757405.4	15.45	835166.9	17.04	870199.2	17.75	782308.7	15.96	869157.0	17.73
Cropland	822574.4	16.78	887363.8	18.1	938097.7	19.14	885562.1	18.07	965380.7	19.69
Vegetated Wetland	2009.2	0.04	1003.1	0.02	2304.8	0.05	1768.1	0.04	2251.4	0.05
Open Water	6708.5	0.14	7774.4	0.16	9431.6	0.19	8896.3	0.18	5849.8	0.12
Wetland	8717.7	0.18	8777.5	0.18	11736.4	0.24	10664.4	0.22	8101.2	0.17
Otherland	165481.5	3.38	148936.3	3.04	180508.1	3.68	124052.0	2.53	116439.6	2.38
Total	4901359.8	100.00	4901359.8	100.00	4901359.8	100.00	4901359.8	100.00	4901359.8	100.00

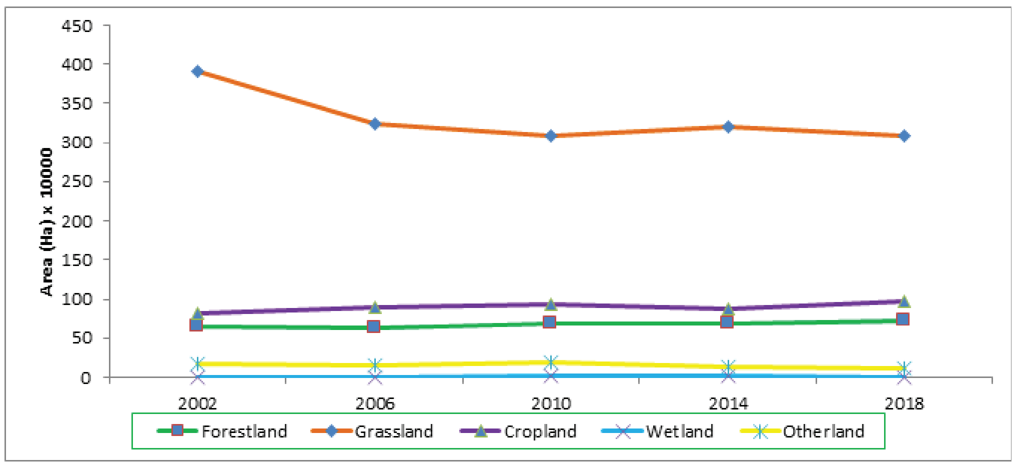


Figure 73: Trend of major land cover types in Mountain Conservation Area (2002 – 2018)

Mountain Conservation area was dominated by grassland, cropland and forestland, which occupied 67%, 17% and 13 % respectively of the total conservation area in 2002. Forestland and cropland increased to 15% and 20% respectively in 2018 while grassland class reduced to 63% in 2018. The increase in forestland during the mapping period was attributed to conservation measures in the major water towers of Mt. Kenya and Aberdare. Cropland which occupy the southern part of the conservation area expanded towards the north encroaching into grassland. This led to the reduction of grassland during the mapping period (Fig 73 and Table 40).

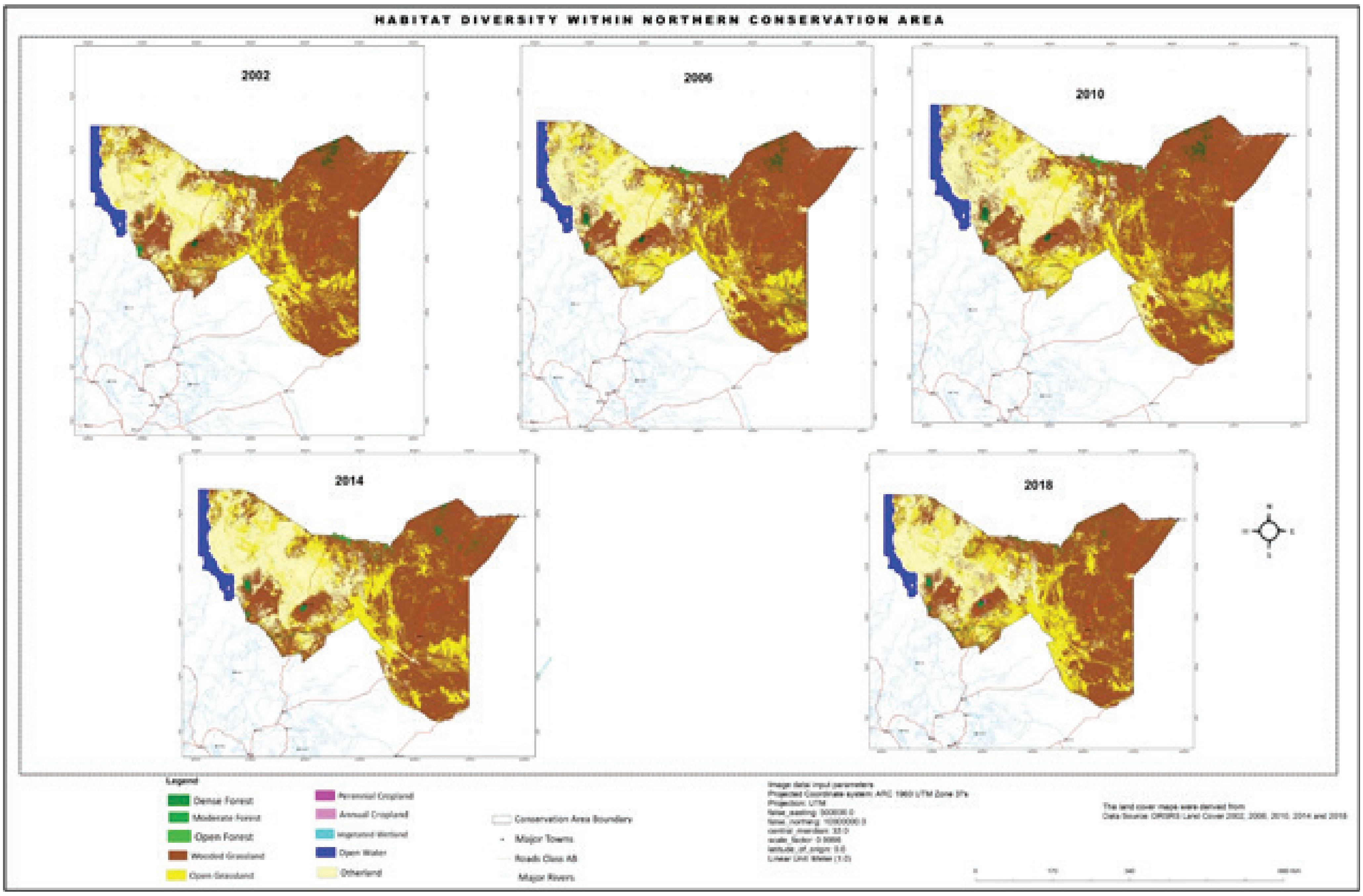


Figure 74: Habitat diversity within northern conservation area

Table 41: *Trend for major land cover types within Northern Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	99781.8	0.63	59156.6	0.37	109093.2	0.69	96315.5	0.61	83798.4	0.53
Moderate Forest	15665.8	0.10	10193.3	0.06	68657.1	0.43	18818.7	0.12	36742.4	0.23
Open Forest	52078.7	0.33	51985.1	0.33	45119.4	0.28	48100.5	0.30	28514.3	0.18
Forestland	167526.3	1.06	121335.0	0.76	222869.8	1.40	163234.7	1.03	149055.1	0.94
Wooded Grassland	9347232.2	58.90	8803265.5	55.47	9013873.2	56.80	8827479.2	55.63	8833069.0	55.66
Open Grassland	2398903.5	15.12	2786509.3	17.56	2565873.7	16.17	2639243.9	16.63	3001499.4	18.91
Grassland	11746135.6	74.02	11589774.8	73.03	11579747.0	72.97	11466723.1	72.26	11834568.4	74.57
Perennial Crops	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Annual Crops	831.1	0.01	5367.1	0.03	2897.3	0.02	2748.1	0.02	8104.4	0.05
Cropland	831.1	0.01	5367.1	0.03	2897.3	0.02	2748.1	0.02	8104.4	0.05
Vegetated Wetland	480.8	0.00	5498.9	0.03	2632.0	0.02	420.9	0.00	1068.9	0.01
Open Water	497037.2	3.13	482459.3	3.04	492726.4	3.10	496151.6	3.13	494213.0	3.11
Wetland	497518.0	3.14	487958.2	3.07	495358.4	3.12	496572.5	3.13	495282.0	3.12
Otherland	3457605.6	21.79	3665181.5	23.10	3568744.2	22.49	3740338.3	23.57	3382606.7	21.31
Total	15869616.6	100.00	15869616.6	100.00	15869616.6	100.00	15869616.6	100.00	15869616.6	100.00

The northern Conservation area was dominated by grassland and otherland which occupied 74% and 22% respectively in 2002. Forestland and wetland occupied 1% and 3% of the total land area respectively in the year 2002. Forestland reduced slightly from 1% in 2002 to 0.9% in 2018. Grassland and wetland class remained almost stable during the mapping period. Cropland was insignificant and remained fluctuating throughout the entire period (Fig 75 and Table 41).

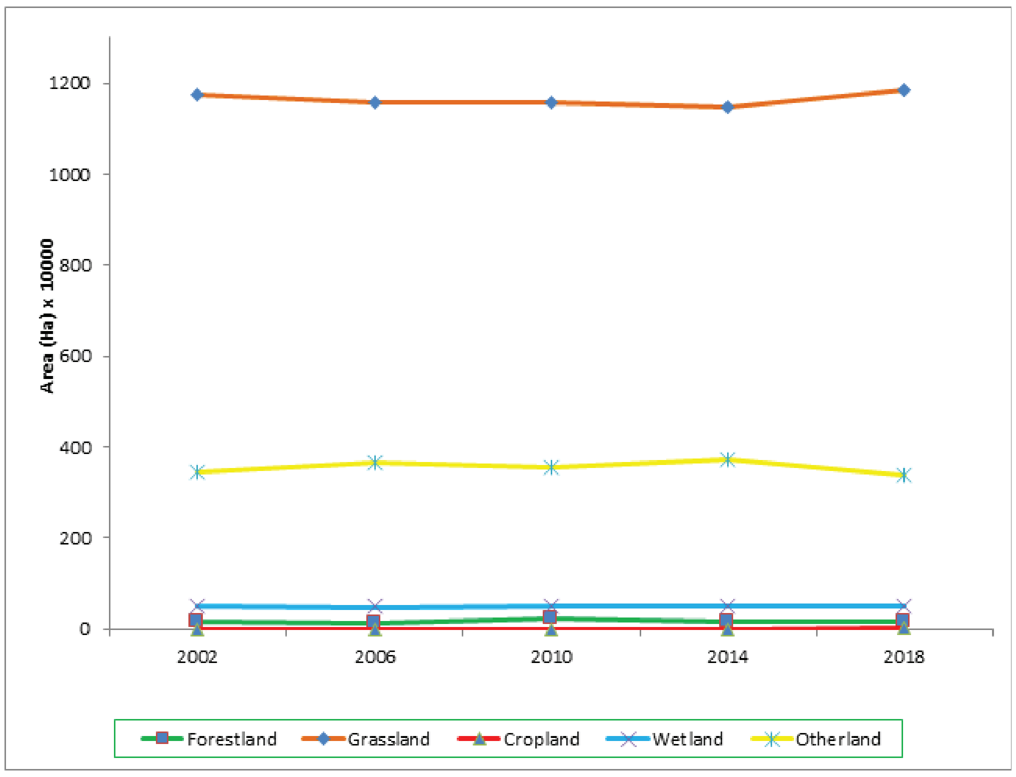


Figure 75: Trend of major land cover types in Mountain Conservation Area (2002 – 2018) Northern Conservation Area

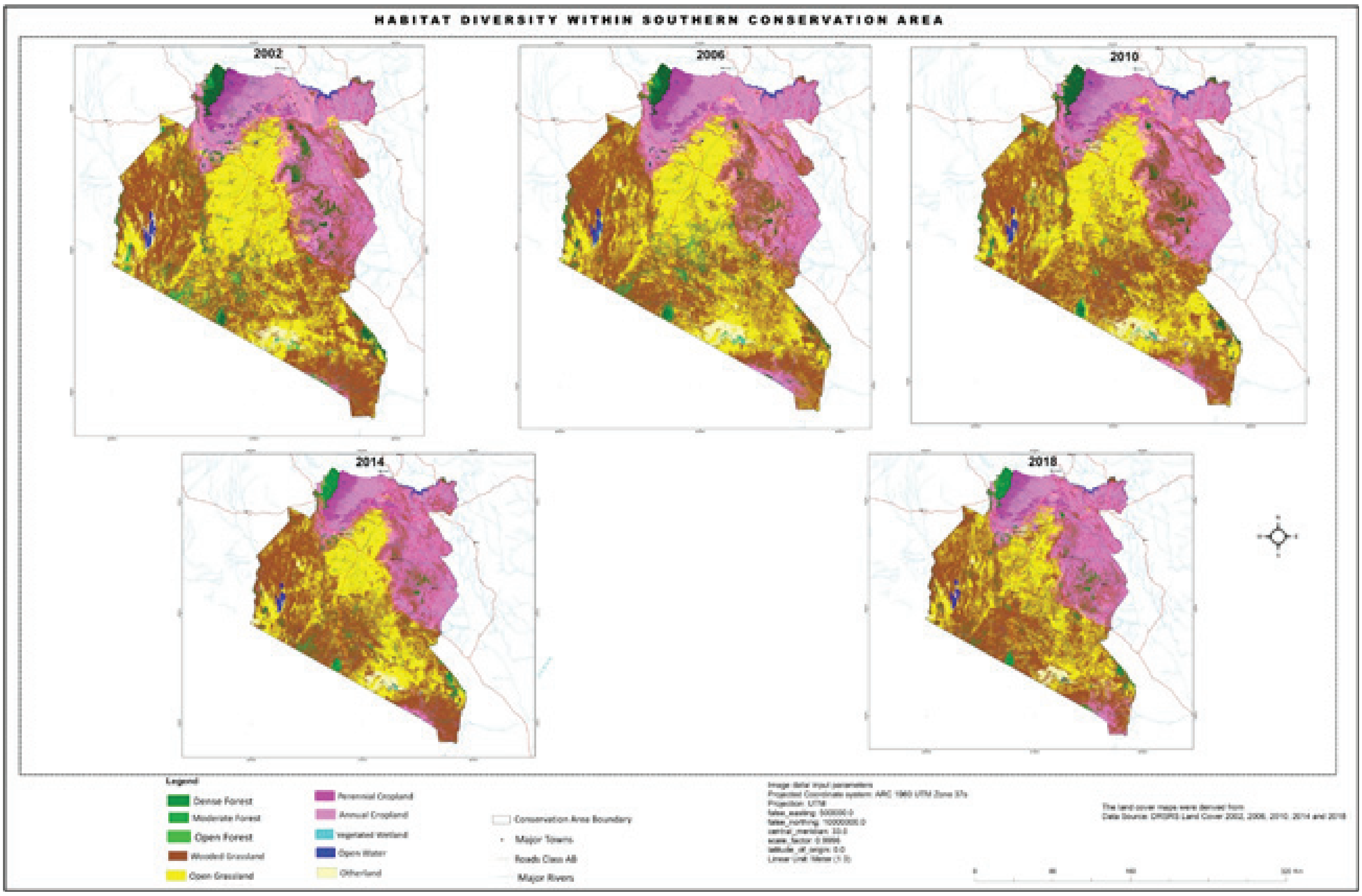


Figure 76: Habitat diversity within southern conservation area

Table 42: *Trend for major land cover types within Southern Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	117502.7	3.22	71437.7	1.96	92153.8	2.53	87200.3	2.39	100695.2	2.76
Moderate Forest	56365.2	1.54	54758.5	1.50	32750.7	0.90	28766.3	0.79	29530.9	0.81
Open Forest	39878.4	1.09	26115.9	0.72	18308.1	0.50	15692.0	0.43	18502.8	0.51
Forestland	213746.3	5.85	152312.1	4.18	143212.6	3.93	131658.6	3.61	148728.9	4.08
Wooded Grassland	1619426.7	44.39	1624557.2	44.53	1734505.4	47.54	1773237.7	48.60	1825580.0	50.04
Open Grassland	1009717.3	27.68	1003012.7	27.49	959852.5	26.31	906227.6	24.84	792229.9	21.71
Grassland	2629144	72.07	2627569.9	72.02	2694357.9	73.85	2679465.3	73.44	2617809.9	71.75
Perennial Crops	52676.6	1.44	66222.8	1.82	37103.2	1.02	63080.2	1.73	54311.6	1.49
Annual Crops	663311.2	18.18	714018.2	19.57	675508.2	18.51	684942.8	18.77	745929.5	20.44
Cropland	715987.8	19.62	780241	21.39	712611.4	19.53	748023	20.5	800241.1	21.93
Vegetated Wetland	3244.3	0.09	4745.5	0.13	3904.7	0.11	2409.6	0.07	1536.7	0.04
Open Water	18061.4	0.50	16692.0	0.46	19729.5	0.54	17902.6	0.49	17188.4	0.47
Wetland	21305.7	0.59	21437.5	0.59	23634.2	0.65	20312.2	0.56	18725.1	0.51
Otherland	68297.3	1.87	66920.5	1.83	74664.8	2.05	69021.8	1.89	62976.2	1.73
Total	3648481.0	100.00	3648481.0	100.00	3648481.0	100.00	3648481.0	100.00	3648481.0	100.00

The southern conservation area is dominated by Grassland and cropland accounting for 72% and 20% of the respective land cover types in 2002. Grassland occupies the central and southern part while cropland occurs in the northern part of the conservation area. During the mapping period, grassland and forestland reduced from 72% and 6% in 2002 to 71% and 4% in 2018 respectively. The reduction in forestland and grassland was at the expense of cropland which increased from 20% to 21% during the same period. Wetland and otherland on the other hand reduced slightly from 0.6% and 1.9% to 0.5% and 1.7% respectively (Fig 77 and Table 42).

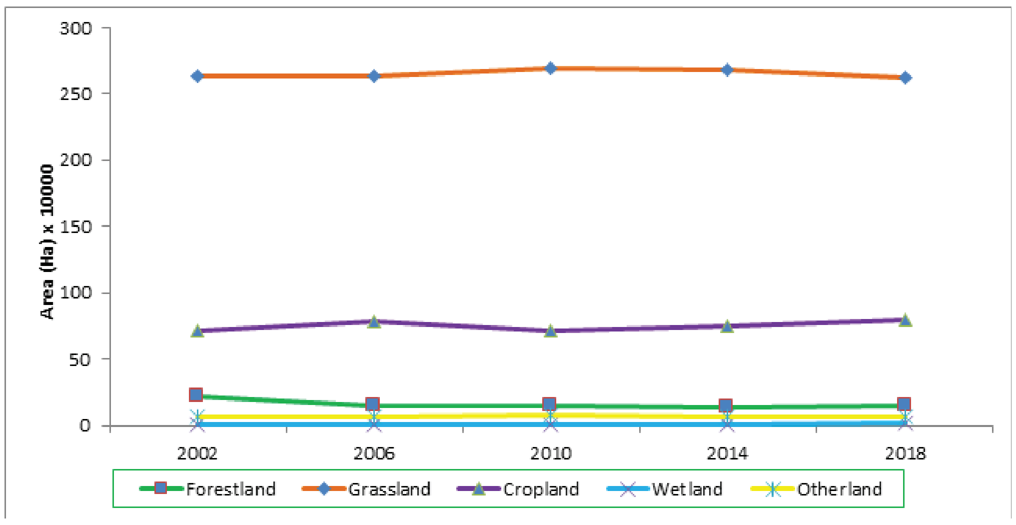


Figure 77: Trend of major land cover types in southern Conservation Area (2002 –2018)

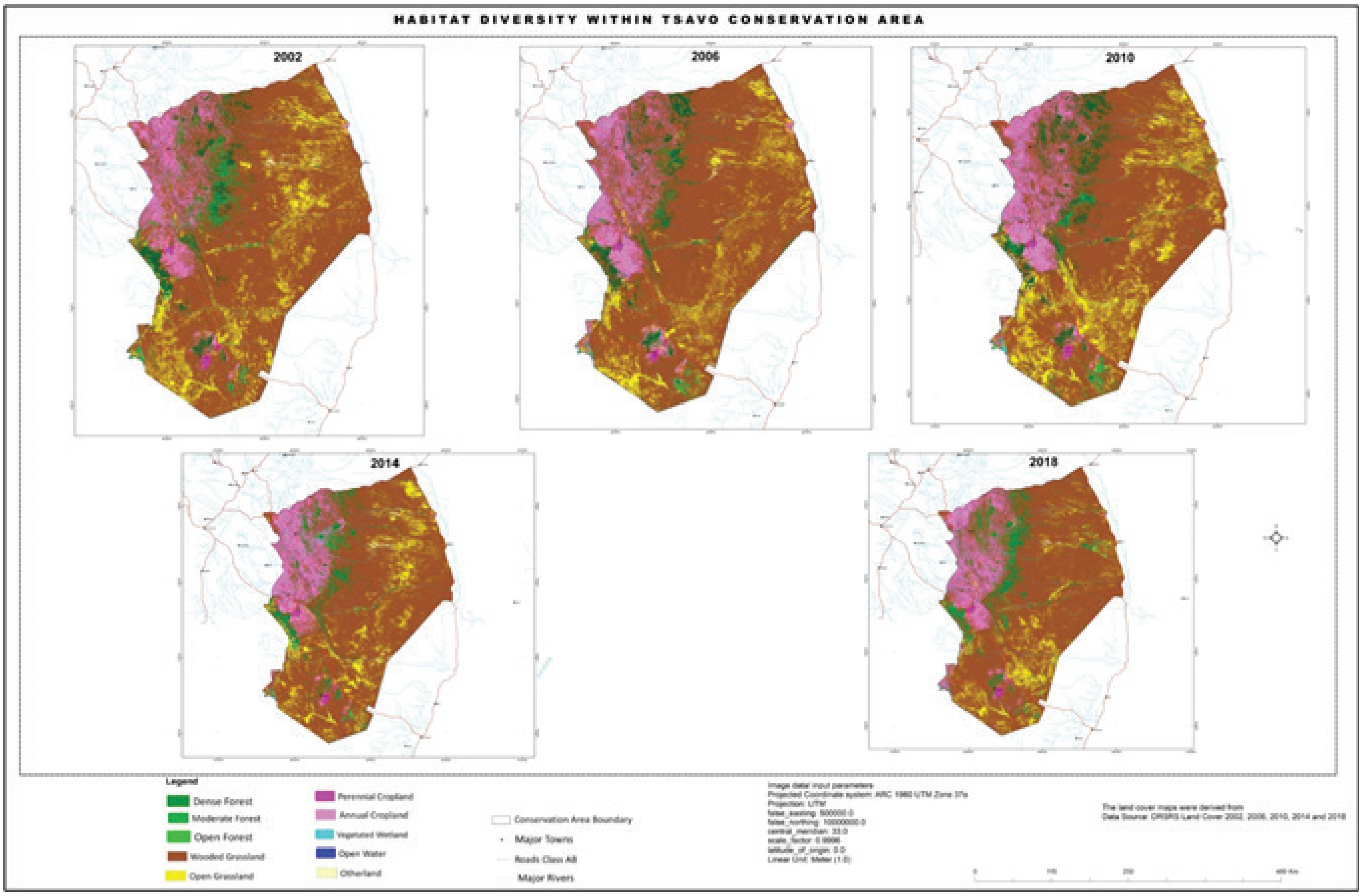


Figure 78: Habitat diversity within tsavo conservation area

Table 43: *Trend for major land cover types within Tsavo Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	254350.9	3.52	282241.3	3.91	365533.0	5.07	304626.8	4.22	317508.3	4.40
Moderate Forest	164232.2	2.28	59365.5	0.82	60010.4	0.83	61515.5	0.85	102721.1	1.42
Open Forest	49122.0	0.68	42539.0	0.59	64829.2	0.90	29342.6	0.41	67723.7	0.94
Forestland	467705.1	6.48	384145.7	5.32	490372.6	6.80	395484.9	5.48	487953.0	6.76
Wooded Grassland	5553785.2	76.97	5669325.4	78.57	5327458.6	73.83	5517277.4	76.46	5597352.4	77.57
Open Grassland	681994.7	9.45	557845.7	7.73	776729.5	10.76	573338.6	7.95	457453.2	6.34
Grassland	6235779.9	86.42	6227171.0	86.30	6104188.1	84.59	6090616.0	84.41	6054805.5	83.91
Perennial Crops	12808.4	0.18	15497.4	0.21	17833.9	0.25	14971.1	0.21	15994.6	0.22
Annual Crops	461895.8	6.40	547336.3	7.59	557697.5	7.73	664000.9	9.20	621197.5	8.61
Cropland	474704.2	6.58	562833.6	7.80	575531.4	7.98	678972.1	9.41	637192.1	8.83
Vegetated Wetland	2076.0	0.03	3046.2	0.04	6615.0	0.09	3462.3	0.05	3456.5	0.05
Open Water	3051.0	0.04	3614.1	0.05	3311.5	0.05	4624.5	0.06	5051.4	0.07
Wetland	5127.0	0.07	6660.4	0.09	9926.5	0.14	8086.8	0.11	8507.9	0.12
Otherland	32604.6	0.45	35110.0	0.49	35902.3	0.50	42761.0	0.59	27462.2	0.38
Total	7215920.7	100.00	7215920.7	100.00	7215920.7	100.00	7215920.7	100.00	7215920.7	100.00

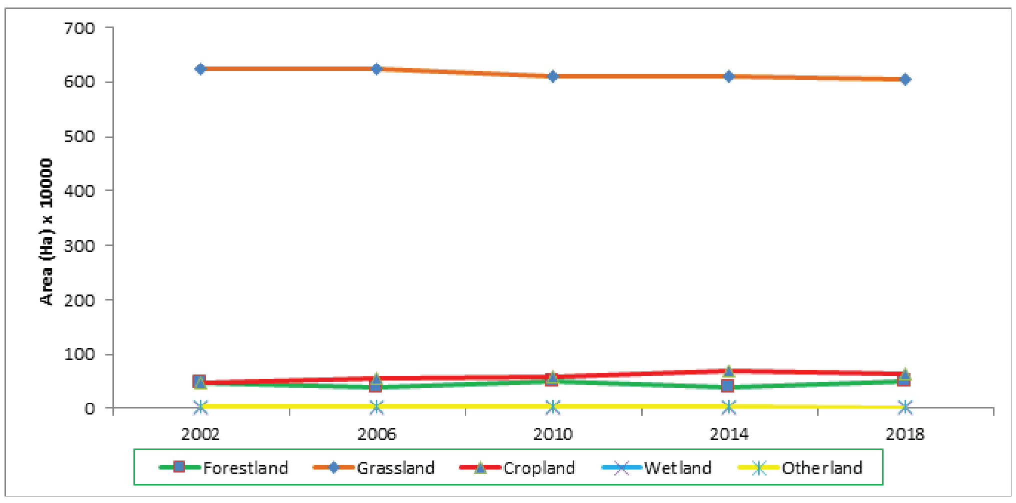


Figure 79: Trend of major land cover types in Tsavo Conservation Area (2002 –2018)

Tsavo Conservation area is dominated by grassland which accounted for 86% of the total area in 2002. Cropland and forestland were also of significance occupying 6.6% and 6.5% of the land cover respectively. Cropland and forestland occupy the north-western part of the conservation area while grassland is spread iacross the entire conservation area. During the mapping period, cropland increased from 6.6% to 8.8% while grassland reduced from 86% to 84%. The expansion of cropland from north-western part of the Tsavo conservation area encroached into the grassland hence reducing the area under grassland. Forestland increased slightly from 6.5% in 2002 to 6.8% in 2018, this may be attributed to conservation efforts by various actors within the area (Fig 79 and Table 43).

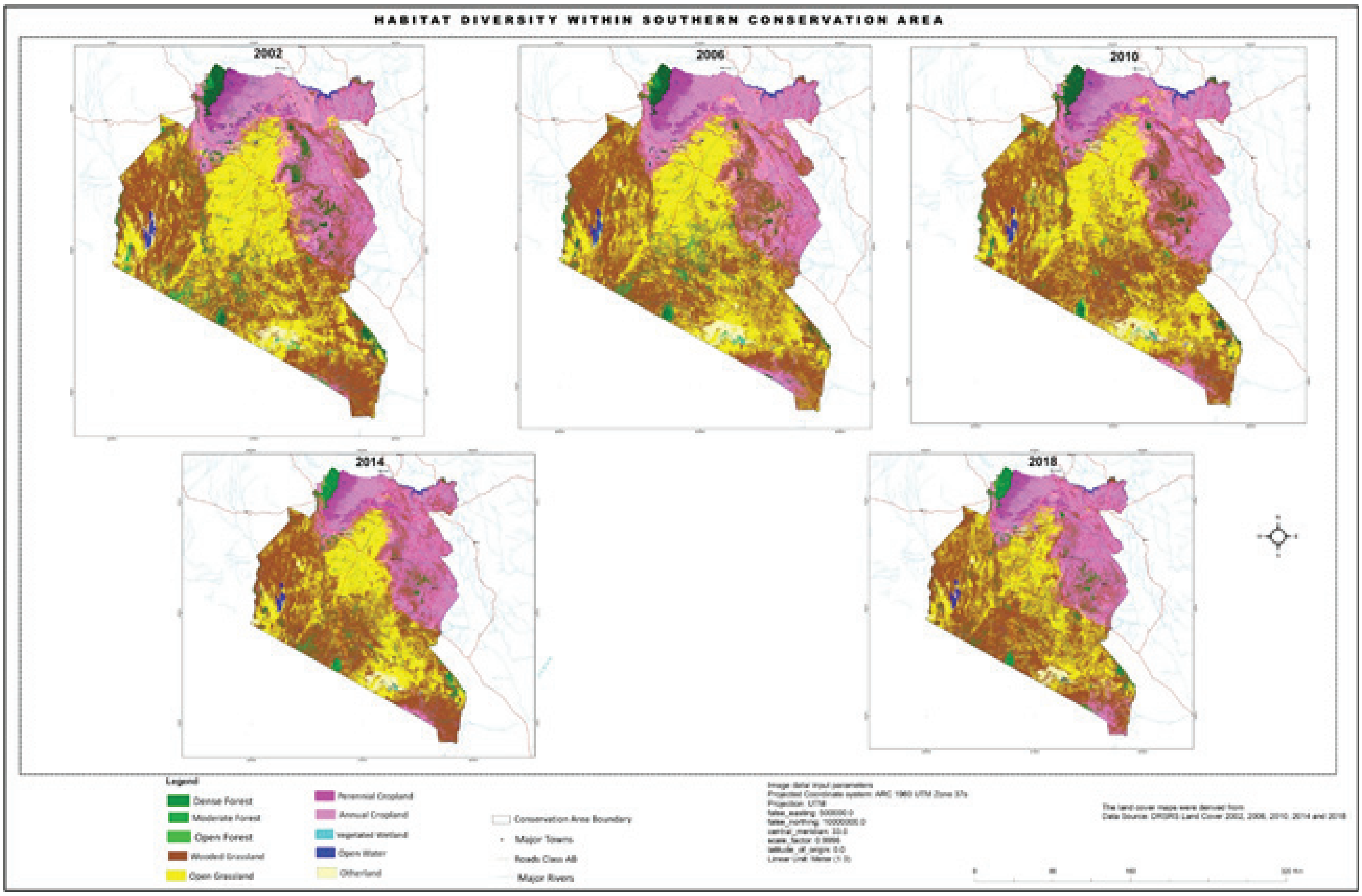


Figure 80: Habitat diversity within western conservation area

Table 44: *Trend for major land cover types within Western Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	150939.3	1.41	190393.7	1.78	203568.6	1.90	150939.3	1.41	133416.1	1.25
Moderate Forest	26293.8	0.25	58243.8	0.54	104900.9	0.98	26293.8	0.25	63077.7	0.59
Open Forest	186071.8	1.74	142595.7	1.33	173015.6	1.62	186071.8	1.74	181598.8	1.70
Forestland	363304.9	3.4	391233.2	3.65	481485.1	4.5	363304.9	3.4	378092.6	3.54
Wooded Grassland	4216164.1	39.40	3729527.6	34.85	3648336.1	34.09	4216164.1	39.40	3643692.1	34.05
Open Grassland	1351498.7	12.63	1273033.0	11.90	1384497.5	12.94	1351498.7	12.63	1449342.0	13.54
Grassland	5567662.8	52.03	5002560.6	46.75	5032833.6	47.03	5567662.8	52.03	5093034.1	47.59
Perennial Crops	69660.2	0.65	98357.6	0.92	72275.8	0.68	69660.2	0.65	33692.9	0.31
Annual Crops	1528305.1	14.28	1861281.9	17.39	1826644.4	17.07	1528305.1	14.28	1852526.4	17.31
Cropland	1597965.3	14.93	1959639.5	18.31	1898920.2	17.75	1597965.3	14.93	1886219.3	17.62
Vegetated Wetland	17502.7	0.16	22680.2	0.21	28917.4	0.27	17502.7	0.16	25655.6	0.24
Open Water	631092.5	5.90	612953.9	5.73	632900.9	5.91	631092.5	5.90	630051.8	5.89
Wetland	648595.2	6.06	635634.1	5.94	661818.3	6.18	648595.2	6.06	655707.4	6.13
Otherland	2523286.3	23.58	2711747.0	25.34	2625757.3	24.54	2523286.3	23.58	2687761.1	25.12
Total	10700814.3	100.00	10700814.3	100.00	10700814.3	100.00	10700814.3	100.00	10700814.3	100.00

Land cover types of Western Conservation area was dominated by grassland which accounted for 52% of the total area in in 2002. The other land cover types of important magnitude included cropland accounting for 15%, otherland (24%) and forestland (3.4%) of the conservation area. During the mapping period, grassland reduced from 52% in 2002 to 48% in 2018. Forestland and cropland on the other hand increased from 3.4% and 15% in 2002 to 3.5% and 18% in 2018 respectively. The increase in cropland and forestland was on the expense of grassland which reduced during the mapping period. Otherland class which accounted for 24% of the conservation area in 2002 increased to 25% in 2018. The increase in the class otherland may be attributed to the new massive infrastructure development within the conservation area where much of land is converted to settlements, roads and related infrastructure (Fig 81 and Table 44).

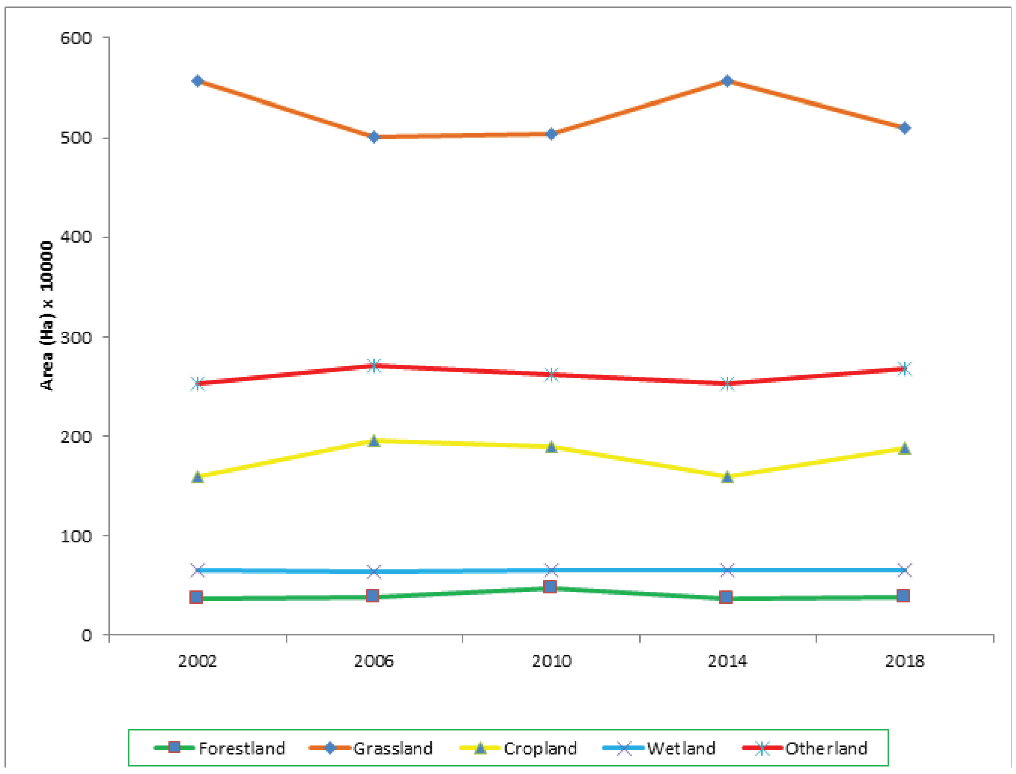


Figure 81: Trend of major land cover types in western Conservation Area (2002 –2018)

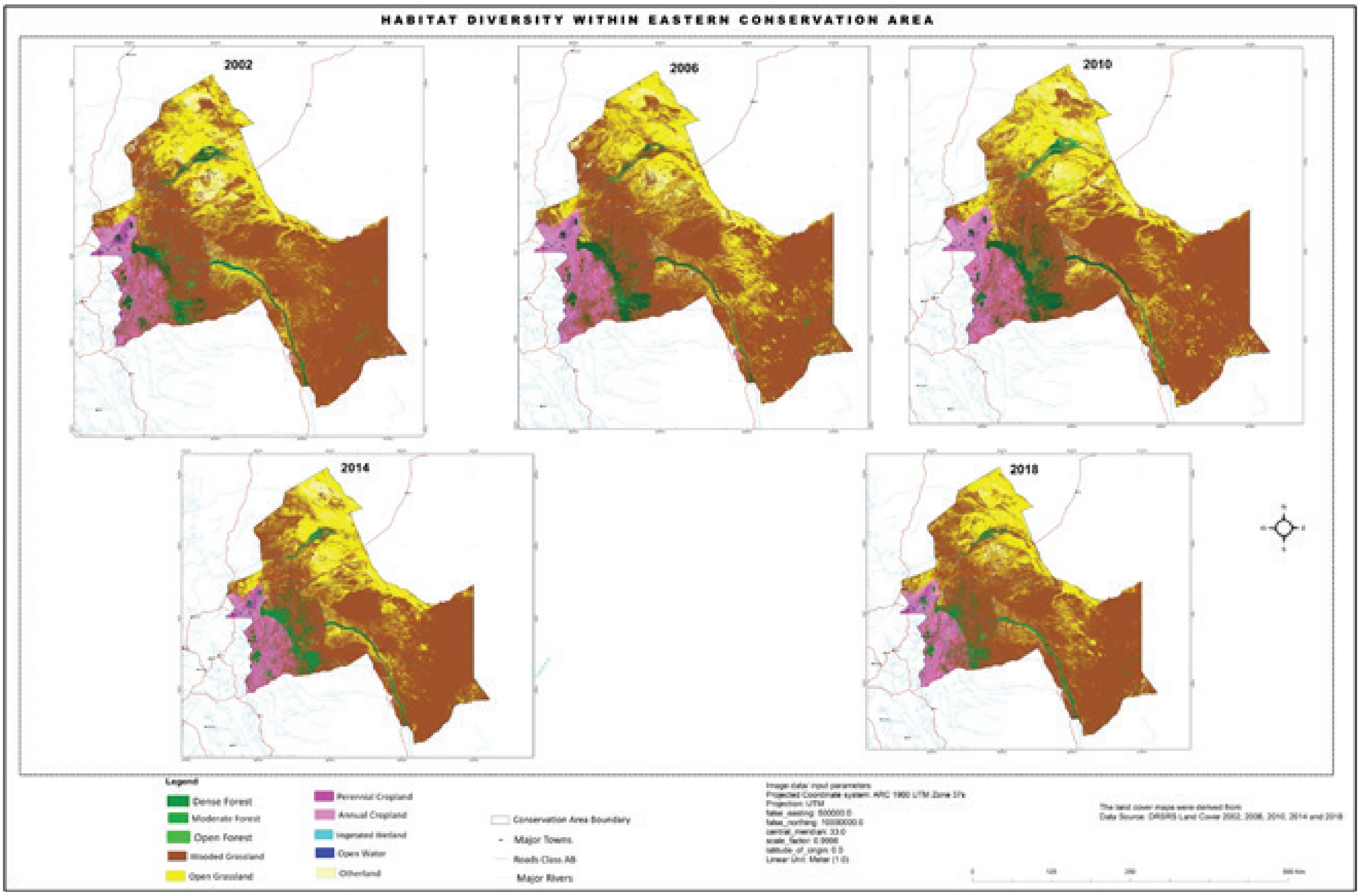


Figure 82: Habitat diversity within Eastern conservation area

Table 45: *Trend for major land cover types within Eastern Conservation Area*

Land Cover Classes at Central Rift C.A	2002		2006		2010		2014		2018	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Dense Forest	210086.4	2.60	270501.2	3.35	344663.0	4.27	349842.2	4.33	251830.5	3.12
Moderate Forest	55784.5	0.69	41647.8	0.52	32521.3	0.40	17999.5	0.22	57111.8	0.71
Open Forest	74222.3	0.92	30150.8	0.37	53534.3	0.66	14262.6	0.18	20404.6	0.25
Forestland	340093.2	4.21	342299.8	4.24	430718.6	5.33	382104.3	4.73	5691703.5	4.08
Wooded Grassland	5668043.8	70.19	5460347.0	67.62	5323484.6	65.93	5415768.9	67.07	1430970.2	70.49
Open Grassland	1400902.2	17.35	1580677.6	19.58	1485280.2	18.39	1599767.2	19.81	20151.2	17.72
Grassland	7068946	87.54	7041024.6	87.2	6808764.8	84.32	7015536.1	86.88	431645.3	88.21
Perennial Crops	19964.6	0.25	12385.7	0.15	10047.6	0.12	23163.2	0.29	66.1	0.25
Annual Crops	352595.7	4.37	405951.8	5.03	439053.7	5.44	402623.2	4.99	12639.2	5.35
Cropland	372560.3	4.62	418337.5	5.18	449101.3	5.56	425786.4	5.28	158283.5	5.6
Vegetated Wetland	75.2	0.00	46.9	0.00	6.2	0.00	4.4	0.00	8074805.9	0.00
Open Water	10292.9	0.13	10004.9	0.12	9678.1	0.12	8088.4	0.10	251830.5	0.16
Wetland	10368.1	0.13	10051.8	0.12	9684.3	0.12	8092.8	0.1	57111.8	0.16
Otherland	282838.5	3.50	263092.3	3.26	376537.1	4.66	243286.4	3.01	20404.6	1.96
Total	8074805.9	100.00	8074805.9	100.00	8074805.9	100.00	8074805.9	100.00	5691703.5	100.00

The land cover types that dominate Eastern Conservation area include grassland, cropland and forestland. Cropland occupies the western part of the conservation area while forestlands occur along the river banks and at the periphery of the croplands. In 2002, their respective land occupied 87.5%, 4.6% and 4.2% of the total conservation area. Forestland reduced from 4.2% to 4.1% during the mapping period. Grassland and cropland on the other hand increased from 87.5% and 4.6% to 88.2% and 5.6% respectively (Fig 83 and Table 45).

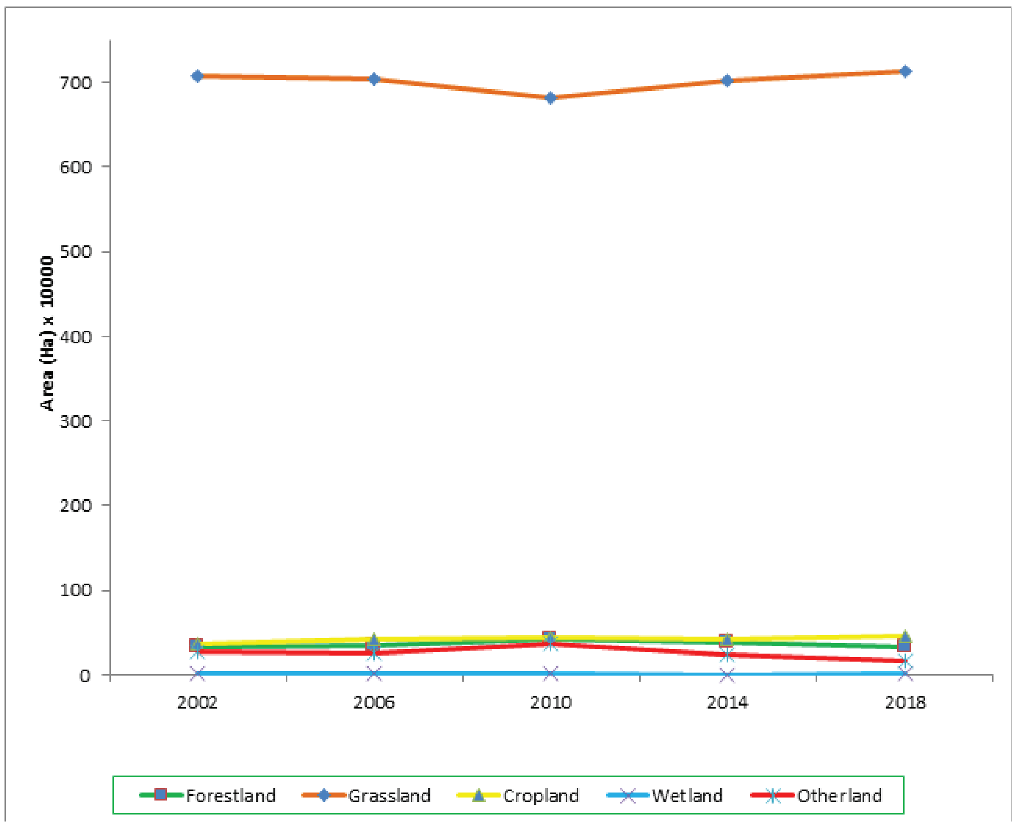


Figure 83: Trend of major land cover types in eastern Conservation Area (2002 –2018)

KENYA WILDLIFE RESOURCES

Kenya is endowed with high bio-diverse habitats that support a vast variety of wildlife species. The habitats include coastal/marine ecosystems, freshwater and saline lakes, tropical montane forests, savannah plains and arid and semi-arid. 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 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 which improve the economic development and livelihood of the citizenry. The five critical water towers namely: Mt. Kenya, Aberdare, Chyulu, Mt. Elgon and Marsabit are within the national parks. It is 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), antelopes including the Sitatunga (Tragelaphus spekii), Bongo (Tragelaphus eurycerus) and Roan antelope (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).

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 endemic 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 (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) Formulation and implementation of wildlife policies jointly with the ministry under which it falls and e) domestication and implementation of 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 3) the citizenry either privately or communally through wildlife conservancies and private or public ranches represented by the umbrella organization called Kenya wildlife conservancies associations (KWCA) and 4) 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

Kenya's Designated Conservation Areas includes the parks, reserves, sanctuaries and conservancies (Table 46 and Table 47 and fig 84)

Table 46: *Categories of Wildlife Conservation Areas in Kenya*

No.	Category	Total number	Acreage Km^2	% acreage
1	National Park-Terrestrial	24	29,504	19.77
2	National Park- Marine	3	76	0.05
3	National Reserve- Terrestrial	26	17,358.8	11.63
4	National Reserve- Marine	6	871	0.58
5	National Sanctuary	6	265.79	0.18
6	Conservancy	206	101,159	67.79
	Total		149,234.59	100.00

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 Km^2.

Plate 32: Lions Relaxing at the Nairobi National Park (KWS)

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. Most National Reserves are managed by County governments 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 Lamu, Kilifi, Mombasa and Kwale counties covering a total 871km2. Kiunga Marine National Reserve is the largest, followed by Mombasa Marine National Reserve while Mpunguti is the smallest.

Sanctuaries

A wildlife sanctuary is an area of land or water set aside and maintained by the government, community, individual or private entity for conservation of 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 a total area of about 265.79Km2.

Sanctuaries are created for various reasons amongst them: spectacular views and abundant birdlife such as Lake Elementaita (plate 33); conservation education and rescue centers:Kisumu impala sanctuary (plate 34); 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 33: Lake Elementaita Sanctuary

Plate 34: Entrance gate at the impala widlife sanctuary

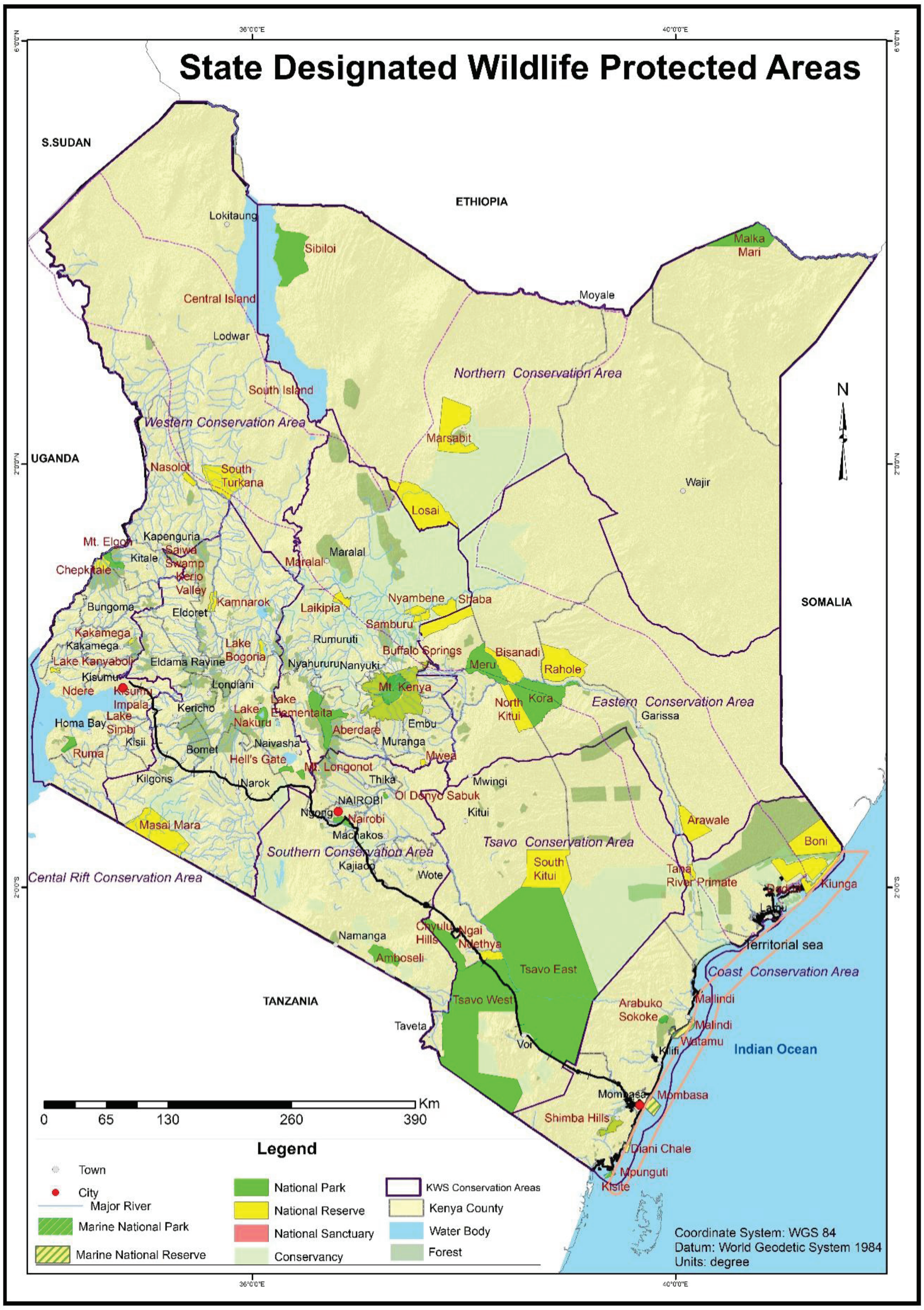


Figure 84: Kenya's National Parks, Reserves and Sanctuaries

Table 47: *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

Growth of State Designated protected areas in Kenya

The first protected area was Tsavo Road and Railway National Reserve before the second world war of 1939-1945. This was followed by Nairobi (1946), Tsavo and Aberdare National Parks. No protected areas were established between 1951 and 1963, this may have been attributed to 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 with a decline in the subsequent years (Fig 85).

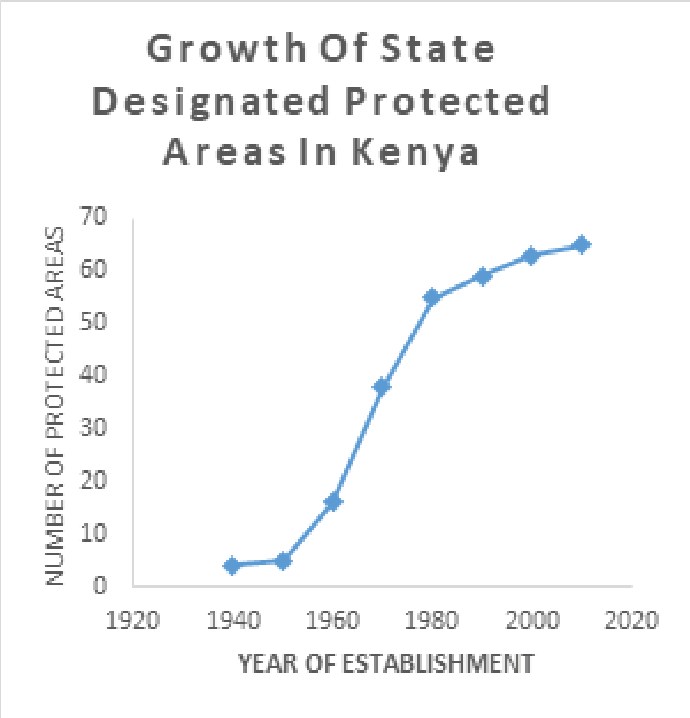


Figure 85: Growth of state designated protected areas in kenya

Wildlife Conservancies in Kenya

A conservancy is defined in WCMA 2013 as land set aside by an individual landowner, corporate body, group of owners or a community for purposes of wildlife conservation in accordance with the provisions of the Act. In the recent past, conservation efforts have 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 and stands at 206 as at April, 2023 (Figure 6 and table 3). They cover a total of 101,159 Km2. 146 are operational and registered under KWCA while 60 are emerging. Majority (94) of these conservancies are community owned while the rest are privately owned (58), co-managed or are group ranches. The largest conservancy in the country is Shurr covering 10,408Km2 (Marsabit County) followed by Cherab covering 8774Km2 (Isiolo County) and Malkahalaku covering 8287 Km2 (Tana River County). As at April, 2023, Kenya had 206 conservancies, which cover about 101,159Km2 representing about 17% of Kenya's land mass. The conservancies directly benefit over 930,000 households and directly provide 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 rhino (plate 35), White rhino, Grevy's zebras, hirola, wild dog, giraffes (plate 36 and plate 37) and elephants.

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.

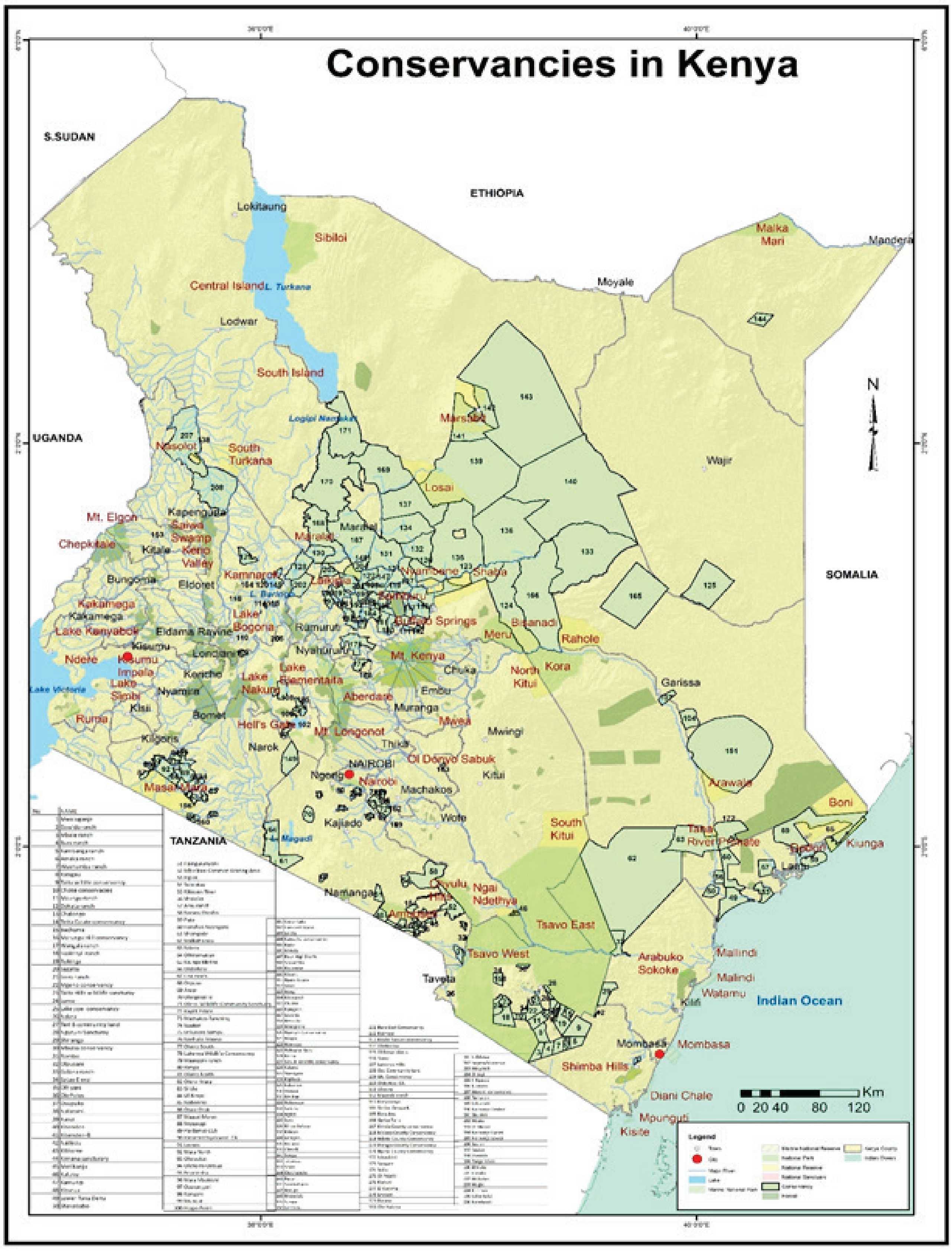


Figure 86: Kenya Wildlife Conservancies

Plate 35: Baby Nachami Born in Sera Community Conservancy Samburu
Credits Northern Rangelands Trust

Plate 36: White Giraffe in Ishaqbini Conservancy
Credits Northern Rangelands Trust

Table 48: *Kenya's Conservancies by County, Size and Status*

No.	NAME	County	Area Km2	Status
1	Shurr	Marsabit	10407.90	Operational
2	Cherab	Isiolo	8774.49	Emerging
3	Malkahalaku	Tana River	8286.71	Emerging
4	Melako	Marsabit	5502.72	Operational
5	Bura East Conservancy	Garissa	5078.16	Operational
6	Saricho	Isiolo	3872.20	Emerging
7	Garba Tulla	Isiolo	3781.41	Emerging
8	Biliqo Bulesa	Isiolo	3772.74	Operational
9	Sera	Samburu	3304.93	Operational
10	Baragoi County Conservancy	Samburu	2930.36	Emerging
11	Bora Ana	Garissa	2508.28	Emerging
12	Kinna	Isiolo	2159.39	Emerging
13	Ndoto County Conservancy	Samburu	1953.74	Emerging
14	Kalepo	Samburu	1818.25	Operational
15	Kirisia County conservancy	Samburu	1815.79	Emerging
16	Nyiru County Conservancy	Samburu	1748.47	Emerging
17	Awer	Lamu	1641.07	Operational
18	Sabuli Wildlife conservancy	Wajir	1443.63	Operational
19	Ngilai	Samburu	1247.89	Operational
20	Songa	Marsabit	1228.84	Operational
21	Malaso County Conservancy	Samburu	1200.69	Emerging
22	Ndera	Tana River	1163.71	Operational
23	Meibae	Samburu	1013.95	Operational
24	Nalowuon	Samburu	775.25	Operational
25	Nakuprat Gotu	Isiolo	715.94	Operational
26	Nasaru Olosho	Kajiado	673.56	Emerging
27	Ishaqbini	Garissa	659.25	Operational
28	Shompole	Kajiado	617.58	Operational
29	Jaldessa	Marsabit	603.26	Operational
30	Lower Tana Delta	Tana River	517.85	Operational
31	Mbirikani Common Grazing Area	Kajiado	503.71	Emerging
32	Kalama	Samburu	498.66	Operational
33	Kaptuya	Baringo	463.06	Operational
34	Hanshak Nyongoro	Lamu	457.39	Operational
35	Suswa	Narok	420.16	Operational
36	Ol Pejeta	Laikipia	410.90	Operational
37	Taita willife conservancy	Taita Taveta	409.59	Emerging
38	Ltungai	Samburu	390.47	Operational
39	Mukutan	Laikipia	380.00	Operational
40	Westgate	Samburu	363.28	Operational
41	Mara North	Narok	348.26	Operational
42	Nasuulu	Isiolo	341.88	Operational
43	Leparua	Isiolo	331.28	Operational
44	Lualenyi ranch	Taita Taveta	322.13	Emerging
45	Kamuthe conservancy	Garissa	303.94	Operational
46	Nkoteiyia	Samburu	303.52	Operational
47	Rukinga	Taita Taveta	299.08	Operational
48	Pate	Lamu	281.07	Operational
49	Olkiramatian	Kajiado	269.81	Operational
50	Galana ranch	Tana River	268.76	Operational
51	Shirango	Kilifi	268.69	Operational
52	Amu ranch	Lamu	248.98	Operational
53	Nanapisho	Isiolo	248.94	Operational
54	Loisaba	Laikipia	236.79	Operational
55	Pardamat CCA	Narok	234.38	Operational
56	Naapu	Isiolo	231.58	Operational
57	Nannapa	Isiolo	230.80	Operational
58	Kiunga Marine	Lamu	227.55	Operational
59	Ol Jogi	Laikipia	226.01	Operational
60	Kipini	Lamu	221.74	Operational
61	Chachabole	Mandera	218.87	Emerging
62	Kasigau	Taita Taveta	215.93	Operational
63	Mgeno conservancy	Taita Taveta	213.08	Emerging
64	Naboisho	Narok	211.30	Operational
65	Soysambu	Nakuru	209.24	Operational
66	Mugie	Laikipia	206.42	Operational
67	Mpala	Laikipia	204.82	Operational
68	Lolldaiga	Laikipia	200.30	Operational
69	Segera/Mukenya	Laikipia	196.93	Operational
70	Maungu ranch	Taita Taveta	195.88	Emerging
71	Olentile	Laikipia	195.59	Operational
72	Kabarion	Baringo	194.00	Emerging
73	Lumo	Taita Taveta	191.41	Operational
74	Suyian	Laikipia	181.92	Operational
75	Ruko	Baringo	178.96	Operational
76	Mbale ranch	Taita Taveta	168.75	Emerging
77	Bura ranch	Taita Taveta	163.68	Emerging
78	Lewa	Meru	163.44	Operational
79	Kirimon	Laikipia	163.17	Operational
80	Kambanga ranch	Taita Taveta	159.32	Emerging
81	Wushumbu ranch	Taita Taveta	159.28	Emerging
82	Narupa	Samburu	157.15	Operational
83	Olorgesailie	Kajiado	151.64	Operational
84	Shakababo	Tana River	150.85	Emerging
85	Naibunga Lower	Laikipia	145.23	Operational
86	Naibunga Upper	Laikipia	145.01	Operational
87	Shakako	Tana River	139.47	Emerging
88	Solio	Laikipia	133.47	Operational
89	Bour-Algi Giraffe	Garissa	129.60	Operational
90	Kapiti Estate	Machakos	128.07	Operational
91	Kiturua	Kajiado	128.04	Operational
92	Marula	Nakuru	125.46	Operational
93	Ilaingurunyoni	Kajiado	124.56	Emerging
94	Ol Maisor	Laikipia	121.33	Operational
95	Rombo	Kajiado	120.81	Emerging
96	Ole Naishu	Laikipia	120.50	Operational
97	Borana	Laikipia	118.66	Operational

No.	NAME	County	Area Km2	Status
98	Izera ranch	Taita Taveta	109.33	Operational
99	Kitenden	Kajiado	109.31	Operational
100	Naibunga Central	Laikipia	108.27	Operational
101	Olare Orok	Narok	100.75	Operational
102	Sosian	Laikipia	99.68	Operational
103	Lorogon	Turkana	95.88	Emerging
104	Taita Hills wildlife sancturay	Taita Taveta	95.42	Operational
105	Oloisukut	Narok	93.16	Operational
106	Il Ngwesi	Laikipia	92.87	Operational
107	Selenkay	Kajiado	91.93	Operational
108	Lekurruki	Laikipia	90.38	Operational
109	Bachuma	Taita Taveta	89.01	Operational
110	Choke conservacies	Taita Taveta	85.62	Operational
111	Teri B community land	Taita Taveta	83.99	Emerging
112	Maiyanat	Laikipia	80.57	Emerging
113	Swara Plains	Machakos	80.33	Operational
114	Oza Community land	Taita Taveta	78.79	Emerging
115	Shulmai	Laikipia	72.55	Emerging
116	OleNarika	Kajiado	72.36	Emerging
117	Ol Kinyei	Narok	66.43	Operational
118	Naretunoi	Kajiado	65.77	Operational
119	Sagalla	Taita Taveta	61.68	Emerging
120	Lemek	Narok	60.84	Operational
121	Kitenden-B	Kajiado	59.93	Operational
122	El Karama	Laikipia	58.18	Operational
123	Machakos Ranching	Machakos	57.56	Operational
124	Ngare Ndare	Meru	55.11	Operational
125	Olchorro Oiroua	Narok	54.43	Operational
126	Orpuaa	Narok	54.27	Operational
127	Olarro South	Narok	54.26	Operational
128	Oserongoni	Nakuru	48.85	Operational
129	Amaka ranch	Taita Taveta	47.58	Operational
130	Motorogi	Narok	47.08	Operational
131	Dawida ranch	Taita Taveta	46.78	Operational
132	Olderkesi CA	Narok	46.68	Emerging
133	Maasai Moran	Narok	46.34	Emerging
134	Siana	Narok	46.23	Operational
135	Morani conservancy	Laikipia	45.80	Emerging
136	Kikesen River	Kajiado	43.57	Emerging
137	Mbulia conservancy	Taita Taveta	43.53	Operational
138	Nalarami	Kajiado	42.27	Operational
139	Kimintet Nyekweri CA	Narok	41.09	Emerging
140	Kiplombe	Baringo	39.76	Emerging
141	Olerai Wildlife Community Sanctuary	Kajiado	39.57	Operational
142	Olosira	Kajiado	39.36	Emerging
143	Tumaren	Laikipia	38.92	Operational
144	Olderkesi	Narok	38.90	Operational
145	Mara Mbokishi	Narok	38.69	Emerging
146	Mwaluganje	Kwale	37.56	Operational
147	Satao Elerai	Kajiado	34.85	Operational
148	Nashulai Maasai	Narok	30.61	Operational
149	Oltiyani	Kajiado	30.30	Operational
150	Maanzoni ranch	Machakos	29.72	Operational
151	Olarro North	Narok	29.38	Operational
152	Kanzi	Kajiado	29.22	Operational
153	Teita Estate conservancy	Taita Taveta	29.02	Operational
154	Ngutuni Sancturay	Taita Taveta	27.80	Operational
155	Motikanju	Kajiado	27.71	Operational
156	Kipepeo	Laikipia	27.33	Emerging
157	Ndara	Taita Taveta	27.03	Emerging
158	Enkusero Sampu	Kajiado	26.62	Operational
159	Kimana sancturary	Kajiado	25.91	Operational
160	Enonkishu	Narok	23.90	Operational
161	Kadura	Laikipia	23.88	Emerging
162	Nailepu	Kajiado	22.81	Operational
163	Lisa ranch	Machakos	22.20	Operational
164	Kamungi	Makueni	21.73	Operational
165	Mwambi ranch	Machakos	21.43	Emerging
166	Marungu Hill conservancy	Taita Taveta	21.11	Emerging
167	Isaaten	Narok	20.90	Operational
168	Kilitome	Kajiado	20.10	Operational
169	Chuine	Baringo	18.05	Operational
170	OlePolos	Kajiado	17.78	Operational
171	Enosoit	Laikipia	17.08	Emerging
172	Sangare	Laikipia	16.86	Operational
173	Osupuko	Kajiado	15.93	Operational
174	Loldia	Nakuru	15.64	Operational
175	Kaluku	Makueni	15.60	Operational
176	Kanyoonyo	Kitui	15.00	Emerging
177	Lukenya Wildlife Conservancy	Machakos	14.60	Operational
178	Lalke Solai	Nakuru	12.90	Operational
179	Ngenyin Conservancy	Baringo	12.45	Emerging
180	Kigio	Nakuru	12.16	Operational
181	Lukenya Hills	Machakos	11.74	Emerging
182	Kiborgoch	Baringo	11.62	Operational
183	Tango Maos	Laikipia	9.55	Emerging
184	Wangala ranch	Taita Taveta	9.24	Emerging
185	Olerai Mara	Narok	9.19	Operational
186	El Malo	Laikipia	8.57	Emerging
187	Rimpa	Kajiado	7.44	Operational
188	Dokata ranch	Kwale	6.98	Emerging
189	Mundui	Nakuru	6.71	Operational
190	Ulu Conservancy	Makueni	4.80	Emerging
191	Olpusare	Kajiado	4.45	Operational
192	Hippo Point	Nakuru	3.77	Operational
193	Kaimosi	Vihiga	2.68	Emerging
194	Crater Lake	Nakuru	2.66	Operational
195	Oldonyo Waus	Kajiado	2.63	Operational
196	Kongoni	Nakuru	1.54	Operational
197	Irong	Baringo	1.54	Operational
198	Kiborit	Baringo	1.38	Emerging
199	Silole	Narok	1.30	Operational
200	Lake jipe conservancy	Taita Taveta	1.18	Operational
201	Crescent Island	Nakuru	1.00	Operational
202	Lentolia	Nakuru	0.59	Operational
203	Kitale Nature conservancy	Trans Nzoia	0.53	Operational
204	Kamgoin	Baringo	0.42	Emerging
205	Chalongo	Taita Taveta	0.39	Operational
206	Sinibo Geopark	Baringo	0.34	Emerging

Plate 37: Rothschild Girraffes in Ruko community conservancy in Baringo, Kenya

Wildlife Corridors and Dispersal Areas

As at April 2023, the KWS and conservation partners had identified a total of 114 wildlife corridors in Kenya based on tracking data of tagged wildlife (Figure 87). These wildlife corridors and dispersal areas connect core habitats and are critical for species' survival and long-term viability of ecosystems. 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.

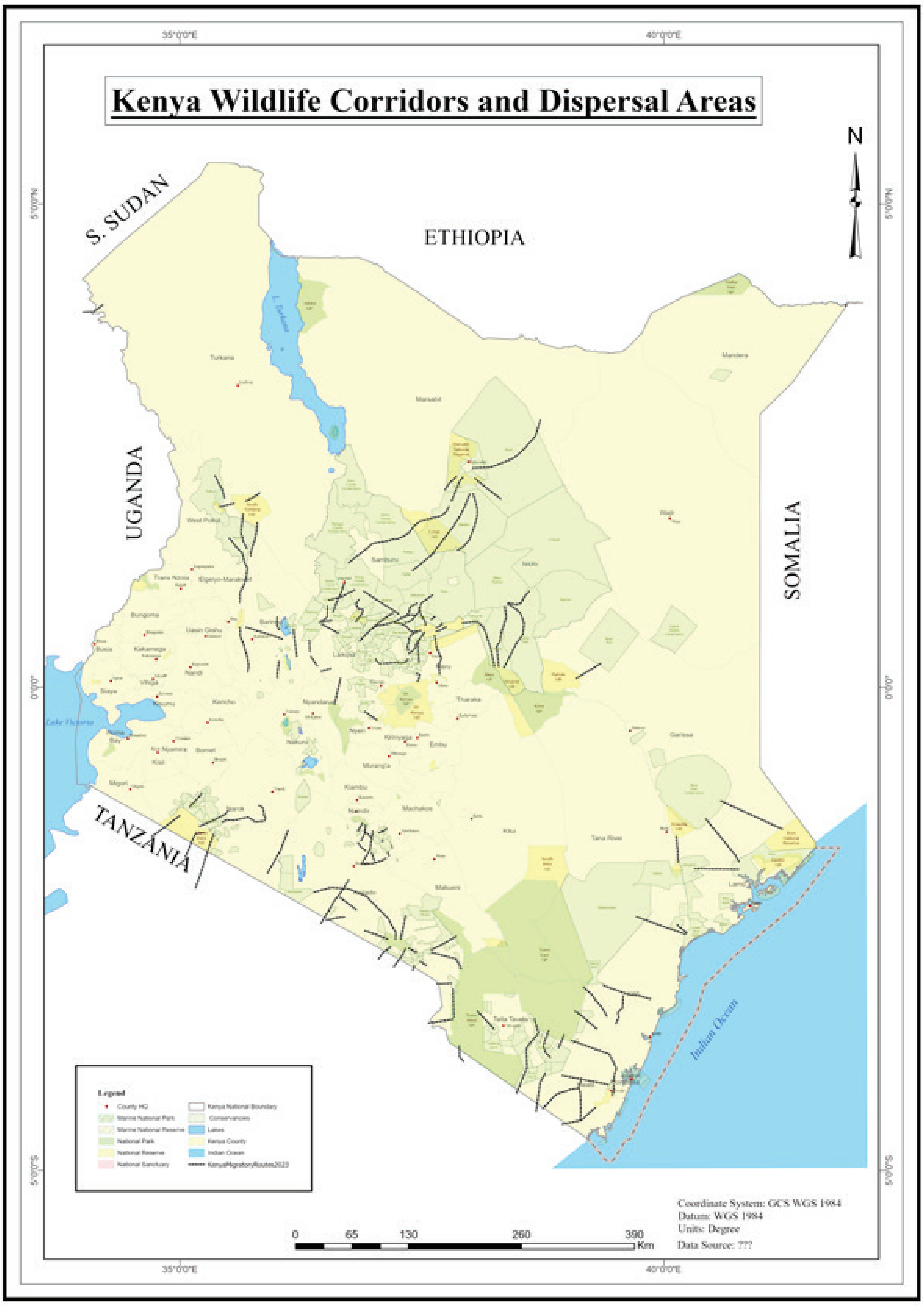


Figure 87: Wildlife Corridors and Dispersal Areas in Kenya:

KWS Administration units in Management of Kenya's Wildlife Resources

To effectively administer and manage Kenya's wildlife resources, KWS partitioned the country into eight regions referred to as Conservation Areas (Fig 11). These are Northern Conservation Area (NCA), Mountain Conservation Area (MCA), Coast Conservation Area (CCA), Southern Conservation Area (SCA), Western Conservation Area (WCA), Eastern Conservation Area (ECA), Central Rift Conservation Area (CRCA) and Tsavo Conservation Area (TCA). The headquarters of KWS is located in Nairobi along Langata road. The conservation area maps below clearly show the national parks, national reserves, national sanctuaries and conservancies. The number of protected areas in each Conservation Area is indicated in table 49.

Table 49: *Kenya's Protected Areas in each Conservation Area*

No.	Conservation Area	No. of Parks	No. of Reserves	No. of Sanctuaries
1	Western	4	4	4
2	Central Rift	3	4	0
3	Southern	3	0	0
4	Mountain	3	6	1
5	Northern	5	2	0
6	Tsavo	3	3	0
7	Coast	5	10	0
8	Eastern	2	6	0

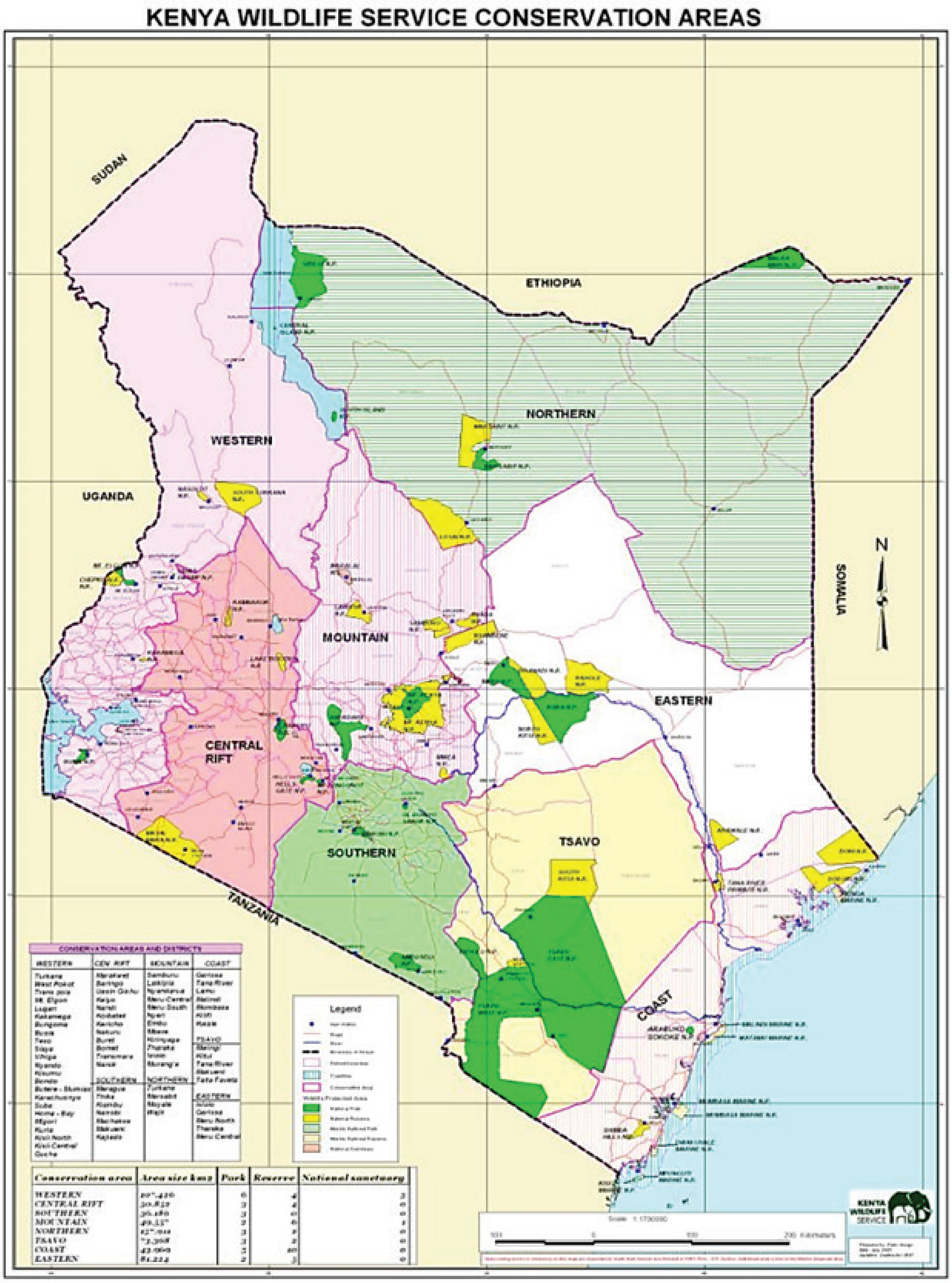


Table 50: *KWS Administrative Conservation Areas*

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 is in the southern rangelands of the country from the Maasai Mara in the west and down to Tsavo 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 eastern region (Figure 88).

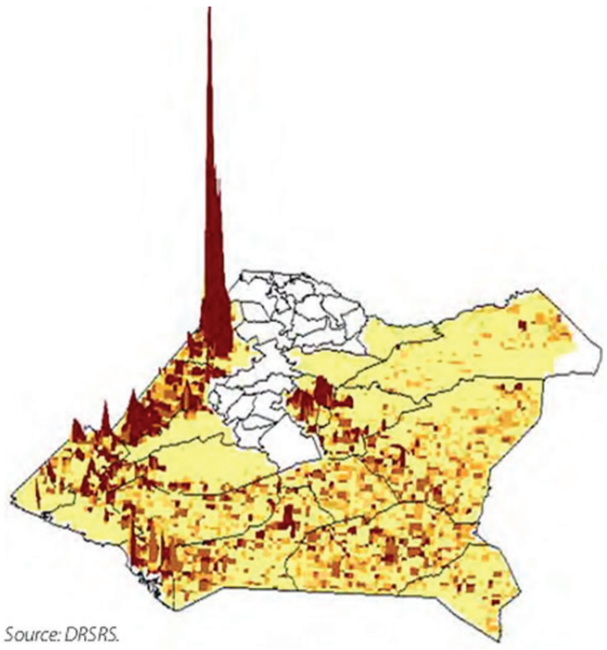


Figure 88: three-dimensional depiction of total wildlife abundance and distribution in Kenya.

Population status of 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 rangelands, aerial survey of wildlife is usually used since it is the most efficient and cost effective. For this reason therefore, KWS undertakes Ecosystem-wide aerial total count of wildlife every 3-5 years in key priority ecosystems that harbor high density of large mammals. These ecosystems are Tsavo, Laikipia-Isiolo-Samburu, Amboseli-Magadi, Mara, Athi-Kapiti, Boni-Dodori, Nasalot and Nakuru-Naivasha (Figure 89).

The larger northern Kenya represented by Marsabit, Wajir, Garissa and Mandera Counties are covered largely by sample surveys undertaken by DRSRS in collaboration with KWS and Wildlife Research and Training Institute (WRTI). Aerial survey method is suitable mainly for large grazer and browser species the size of Thomson gazelle and above (including ostriches). However, carnivores are sampled using specialized methods such as call backs, explicit capture-recapture or spoor counts. Small mammals and other lower taxa are surveyed using transects, traps and other specialized methods usually spearheaded by National Museums of Kenya. Key forest dwellers like elephants of Mau forest complex are sampled using dung counts.

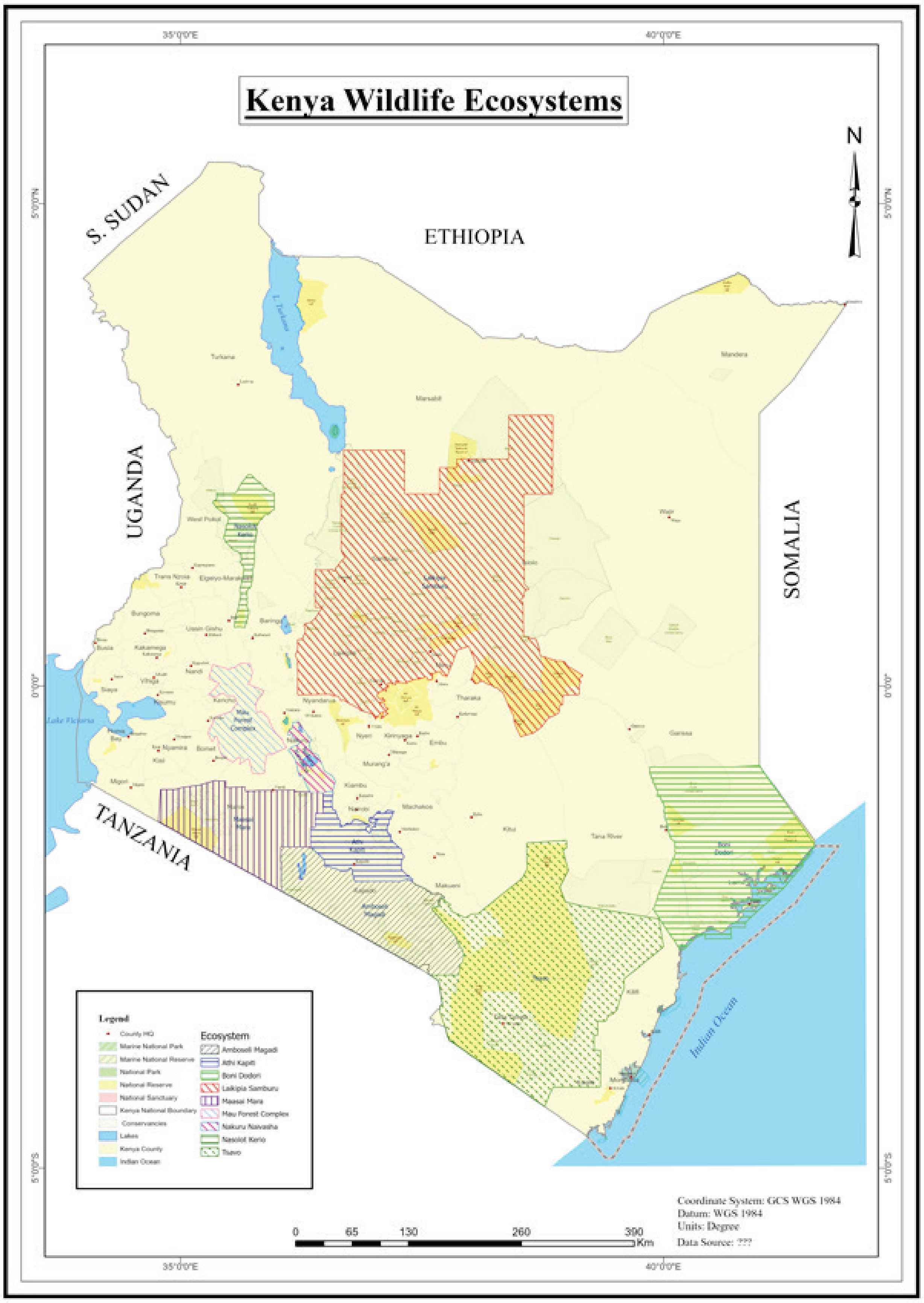


Figure 89: Major Wildlife Ecosystems in Kenya

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. The results of this national wildlife census are highlighted (Fig 90 and Fig 91)

Figure 90: Population of critically endangered wildlife species

Figure 91: Population of endangered wildlife species

Species Distributions as per 2021 census

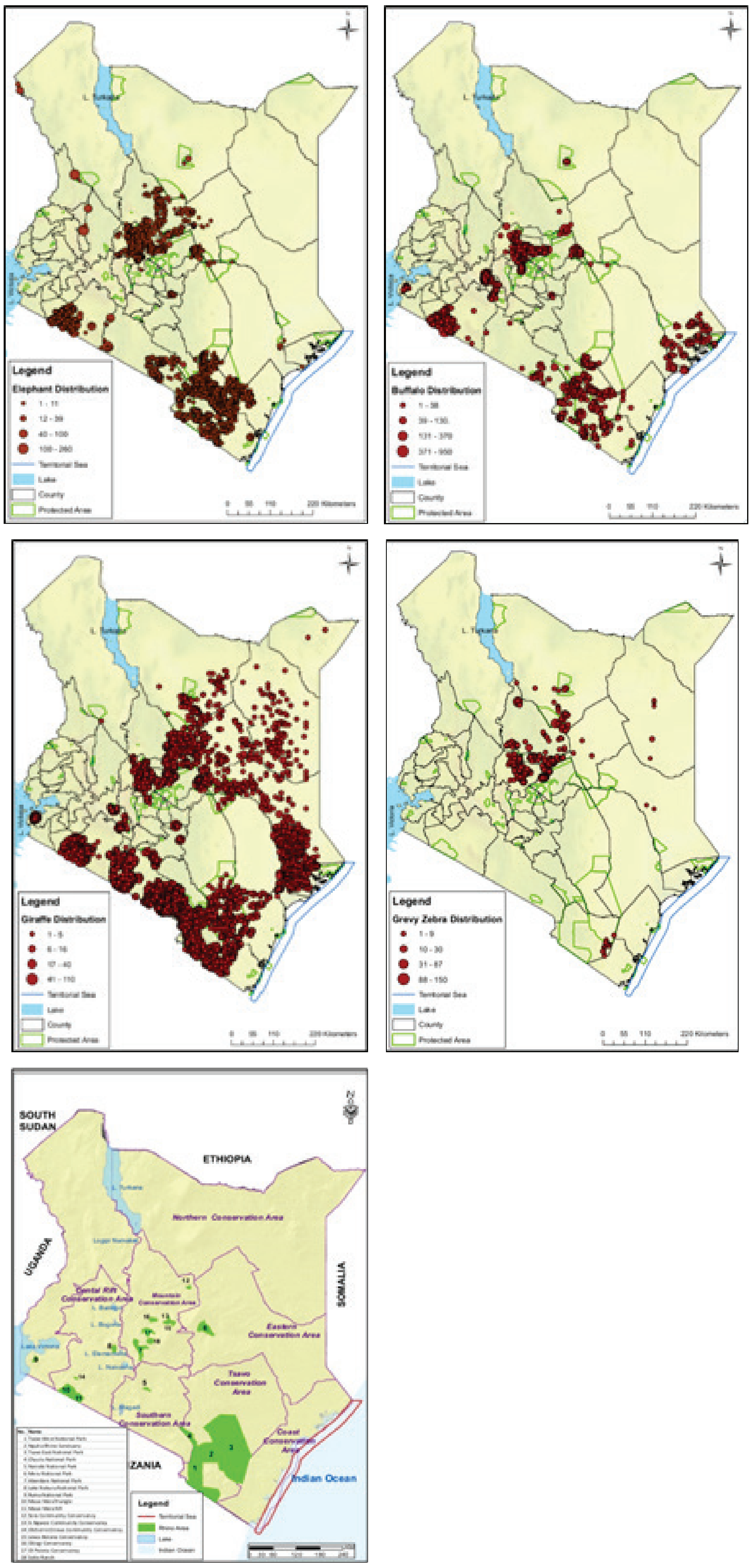


Figure 92: Spatial distribution of specific wildlife species

Population Trends for some select species

Apart from a few large mammal species like elephants and rhinos whose populations have remained stable or increasing in Kenya, most of the other species populations have been on a declining trend with some like Roan antelope being on the verge of local extinction.

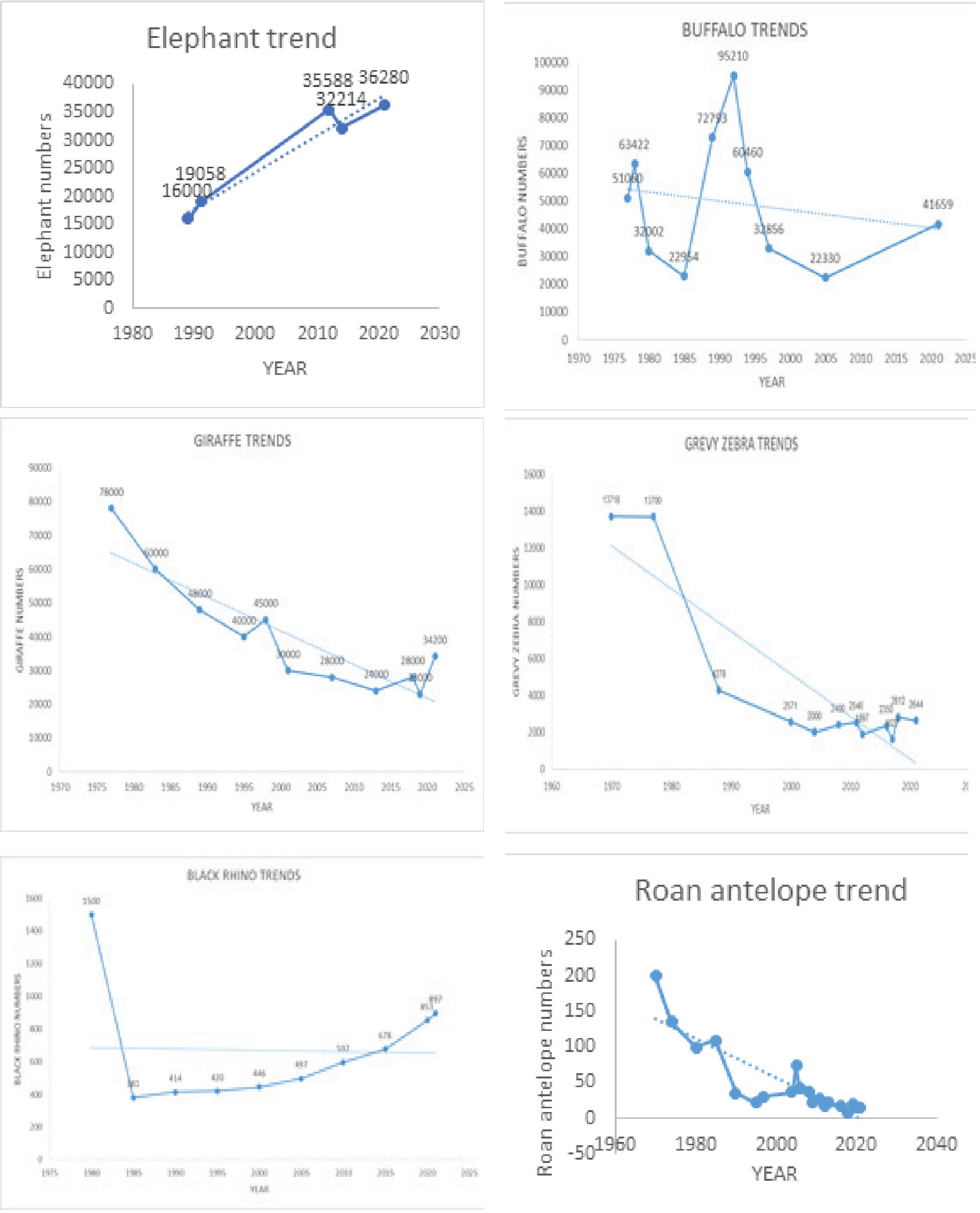


Figure 93: Population trends of some wildlife species

Threat categorization and listing of species.

The World Conservation Union (IUCN) has provided criteria for ranking of threats to wildlife species in the red list data book. Besides the above IUCN categories, Kenya has listed 242 wildlife species deemed nationally threatened in the wildlife Act (WCMA 2013) schedule 6. The Kenyan categorization introduced an extra category of protection of species called "protected". The sixth schedule has six categories namely; critically endangered, endangered, vulnerable, near threatened, threatened and protected (Table 51).

Table 51: *The IUCN red list*

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

The status of Kenya's wildlife species threat listing under IUCN and National criteria is depicted in Fig 94 and and Fig 95 below classified at various taxa.

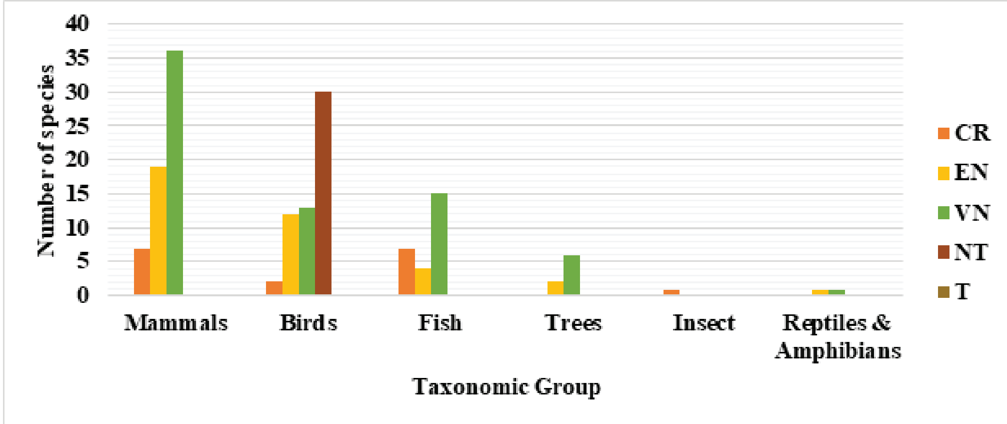


Figure 94: IUCN threat listing of Kenya wildlife species by taxa.

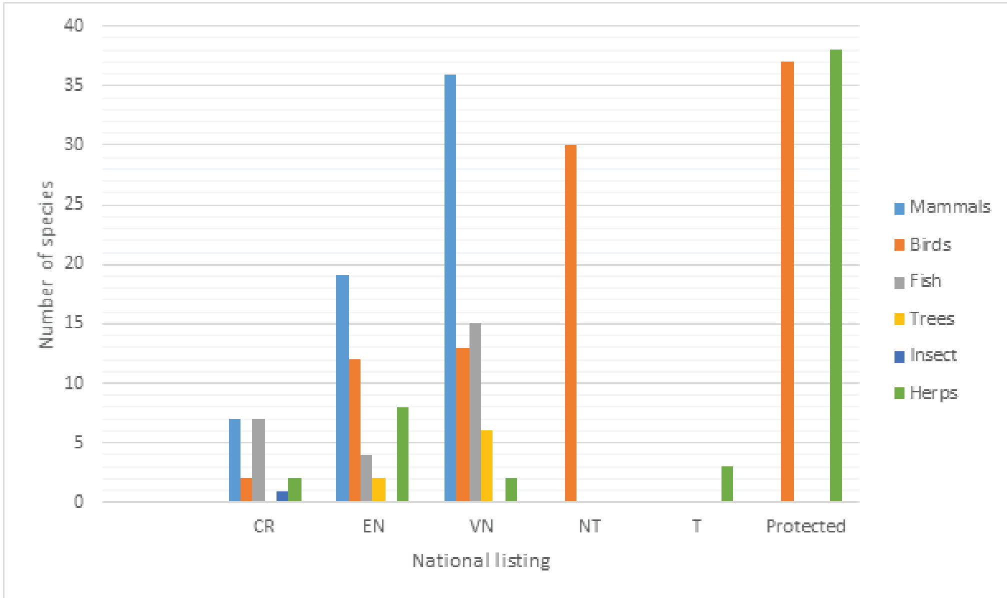


Figure 95: National threat listing of Kenya wildlife species by taxa

Critically endangered wildlife species

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

World Heritage Sites

Kenya's host most of the World Heritage sites and Biosphere reserves (Fig 96)

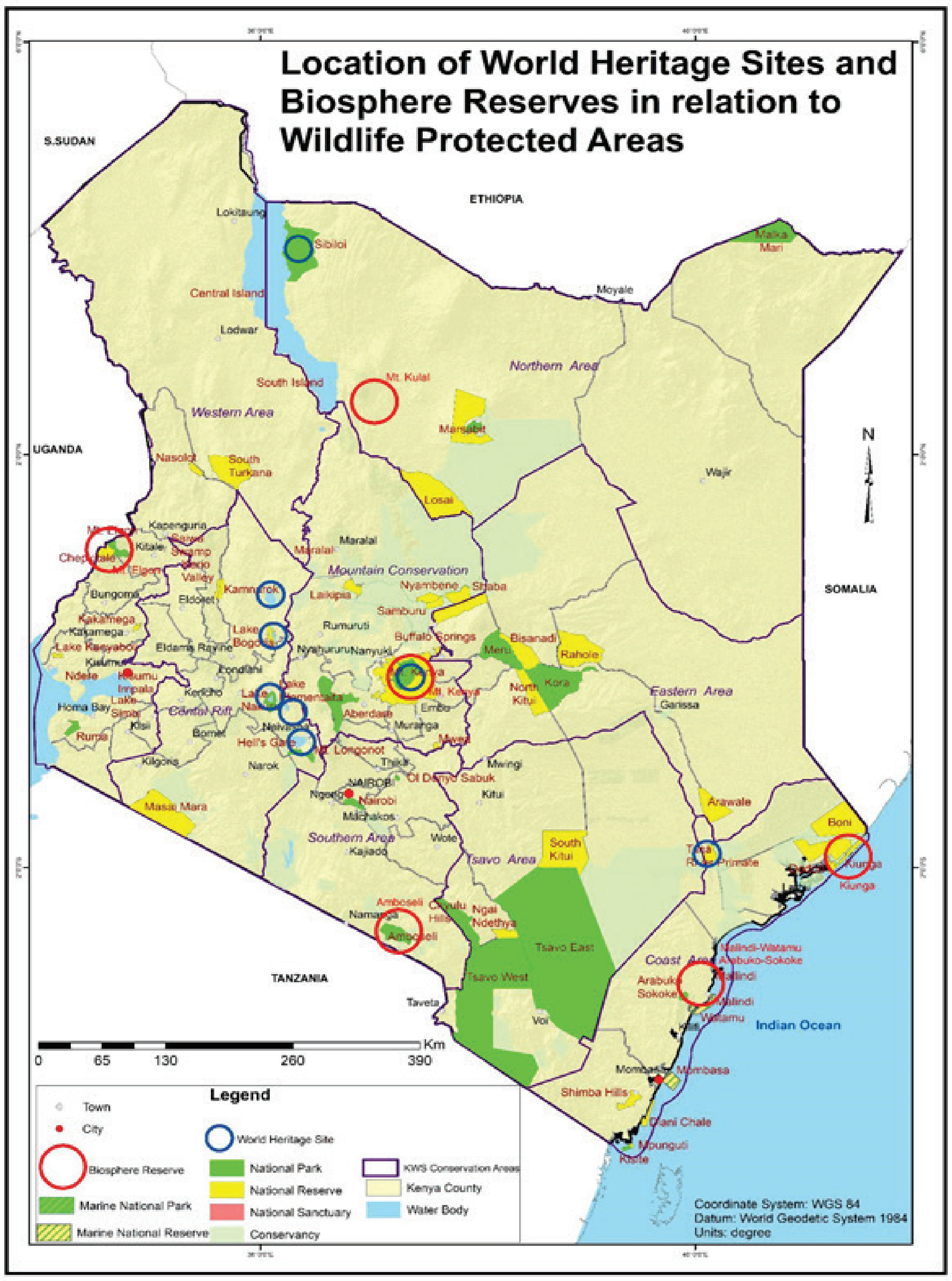
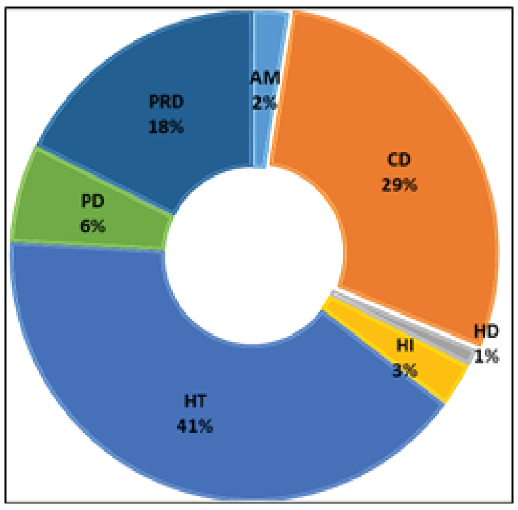


Figure 96: Kenya's World Heritage sites and Biosphere Reserves

Plate 39: A Giraffe trapped and killed while crossing a fence within the Amboseli Ecosystem



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

Figure 97: Type and relative prevalence of HWCs

Wildlife Threats and Challenges

Human Wildlife Conflict (HWC)

Increasing human-wildlife conflicts pose a major problem in wildlife areas(plate 38 and 39). Acute water shortages and inadequate pastures during dry seasons severely impact on wildlife, livestock and humans. This triggers competition for what is available of the resources, thus resulting in conflict. Human wildlife conflicts have been attributed to, besides climate variability and change, also on increased human activities in areas originally preserved for wildlife. At present, compensation relating to human wildlife conflict undertaken by the national Government, with the amounts payable relating to the human injury and deaths that would have occurred, and wildlife-caused damages to crops, livestock and property. These payments have been unsustainable.

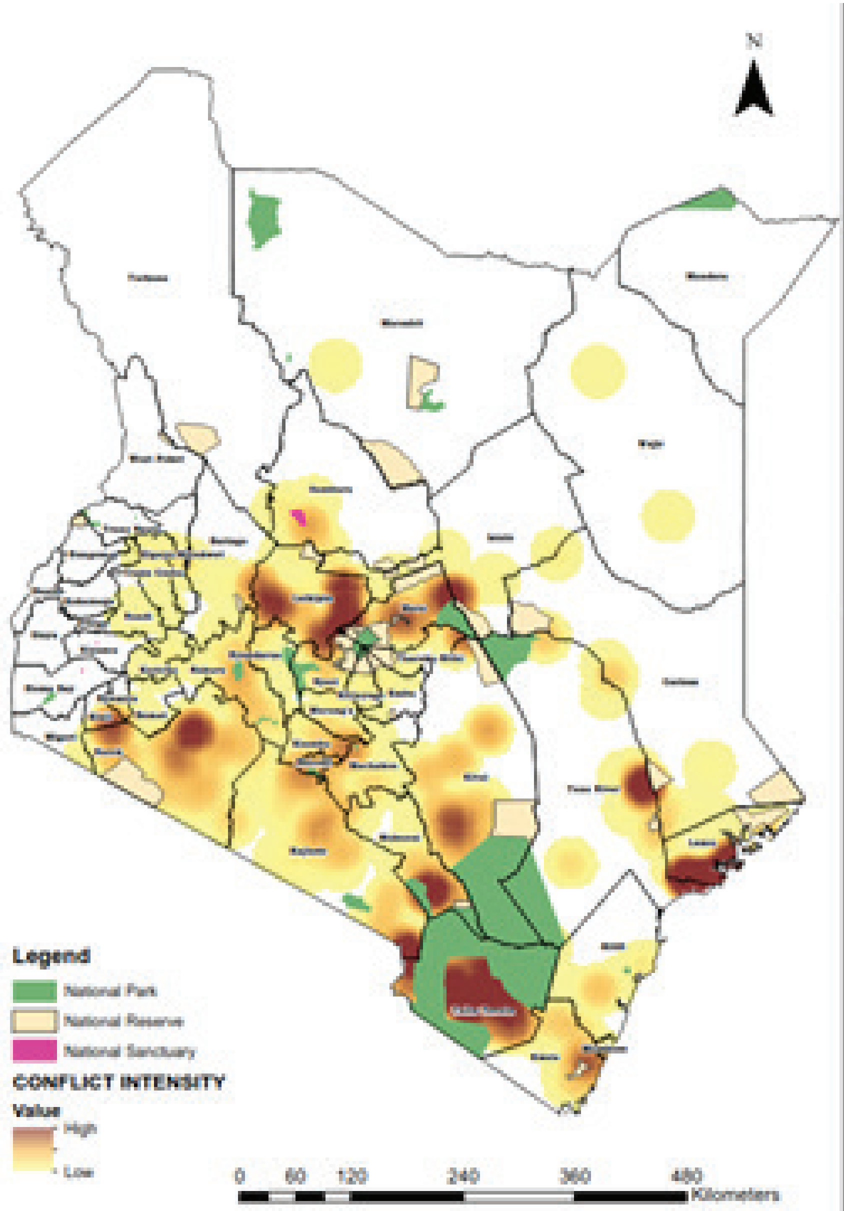


Figure 98: HWC hotspots in the country

Plate 38: Sheep killed by a lion

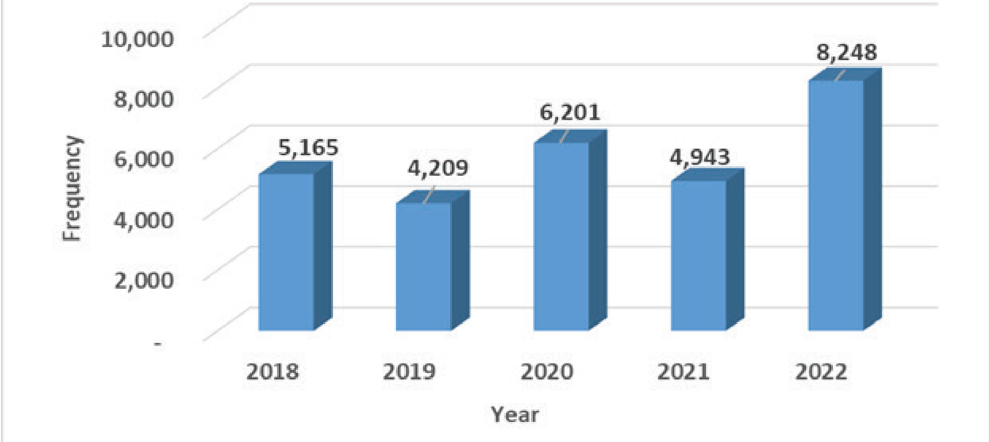


Figure 99: FIVE YEAR COMPARATIVE ANALYSIS OF HWC INCIDENTS 2018 TO 2022

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

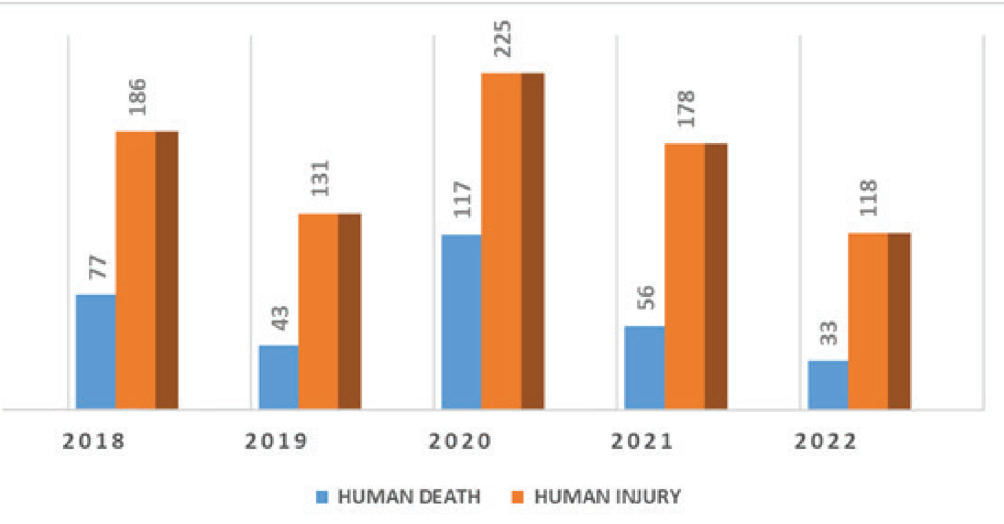


Figure 100: FIVE YEAR COMPARATIVE ANALYSIS OF HUMAN ATTACK (Death & Injury INCIDENTS 2018 TO 2022

326 Cumulatively number of people killed.

838 Cumulatively number injured.

2020 recorded highest incident rates for both death and injuries followed by 2018

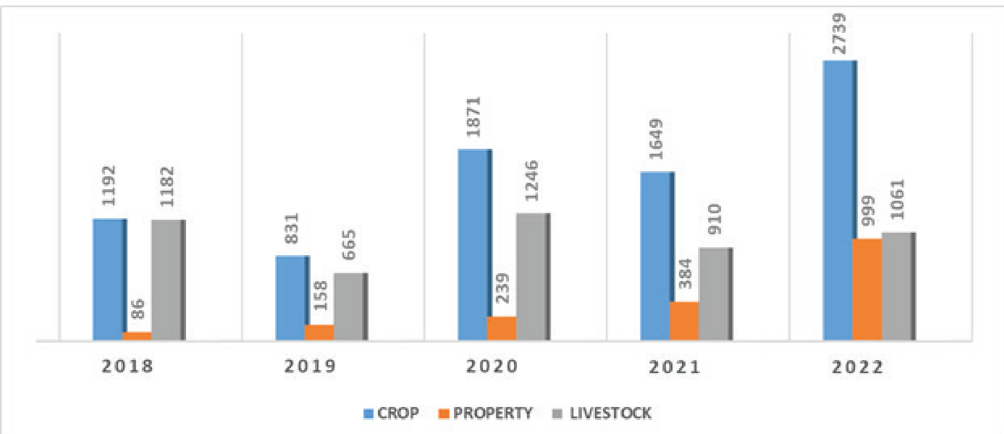


Figure 101: FIVE YEAR COMPARATIVE ANALYSIS OF ATTACKS ON PROPERTY) INCIDENTS 2018 TO 2022

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.

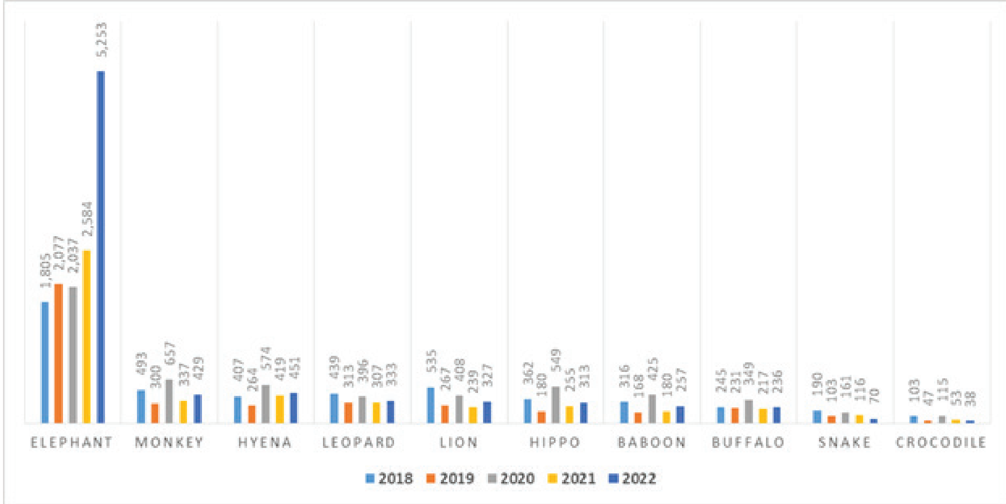


Figure 102: FIVE YEAR COMPARATIVE ANALYSIS OF ATTACKS ON PROPERTY) INCIDENTS 2018 TO 2022

90% of reported incidents in the review period caused by this 10 species

Elephant has the highest number of conflicts recorded in all of the 5 years

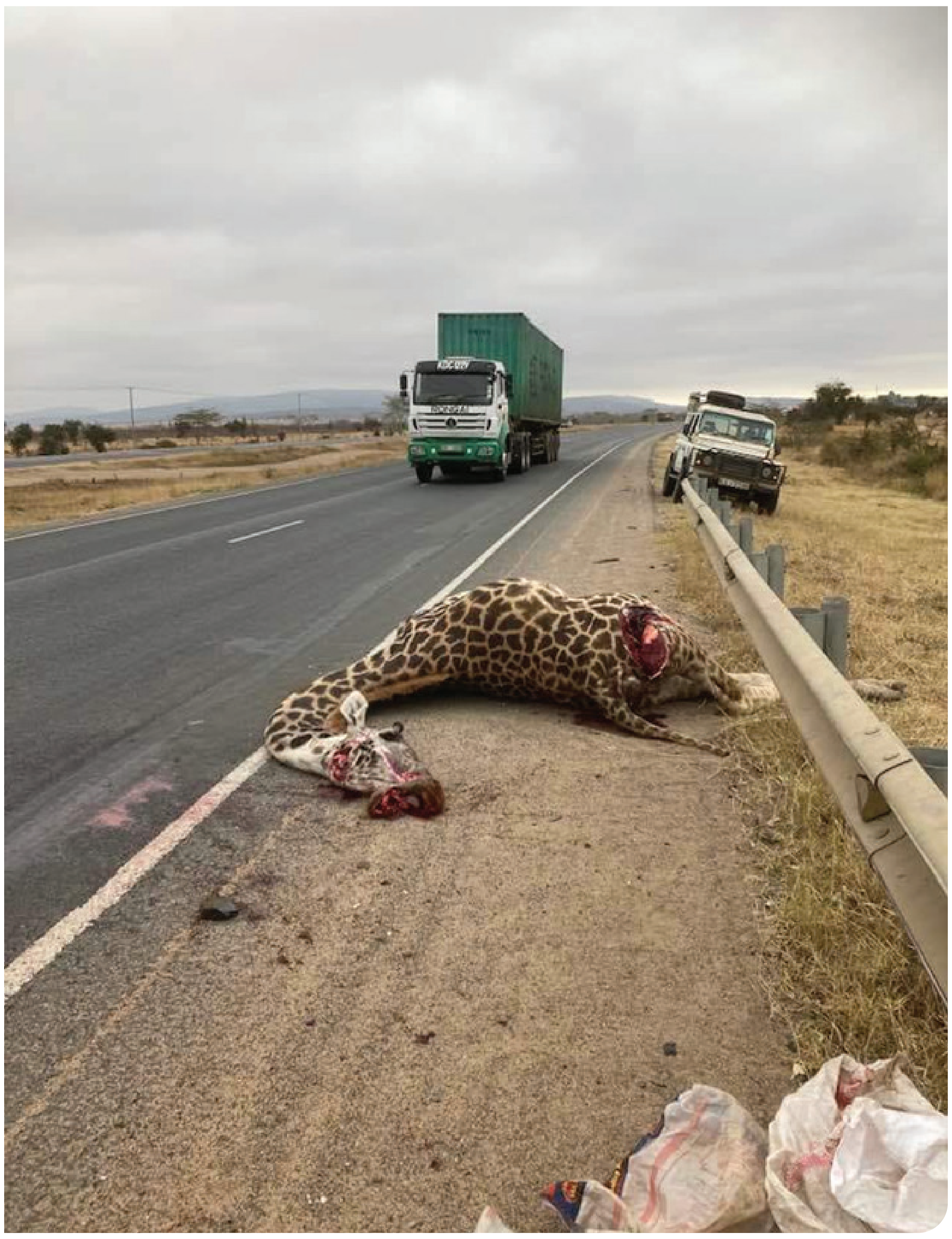


Plate 40: Giraffe knocked down by a vehicle around Maanzoni Lodge along Nairobi-Mombasa Road

b) 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

c) Land use and habitat fragmentation

Land is one of the most important resources in Kenya. Economic activities like agriculture, wildlife conservation, urban development, human settlement, and infrastructure depend on land. Until recently, wildlife conservation has not been a formally recognized land-use option in Kenya resulting in failure to adequately integrate wildlife conservation in land-use planning activities. 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.

In addition to the above, Natural habitats provide an important resource base for the livelihoods of rural communities. However, the rapidly increasing populations, incidences of poverty, demand for fuel wood, and other complex socio-economic factors have put enormous pressure on the scarce productive lands, thus forcing large segments of the rural poor to resort to poor land-use practices like deforestation, charcoal burning, overgrazing, and livestock incursions in wildlife protected areas. This is causing severe degradation of wildlife habitats.

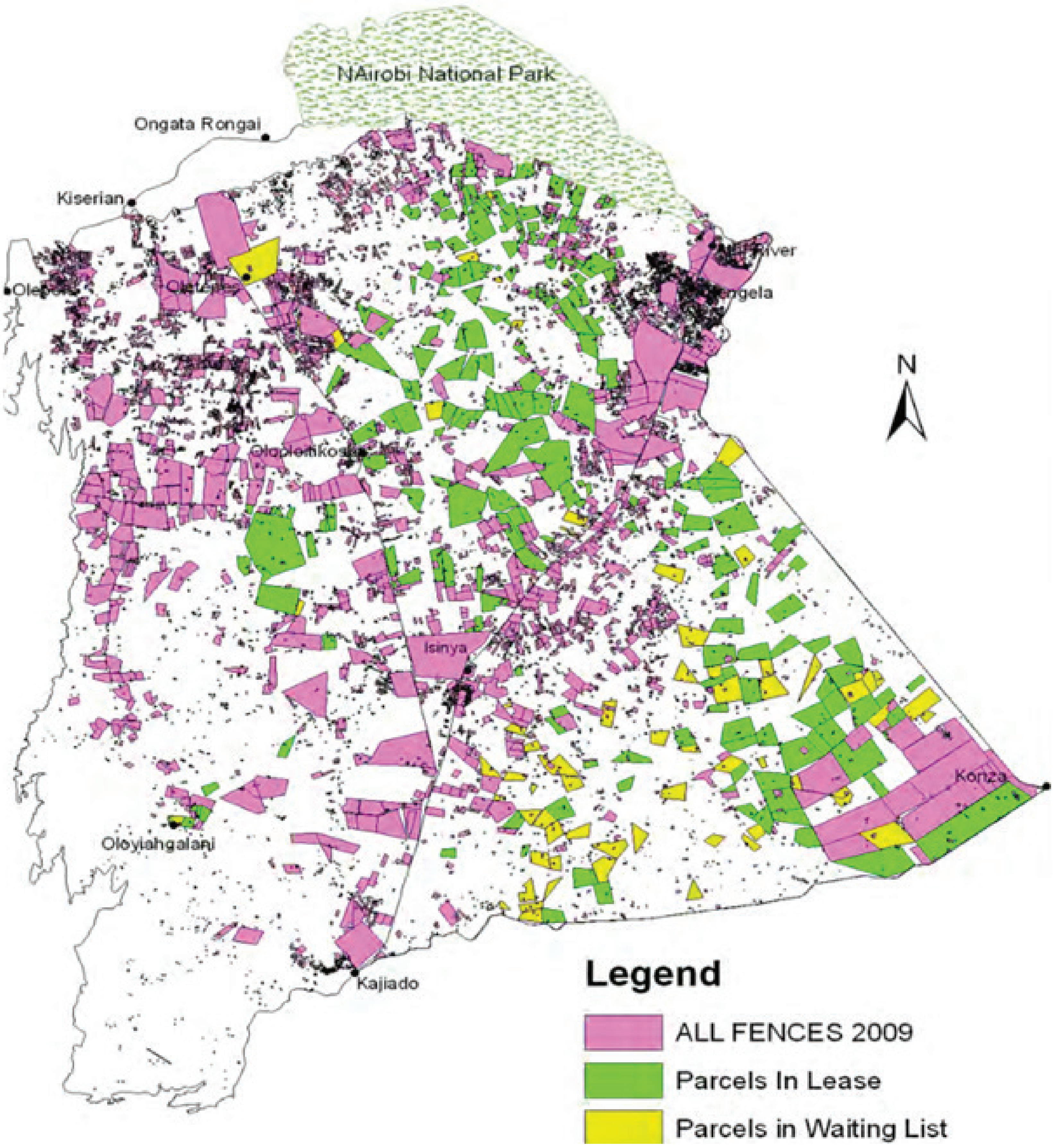


Figure 103: Illustration of habitat fragmentation. Map of dispersal area for the Nairobi National Park ecosystem showing status of fenced parcels of land as at 2009. The situation is even more fragmented now.

Plate 41: Industrial Land Use Activity located inside Nasaru Conservancy in Amboseli Ecosystem

d) 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 104.

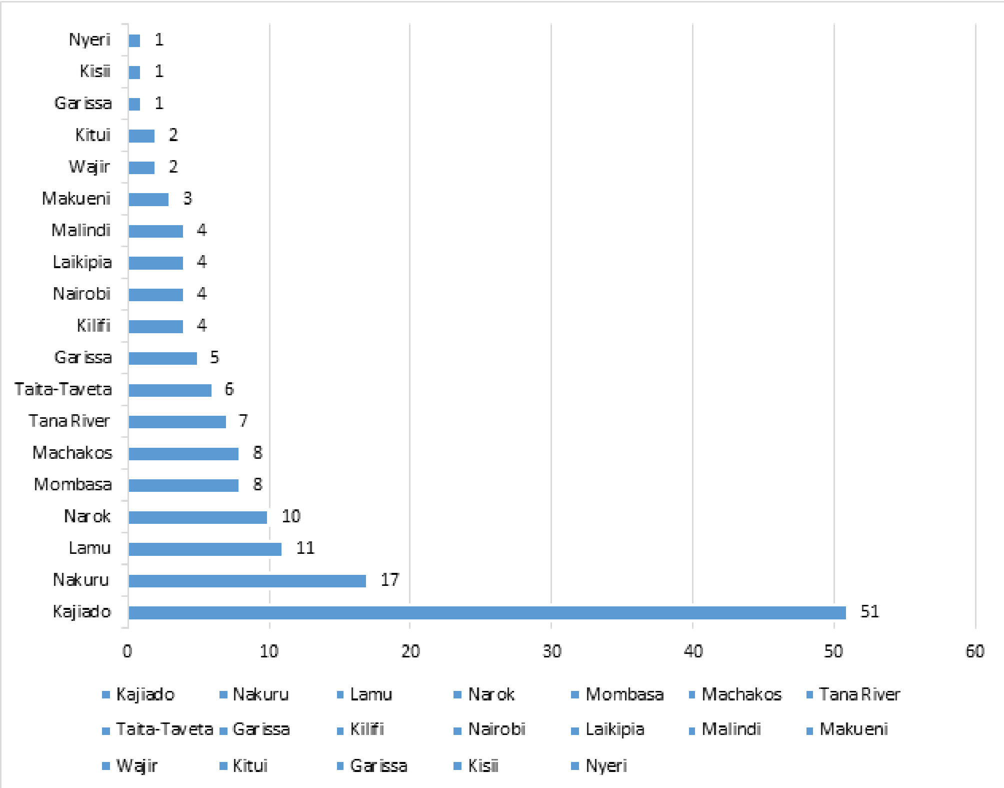


Figure 104: Bush meat cases analyzed in the forensic lab for prosecution purposes in 2015

Table 52: *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

e) Inadequate incentives:

Whereas protected areas have been set aside for purposes of wildlife conservation, a significant percentage of Kenya's wildlife inhabit communal and private lands that also serve as wildlife dispersal areas for the protected areas. At present, there are inadequate incentives to motivate communities and land owners to adopt land-use practices that are compatible with wildlife conservation and management. The situation is aggravated by the existence of incentives in other sectoral policies that distort land-use decisions

f) Ineffective protected area management and partnerships:

Most wildlife protected areas in Kenya were established without due regards to the surrounding landscapes. As a result, boundaries between the areas and the wider landscapes and community spaces were not distinct. This has been a cause of widespread human-wildlife conflicts. While efforts are ongoing to erect fences and other barriers that mark the boundaries, these inadequately deter wildlife from escaping into the community spaces where they destroy property, as well as communities gaining access to the protected areas to graze their livestock. The conservation and management of wildlife outside the protected areas is hardly ever integrated into the broader protected area management.

g) Drought and Climate Change

Climate change occurs once there is a change in frequency of climatic events such as rainfall or temperature. Kenya experienced prolonged drought in 2022 which led to either failed or depressed rainfall across the country. Inadequate soil moisture caused by a shortage of precipitation, increased temperature and excess evapotranspiration made trees and grass dry up fast and shed leaves leaving little browse and graze material. As a result, at least 7019 wildlife mortalities were recorded countywide mainly concentrated in the southern rangelands of Amboseli Ecosystem and affecting at least 25 large animal species (Table 53).

Table 53: *2022 drought-related wildlife Mortalities in Kenya*

	Species	Tsavo CA	Mountain CA	Southern CA	Central Rift CA	Coast CA	Western CA	Eastern CA	Northern CA	TOTAL
1	Elephant	110	102	132	0	1	0	1	2	348
2	Black rhino	1		0	0	0	0	0	0	1
3	Grevy Zebra	0	75	N/A	N/A	N/A	N/A	4	8	87
4	Giraffe (all spp)	No data	54	127	No data	14	No data	87	8	290
5	Wildebeest	No data	No data	3927	No data	No data	0	No data	No data	3927
6	Common Zebra	16	69	1561	No data	No data	No data	4	No data	1650
7	Buffalo	20	341	76	6	1	No data	48	No data	492
8	Impala	No data	103	111	No data	No data	No data	No data	No data	214
9	Grant gazelle	No data	No data	174	No data	No data	No data	19	No data	193
10	Thomson gazelle	No data	2	131	No data	No data	No data	No data	No data	133
11	Eland	4	48	47	No data	No data	No data	No data	No data	99
12	Warthogs	No data	40	28	No data	No data	No data	103	No data	171
13	Oryx	No data	6	14	No data	No data	No data	1	No data	21
14	Hartebeest	3	12	6	No data	No data	No data	No data	No data	21
15	Gerenuk	No data	No data	19	No data	No data	No data	8	No data	27
16	Lesser kudu	No data	No data	16	No data	No data	No data	6	No data	22

	Species	Tsa-vo CA	Moun-tain CA	South-ern CA	Cen-tral Rift CA	Coast CA	West-ern CA	East-ern CA	North-ern CA	TO-TAL
17	Reedback	No data	No data	9	No data	No data	No data	No data	No data	9
18	Hippos	No data	2	6	No data	No data	No data	No data	No data	8
19	Dikdik	No data	No data	7	No data	No data	No data	No data	No data	7
20	Baboon	No data	No data	5	No data	No data	No data	No data	No data	5
21	Bushbuck	No data	No data	2	No data	No data	No data	No data	No data	2
22	Ostrich	No data	No data	3	No data	No data	No data	8	No data	11
23	Waterbuck	No data	No data	2	No data	No data	No data	1	No data	3
24	Suni	No data	No data	No data	No data	1	No data	No data	No data	1
25	Topi	No data	No data	No data	No data	0	0	3	No data	3

Plate 42: Impact of Drought on Wildlife

h) 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 (Fig. 24)

Figure 105: Infrastructural threats to wildlife protected areas

KEY MESSAGE

Kenya's wildlife is one of the richest and most diverse globally. Our wildlife and its associated habitats and ecosystems are not just a significant economic asset, but a rich natural heritage as well. Traditionally, wildlife in Kenya has been seen through the lens of tourism. This view conceals the other benefits associated with our wildlife including provision of an array of ecosystem services and products that are at the centre of the livelihoods of Kenyans and the country's sustainable development. Examples of the ecosystem services include watershed protection, provision of clean water, air, sequestration of carbon dioxide, crop pollination, and control of soil erosion. These environmental goods and services support broad range of economic activities across a range of sectors, including agriculture, forestry, livestock, fisheries, energy and industry.

Despite the above benefits, land-use changes, infrastructure development within protected areas, degradation of wildlife habitats, illegal bush meat trade, human-wildlife conflicts and effects of climate change remain key threats and challenges to wildlife conservation in Kenya. Additionally, rapid expansion of crop cultivation and high-density settlements, proliferation of fences, mining and unplanned development contribute to widespread fragmentation of wildlife habitat and loss of migratory corridors and dispersal areas. To reduce and reverse this trend, we recommend the following:

1. Securing through gazzettement all identified and verified wildlife corridors and dispersal areas in Kenya.
2. Government to foster the integration of wildlife corridors and dispersal areas into national and county spatial plans.
3. The national land policy to promote wildlife conservation as a land-use option;
4. KWS and the line ministry to develop an incentive framework for both conservancies and landowners who host wildlife in dispersal and connectivity areas;
5. Support the development and implementation of ecosystem-based management Plans for key wildlife ecosystems

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 (Figure 106). These montane areas has distinct plants characteristics unique to the different habitats from the high altitude Afromontane to the coastal lowlands (Plate 43).

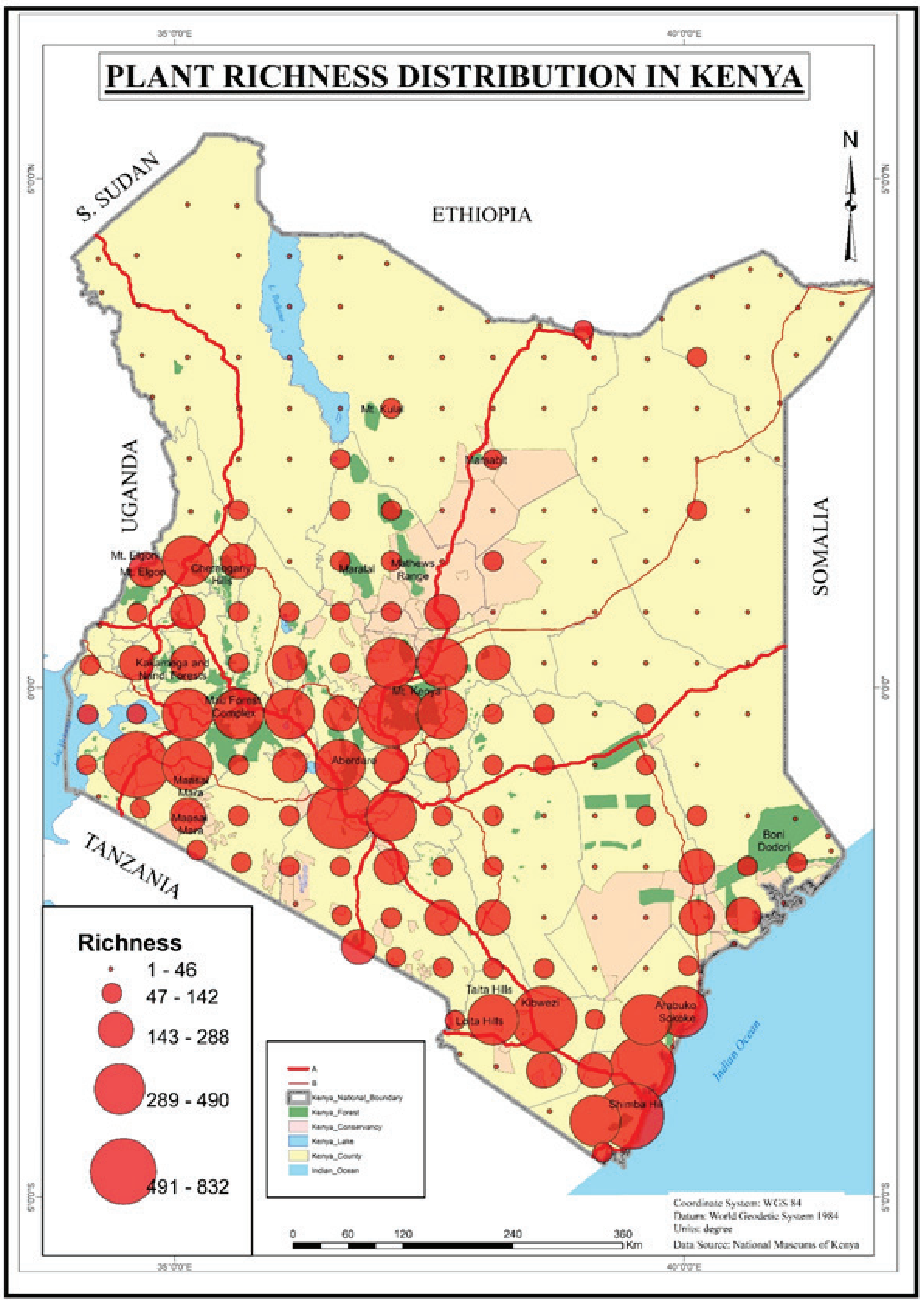
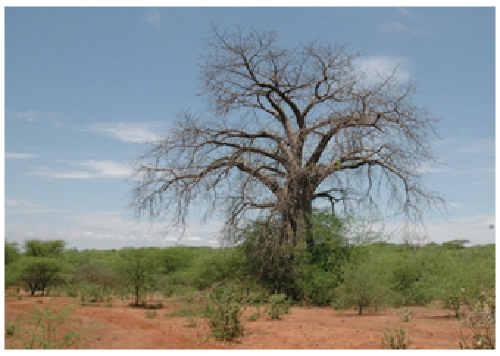


Figure 106: Plant richness distribution in kenya

Afromontane: Lobelia deckenii ssp keniensis



Woodland savanna: Adansonia digitata

Wetlands: Nymphaea nouchali var caerulea

Mongrove: Rhizophora mucronata

Plate 43: Habitat types and associated plant species. Afromontane is unique with Lobelia deckenii ssp keniensis, Woodland savananna is characterized by Adansonia digitata,. The aquatic freshwater is common with Nympahaea nouchali, and in the coastal waters are dominated by mangroves e.g Rhizophor mucronata.

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 (Plate 44).

Aloe secundiflora

Aloe lateritia

Aloe ngongensis

Aloe ballyi

Plate 44: Aloe vera is one of the most important cultivated medicinal plants and, some Aloes are very poisonous, always confirm with an expert on the taxonomy before consumption.

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 (Figure 107). AIPS spread is facilitated by increasing cross-border trades and development projects such as road constructions among others (GISP, 2004). AIPS such as Parthenium, Cuscuta sp.; water hyacinth, and Opuntia are some common AIPS that has spread across the length and breadth of our country (Plate 45).

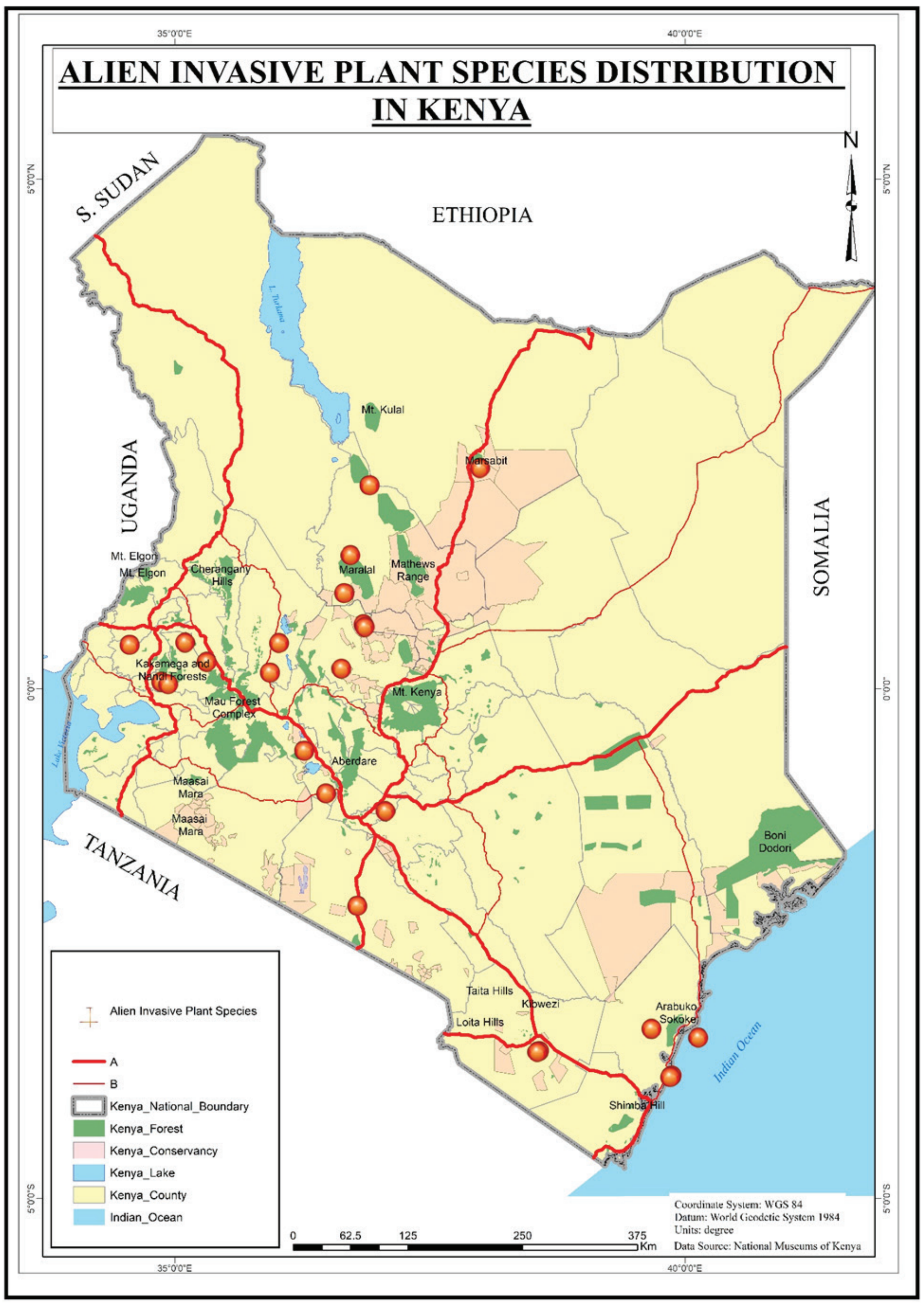


Figure 107: Alien invasive plant species distribution in kenya

Opuntia ficus indica

Parthenium hysterophorus

Cuscuta sp

Eichhornia crassipes

Plate 45: The Alien Invasive Plant Species – Opuntia ficus indica, Parthenium hysterophorus, Cuscuta s., and Eichhornia crassipes

Reptiles and Amphibians

Reptiles and amphibians 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.

Reptile and Amphibians 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 108). 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))(Figure 109). 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

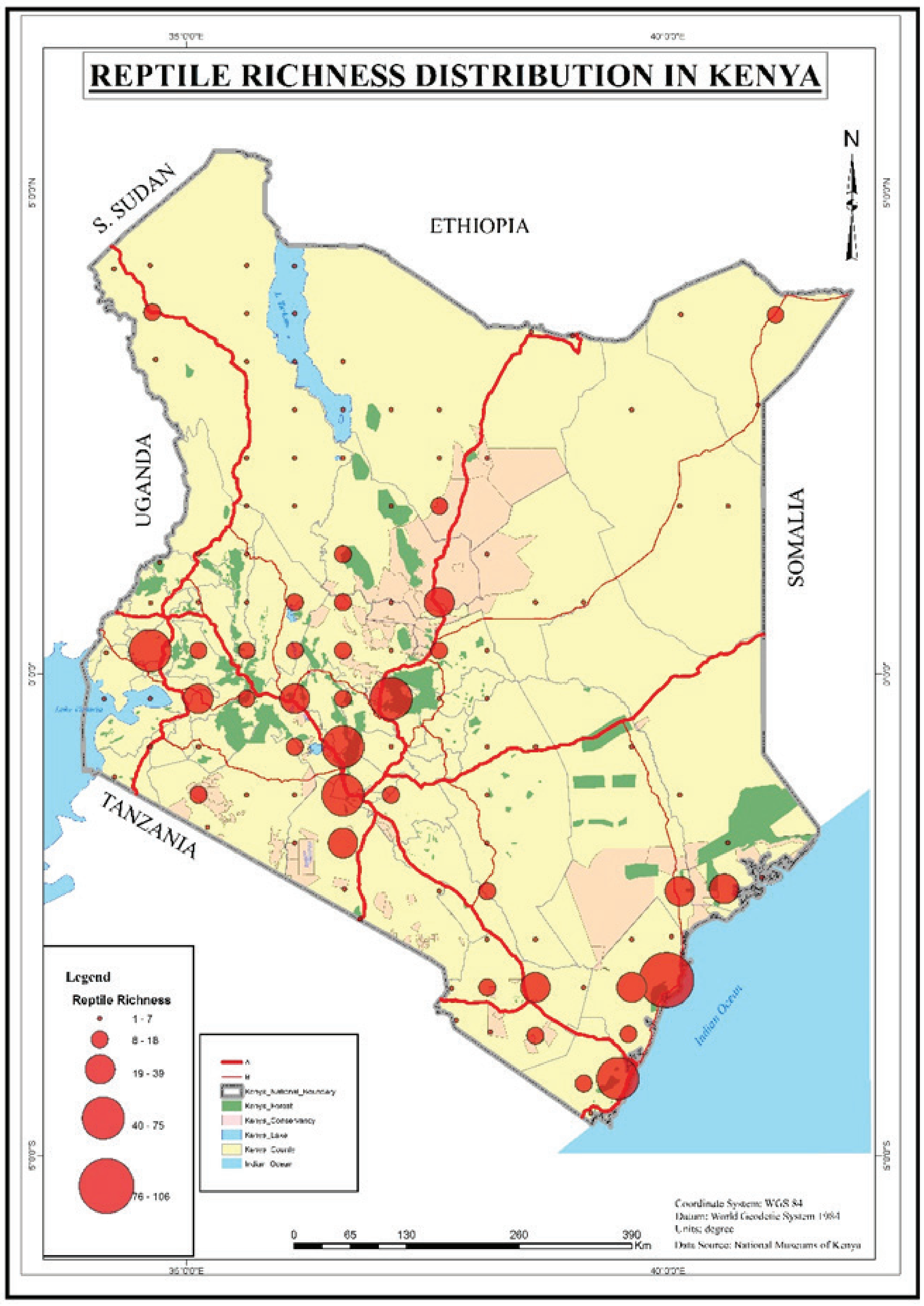


Figure 108: Reptile distribution in kenya

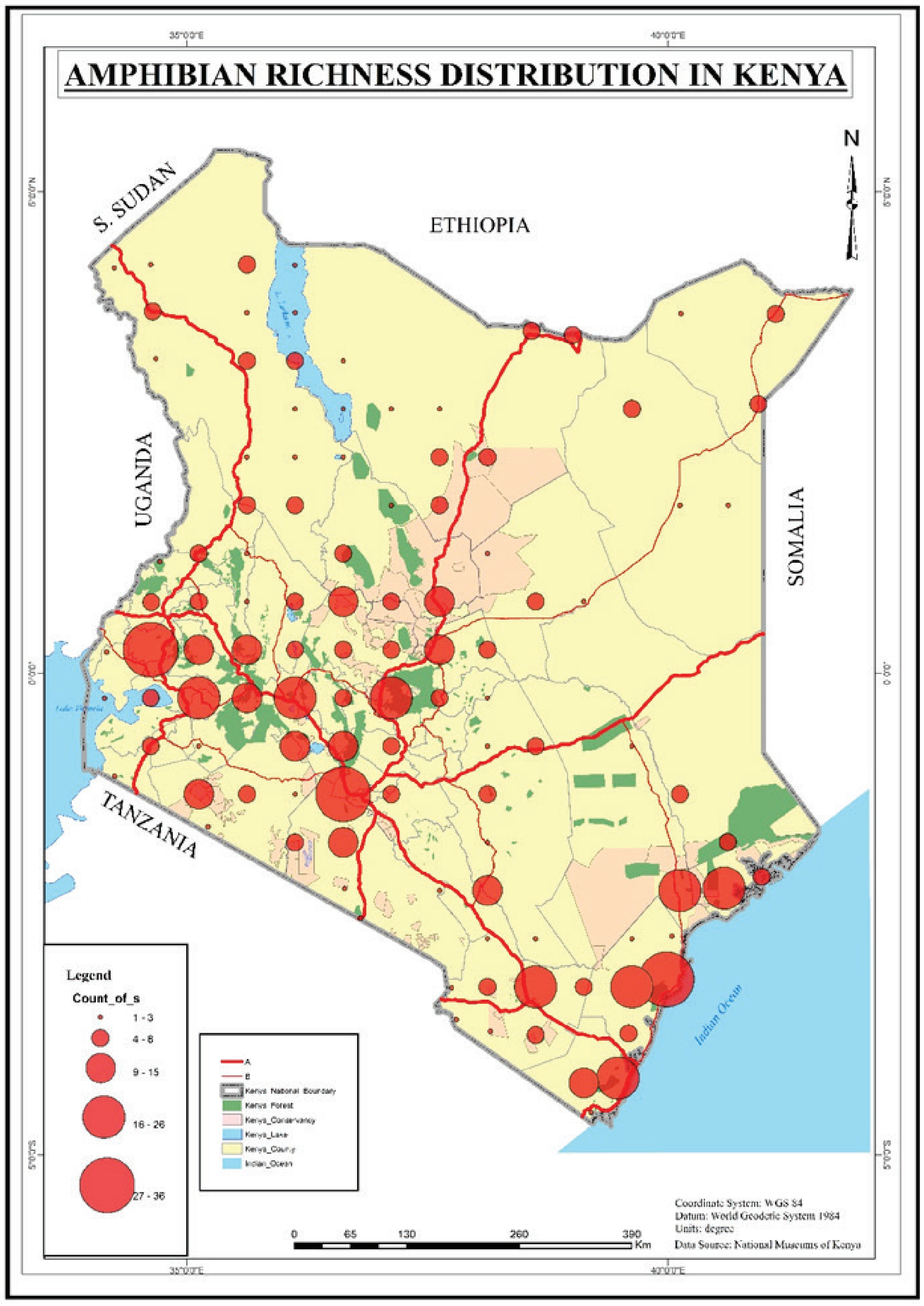


Figure 109: Amphibian richness distribution in kenya

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
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
32. Pelusios broadleyi Lake Turkana Hinged Terrapin

Eastern Forest Cobra (Naja subfulva)

Leopard tortoise (Stigmochelys pardalis)

Plate 46: Reptiles

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
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. 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

Savanna ridged frog (Ptychadena anchietae)

Argus reed frog (Hyperolius argus)

Plate 47: Amphibians

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 110). This might be an under-estimate considering that only small fractions of cases are reported to the hospitals.

Plate 60: Leopard tortoise (Stigmochelys pardalis)

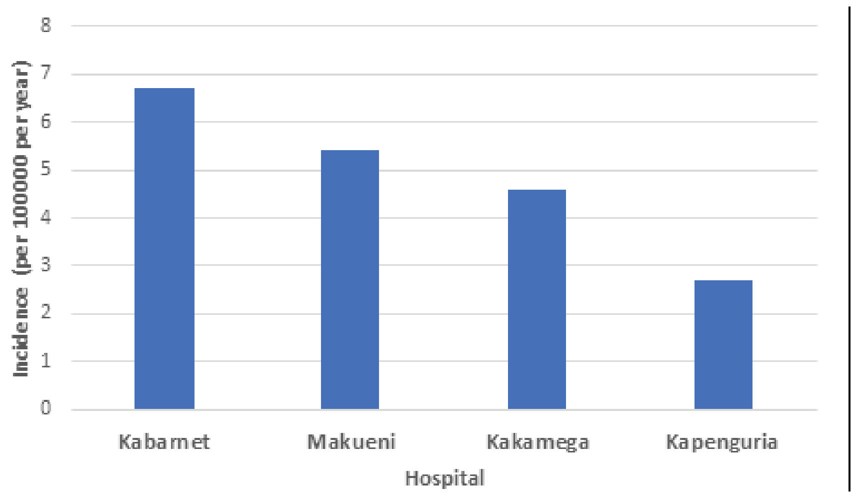


Figure 110: Incidence of snake bites in four hospitals between 2007 – 2009

Conservation Threats

A total of 23 species of reptiles and amphibians are threatened with extinction (Table 54). 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

Table 54: Threatened reptiles and amphibians

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

Invertebrate Species Diversity

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 55.

Table 55: *Distinctive features and examples of major groups 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 56.

Table 56: *Trend of invertebrate species and proportion of conservation threatened species*

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%)

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 57 below.

Table 57: *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

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 111). In these major biomes several invertebrate species are endemic or near-endemic thus calling for conservation of biomes.

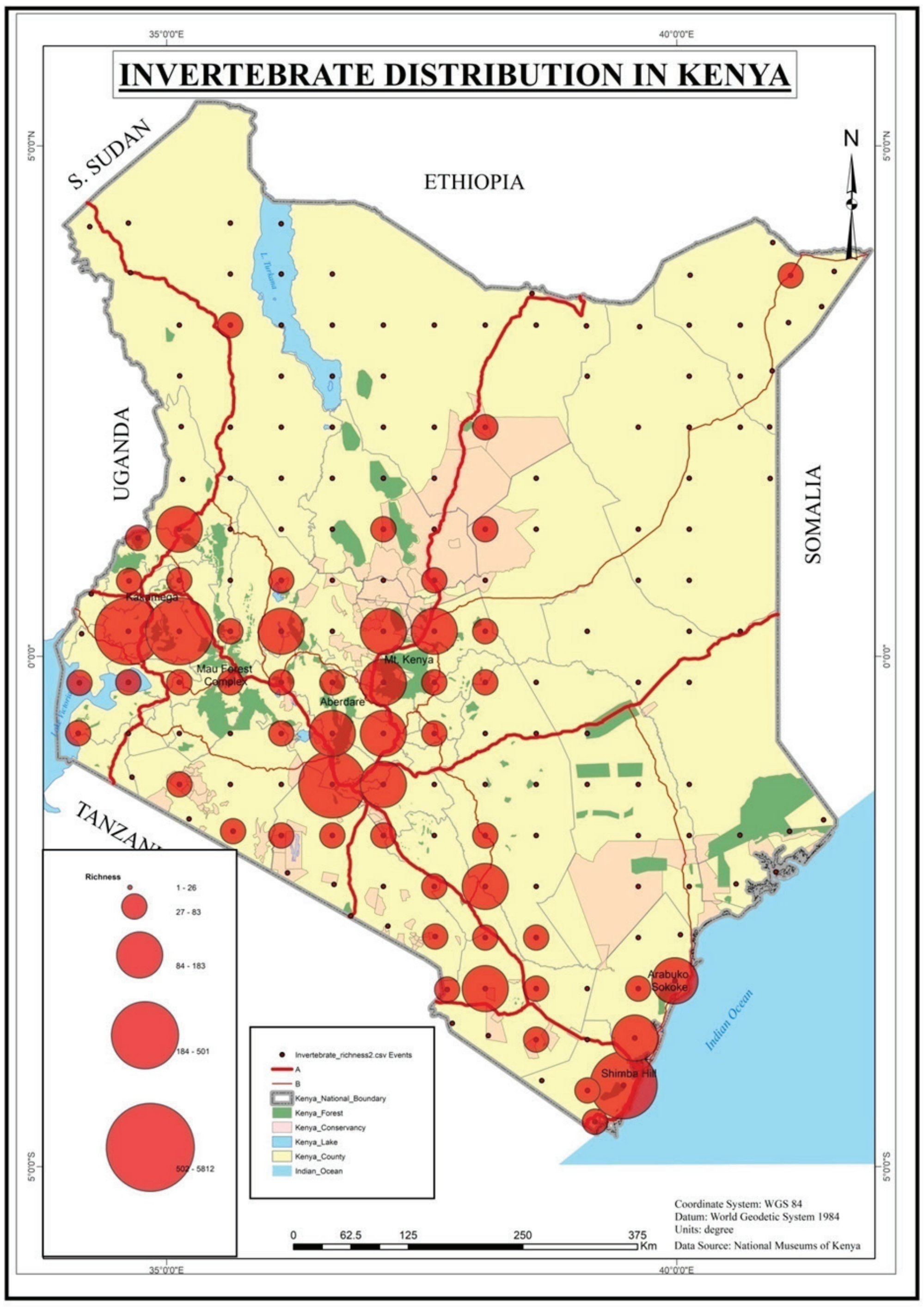


Figure 111: Invertebrate species richness distribution in Kenya.

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).

Termite nest   Dorylus molestus

Plate 48: Role of invertebrates; termites and ants in breaking down organic matters contributing to nutrient cycling - Termite nest, and ant (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 58 and Plate 49.

Table 58: *Bio-indicators of environmental change*

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

Beetle - Eudicella smithi tetraspilota   *Flies: Synagris aestauns*   *Moth: Pelopidas mathias*

Plate 49: Example of key insect groups - Eudicella smithi tetraspilota, Synagris aestauns, Pelopidas mathias

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

Neomyia green housefly   *Coeliades forestan*   *Apis mellifera*

Plate 50: Examples of insect pollinators - Neomyia green housefly, Coeliades forestan, and Apis mellifera

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 orchards. Angoumois moth, warehouse moth, flour moth (Lepidoptera), silverfish (Zygentoma) and grain weevil, drugstore beetle, and granary weevil (Coleoptera) are pests of store products(Plate 51).

Mylabris aperta taborensis   *Papilo demodocus larvae*   *Lixus rhomboidalis*

Plate 51: Example of pests of crops, trees and stored products - Mylabris aperta taborensis, Papilo demodocus larvae, Lixus rhomboidalis

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), 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).

Anoplocnemis signata   *Lidalia intermedia*   *Dalsira costalis*

Plate 52: Examples of bio-control agents for pests (natural enemies) - Anoplocnemis signata, Lidalia intermedia, and Dalsira costalis

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. 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.

Coccid scale insects   *Giant red velvet mite*   *Cochineal scale insects on cactus*

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 59).

Table 59: *Some vectors and the medical disease they transmit*

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

Source: WHO, 2017.

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) (Table 60). 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).

Table 60: *Commonly consumed insects 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 (Plate 53)

Source: Munke-Svendsen et al., 2016

Plate 53: A family enjoying Ugali and fried Cirina forda larvae (maungu)

i) Invertebrates for ecotourism attraction

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 (Plate 54). 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.

Junonia natalica *Echinometra sp* *Papilio dardanus*

Plate 54: Example of invertebrates for ecotourism attraction - Junonia natalica, Echinometra sp., Papilio dardanus

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 (Plate 55). The outcome is reduction of vegetation cover which acts as floral resources for pollinators and food for many invertebrates. Habitat degradation as a result of pollution and other anthropogenic effects in ecosystems, like overgrazing and grassland burning.
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.

Plate 55: Human activities affecting habitats and species – overgrazing and burning of bushes/grassland

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(Figure 112). 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 113) 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 (Plate 56). 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.

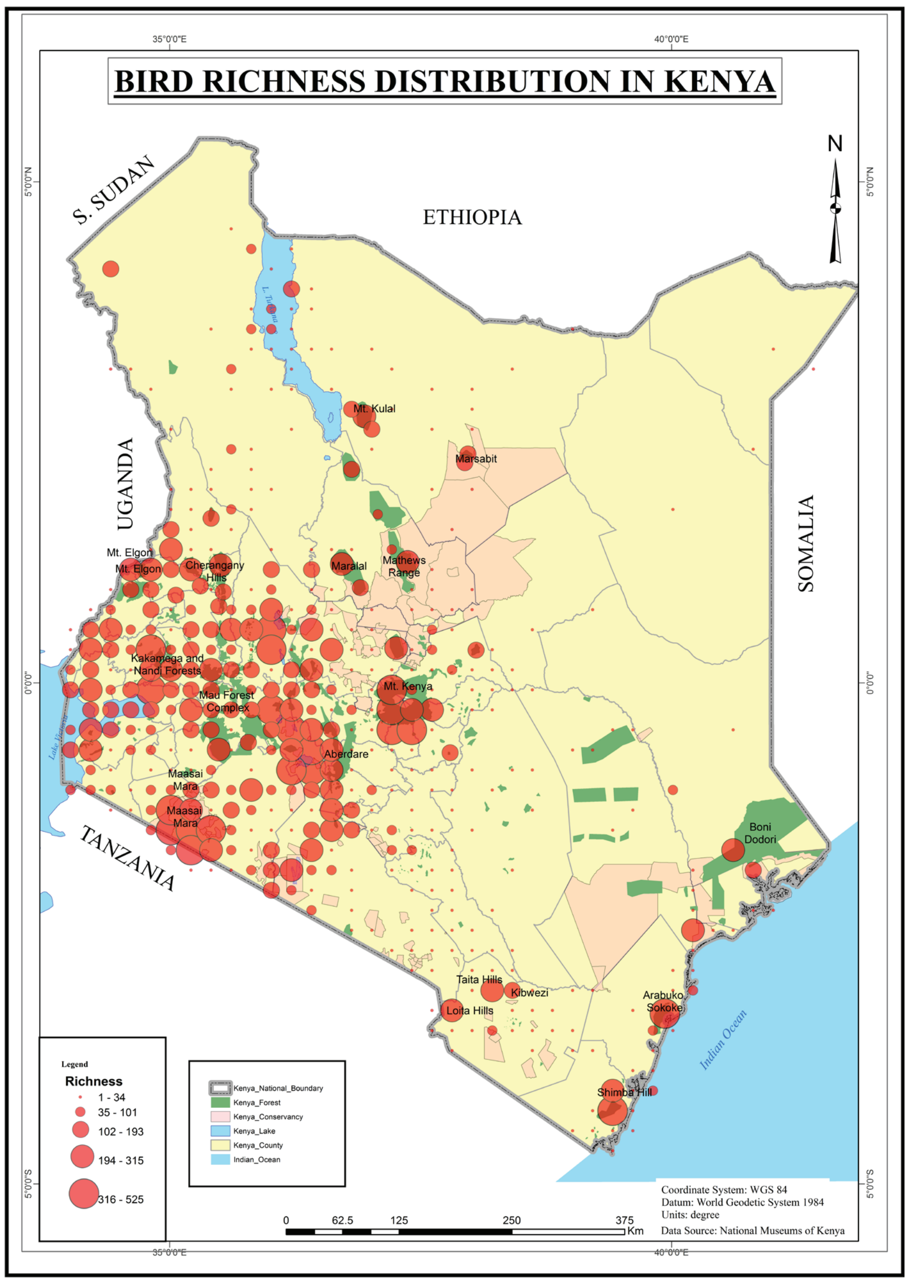


Figure 112: Map showing species richness in Kenya

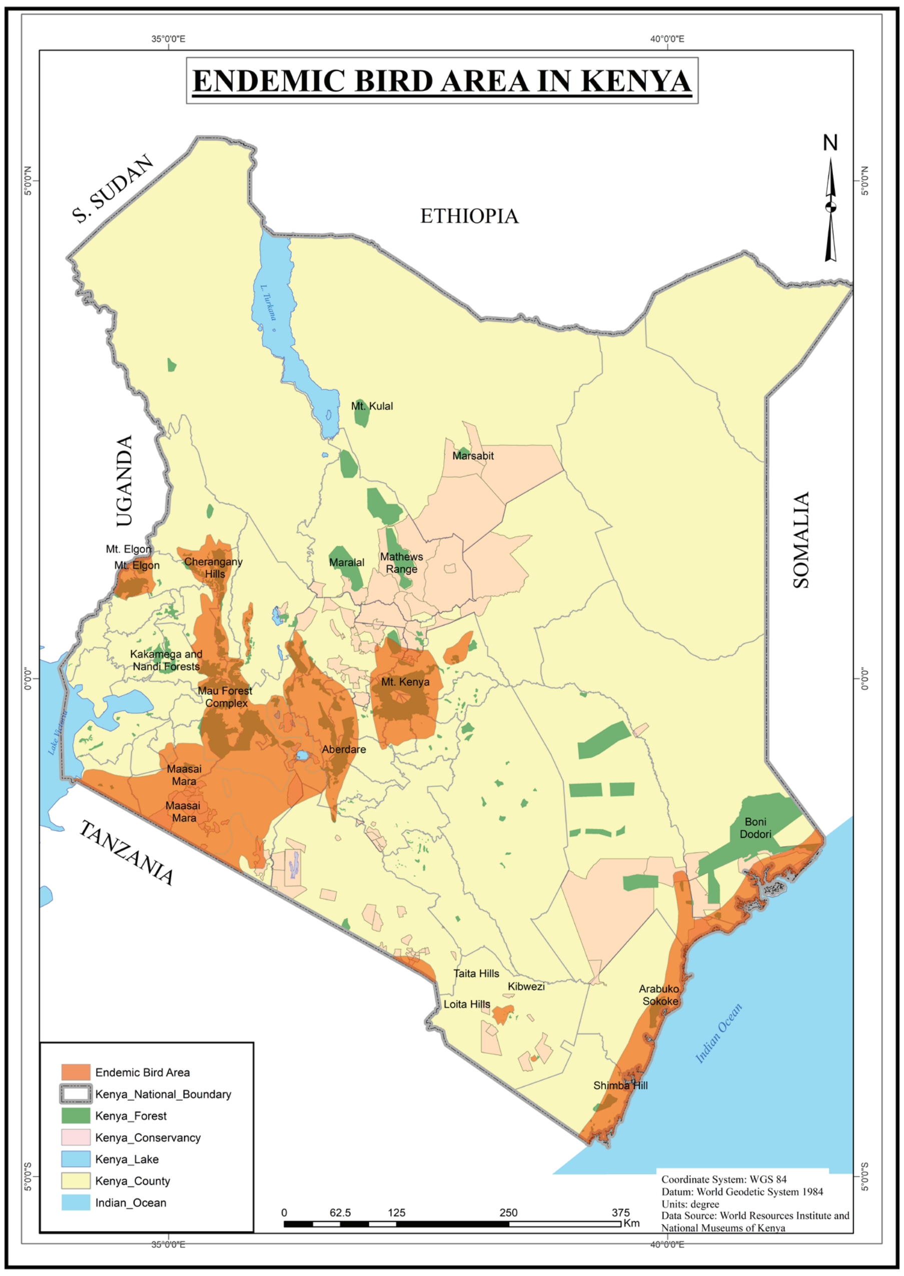


Figure 113: Endemic Bird Areas

Important Bird Areas (IBAs)

Kenya's 63 Important Bird Areas (IBAs) cover a total of 5.7 million hectares or about 10% of the land area with sites varying in size from 1 hectare to 1 million hectares. These areas comprise diverse habitat types from wetlands to dry areas of the country. IBAs are identified using a set of standardized, globally applicable categories and criteria, covering different aspects of Vulnerability (globally threatened species) and Irreplaceability (restricted-range, biome-restricted and congregatory species). IBAs are also important for other taxonomic groups. For example, in East Africa, a network of 228 IBAs in Ethiopia, Kenya, Tanzania and Uganda captures 90–97% of the total species diversity of endemic mammals, snakes and amphibians found in this region. IBAs contribute to the global persistence of biodiversity, including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems. 33% of IBAs lack any form of formal protection and a further 45% are only partially protected. Achieving adequate protection for these sites is among the most urgent of global conservation priorities

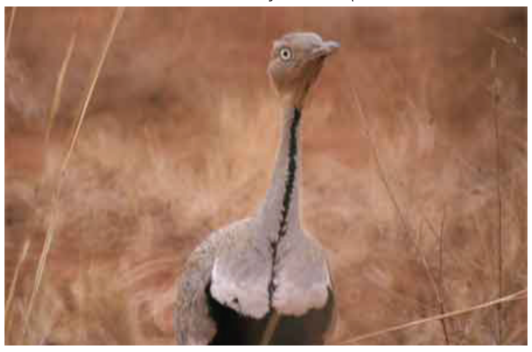
The IUCN red list shows a steady and continuing deterioration in the status of the world's birds since the first comprehensive assessment in 1988. Species experience varying levels of threats which predispose them to gradual decline with some threatened to extinction. Others, Endemic Species, have restricted range of movement making them vulnerable to habitat destruction. Due to these, the species are categorized differently by IUCN red list of threatened species as Critically Endangered, Vulnerable (VU), Near Threatened (NT), Data Deficient (DD), or Extinct (EX). in Kenya, about 2 bird species are Critically Endangered and Endemic, Endangered and Endemic are 3, Endangered species 6, Vulnerable and Endemic 1, Vulnerable 14, Endemic species 2, and Near Endemic species are 44 (Table 61). Appropriate interventions have been recommended for each threat category. These include Bird species and habitat monitoring programs e.g. Annual Waterfowl Census, IBA monitoring of species, Community participation, bird friendly livelihood initiatives and gender mainstreaming in related activities.

Table 61: *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

Jackson's Francolin Pternistis jacksoni (LC

Sokoke scops owl, Otus ireneae (EN)



Black-bellied Bustard Lissotis melanogaster (LC)

Sharpes Longclaw Macronyx sharpei (EN)

Plate 56: Examples of bird species

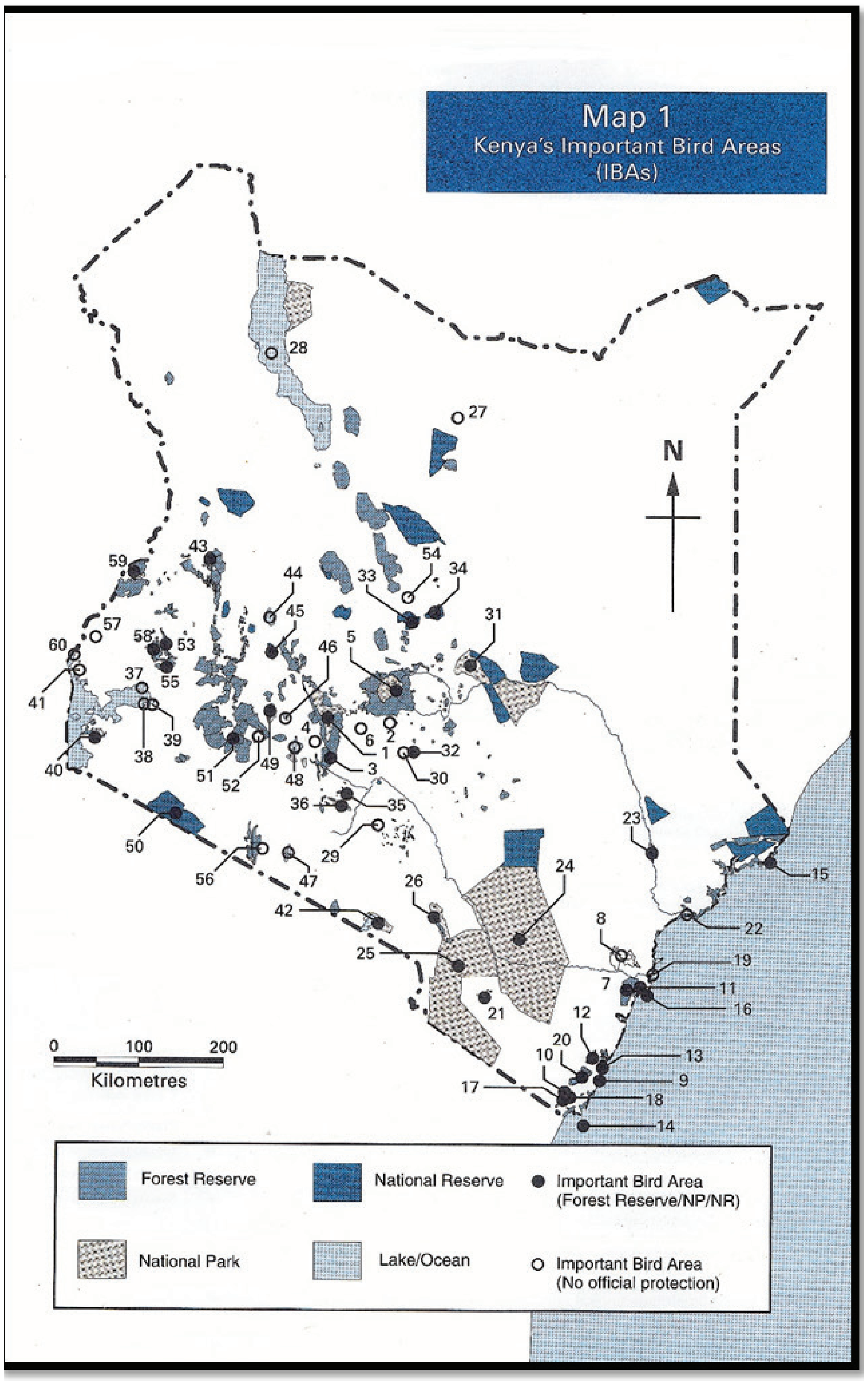


Figure 114: Important Bird Areas (IBAs) in Kenya

Table 62: *Key to IBA sites to IBA map*

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

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 57: 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.

Water Hyacinth in Lake Naivasha.

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

Agricultural activities in the Taita Hills Forest.

Plate 58: Threats to conservation of IBAs

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(Plate 59).

Plate 59: Examples of small mammals

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.

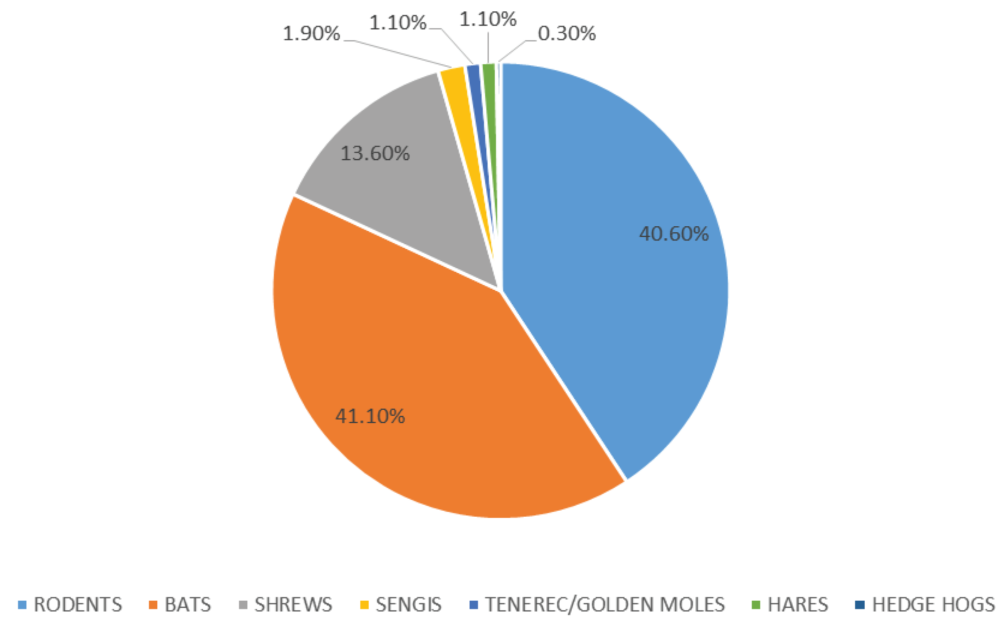


Figure 115: Small mammals species composition within each order in Kenya

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.

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.

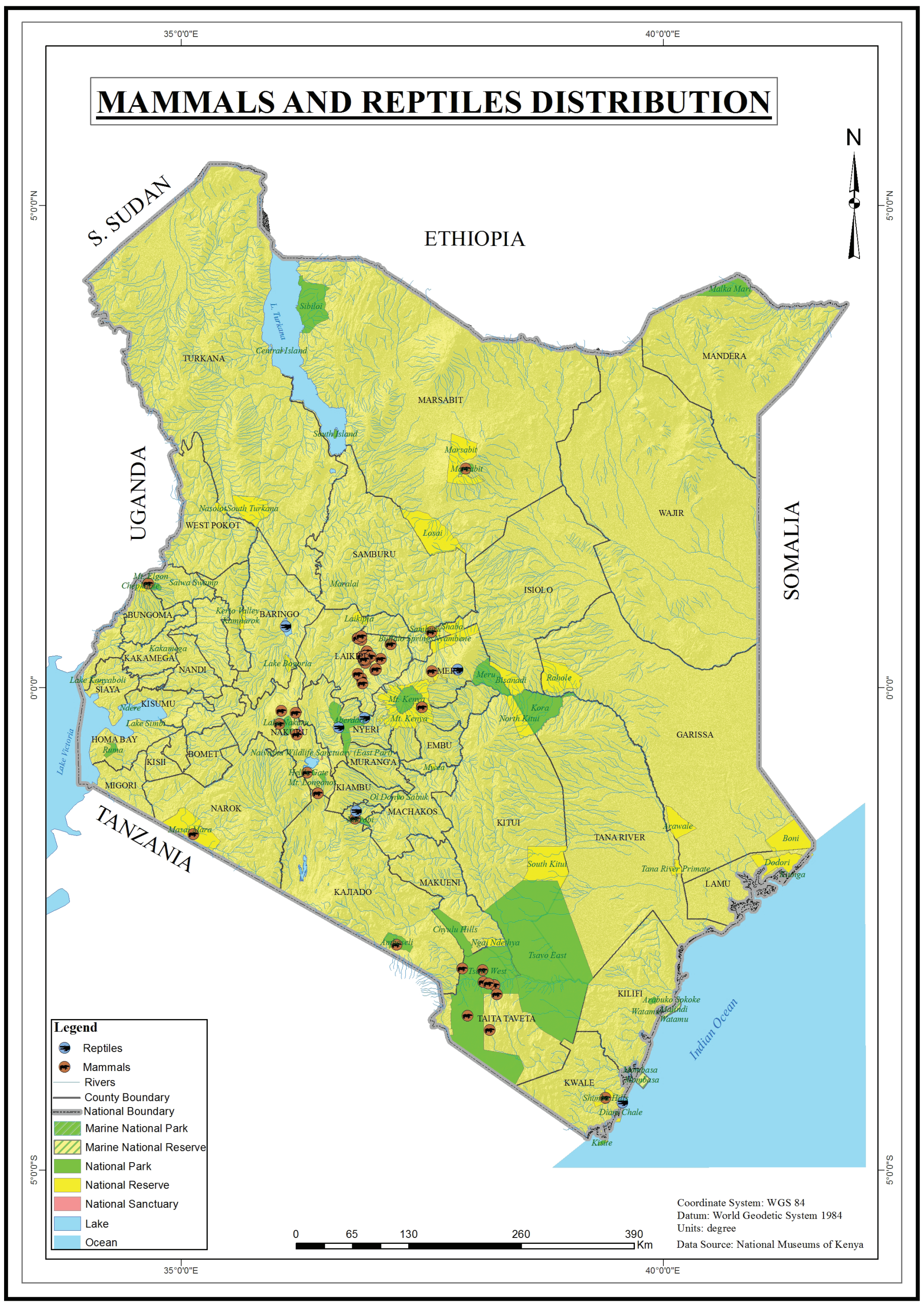


Figure 116: Mammals richness distribution in Kenya

Generally, Wet Savanna and forest ecosystems host more species of small mammals than other ecosystems in Kenya (table 63). However it is important to note that species poor ecosystems host endemic species and therefore need equal conservation effort and commitment.

Table 63: *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

KEY MESSAGE

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 AND LEGAL 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 64.

Table 67: *Main policies relevant to crop and livestock production in Kenya*

Policy/ Strategy/ Act	Description
The Constitution of Kenya 2010	The Constitution underpins all public policies and legislation in Kenya and agriculture is one of the devolved functions under the Fourth Schedule.
Kenya Vision 2030	The national economic policy for all sectors, including agriculture and the environment. It identifies agriculture as the driver of growth through transformation of smallholder and subsistence agriculture to innovatively and commercially-oriented agriculture.
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
Draft National Agricultural Soil Management Policy 2020	It proposes a wide range of measures and actions responding to key agricultural soil issues and challenges. It provides a framework for an integrated approach to sustainable management of agricultural soils in the country.
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 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.
Crop Production And Livestock Act 2012	The Act makes provision for the control and improvement of crop production and livestock, and the marketing and processing.
Agriculture and Food Authority Act (AFA) Act 2013	The Act consolidates the laws on regulation and promotion of agriculture and makes provision for the respective roles of national and county governments.

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 73). 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,

Plate 73: Soil as a medium for growing our crops. Photo credit: KALRO

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 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.

Major Soil Types

Kenya is generously endowed with soil resources, which vary with age, as well as climatic, biotic, topographic and geologic conditions (figure 117). 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 65). 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 1 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.

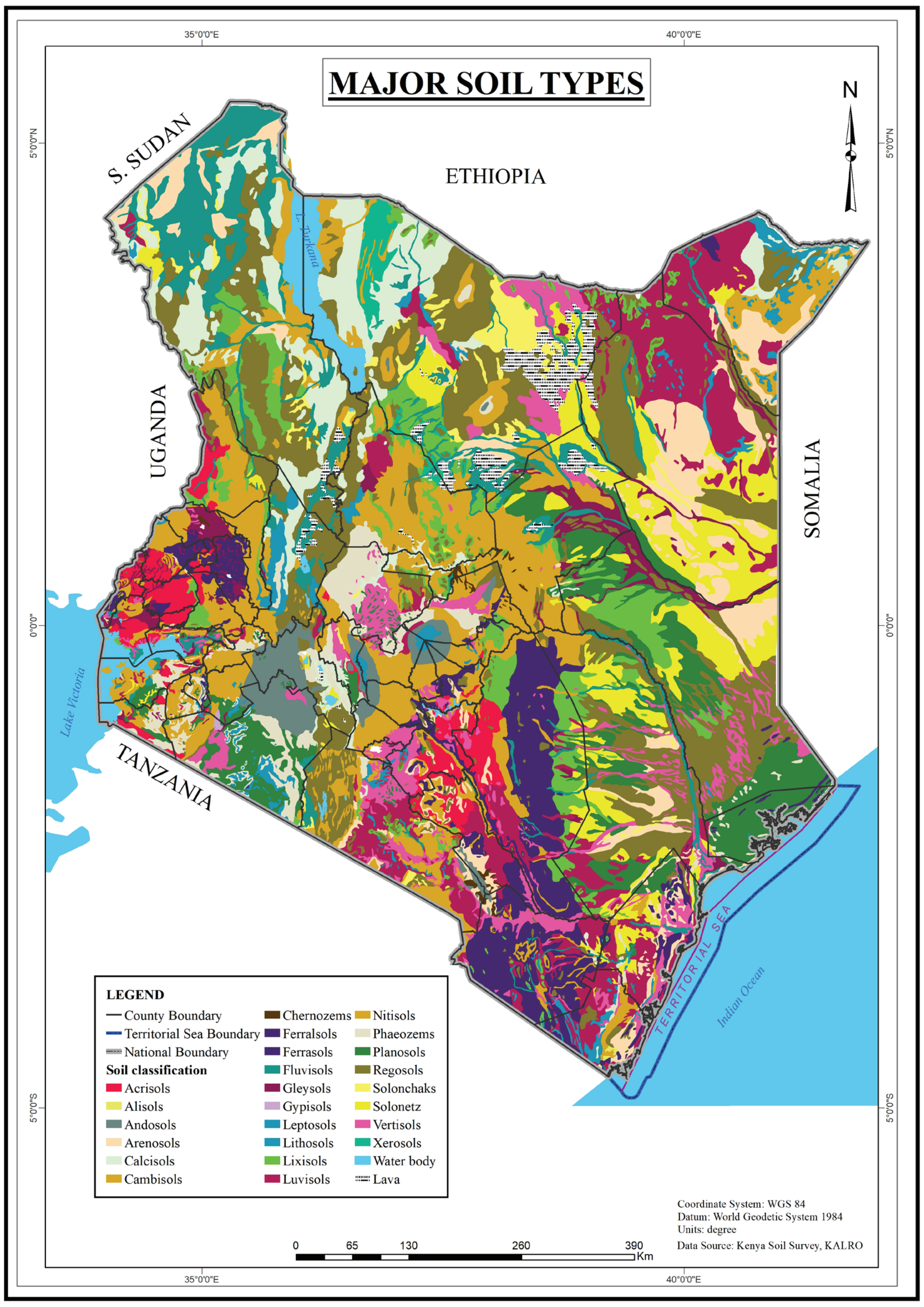


Figure 117: Distribution of the major soil types across Kenya. The different colours indicate variations in the chemical, physical, and biological characteristics of the soils.

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 118,119,120 & 121 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 64: *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.	

Source: IUSS Working Group WRB (2015)

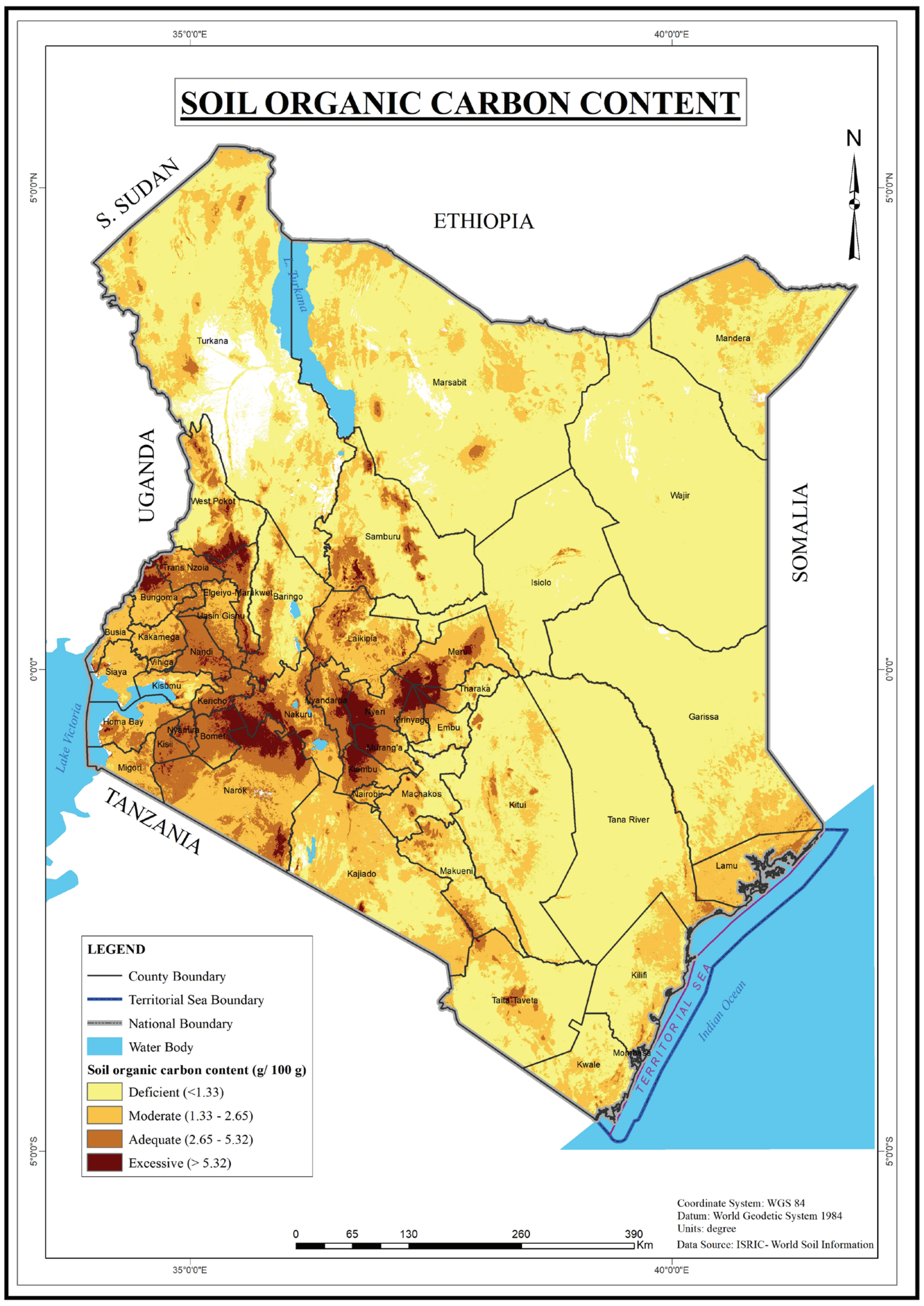


Figure 118: Map of soil organic carbon content in Kenya

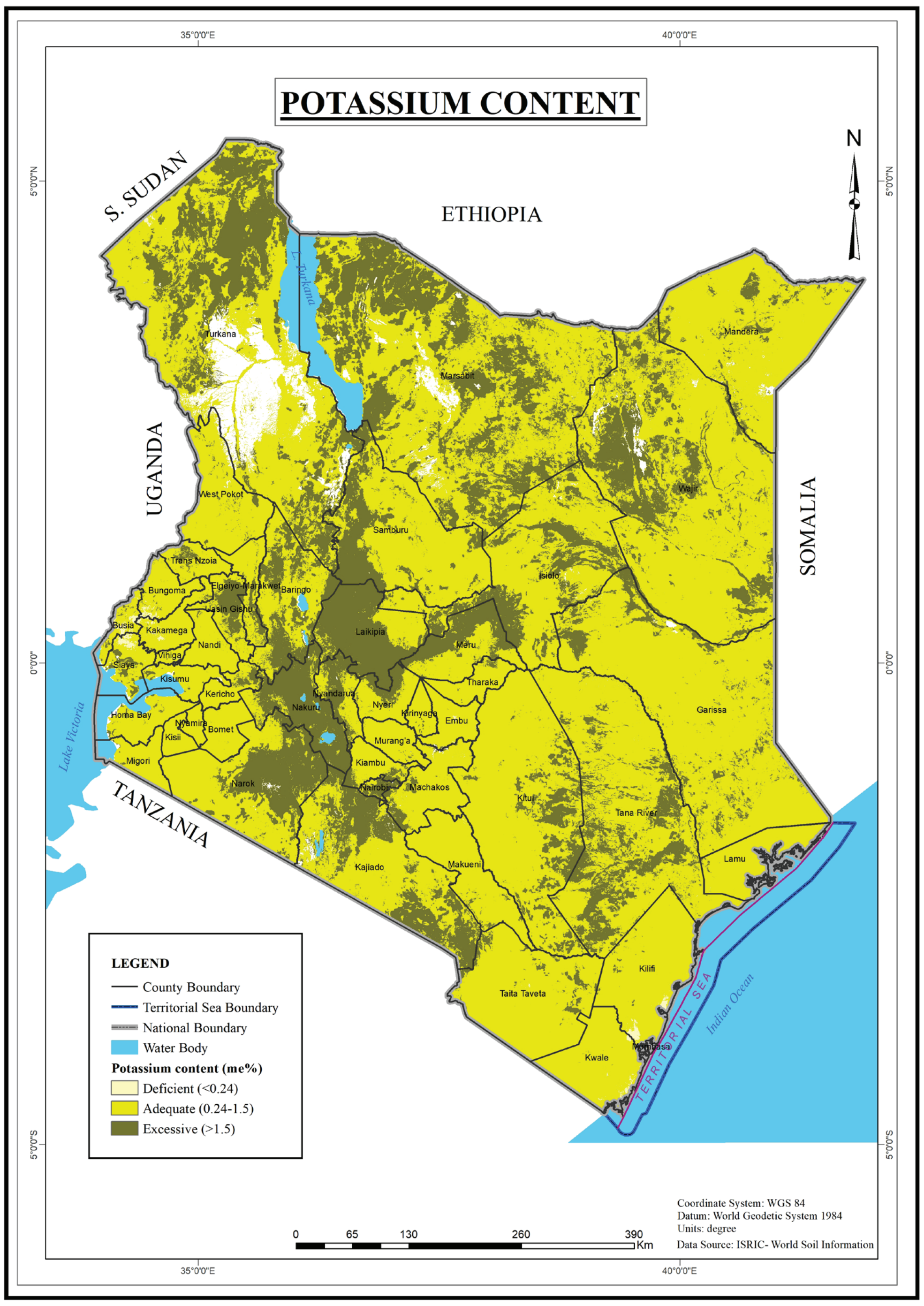


Figure 119: Map of Kenya potassium content

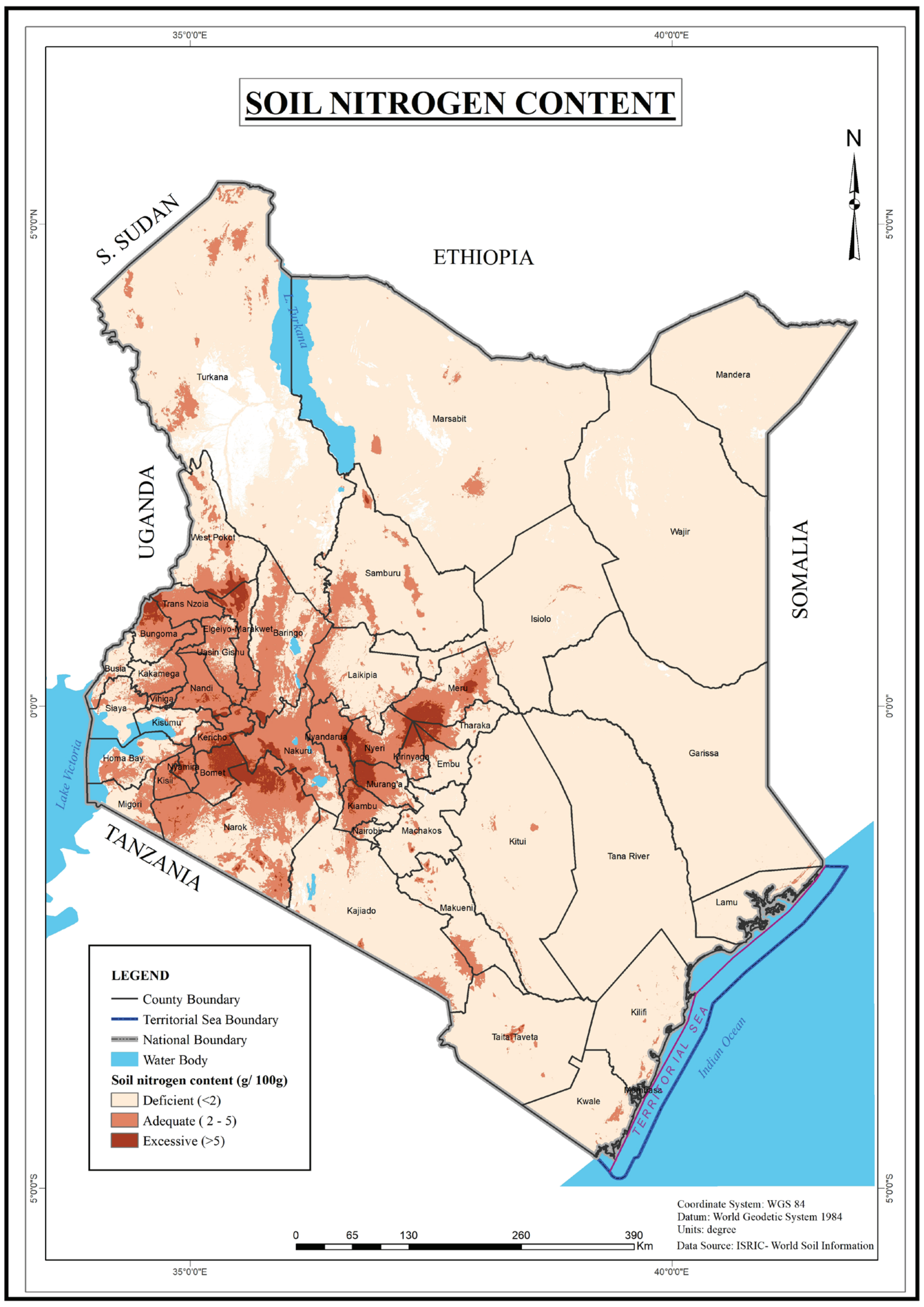


Figure 120: Map of soil nitrogen content in Kenya

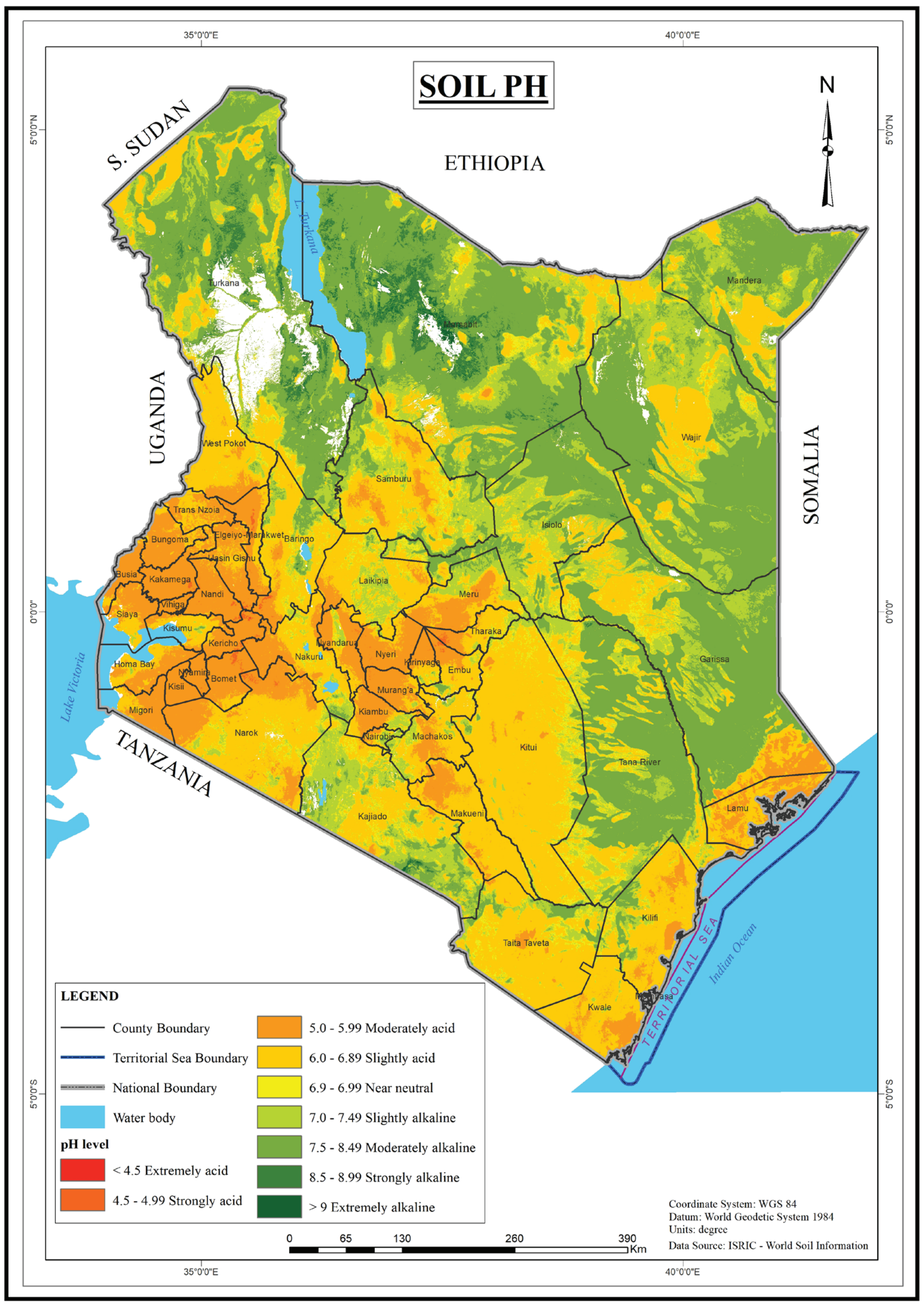


Figure 121: Map of Kenya soil pH

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 123).

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 65; Figure 122). 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 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 65).

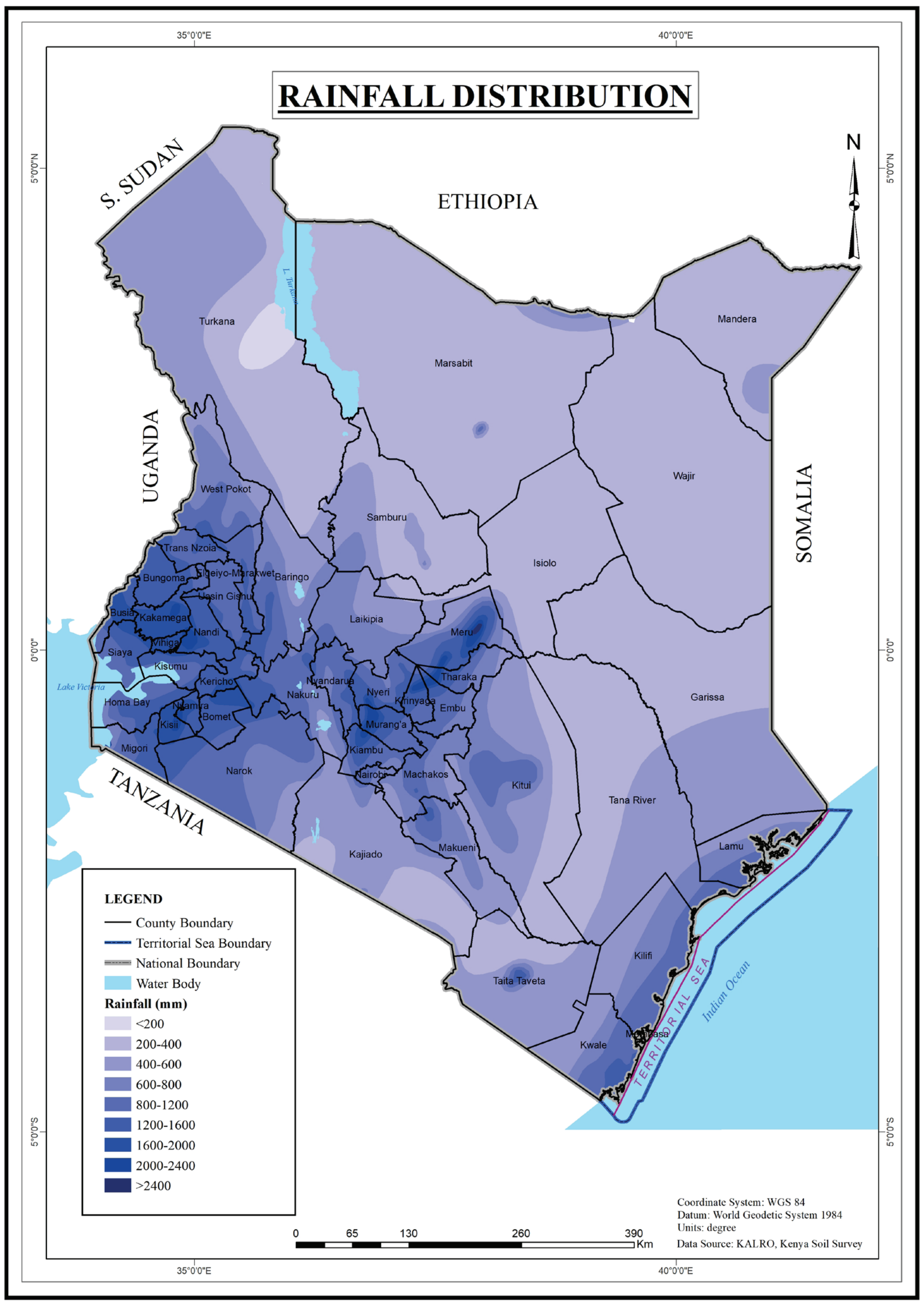


Figure 122: Rainfall distribution in Kenya

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.

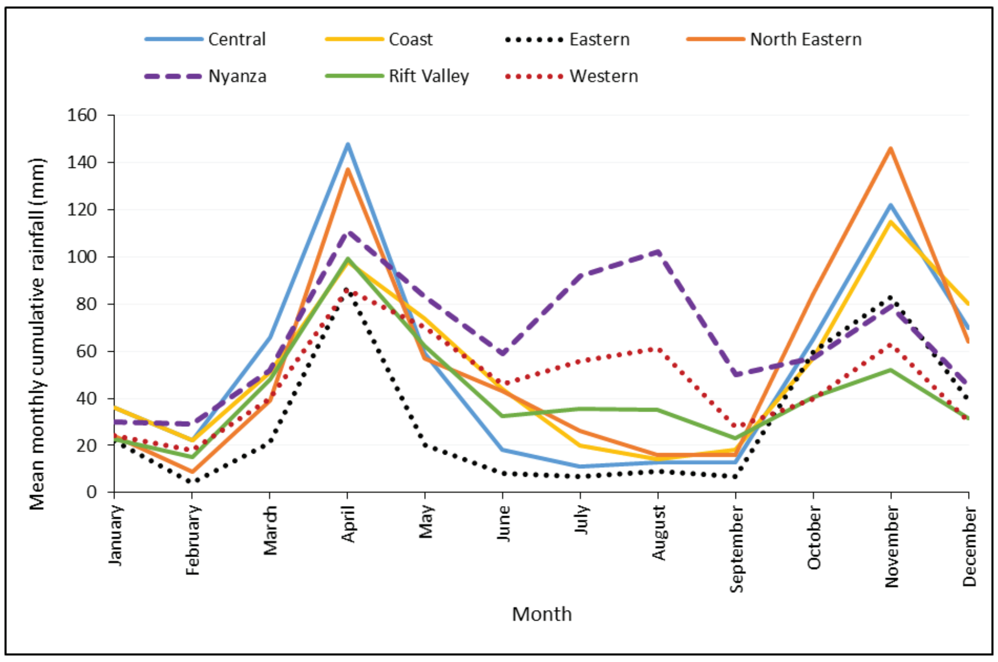


Figure 123: Monthly rainfall pattern by region. Source: D'Alessandro et al. (2015)

Agro-Climatic Zones

The Agro-Climatic Zones (ACZs) map (Figure 125) 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

Plate 74: Sorghum production under rain-fed conditions. Photo credit: KALRO

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 65: *Moisture availability zones*

Zone	Climatic designa-tion	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, maize, Irish potatoes, vegetables, and dairy production (intensive and semi-intensive)	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	Cassava, maize, sugarcane, cotton, sunflower, ground nuts and cashew nuts, dairy production (extensive grazing), and agro-pastoralism	5
V	Semi-arid	450-900	1,650-2,300	25-40	Medium to low	Sorghum, millet, agro-pastoralism and ranching	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	Pastoralism	46

Source: Sombroek et al. (1982)

Table 66: *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)

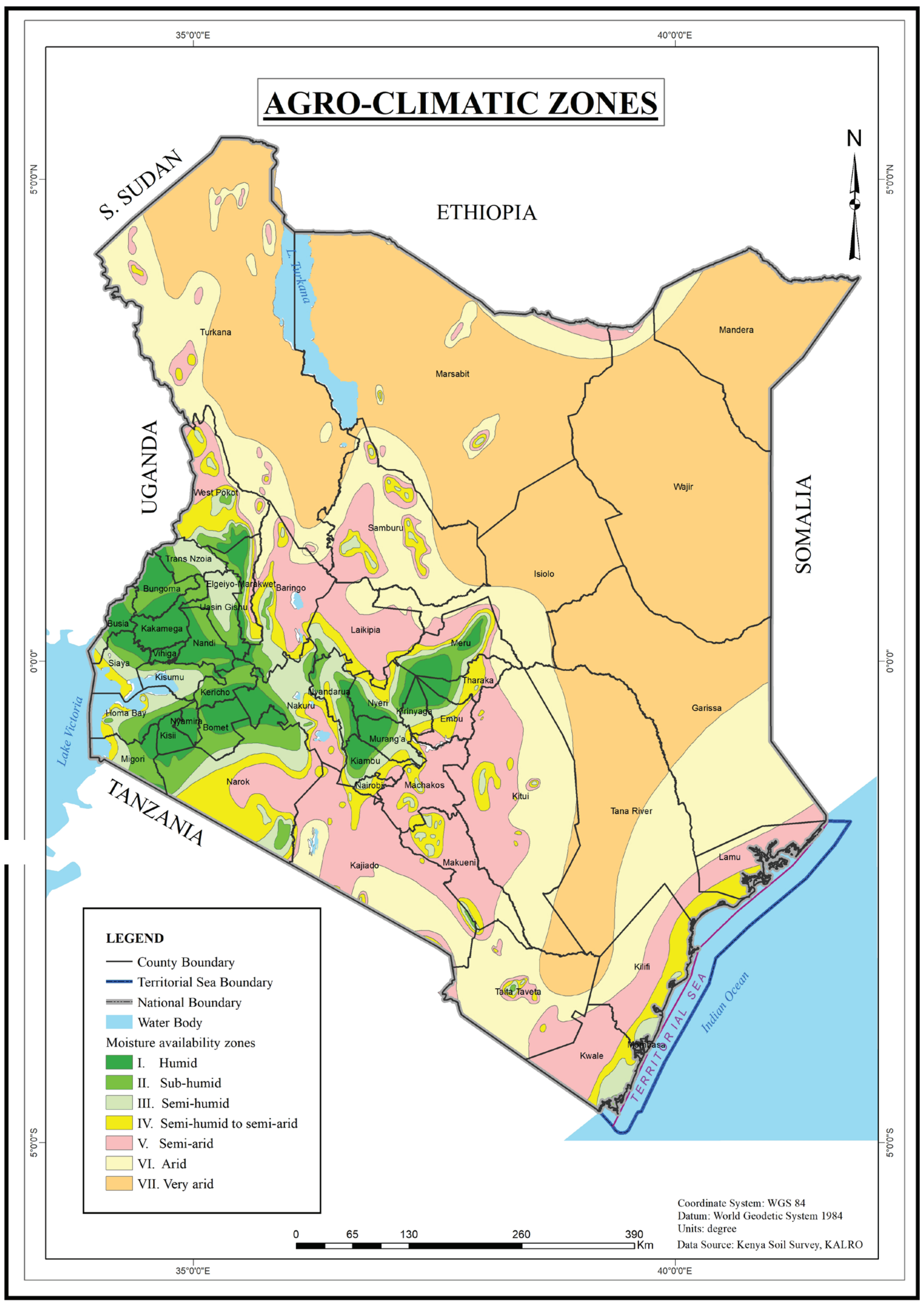


Figure 124: Agro-climatic zones in Kenya

Topographic Resources

1Like 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 125). 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.

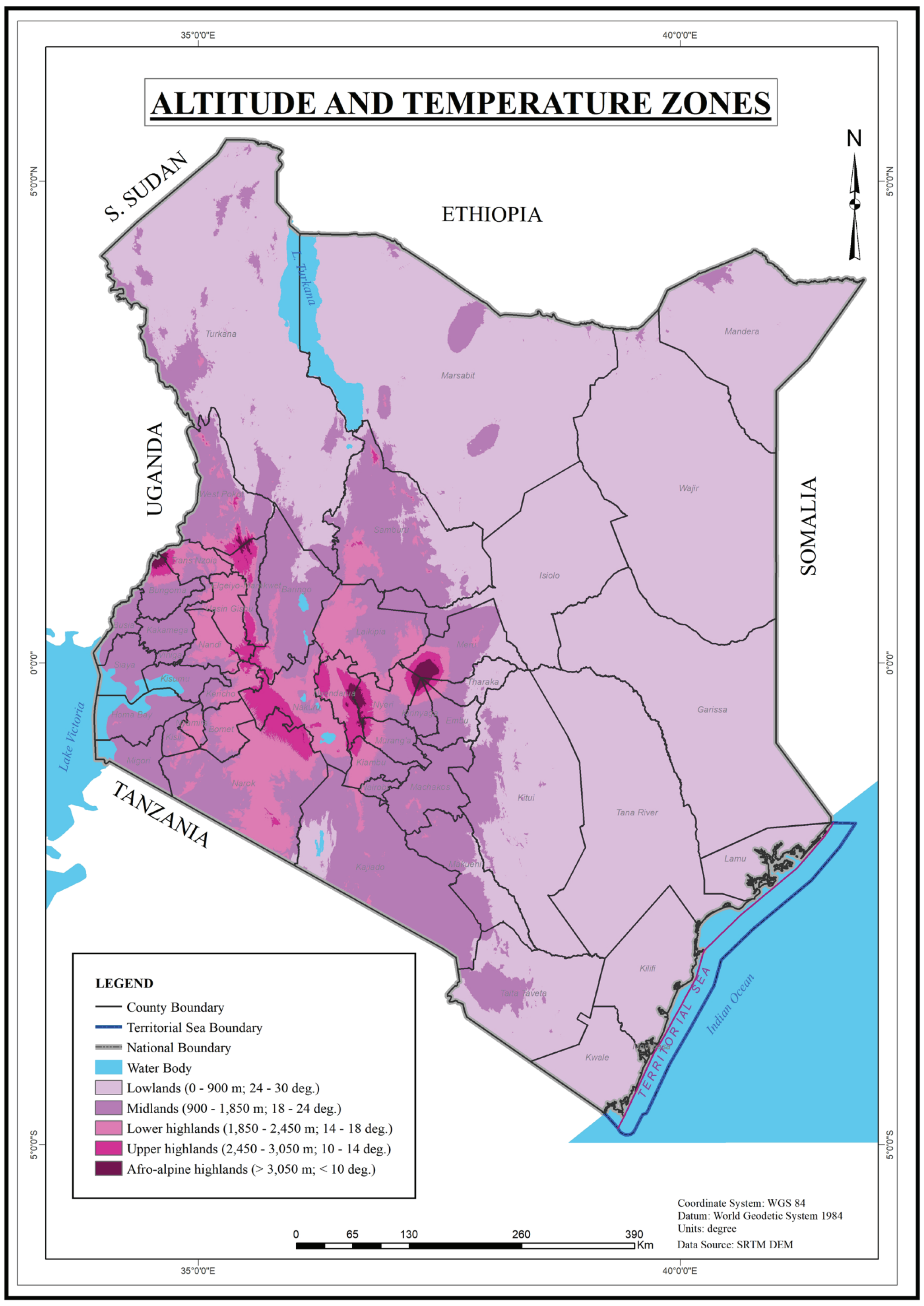


Figure 125: Altitude and temperature zones in Kenya

Crop Production

In Kenya, crops are produced under rain-fed and irrigated systems (Plate 74, 75 and 76), 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), (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 126 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).

Plate 75: Sorghum crop growing in a farmer's field. Photo credit: KALRO

Plate 76: Maize production under irrigated conditions. Photo credit: National Irrigation Authority

Plate 77: Vegetable production on vertical gardens for healthy and organic lifestyles in the urban areas. Photo credit: KALRO

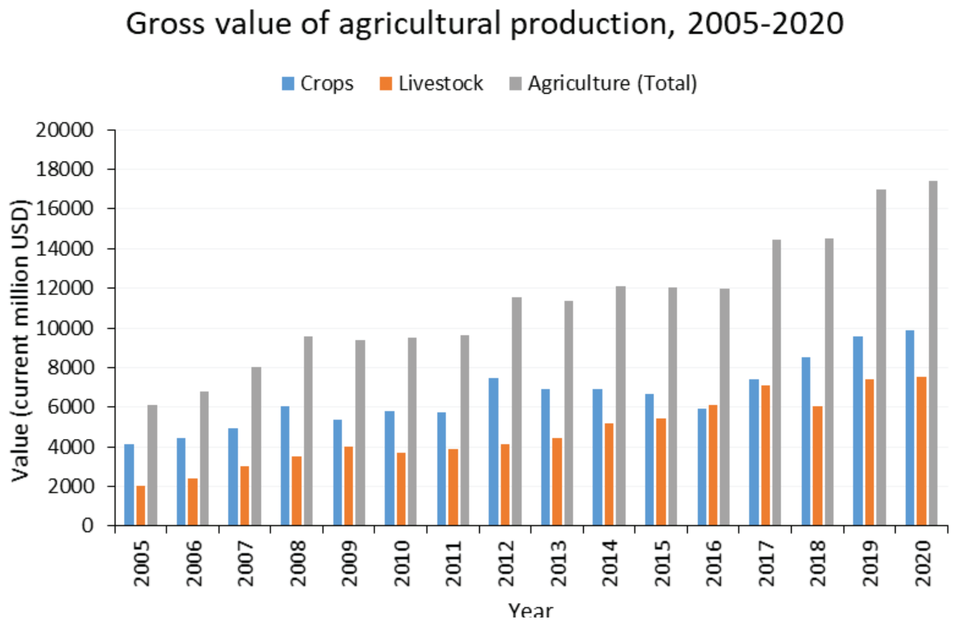


Figure 126: Gross value of agricultural production, 2005-2020. Source: FAOSTAT

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 68) 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 127 to 131).

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 68: *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 2-10º C	Glacier; Mountain swamps	Cattle-Sheep Zone			Sheep Zone		* High altitude deserts	
UH Upper Highland Zones Ann. mean 10-15º 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 º C Mean min. 8-11º C Normally no frosts	Forest Zones	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 18-21º C Mean min. 11-14º C	Forest Zones	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 21-24º C Mean max. > 14º C	Forest Zones	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 > 24º C Mean min. > 31º C	Forest Zones	* Rice-Taro Zone	* Rice-Sugarcane Zone	* Cotton Zone	* Sorghum - Groundnut Zone	Livestock-Millet Zone	Ranching Zone	Nomadism Zone
CL Coastal Lowland Zones Ann. mean > 24º C Mean min. < 31º C	Forest Zones	* 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

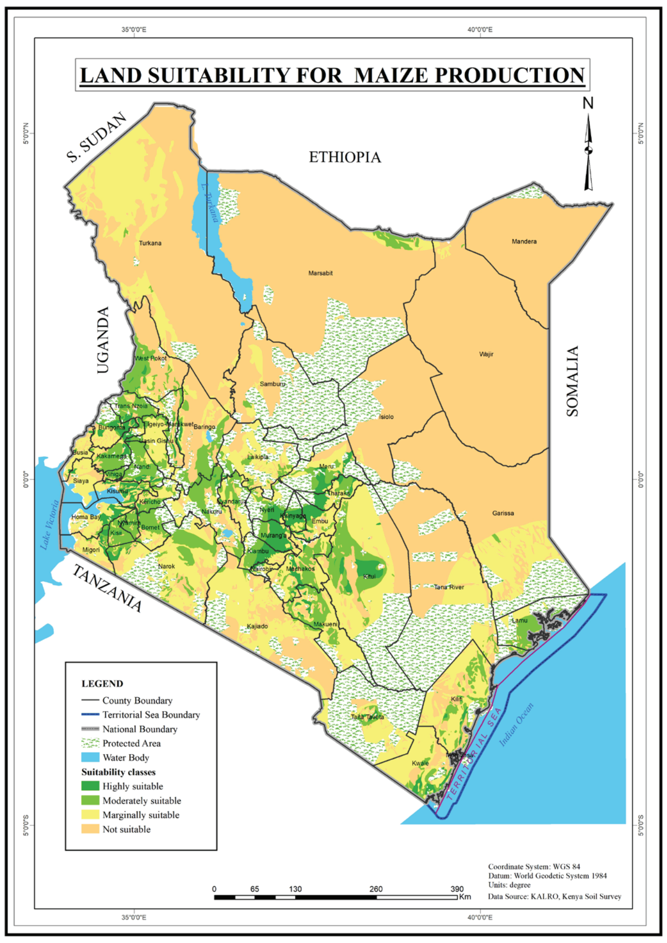


Figure 129: Land suitability for maize production

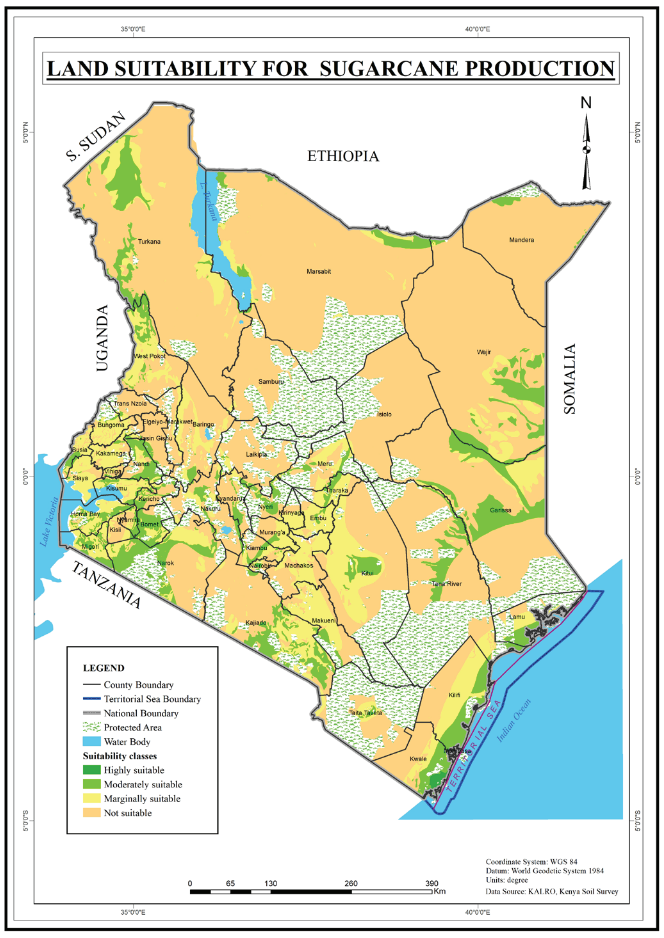


Figure 128: Land suitability for sugarcane production

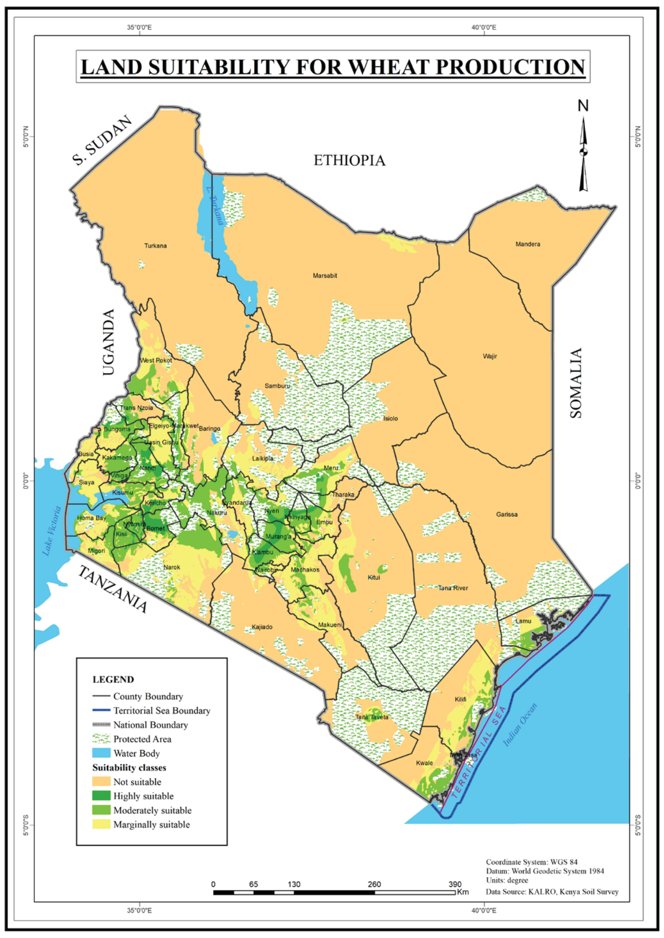


Figure 127: Land suitability for wheat production

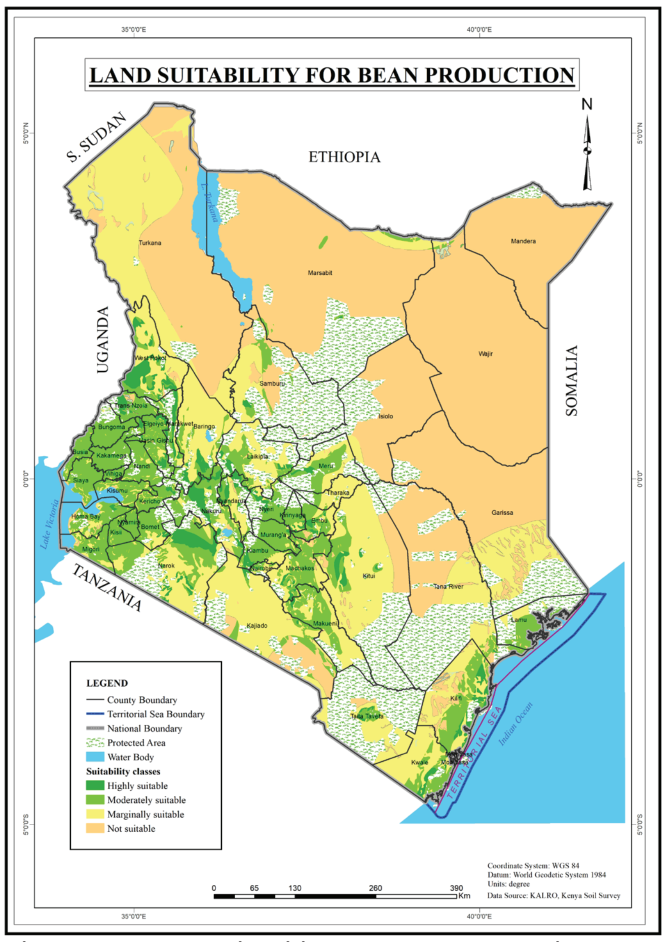


Figure 130: Land suitability for beans production

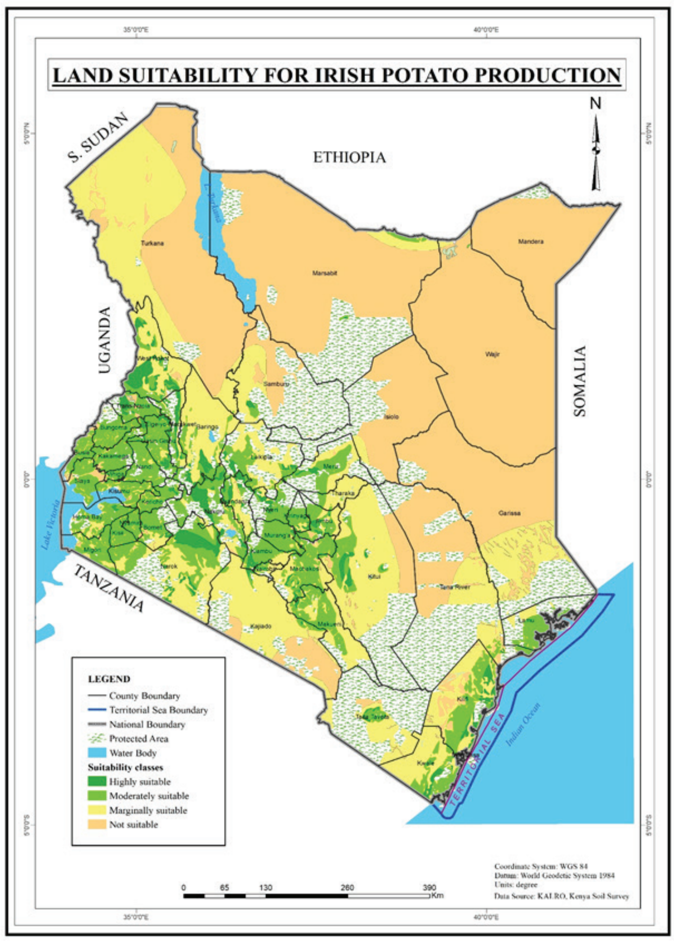


Figure 131: Land suitability for irish potato production

Trends in Crop Production

Generally, the production of major crops has grown over time (Figure 132 to 134). 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 69; Figure 132 and 133). 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 134). The negative growth in barley and coffee production has mainly been contributed by the sustained reduction in their yields and acreage since 1990.

Table 69: *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

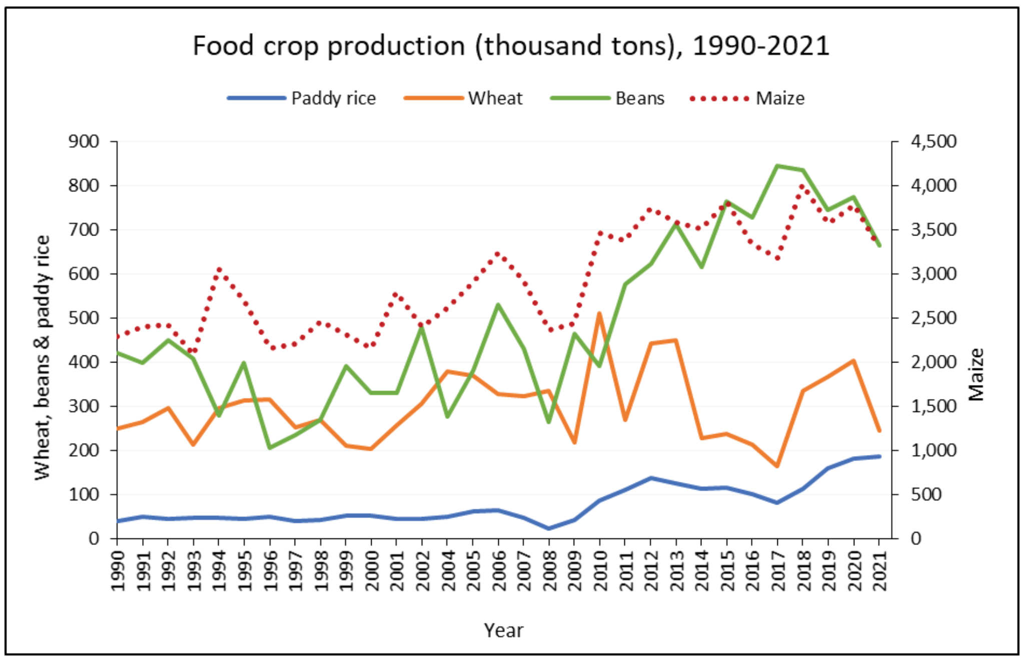


Figure 132: Maize, beans, wheat and rice production, 1990-2021. Source: FAOSTAT

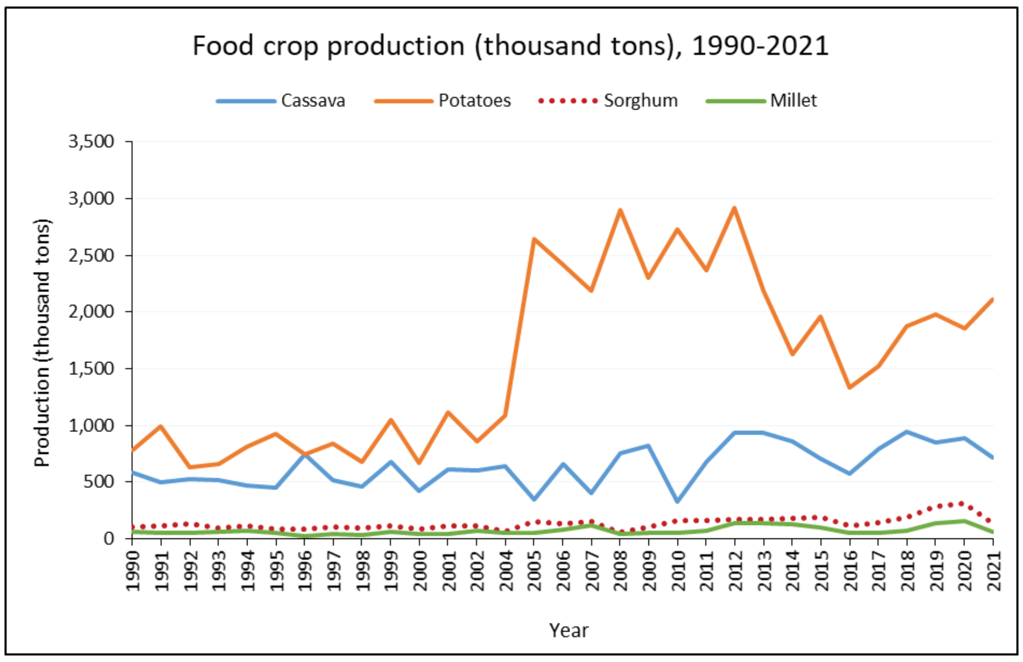


Figure 133: Cassava, potato, sorghum and millet production, 1990-2021. Source: FAOSTAT

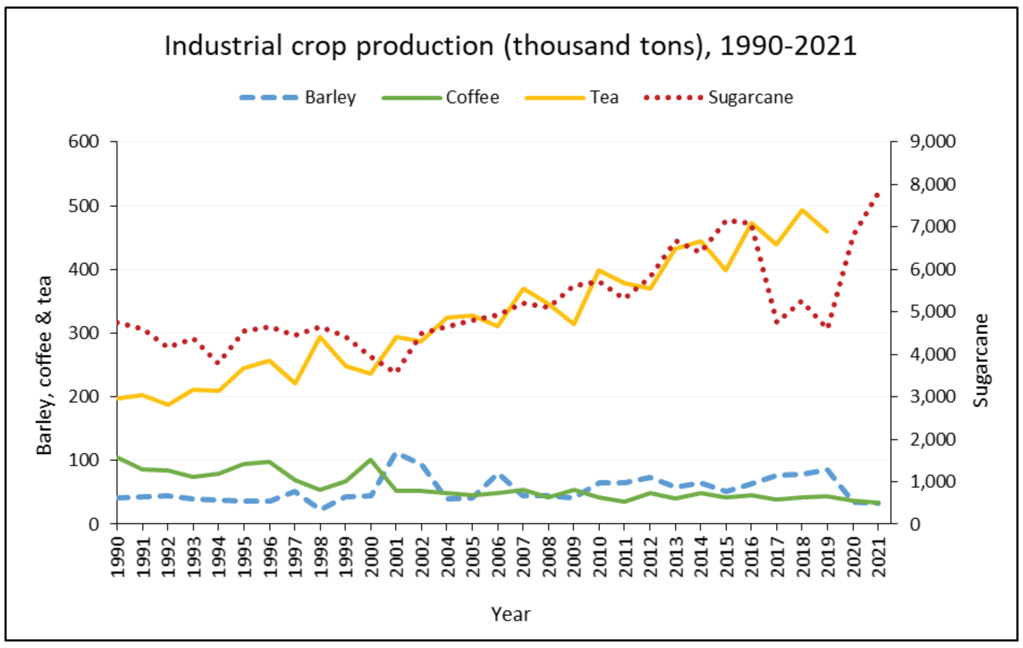


Figure 134: Tea, coffee, sugarcane and barley production, 1990-2021. Source: FAOSTAT

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 78).

Plate 78: 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 70).

Table 71: *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

Source: FAO (2018)

Table 70: *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

Source: FAO (2018)

Livestock and Livestock Products

Kenya has approximately 27.9 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 and Livestock Development [MoALD], 2022). Overall, the livestock population has been on an upward trend from 1990 to 2021 (Figure 135) owing to the increasing demand for livestock products. 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; MoALD, 2021) (Figure 136). 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.

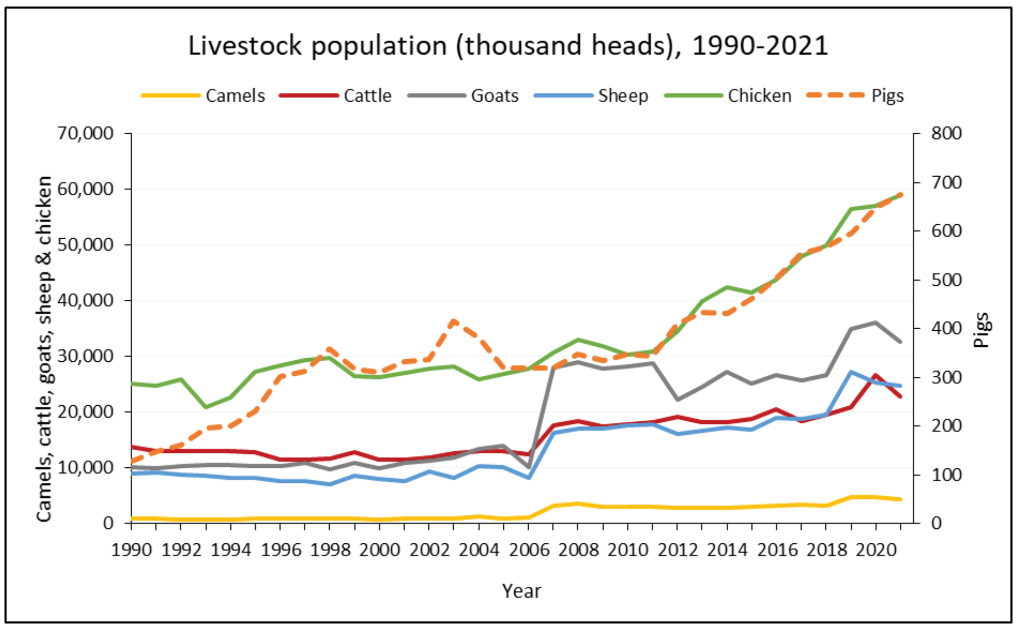


Figure 135: Livestock population trends, 1990-2021. Source: FAOSTAT

Plate 80: Indigenous cattle at a watering point. Photo credit: MoALF

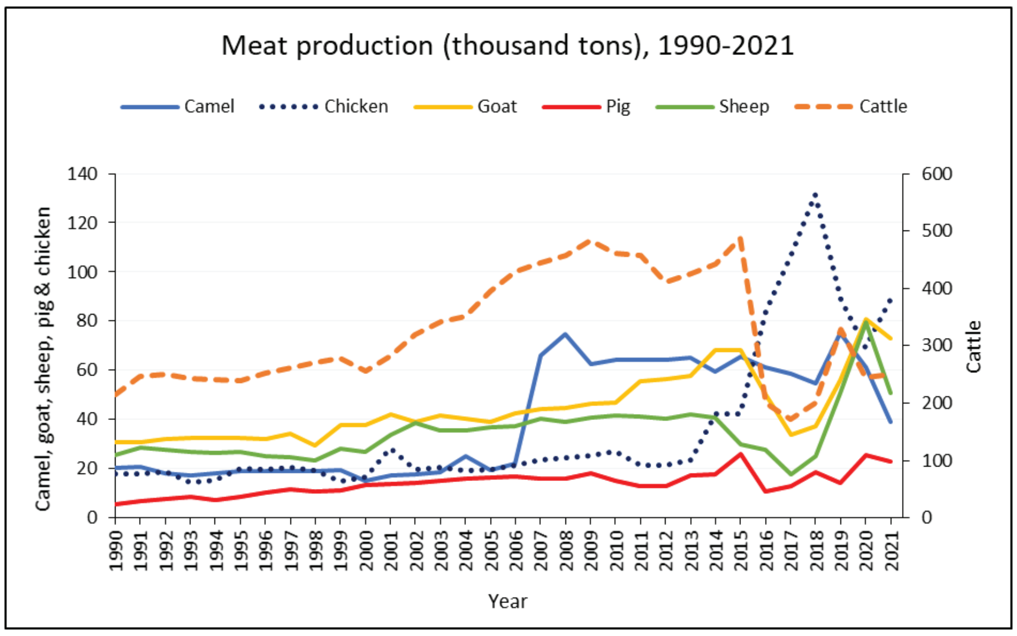


Figure 136: Meat production trends, 1990-2021. Source: FAOSTAT

Beef Cattle

Beef cattle population is estimated at 17.8 million, the main species of which are the East African Zebu, Boran, Sahiwal and cross-breeds (Plate 79 and 80). The highest concentration of these cattle is in the ASALs, with beef being mainly derived from pastoral and agro-pastoral production systems. In 2021, about 527,190 tons of beef were produced valued at KES 251.9 billion (MoALD, 2021) (Figure 136). 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 1,731 tons of hides valued at KES 485.9 million were produced in 2021 (Figure 136).

Plate 79: Improved Sahiwal bull. Photo credit: KALRO

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 8). In 2021, the dairy cows produced 4.6 billion litres of milk valued at KES 236.7 billion (MoALD, 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 21). 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 81: Friesian dairy cow. Photo credit: Laban Robert

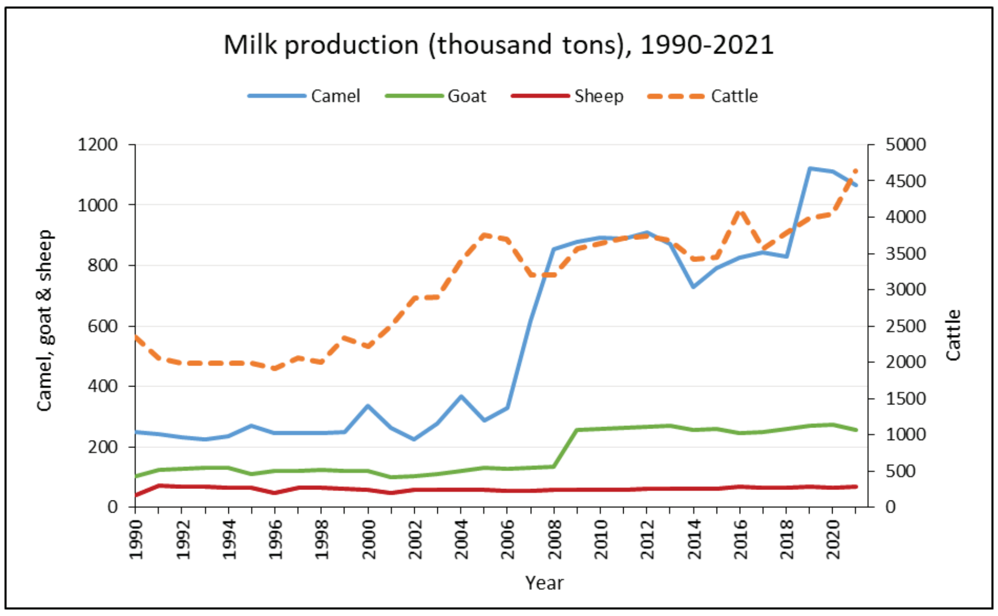


Figure 137: Milk production trends, 1990-2021. Source: FAOSTAT

Plate 83: 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 (Plate 82 and 83). 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 (MoALD, 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 138). 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 82: A flock of Galla goats. Photo credit: KALRO

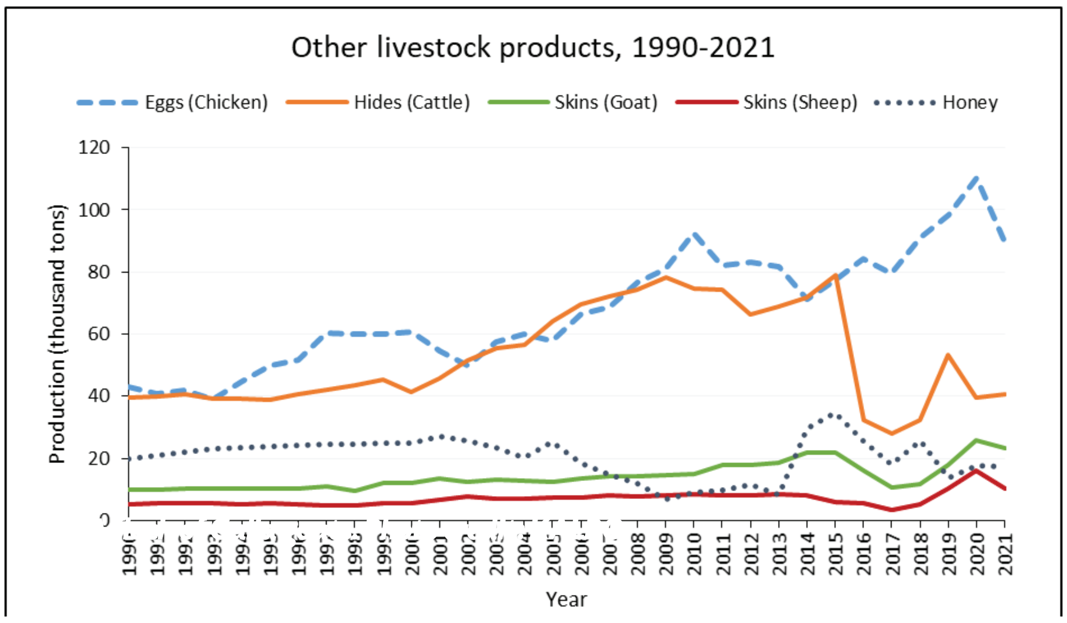


Figure 138: Hide, skin, honey and egg production trends, 1990-2021. Source: FAOSTAT

Camel

Camel keeping is mainly practiced in northern Kenya (Plate 84). 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 (MoALD, 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 84: 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 85). 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 (MoALD, 2021). The pig's shorter life cycle coupled with good return rates and optimum feed efficiency makes it more suitable for farmers. optimum feed efficiency makes it more suitable for farmers.

Plate 85: 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 86), while 16.2 percent are commercial layers and broilers (Figure 136). 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 (MoALD, 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 86: 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 87) 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; MoALD, 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 87: 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 88). 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 88: A donkey at a watering point. Photo credit: MoALF

Market Trade Flows of Livestock and Livestock Products

Markets allow for the flow of livestock and livestock products from areas of surplus production to areas of deficit production; hence, assuring food security. Figure 139 shows the main slaughter houses, livestock trade routes and markets used for livestock transactions in Kenya. It is evident that commodity largely flows to the urban centres and that the livestock trade routes are informal. At the border of Kenya and Ethiopia, the informal markets are at Sololo, Moyale and Rhamu, while along the border of Kenya and Somalia, the markets at Diff and Bannisa. In addition, at the Kenya-Uganda border, the market is at Suam, while along the Kenya-Tanzania border, the informal markets are at Namanga, Taveta and Loitokitok. Once purchased from the markets, a large proportion of livestock are trucked for slaughter to the main urban towns with the main slaughter houses being concentrated within the environs of Nairobi.

Figure 139: Major livestock routes and markets

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.

Plate 89: Severely degraded landscape in West Pokot County. Photo credit: KALRO

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 CO_2 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 CO_2 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 CO_2 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.

Invasive and Alien Species

Invasive and alien plant species, such as *Striga hermonthica* (witch weed), *Prosopis Juliflora* (mathenge), *Opuntia stricta* (Cactus), *Acacia reficiens* (false umbrella thorn tree), *Ipomoea carnea* (pink morning glory) are a threat to crops, livestock, agro-ecosystems and human welfare due to their proliferation and spread at alarming rates. The invasive and alien species have infested large proportions of croplands and rangelands in Kenya (Plate 90), leading to low crop and livestock productivity, suppression or replacement of native biodiversity, alteration of local ecosystem functions and, in some cases, livestock mortalities due to the decrease in livestock forage.

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.

Plate 90: *Prosopis*-infested farmland in Marigat, Baringo County. Photo credit: Purity Rima

KEY MESSAGE

As a country, Kenya is endowed with a diversity of valuable agro-based resources, including soils, agro-ecological climates, topography, crops and livestock. These are the pillars of food security, nutrition and rural livelihoods. However, the crop and livestock sub-sectors face enormous challenges that continue to retard the various gains made in advancing food security over the years. Overreliance on rain-fed crop and livestock production is a major hindrance to increased productivity especially in a changing climate. Therefore, there is an urgent need to enhance water availability and efficient use for agriculture by adopting climate- and water-smart solutions.

CHAPTER 05

EXTRACTIVE RESOURCES

Petroleum Resources

Importance of Fossil Fuels

Fossil fuels are a critical form of primary energy not only for Kenya but globally as shown in figure 140 below. The global percentage of primary energy derived from fossil fuels is 81.79% while countries like South Africa and India consume more than the global average at 94.24% and 88.46% respectively.

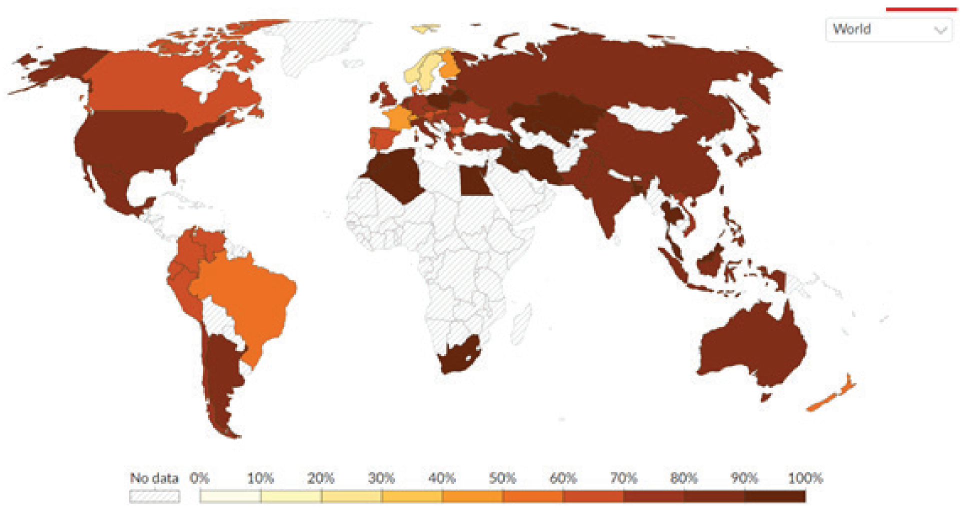


Figure 140: Share of primary energy from Fossil Fuels, 2023 (Our World in Data, Energy Institute Statistical Review of World Energy-2023)

In Kenya, fossil fuels account for approximately 5% of total energy consumed in 2022, as shown in figure 141, with petroleum products mainly used for road transport, accounting for 75% of total petroleum consumption, while aviation and manufacturing account for 11.1% and 8.7% respectively, while the 5.2% is multiuse in homes and for manufacturing as shown in figure 142.

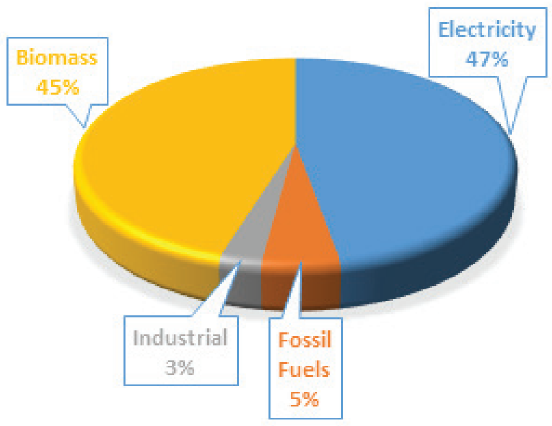


Figure 141: Total Energy Consumption, 2022 Economic Survey 2023

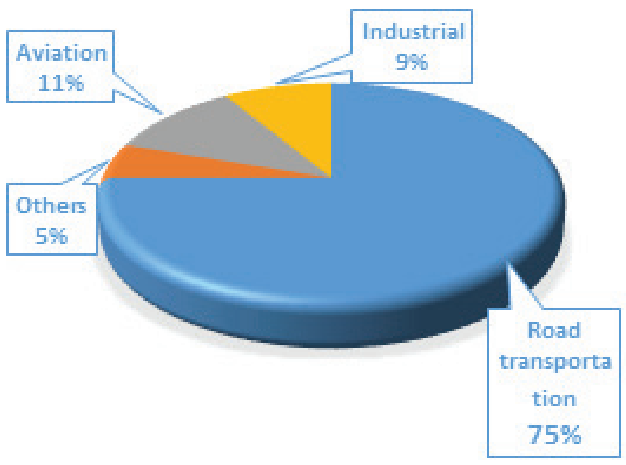


Figure 142: Petroleum Consumption by end user

Although Kenya has approximately 70% connection to electricity, Least Cost Power Development Plan, 2022 of which more than 80% is from renewable sources. The access is adequate for lighting, and basic household usage but still not sufficient to spur industrial growth as such, the country is in need of all energy sources even as it moves to green energy.

The oil and gas potential evaluation by Beicip-Franlab, 2020 identified exploration potential in the 4 main basins (Lamu, Anza, Mandera and Tertiary rift basins), with approximately 2544 million barrels of oil initially in place (OIIP) with a probability of success (PoS) >20% and 136 Trillion cubic feet (Tcf) of gas with a probability of success (PoS) >20%. With such resources potential, the sector can greatly contribute to the GDP as well as provide raw material (natural gas) for power generation, manufacture of fertilizers as well as petrochemicals for both the local and export market.

Phases in Petroleum Exploration and Production

The petroleum industry is broadly divided into three categories namely:

I. Upstream further divided into exploration, development and production

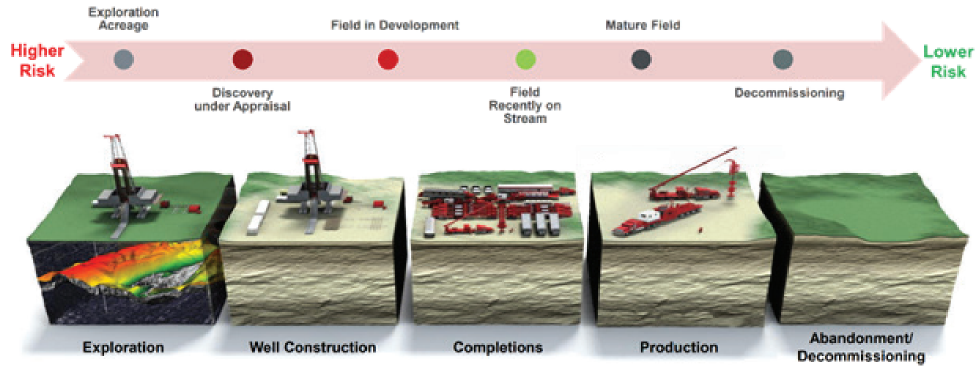


Figure 143: Upstream petroleum

II. Midstream further divided into Storage, refining and transportation. The sector includes the Kenya Pipeline Company (KPC) and Kenya Petroleum Refineries Limited (KPRL).

Plate 91: Midstream petroleum showing Kenya Petroleum Refineries Limited (KPRL), MoEP

III. Downstream classified as Supply and distribution to the end users. The State Department for Petroleum is embarking on an LPG projects, through Mwananchi gas, Clean Cooking Gas for schools.

Plate 92: Downstream petroleum distribution to end users, MoEP

Upstream Petroleum in Kenya

South Lokichar Development

In March 2012, Kenya announced discoveries of oil and gas in the South Lokichar Basin in Turkana County. The discovery positioned Kenya as a formidable strategic partner in the region with increased interest among investors on opportunities available in exploration, development and production.

With the discovery of oil and gas there is need to put in place appropriate policy, legal, regulatory, and guidelines. Key among these is the development of robust frameworks for management of accruing revenues, benefit sharing, local content development and management of stakeholder expectations. This will ensure the country benefits from petroleum resources and is able to deal with challenges associated with exploiting the resources in a sustainable manner.

Plate 93: Discovered oil and gas resources in Turkana County, MoEP

In 2021, the Kenya Joint Venture (KJV), also referred to as Contractor, between Africa Oil Corporation, Tullow Oil and Total Energies Kenya, submitted a Field Development Plan (FDP) to the Energy and Petroleum Regulatory Authority (EPRA). The Authority, working with the Contractor, reviews the FDP suggesting modifications which are mutually agreed and the Authority advises the Cabinet Secretary to approve the same. The approved FDP is taken to Parliament for ratification before the Contractor executes it.

Table 72: *FDP approval process*

1.	Review of FDP	The minister and the contractor must jointly consider the field development plan. If there are no modifications or revisions, the FDP will be regarded as approved after 60 days
2.	Ratification by parliament	In the current Petroleum Act passed in 2019, the FDP must go through a ratification process in parliament, including undertaking public participation.
3.	Government participation	The government may choose to exercise its participation rights. Government will be required to give its share of capital for the development work.

The FDP sets out the Contractors Preliminary Concept for the Development of the Hydrocarbon Resources.

It also outlines:-

1. Details of proposed development area.
2. Drilling and completion of development wells.
3. Facilities for production, storage & transportation of hydrocarbons.
4. A production forecast.
5. An estimate of the investment expenses and the time to complete each phase of the project.

According to the Petroleum Master Plan, 2020, execution of the South Lokichar project is projected to provide approximately 10,000 direct and indirect jobs and an annual contribution of $ 2 Billion USD to the economy.

Early Oil Pilot Scheme (EOPS)

In March 2017, the government entered into an agreement with the Contractor for the Early Oil Pilot Scheme Agreement (EOPSA). The agreement authorized the Contractor to conduct extended well tests from selected fields with the objective of maturing the fields (collecting more data to learn more about the reservoir and validate the dynamic models) for the purpose of the full development project. The petroleum recovered from the exercise was termed Early Oil Petroleum and was transported to Mombasa Kenya Petroleum Refinery Limited, tanks via road utilizing special tanktainers.

Plate 94: Crude oil being pumped into tanktainers for EOPS, MoEP

EOPS served the following purposes:

1. Enhanced the credibility of oil production in Kenya (locally, nationally and internationally).
2. Created local employment and business opportunities (albeit at a small scale).
3. Established enabling commercial and infrastructure arrangements to facilitate future full field development.
4. Provided important reservoir information to assist in planning for the future full field development.
5. Established an international market place for Kenya's crude oil at a relatively low cost with a scope for more preferential price discounts in the future.
6. Introduced Kenya Crude Oil into International Markets ahead of full production

Plate 95: Flagging off of EOPS crude oil, 2019, MoEP

Exploration potential of the Kenyan Petroleum Basins

Kenya has 63 petroleum blocks spread across 4 basins and 91 exploratory wells, with approximately 90,221-line km of 2D seismic and more than 6,300 km2 of 3D seismic data. The country has a complex geology related to East African geotectonics. The architecture and evolution of the basins since the Paleozoic show:

i. Metamorphic Precambrian Basement
ii. Permo Carboniferous rifts strike slip pull apart continental basin with

the deposition of Permo Triassic Karoo sediments in the Lamu and Mandera Basins in Kenya and Majunga Basin in Madagascar

iii. North North East South South West to North South oriented passive margin development related to the dextral strike slip movement of Madagascar from the East Africa coast since the Jurassic along the Davie Walu ridge resulting in the evolution of the Lamu Basin

iv. Tertiary rifts starting in Eocene times with a North South average orientation resulting in the formation of the East Africa Rift System and several rift related grabens (Turkana, Gatome Lokichar, Kerio, Suguta sub basins)

Stratigraphy is of paramount importance in the exploration for mineral deposits in sedimentary rocks because the scientific exploration for any such deposit requires that the geological events which determined its formation and location be known. The chart in figure 144 outlines the different stratigraphic periods for reference.

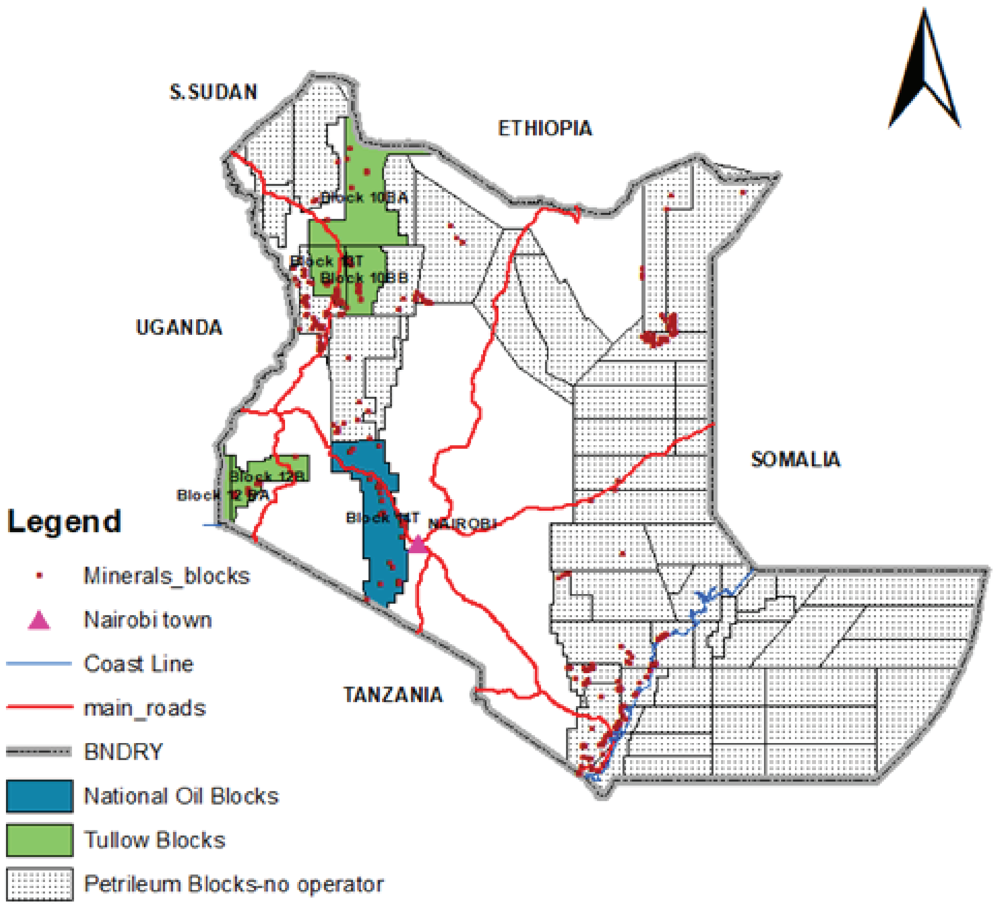


Figure 144: Petroleum oil blocks

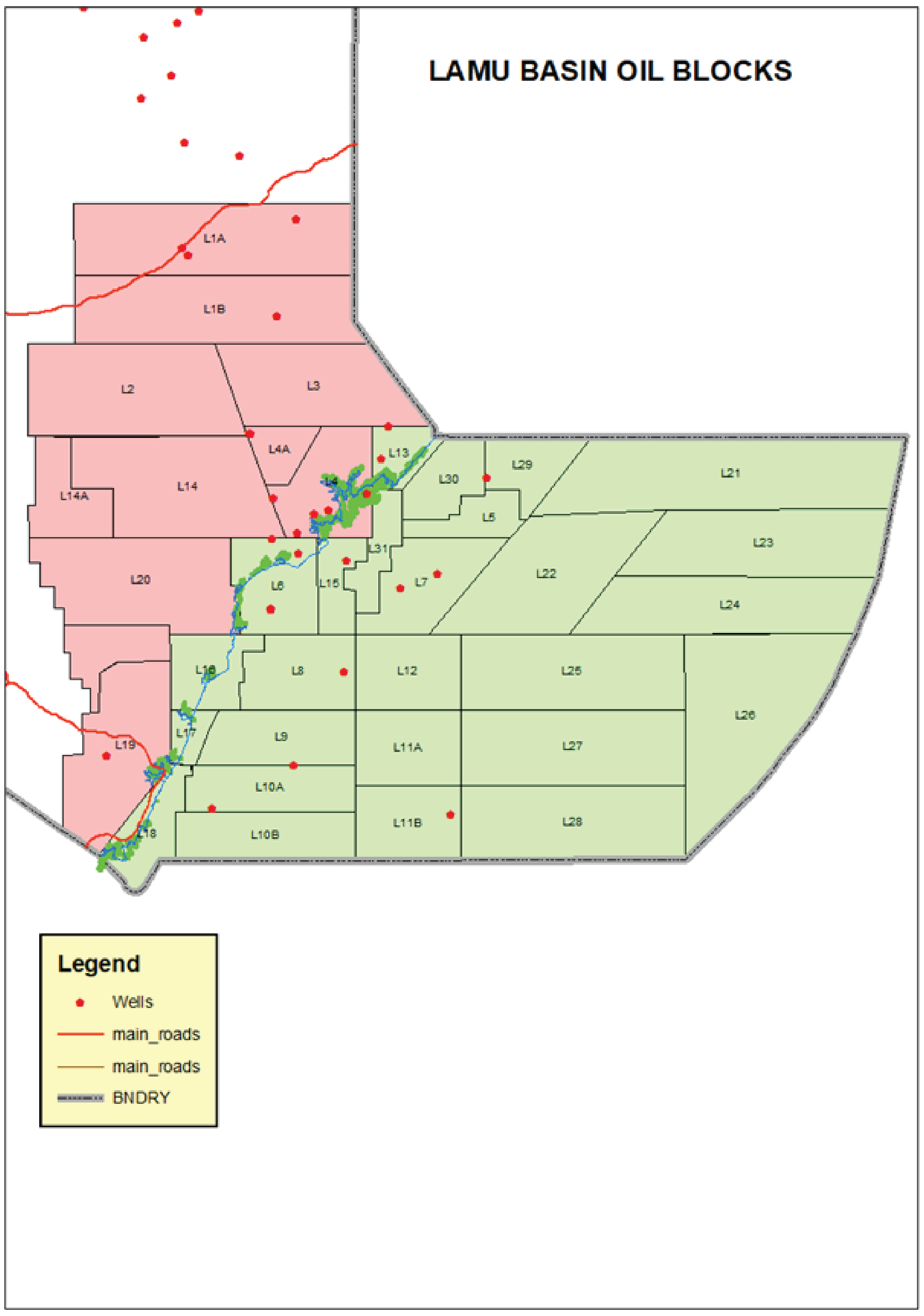


Figure 146: Lamu basin oil blocks

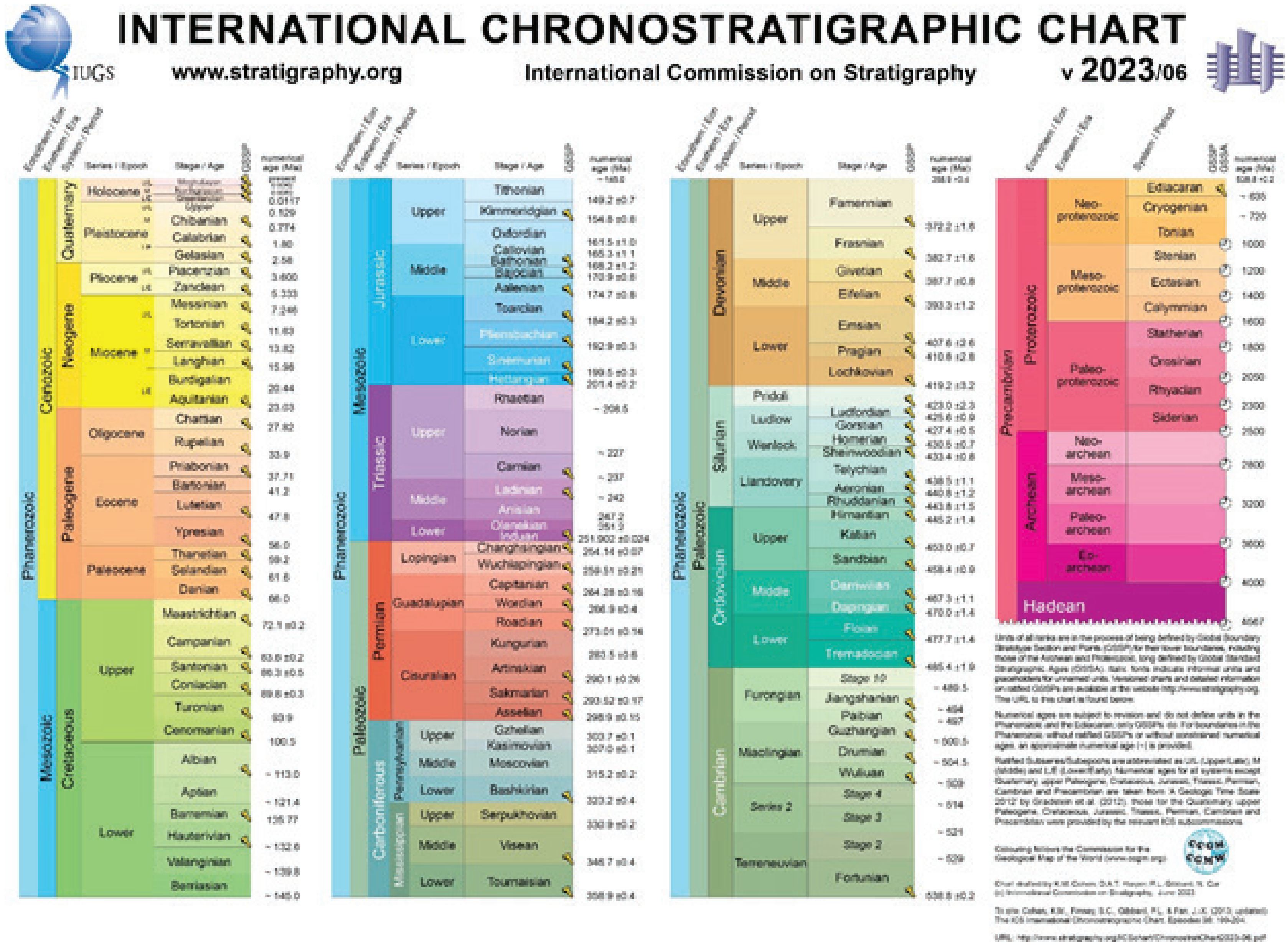


Figure 145: International Chronostratigraphic Chart

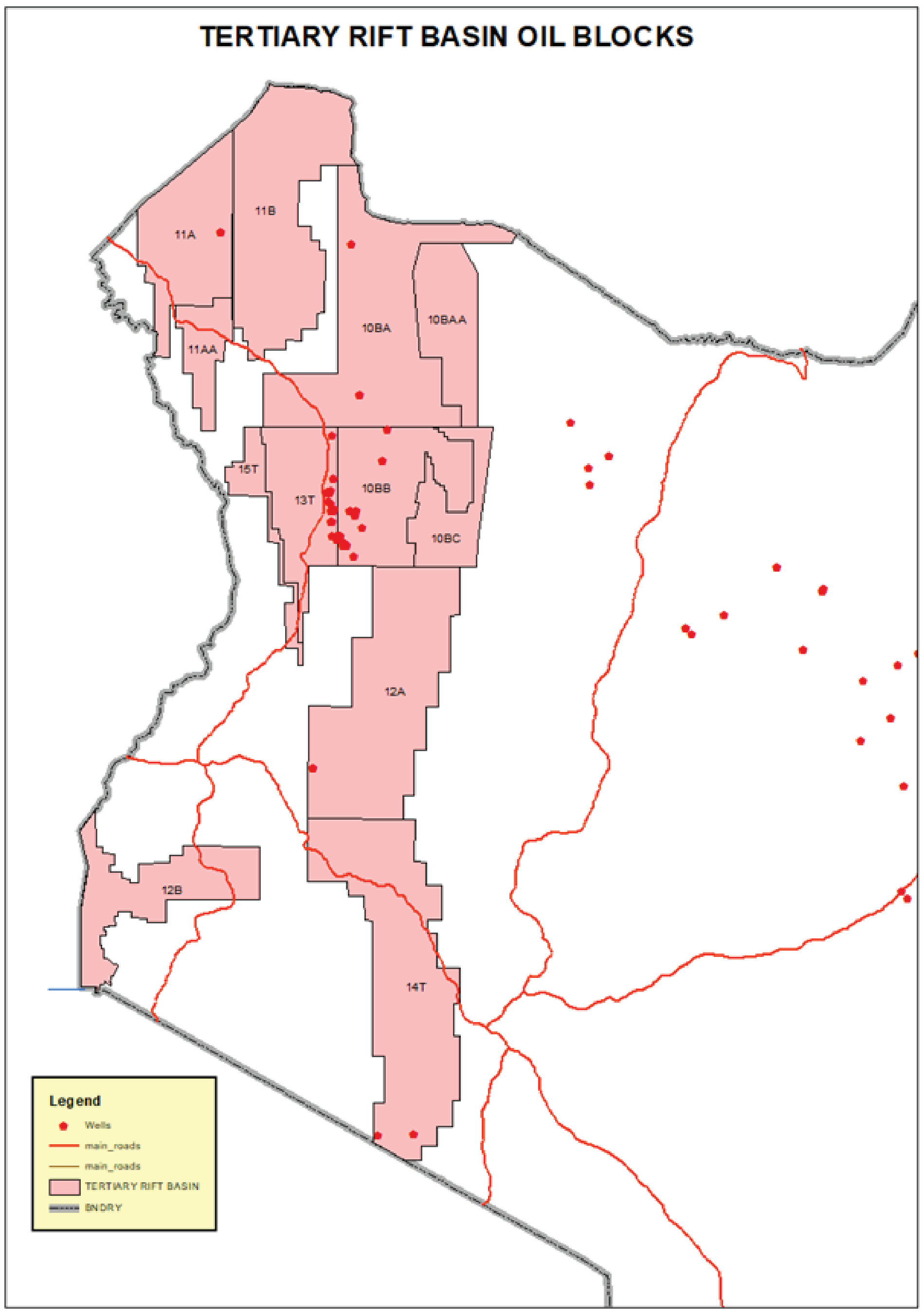


Figure 147: Tertiary rift basin oil blocks

Figure 149: Mandera rift basin oil blocks

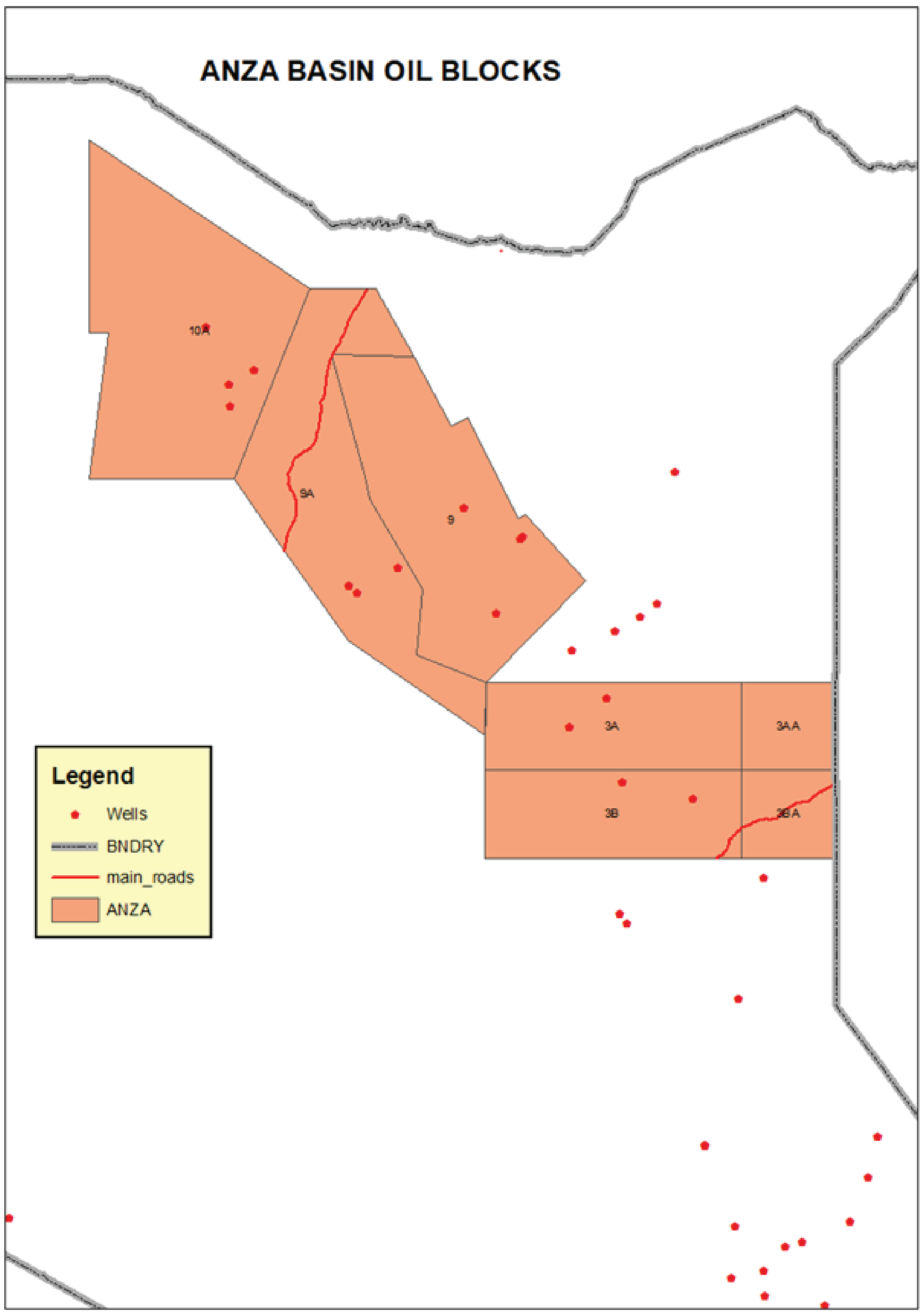


Figure 148: Anza basin oil blocks

I. Lamu Basin

The Lamu basin extends over 256 000 km² both onshore and offshore The basin stratigraphy spans Permo Triassic (Karoo) to Pliocene Sedimentation. The Lamu onshore was tested by 15 wells drilled between 1959 and 1986 with no wells drilled onshore after 1986. 6 wells were drilled more recently between 2008 and 2020; 3 of the wells indicated minor Oil and Gas shows with sub commercial discoveries and shows made offshore.

The onshore Lamu is poorly explored while the Lamu offshore is the most explored basin in Kenya and is covered by rather extensive 2 D and 3 D seismic in the offshore.

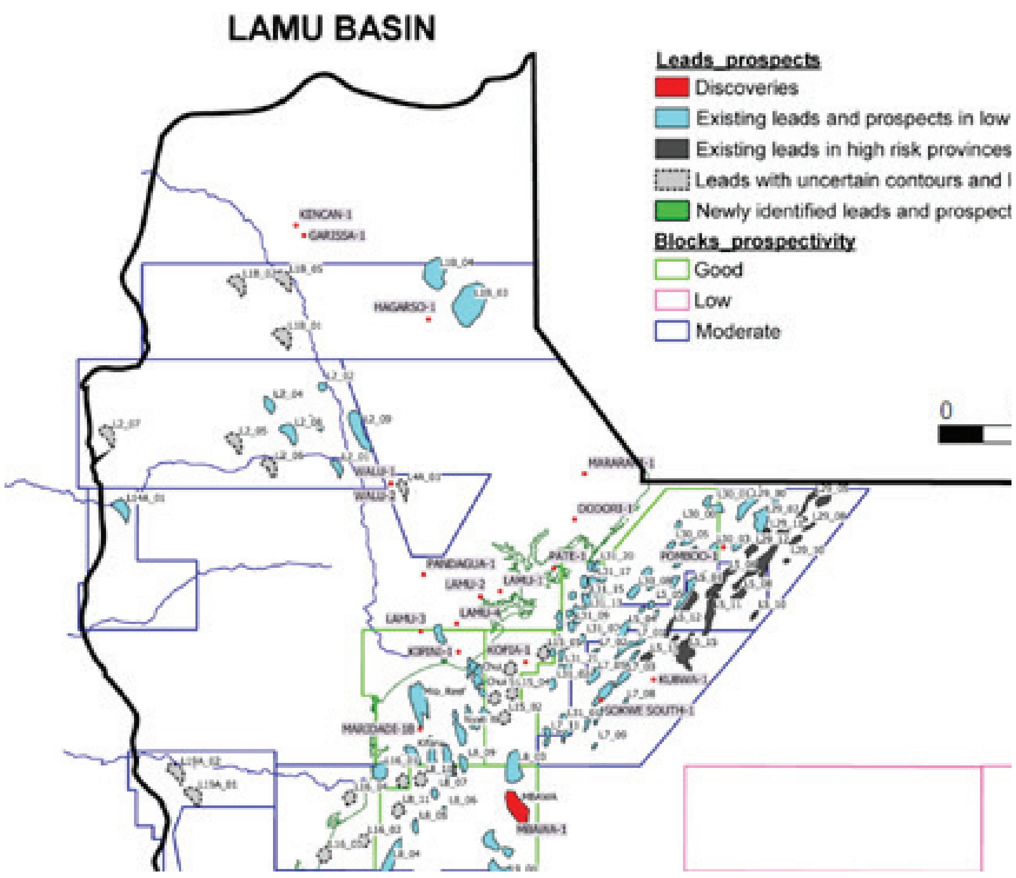


Figure 150: Lamu Basin showing Petroleum Exploration Blocks, MoEP

The Lamu basin can be subdivided into 3 petroleum provinces:

a. Lamu Onshore Province:

The Lamu onshore province displays low to medium opportunities. The Composite Common Risk Segment (CCRS) maps indicate that all identified plays have moderate to high risk. The confidence in the interpretation is mostly limited in areas where data (seismic) is limited.

Small/mid-size gas resources can be expected with fair POS (25%) and fair resources (~100 Bscf); and a moderate to high level of development success (economic potential).

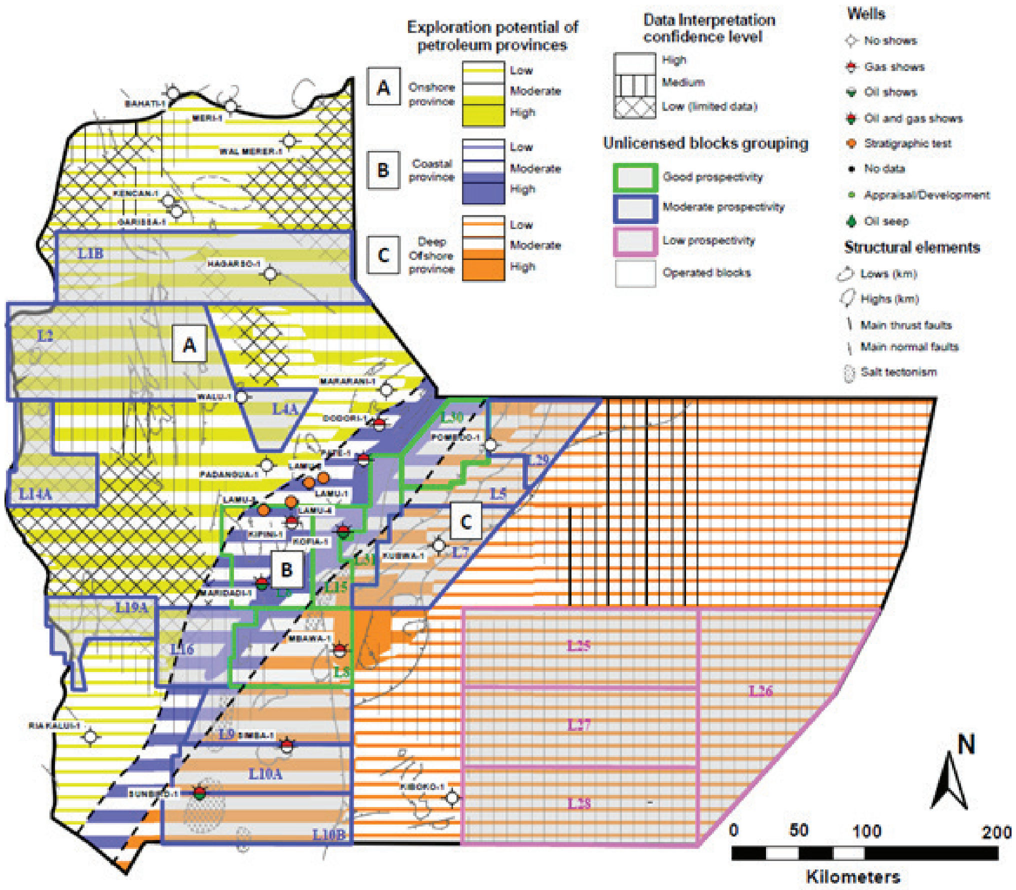


Figure 151: Lamu Basin Petroleum Provinces, MoEP

b. Lamu Coastal Province:

The Lamu coastal province display the highest exploration opportunities. Seismic data acquisition ensuring continuity between onshore and offshore should help in identifying promising leads, since the petroleum system elements are working well (HC charge-mostly gas, seals and high-quality reservoirs).

The Lamu Coastal Province corresponds to the area with the best potential in the unlicensed acreage , with up to 67 Tcf unrisked gas resources in the Miocene play, and 45 Tcf in Lower Tertiary plays (Best case). The gas is associated with prospective oil with close to 3000 MMbbl recoverable resources (all plays, best case).

c. Lamu Deep Offshore province:

The Lamu offshore province displays high risk areas in the deep offshore beyond 2000 m water depth, due to a speculative HC charge and lack of high-quality reservoirs. The exploration risk/opportunity is moderate within the Tertiary lobes occurring on the paleo-slopes, which correspond mostly to the present-day continental slope.

The main play in Lamu Deep Water Province corresponds to the Upper Cretaceous, with high unrisked prospective GIIP (32 Bscf best case) and associated liquid (~1500 MMbbl).

II. Anza Basin

The Anza basin extends over 85 000 km² and trends NW SE It follows the same trend as the proven oil bearing basins with similar configuration and age in Sudan to the NW. It contains sediments with variable thickness 2000 m to 8000 m) of mostly of continental, fluvial and lacustrine environments

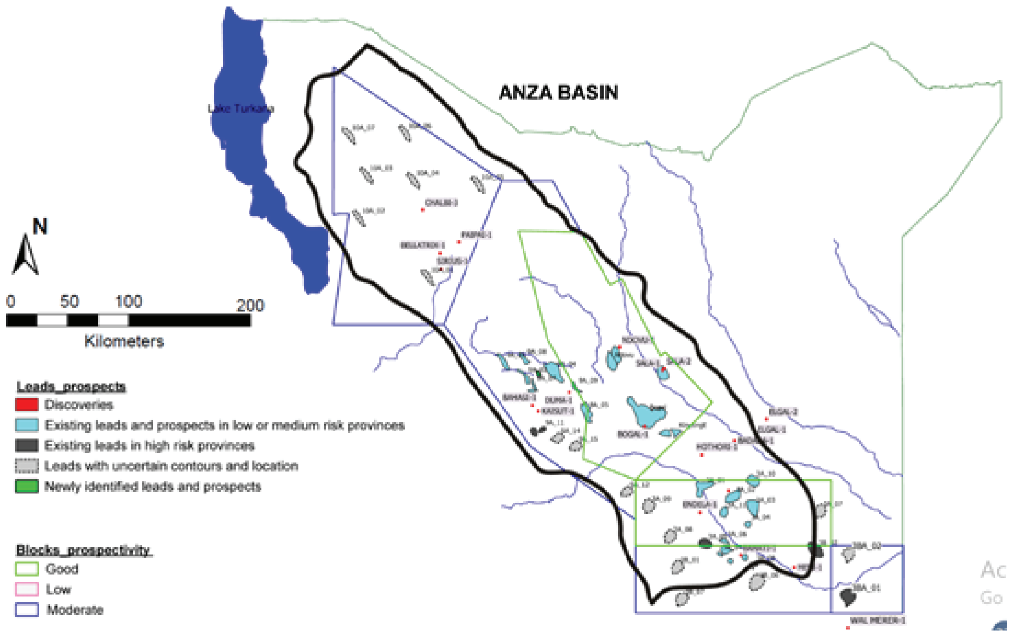


Figure 152: Anza basin, MoEP

The sediments are of Cretaceous to Oligocene age, with possible presence of older sediments (Karoo, Jurassic) underlying the Cretaceous. These older sediments have been found just South of Anza basin boundary (Kencan 1 well) and as well as South East (Elgal wells) and represent deposits of an older and underlying Permo Triassic rift (Karoo). Sub commercial discoveries and shows were encountered through drilling between 1989 and 2014 (Hothori 1 in 1989 Chalbi 1 in 1989 Endela 1 in 1989 Boga 1 l in 2010 Sala 1 in 2014 and Sala 2 in 2014. It is covered by rather extensive 2 D seismic, which was shot over sub basins detected by gravimetry.

a. Anza Shallow Basin Province:

The Anza shallow basin correspond to the Cretaceous structural highs bound by relatively shallow troughs (< 5000 m burial). Some moderate exploration opportunities can be expected, as long as the HC charge (oil type) can effectively occur from Cretaceous paleolakes linked to the structural highs through carrier beds. The Anza Cretaceous play has unrisked prospective GIIP of 6576 Bcf and OIIP 1488 MMbbloe.

b. Anza Deep Basin Province:

The Anza deep province has given encouraging results. The highest opportunities are expected near Badada-1 and Sala-1 (gas provinces with some condensates). The Anza Lower Tertiary play has unrisked prospective GIIP of 55 Bcf and 3311 MMbbloe

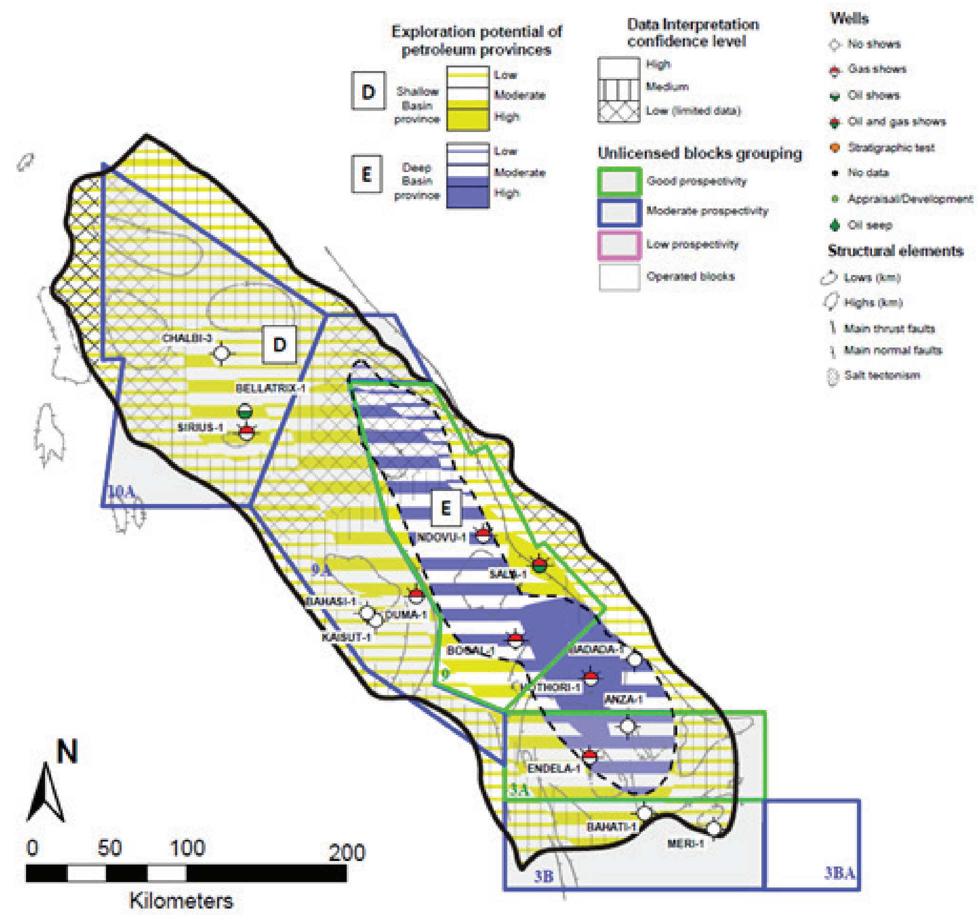


Figure 153: Anza basin exploration potential, MoEP

III. Mandera Basin

The Mandera basin extends over 56,000 km² onshore with sediment thickness reaching 5000m. The Karoo graben axis is approximately oriented South to North North East. An oil show was found in a water well (Tarbaj 1) and analyzed as biodegraded oil of Jurassic origin. It is covered by a reasonable amount of old vintage 2D seismic.

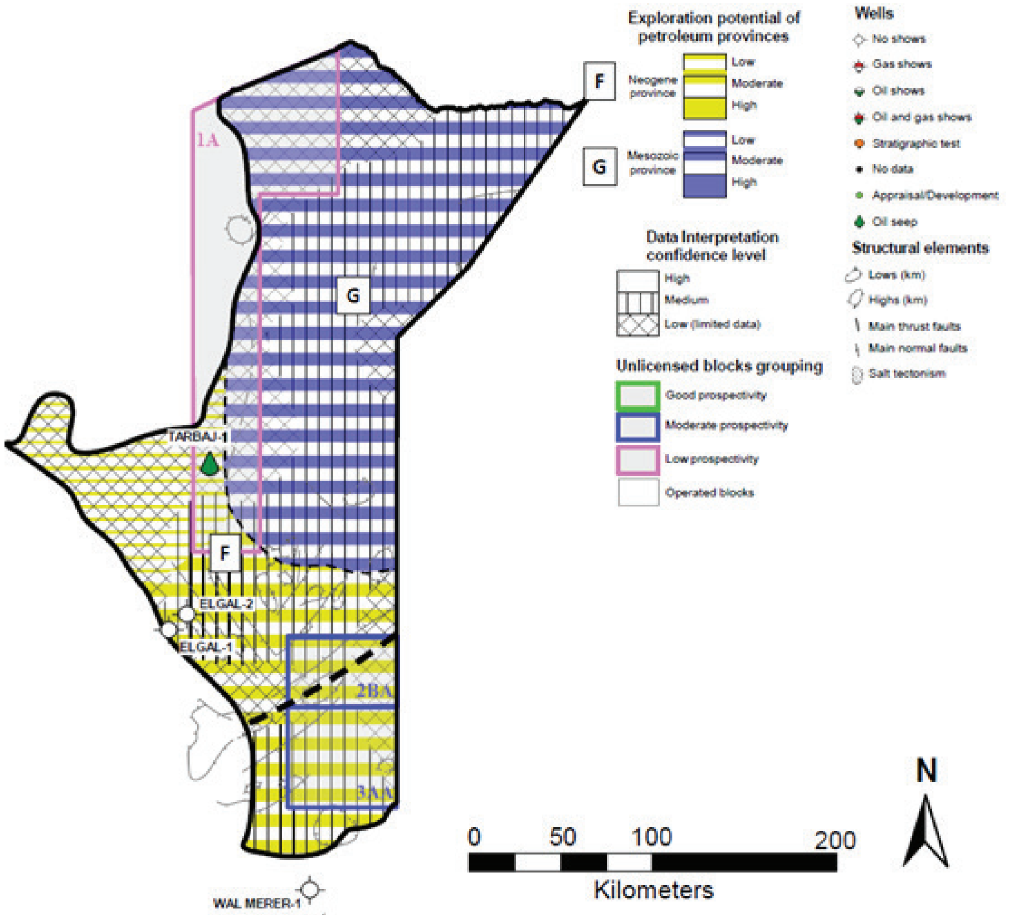


Figure 154: Mandera basin exploration potential, MoEP

The Mandera Basin can be subdivided into 2 petroleum provinces:

a. Neogene Province

It corresponds to the SE extension of the Anza shallow basin province. Moderate risk, mostly related to the seal presence and quality in the Permo-Triassic units below the shallow Neogene cover. The Permo-Triassic play has unrisked prospective GIIP of 1208 Bcf and 14 MMbbloe.

b. Mesozoic Province

The Jurassic province to the North is more an oil prone province, as shown by the Jurassic oil shows at Tarbaj-1. More data would be needed to confirm the exploration potential to the East, by detecting subtle traps in the Jurassic succession. The Jurassic play has unrisked prospective GIIP of 2422 Bcf and 500 MMbbloe.

IV. The Tertiary Basin

The Tertiary Basin includes 5 sub-basins: Lotipiki, Lokichar, Turkana, Suguta Magadi and Nyanza basins.

The Lotipiki basin is located to the NW of Kenya, close to the Sudan border and covers approximately 12 000 km² It is poorly explored with one well, Tarach 1. It is connected to the Turkana basin to the East, which has more data and wells. The Tertiary Rift Basins include the PSC licenses (Blocks 10BB and 13T) associated with the Lokichar discoveries and of open unlicensed Blocks located South of Lokichar including the Suguta Trough.

More than 3186 MMbbl unrisked prospective resources are expected compared with 560 MMbbl contingent resources (2C) in the South Lokichar basin and 873 GIIP Bcf

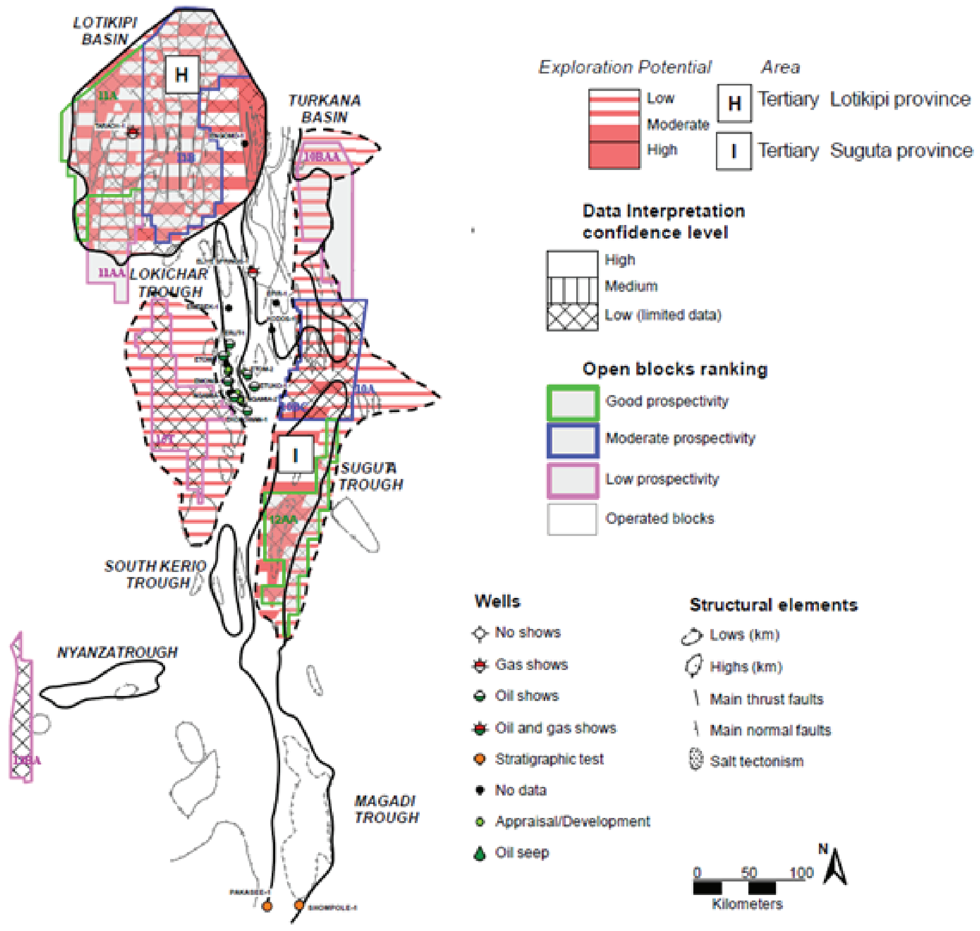


Figure 155: Tertiary basin exploration potential, MoEP

a. Lotikipi Basin:

The Lotipiki basin consists of a single exploration province, with moderate to good exploration opportunities, associated with reservoirs located on the flanks of the N-S grabens and charged by oil and gas generated in Upper Cetaceous or Oligocene paleolakes.

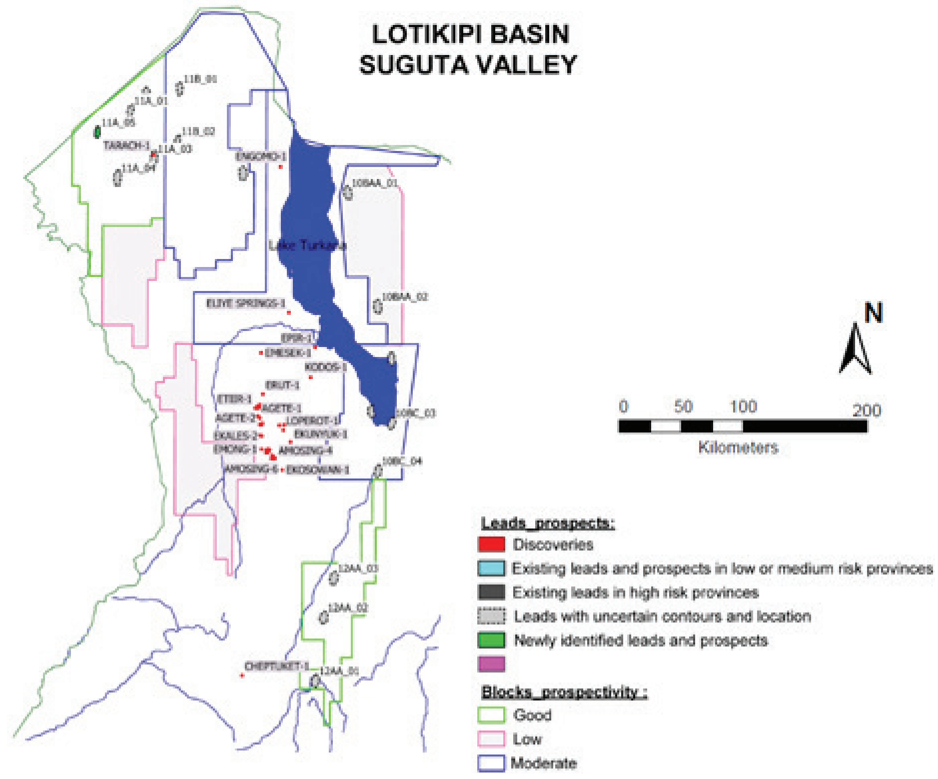


Figure 156: Lotikipi basin exploration potential, MoEP

b. Tertiary Suguta Rift/Nyanza:

The Tertiary Rift exploration province corresponds to the Suguta Trough, East of Kerio and SE of Lokichar. No seismic data are available, but the presence of basement troughs with similar depth as in Lokichar trough suggest that moderate to high exploration opportunities may be found along the basin. Conversely, the Nyanza trough western border may not contain enough sediment to expect a working petroleum system.

3D Multiclient and Block licensing

The Ministry signed a contract for a 3D Seismic Multi-Client data acquisition program that assigns the company the authority to reprocess vintage data as well as shoot new 3D in the Lamu shallow offshore basin.

The 3D multiclient 3D is part of the promotional material to be utilized in the bid rounds to be undertaken for the unlicenced blocks. The announcements for bidding will be published in print and electronic media and will be open globally.

Legislative terrain

The petroleum sector is guided by the policy set out in Sessional Paper No. 4 of 2004 and governed by a number of statutes, principally the Energy Act, No.1 of 2019, and the Petroleum Act, No.2 of 2019 and the regulations thereof. The petroleum regulations include Local Content regulations. The Petroleum Sharing Contract (PSC) that is signed between the Cabinet Secretary and the Contractor additionally governs the upstream sector.

The statutes outline the roles and obligations of the Government and the Contractor as well as the benefits of each party including the community.

Challenges and recommendations

I. Local Content

Oil and gas being nascent in Kenya, the local content is not fully equipped to benefit wholly from the sector. The government shall undertake the following measures to ensure that the value realized from the resource is retained in country.

- Develop and implement local content legislative framework.
- The Authority shall establish a database of the goods and services required for the sector, which shall be accessible by all Kenyans.
- The Authority shall establish a database of the skills required across the different phases of oil and gas exploration and development and work with the Contractor to train Kenyans through CSR programs.
- Establish capacity building programs in conjunction with the local industry association, local training institutions and international institutions;

II. High investment costs especially upstream.

Upstream petroleum exploration is a high risk and capital-intensive venture currently requiring approximately $5 Billion USD for onshore and $20 Billion USD for offshore development. Conversely, the Government has taken the initiative to spearhead primary technical data acquisition in the exploration blocks in order to make them more attractive to oil and gas exploration companies. In addition, the Government reviewed its legal and regulatory framework to provide an enabling environment for investors. The PSC have negotiable clauses as an incentive.

Linkages with different ecosystems

The maps below show the different ecosystems that the petroleum blocks may affect. The relevant environmental laws regulate exploration and exploitation of the petroleum resource.

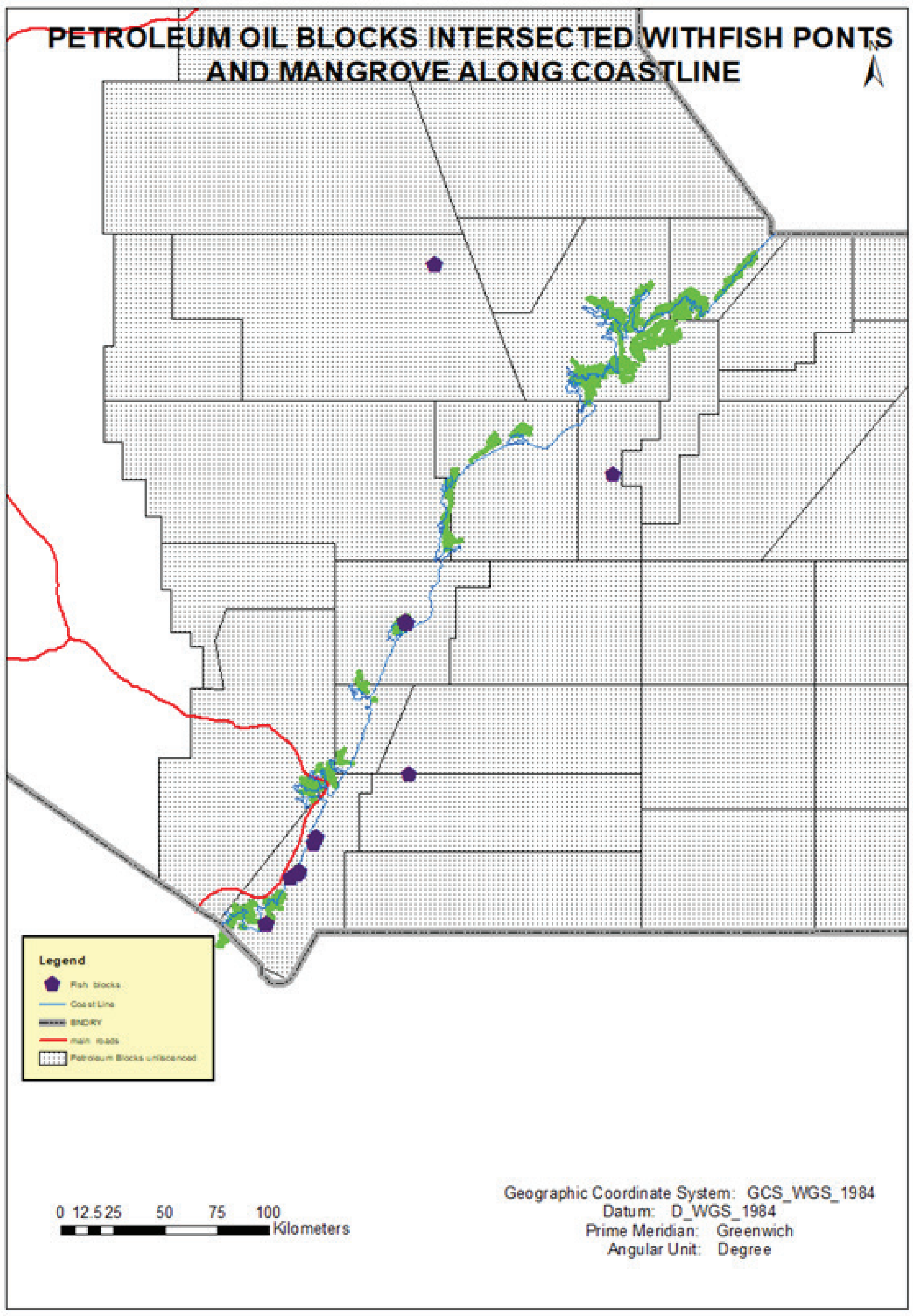


Figure 157: Fish and mangrove in petroleum blocks

The fish that may be affected are as outlined in the table 73 while figure shows that approximately 56,231 hectares of mangroves may be affected by petroleum exploration and development.

Table 73: *Fish that may be affected by petroleum exploration*

Block 10BA	Tullow Oil	Characidae
Block 12A	Unlicensed	Perciformes
Block L9	Unlicensed	Perciformes
Block L14	Unlicensed	Siluriformes
Block 12B	Unlicensed	Cypriniformes
Block 14T	NOCK	Perciformes
Block 1A	Unlicensed	Perciformes
Block L15	Unlicensed	Caproidae
Block L16	Unlicensed	Perciformes
Block 12AA	Unlicensed	Siluriformes
		Perciformes
		Cypriniformes
Block L18	Unlicensed	Perciformes
		Beryciformes
		Anguilliformes
		Aulopiformes
		Syngnathiformes
		Tetraodontiformes
		Scorpaeniformes
		Clupeiformes
		Atheriniformes
		Pleuronectiformes

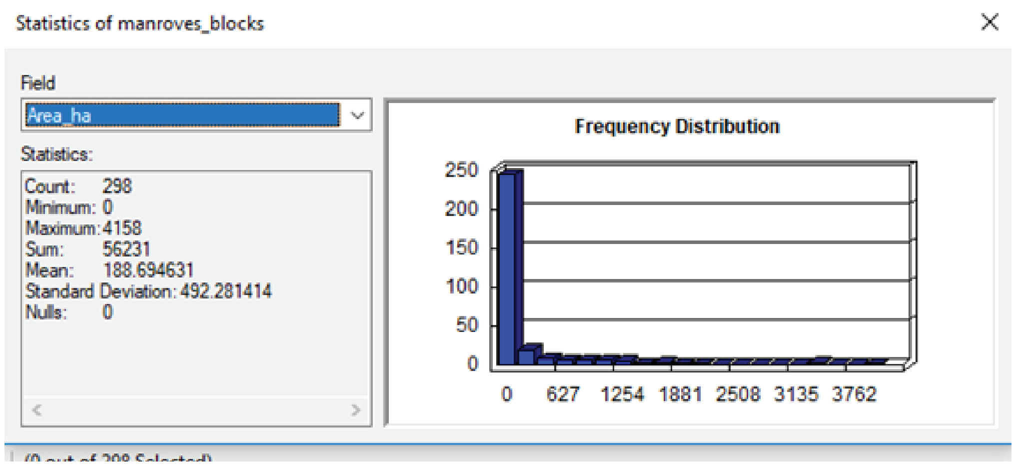
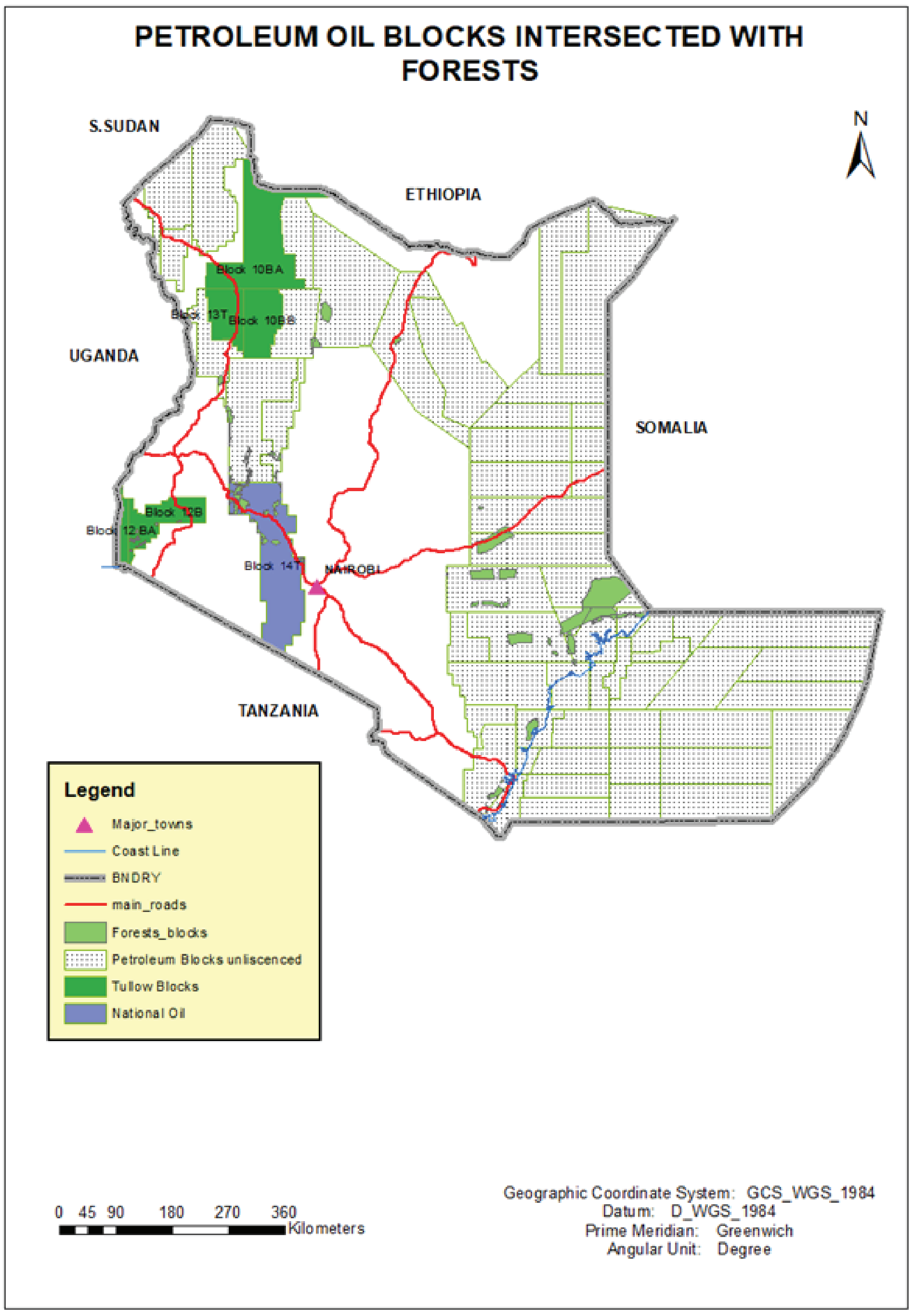


Figure 158: Statistical analysis of mangroves in petroleum blocks



The forest cover in petroleum blocks is approximately 808,847 hectares as shown in figure 159.

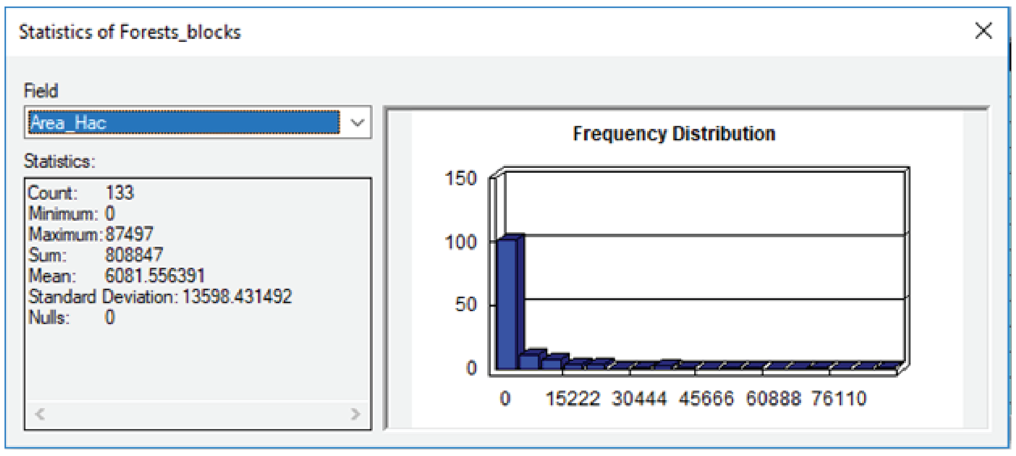


Figure 159: Forest cover in petroleum blocks

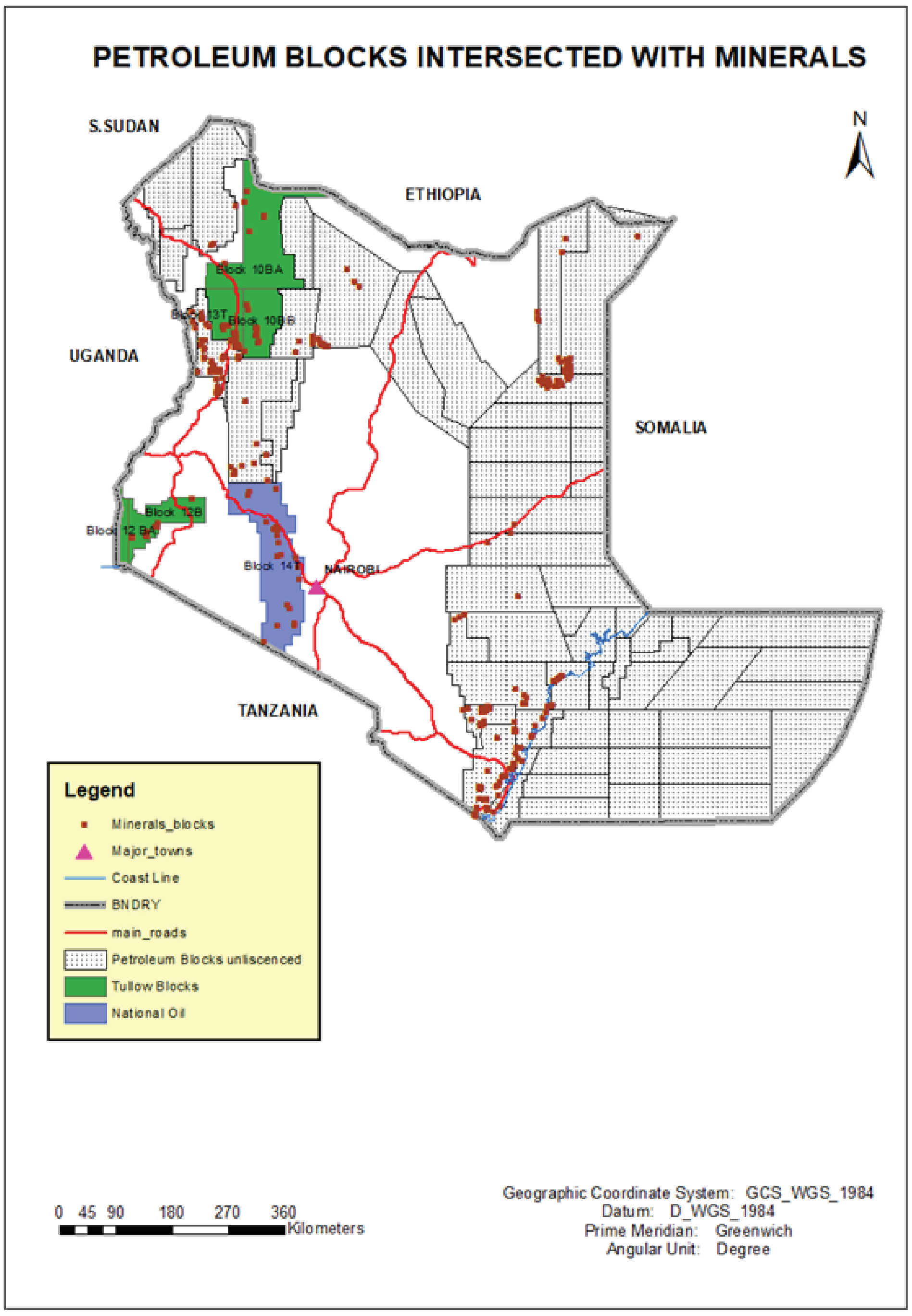
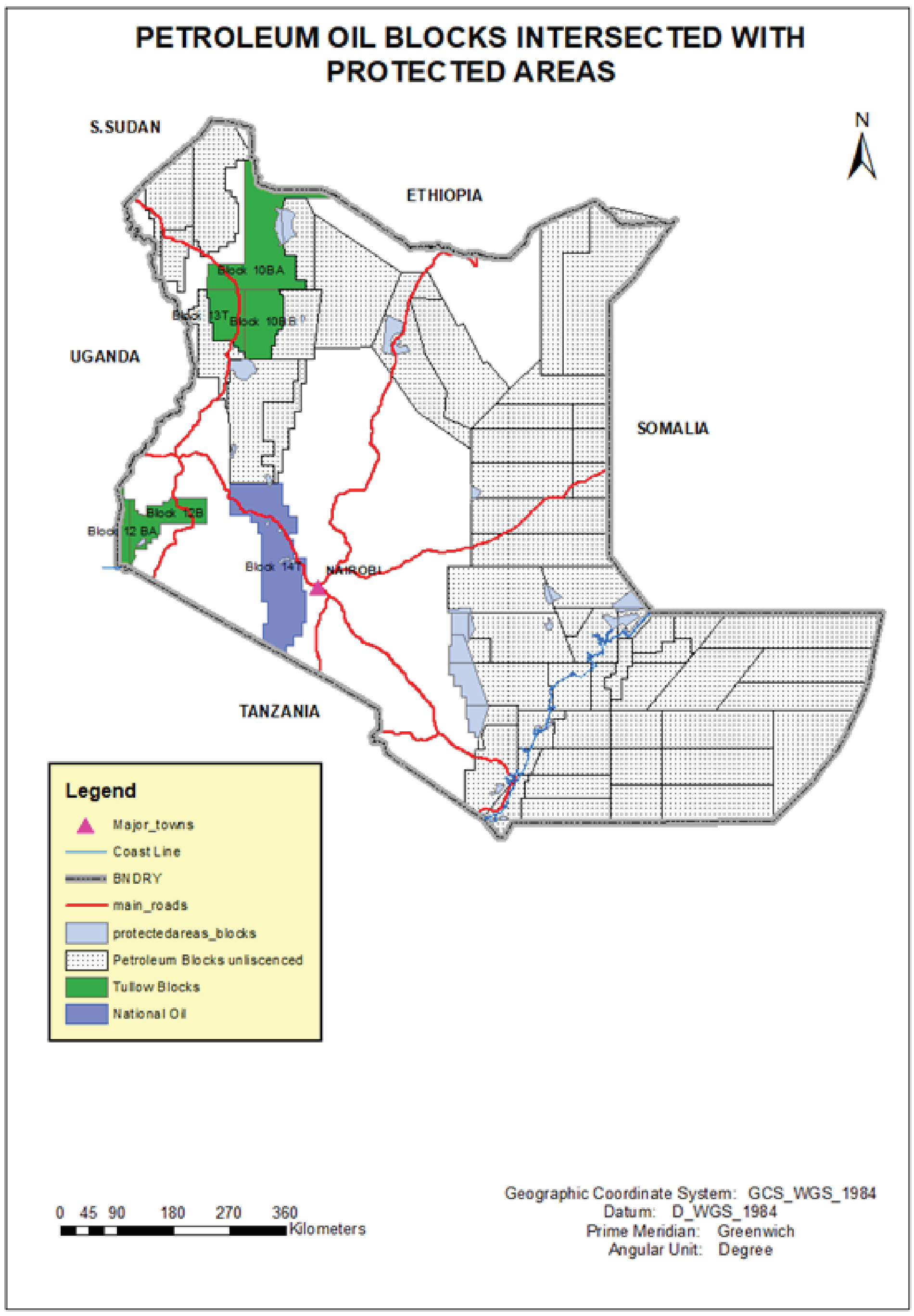


Figure 160: Mineral occurrence in petroleum blocks

Table 74 shows minerals that occur in different petroleum blocks.

Table 74: *Mineral occurrence in petroleum blocks*

Block 1	Gypsum
	Limestone
Block 10A	Nickel
	Nepheline
	Graphite
	Nepheline
	Graphite
	Salt
Block 10BA	Graphite
	Sapphire
	Gold
	Gypsum
Block 10BB	Corundum
	Bentonite
	Gypsum
	Trona
Block 10BC	Trona
Block 11B	Gold
	Corundum
Block 12A	Trona



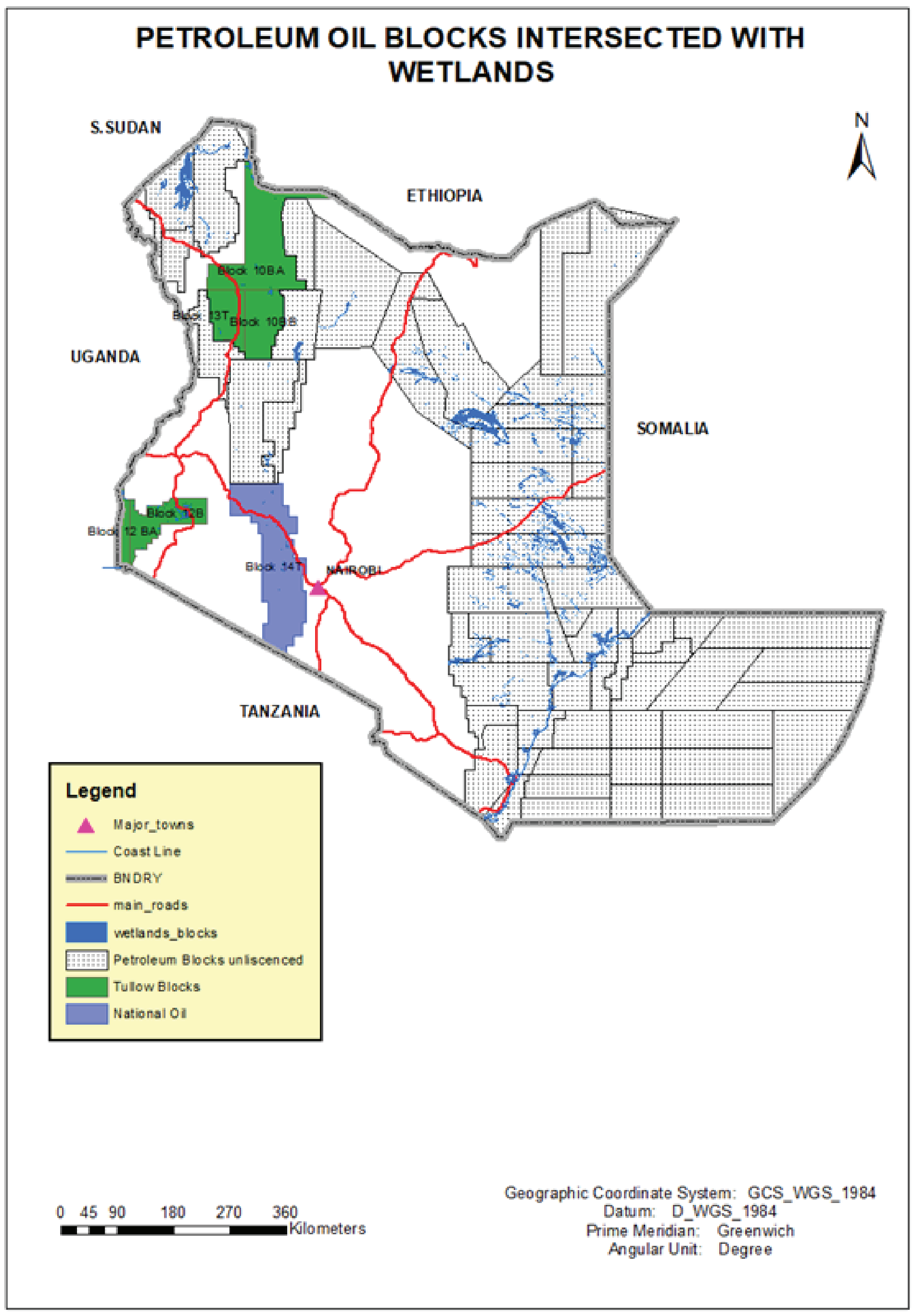


Figure 161: Protected areas across petroleum blocks

The protected areas in petroleum blocks are approximately 665, 745 hectares as shown in figure 162.

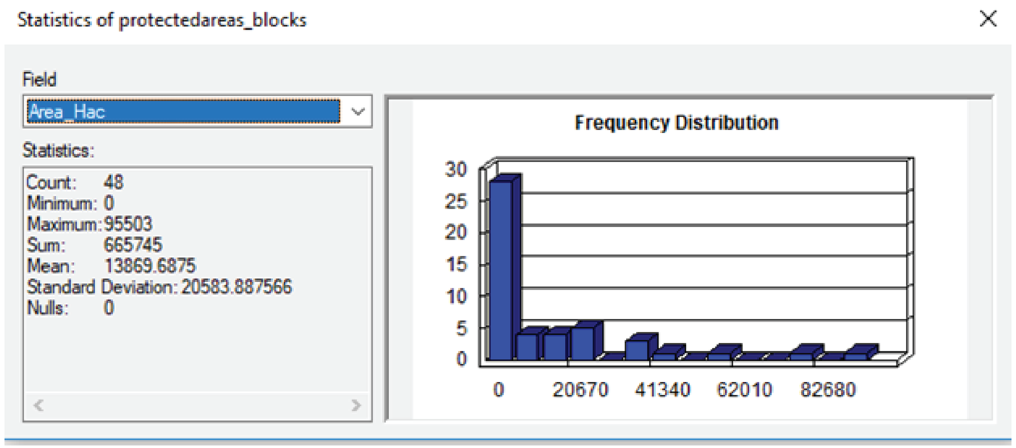


Figure 162: Protected areas across petroleum blocks

Figure 163: Wetlands in petroleum blocks

The wetland areas in petroleum blocks are approximately 1,286,295 hectares as shown in figure 164.

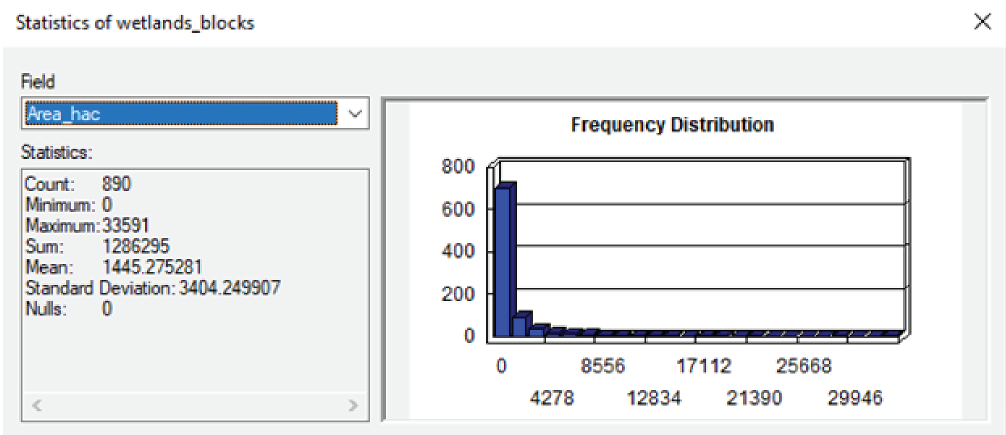


Figure 164: Wetlands in petroleum blocks

Methodology

The data/information available are both quantitative and qualitative

- Quantitative data (Seismic data, gravity data, magnetic data, well logs, estimated reserve capacity,
- Qualitative (Social Corporate responsibility, roads, schools, bore holes
- Maps (and accompanying shapefiles) – The Petroleum National Data Centre (NDC) domiciled at the National Oil Corporation of Kenya is the custodian of governments petroleum data, Ministry of petroleum and minerals (coordinates of the blocks), Survey of Kenya. The data analysis was done through Statistical Excel and GIS Maps

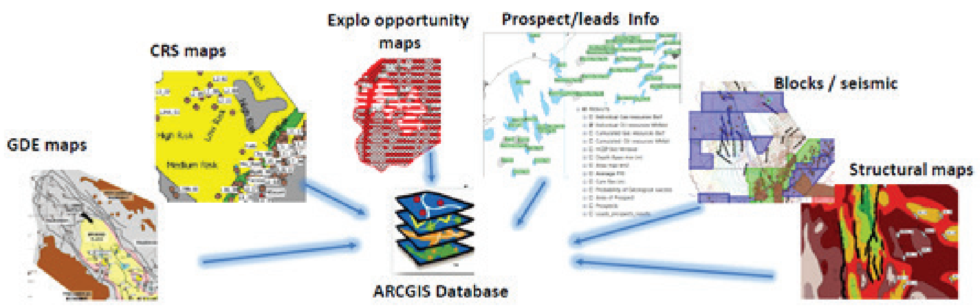


Figure 165: Petroleum ArcGis database components

- The ArcGIS Database on exploration opportunities in Kenya is available through the Ministry of Energy and Petroleum at a cost of US$ 11,000.

KEY MESSAGE

The World Bank classifies Africa as a whole and Kenya in particular as areas with energy poverty, despite being endowed with abundant natural resources. The sector seeks to embrace 'just energy transition' by utilizing fossil fuels even as it moves to green energy. Exploitation of the petroleum resources in Turkana is projected to offer 10,000 direct and indirect jobs and contribute approximately $2 Billion USD to the economy annually.

GEOLOGY AND MINERAL RESOURCE

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 96: 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 97: 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 98: Pegmatite dyke within the Mozambique Belt (M. Nyakinye, 2023)

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 99: Quarternary sediments on Lake Natron (M. Nyakinye, 2023)

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.

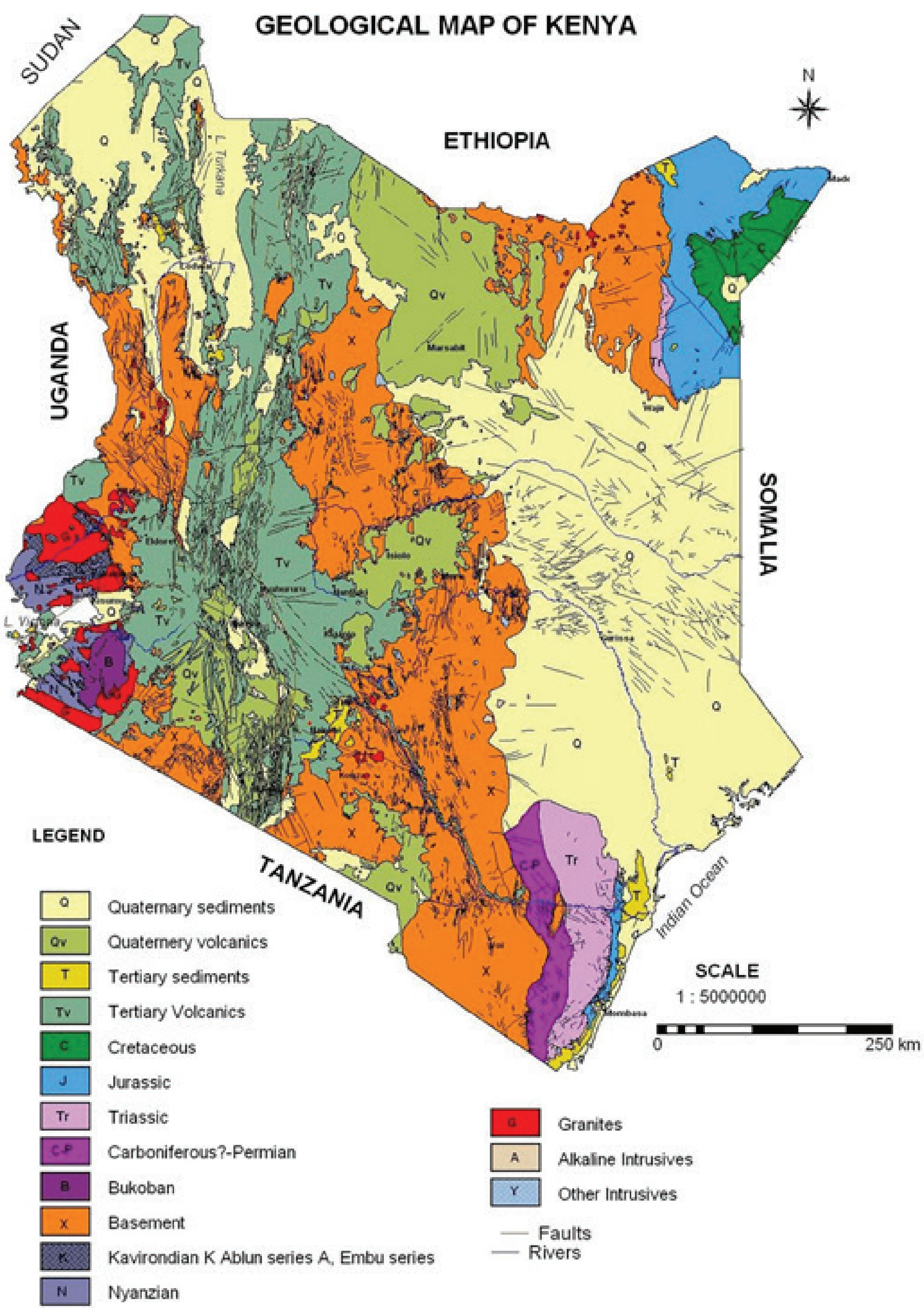


Figure 166: Geological Map of Kenya (Source: Kenya Geological Survey)

Plate 100: Underground gold mining at the Kilimapesa gold mine in Transmara, Narok county (C. Odhiambo, 2023)

Mineral resources of Kenya

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:

v. Construction and industrial minerals building stones and sand

vi. Gemstones (precious and semi-precious stones)

vii. Precious metals, e.g., gold, silver

viii. Base metals e.g. copper, manganese

ix. Diamonds

The following maps and figures show the distribution of mineral Kenya's resources, areas where active mining of various minerals are undertaken and statistics on licensing and production trends of the main minerals being mined.

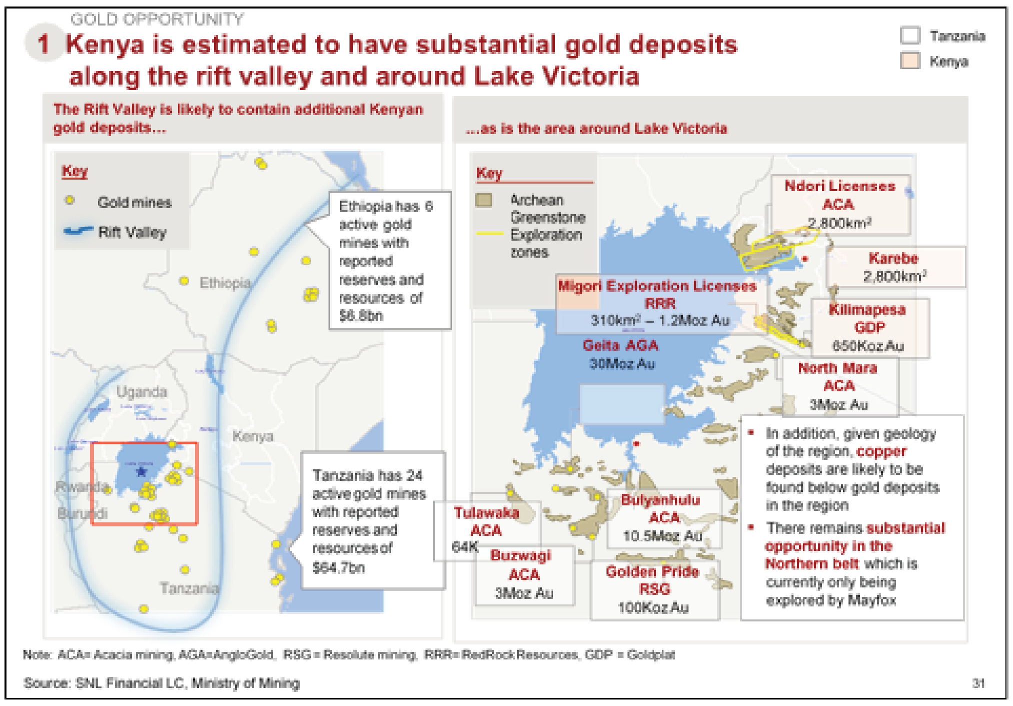


Figure 167: Distribution of Kenya's mineral resources in relation to East Africa (Source: State Department for Mining)

The National Geodata Centre (NGDC)

The Ministry of Mining has developed an online geological data metadata portal as part of the National Geodata Centre project. The portal is hosted by the Ministry of Mining and administered by the Directorate of Geological Surveys and Geoinformation Management (DGSGM). The Ministry is establishing the NGDC as a one- stop-shop for geoscientific data and information for the country. The NGDC is the means by which the Ministry is organising and safeguarding its data and documents in a more systematic and accessible manner, making them readily available to stakeholders with minimal bureaucracy. Development of such a national repository of geoscience information along with the compilation, publication and dissemination of information and data concerning the geology and mineral resources of Kenya and facilitating access to this information by the general public is a requirement under the Mining Act of 2016.

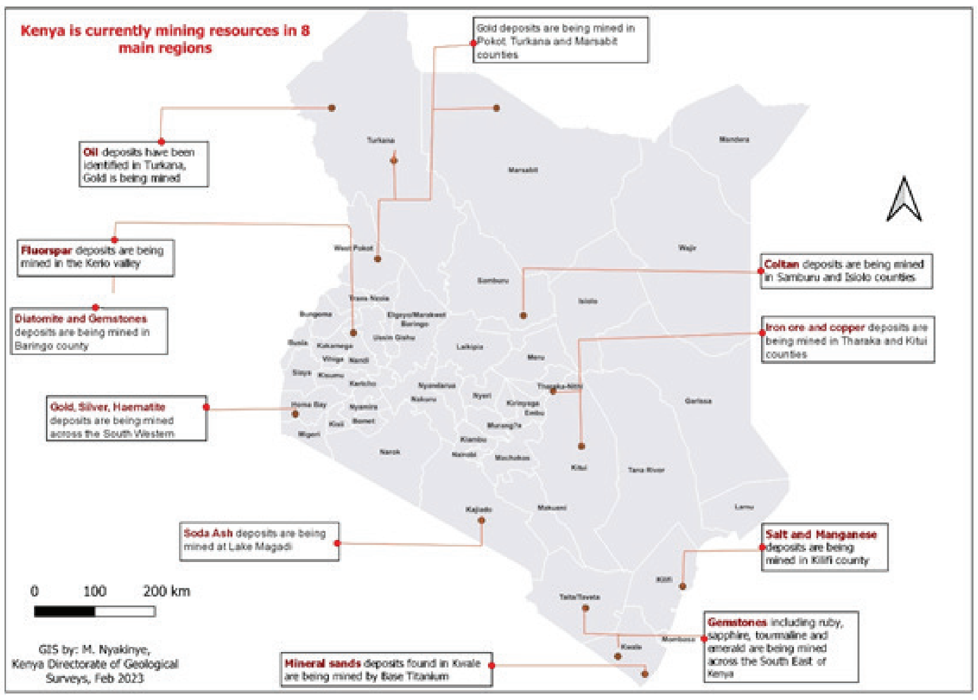
The metadata portal can be accessed here:

https://ngdckenya.bgs.ac.uk/

Table 75: *List and location of most common minerals in Kenya (Source: State Department for Mining)*

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

S/ No	List of Minerals	Area found
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



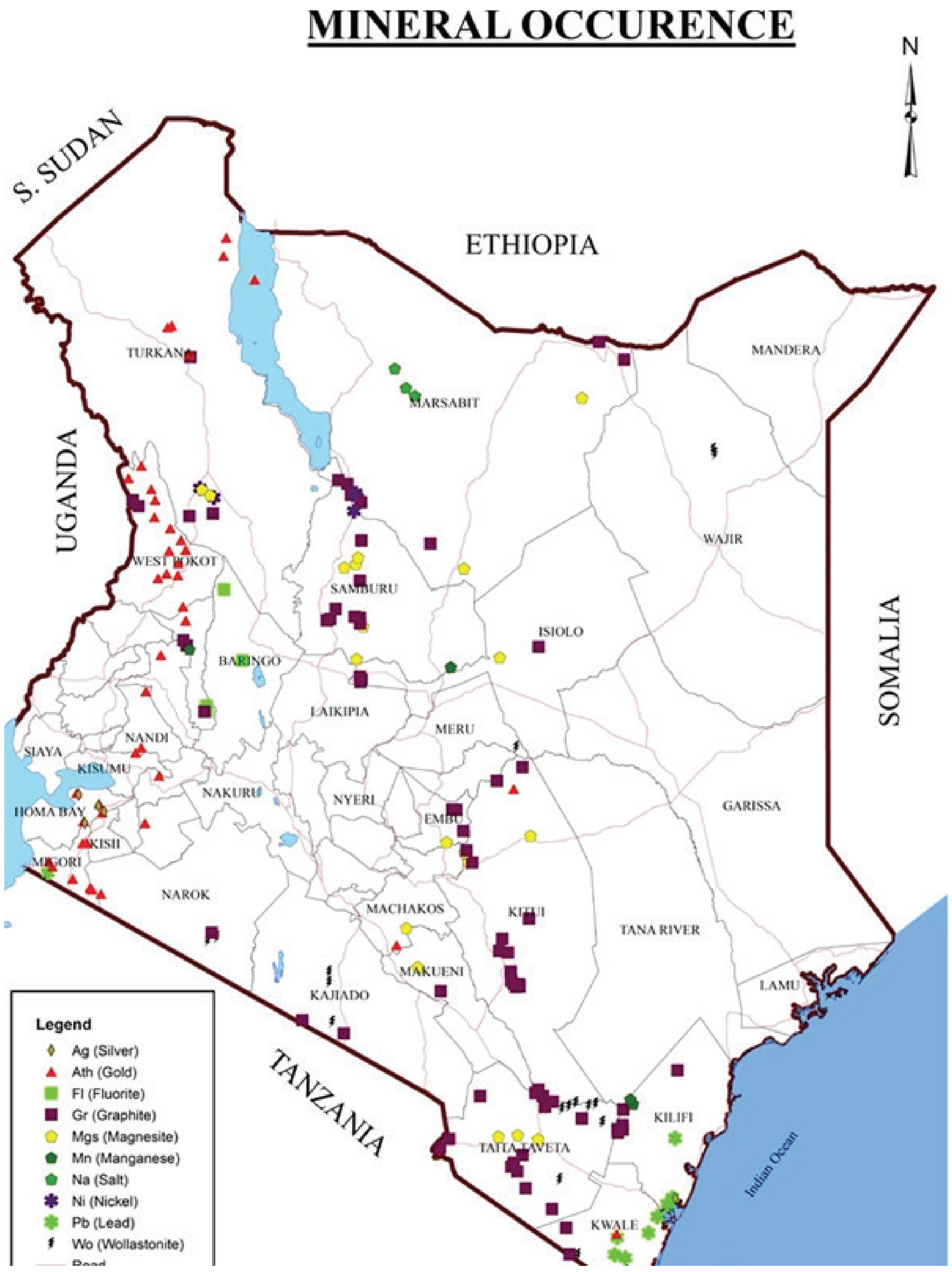


Figure 169: Mineral occurrence map of Kenya
(Source: State Department for Mining)

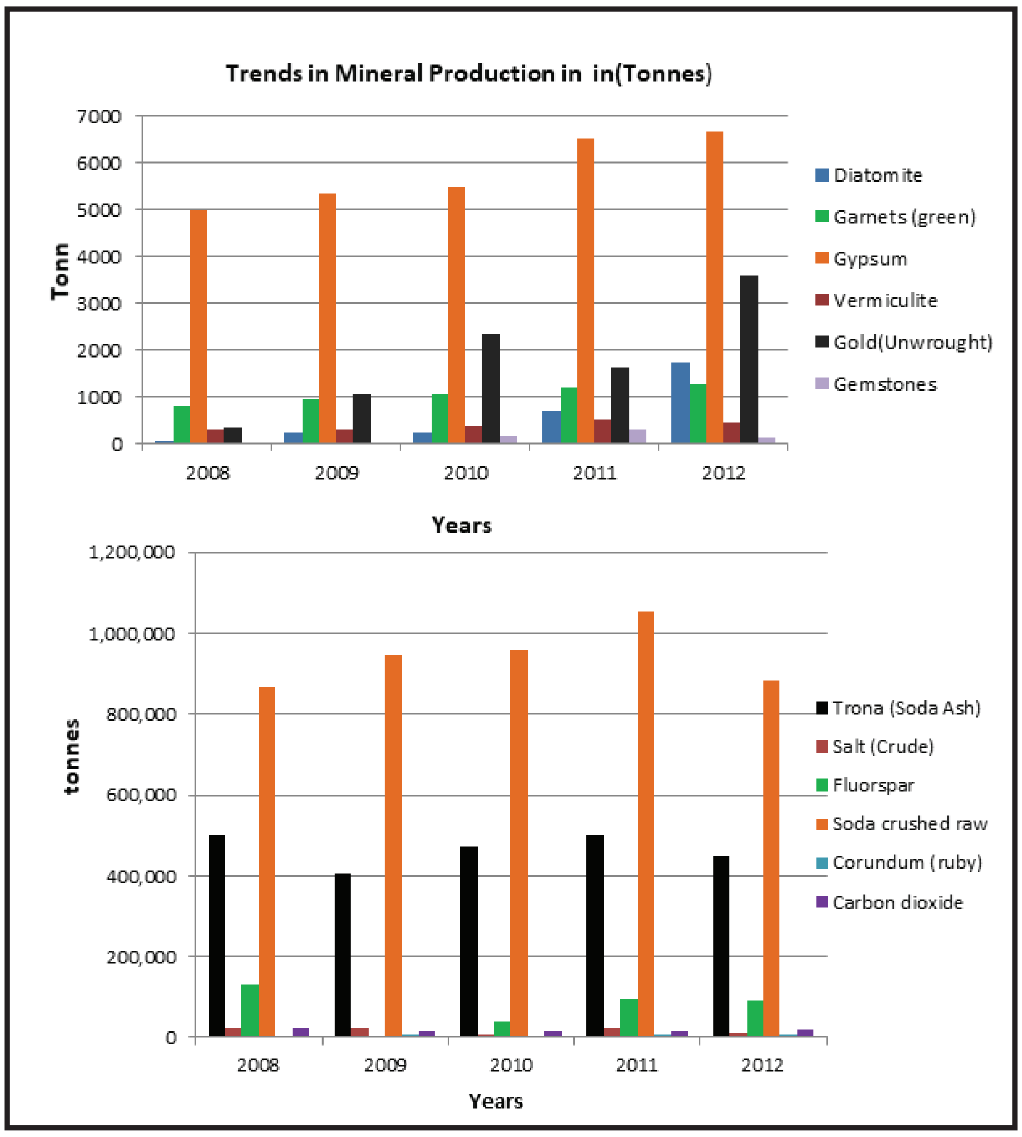


Figure 168: Trends in mineral production in tonnes
Mines and Geology Department.

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 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 areas.

Mineral Licensing and Concessions Management

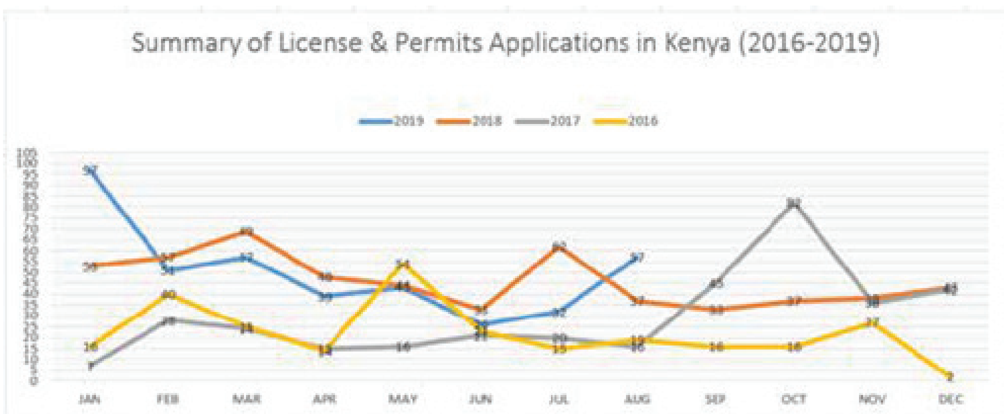


Figure 170: Summary of license & permits applications in Kenya (Source: State Department for Mining)

All licensing for minerals Rights Applications are governed by the Kenya Mining Act 2016. Mining is done on large scale or small-scale operations. Table 75 provides a summary of the various types of licenses and permits issued by the State Department for Mining btween 2016 and 2019. A moratorium on issuance of new licenses has in force from the year 2019 to date (2023). For major mining operations, licenses are required, while for small-scale operations, only permits are required.

The Online Mining Cadastre System

The goal of the Mining Cadastre Portal is to provide an electronic platform for all stakeholders in the mining sector in Kenya to engage directly with the Ministry of Mining, Blue Economy and Maritime Affairs. Before using the Mining Cadaste Portal, an applicant must first Register for access.

Existing mineral rights holders

If you already hold mineral rights, or have a pending application for them, you are required to download and complete the MCP01 Registration Form and submit it, along with supporting documents, to the Mining Cadastre Office, Madini House, Nairobi.

Prospective rights applicants

Those who don't already hold mineral rights in Kenya, are required to use the Self Registration online form to submit their particulars and supporting documents through the portal.

Registering for Mineral Right applications (and do not hold any licences or permits)

Individuals or companies who do not already have licences or applications may register online for access to the Mining Cadastre Portal. The application must be accompanied by the following documents, in digital form, which will be uploaded on the self-registration page:

1. Proof of identity (National Identity Card / Passport)
2. If an employee or agent, a Letter of Authority signed by a company director authorising the individual to act on behalf of the company or person.
3. A user profile will be automatically created in the Mining Cadastre Portal and an email sent to the user's registered email address with a link to set a password for the first time.
4. The Ministry of Mining will then verify the submitted documents and application, and if no problems are detected, an email will be sent to the applicant confirming their successful registration.

Mineral Dealing licence applications

Both holders of existing Mineral Dealer licences and those wishing to apply for the first time must register online for access to the Mining Cadastre Portal. The application must be accompanied by the following documents, in digital form, which will be uploaded on the self-registration page:

1. Proof of identity (National Identity Card / Passport)
2. If an employee or agent, a Letter of Authority signed by a company director authorising the individual to act on behalf of the company or person.
3. A user profile will be automatically created in the Mining Cadastre Portal and an email sent to the user's registered email address with a link to set a password for the first time.
4. The Ministry of Mining will then verify the submitted documents and application, and if no problems are detected, an email will be sent to the applicant confirming their successful registration

Explosives Licence or Permit applications

Both holders of existing Explosives licences/permits and those wishing to apply for the first time must register online for access to the Mining Cadastre Portal. The application must be accompanied by the following documents, in digital form, which will be uploaded on the self-registration page:

1. Proof of identity (National Identity Card / Passport)
2. If an employee or agent, a Letter of Authority signed by a company director authorising the individual to act on behalf of the company or person.
3. A user profile will be automatically created in the Mining Cadastre Portal and an email sent to the user's registered email address with a link to set a password for the first time.
4. The Ministry of Mining will then verify the submitted documents and application, and if no problems are detected, an email will be sent to the applicant confirming their successful registration.

Role of county governments in mining

Whereas the mining function is not devolved, county governments have an important role in the mining sector. One of the most important roles the county governments play in concession management is providing acces consents to mineral rights applicants for land under their jurisdiction (un-adjudicated trust land). County governments also may submit comments, including any objections to a mineral rights application within 21 days in case of Prospecting Licence and 42 days in case of Mining Licence. The Cabinet Secretary thereafter involves the parties in determining the dispute through the Mineral Rights Board.

County governments also give their views during the Environmental Impact Assessment (EIA) process for exploration and mining projects. They also monitor environmental impacts from exploration and mining activities and raise any concerns for redress.

The Cabinet Secretary for Mining is manadated to delineate areas to be gazette as exclusive artisanal mining zones. County governments are involved in identification of these areas to be set apart apart for artisanal mining. County governments also promote artisanal mining in the counties and communities. Also, the representative of the Governor is to be the Chairperson of the County Artisanal Mining Committee.

During post mine closure county governments benefit from future use of land and mine facilities left behind after mining projects. This process is determined through a multi-stakeholder process – involving regulatory agencies, county governments and local communities. Also reclaimed land – forestry, farming, reservoirs (quarries), tourism attraction, mine water supply – as community water projects and irrigation of reclaimed land as well as power supply, post mine industrial use of mine buildings as warehouses, factories, institutions, hostels and hotels.

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 76: *Royalty rates for various minerals (Source: State Department for Mining)*

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 77: *Licenses and permits categories for mineral operations in Kenya (State Department for Mining)*

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	10% of the gross sale value		
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	5% of the gross sale value		
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			

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 prevent the perils and to improve the safety standards of the miners. Small-scale mining popularly known as artisanal mining deplete environmental resources such soil, landscape, vegetation, the ecosystem and water among others. Additionally, human displacement occurs whenever there is expansion or new discovery of mines. This may also lead to migration into the mining areas. Mining areas also become hot spots of sexually transmitted diseases 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).

Post Mining Land Use

The holder of a permit or licence under the Mining Act 2016 shall use the land in accordance with the terms of the permit or licence which are given in section 179. Further PMLU guidelines are provided in the Environmental Impact Assessment Environmental Management Plan which includes decommissioning and rehabilitation. Refer to EMCA 1999 (Revised 2015) Part IV, Section 58.

Recommendations

1. Kenya is still underexplored in terms of mineral resource potential.

There is need to increase mineral exploration spend, both by the government and the private sector. The recently completed Joint Nationwide Airborne Maping (JNAM) project has provided geophysical data that will make a major contribution to the improvement of our knowledge of the mineral potential of the country

2. Access to land for exploration and mining purposes is currently one of the main challenges facing the development of mining sector. There is need to harmonise and simplify the consent acquisition process by mineral rights applicants

KEY MESSAGE

Mineral resources, well managed and equitably allocated have the potential of transforming the development path of our country in general and lives of mining communities in particular. 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. Current project pipeline is limited, but there is significant potential to increase the size of the sector by focusing on capturing the most attractive opportunities.

Plate 101: Open cast mining at Kilimapesa gold mine in Narok county (C. Odhiambo, 2023)

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 dean and secure environment." Kenya considers access to competitively-priced, reliable, quality, safe, and sustainable energy as an essential ingredient for the country's socioeconomic 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 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 show that these areas can support commercial electricity generation as they enjoy wind speeds ranging from 8 to 14 meters 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.' The coal has been analyzed and found to range in rank from lignite to sub-bituminous with calorific values ranging from 16to

27 MJ/kg.

Electricity Generation trends

Kenya continues to record an upward trend in demand with peak demand increasing from1,656MW in FY 2016/17 to 1,993.5MW in FY 2020/21. A new peak of 2036MW was recorded in November 2021. The trend in peak demand for the period 2016/17-2020/21 is shown below.

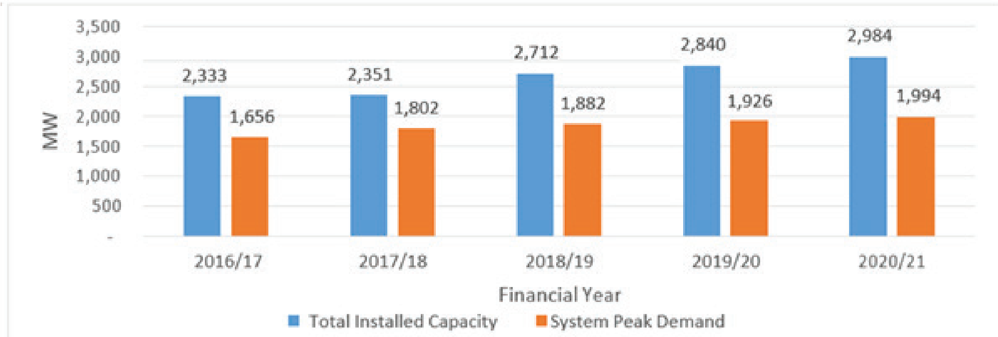


Figure 171: Trend in peak demand for the period 2016/17-2020/21

Source: LCDP Report 2022-2041

Trends in demand

Electricity peak demand grew to 2,149MW as of December 2022 from the recorded peak of 2036MW in 2021 representing a 4.3% growth. In the FY 2021/22, electricity sales grew to 9,813 GWh from 9,203 GWh in 2020/21, a 6.6% growth which is the highest in the last seven years. The energy purchased growth was 4.56% in FY 2021/22, which is a reduction from 5.57% recorded in FY 2020/21 as shown in Figure 171.

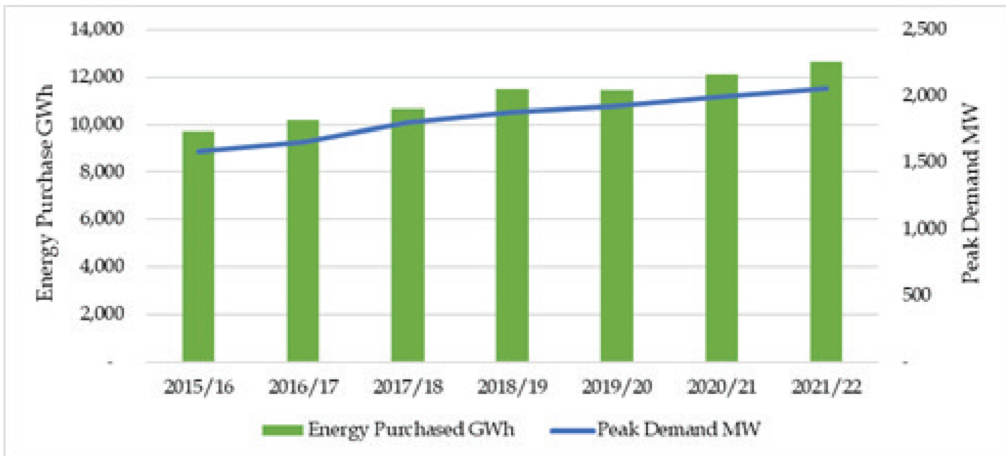


Figure 172: Peak Demand and Energy Purchased trends 2015/16 to 2021/22

There was an increase of 6.6% in electricity consumption in FY 2021/22, which signifies a robust growth in the local economy that has fully recovered from the COVID-19 pandemic shocks. The number of customers connected to the national grid grew to 8,919,440 from 8,278,203 in 2020/21, a 7.7% growth. This growth was primarily due to targeted Government interventions towards universal access by 2026

Demand forecasting

Electricity plays an essential role in modern life and is utilized in various sectors for economic development. Over the past 20 years, electricity consumption in Kenya has grown two and a half times the level in 2001 to 9,203 GWh in 2021.

Demand forecasting involves the application of various indicators namely: electricity consumer behavior, population growth, identified government priority projects, and the national Gross Domestic Product (GDP) in the forecasting model.

Electricity peak demand has been growing gradually over the past ten years with an average annual growth rate of 4.7%. In the period, energy purchased has grown at an annual average rate of 4.5% to 12,101GWh as shown in Figure 172.

Transmission and Distribution

The total length of the transmission and distribution network increased from 213,582 kilometers to 255,581 kilometers between FY 2016/17 and 2020/21. This growth is attributed to the Government's continued effort to strengthen and expand the transmission and distribution network. Table 77 provides a breakdown of lengths for different voltage levels over the past five years.

The total transmission network (400kV, 220kV, 132kV) as of 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 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 intending to attain universal electricity connections. In addition, the sector is implementing projects and programs aimed at reducing system losses and improving system reliability.

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 of 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 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 intending to attain universal electricity connections. In addition, the sector is implementing projects and programs aimed at reducing system losses and improving system reliability.

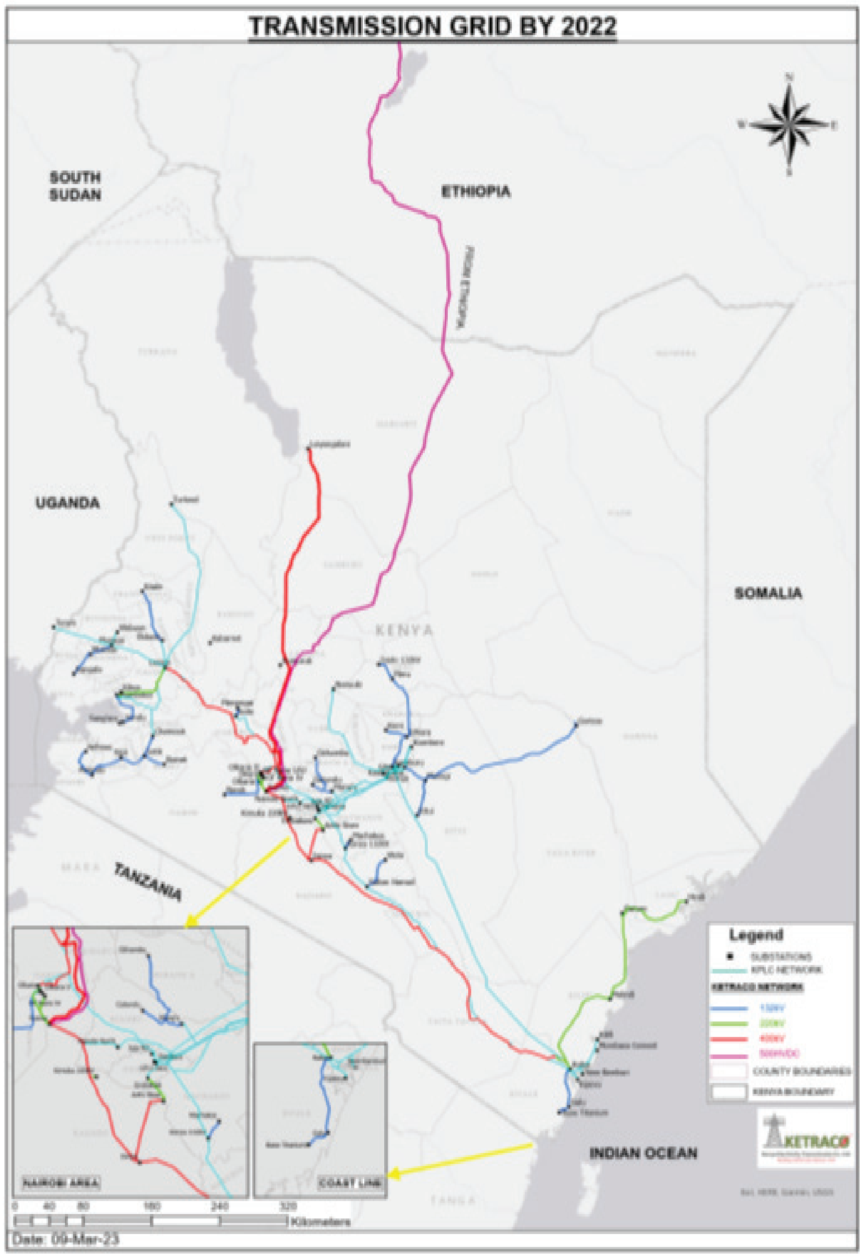


Figure 173: Transmission grid by 2022
Source: LCDP 2022-2041

Sources of Energy in Kenya

By June 2022, the capacity mix comprised 25.5% of hydro, 20.67% fossil fuels, 28.04% geothermal, waste to heat 2.45%, wind 12.82%, solar 7.83%, and bio-energy 2.69%. This capacity includes 280.76 of captive power generation approved by EPRA. Kenya's current effective installed (grid-connected) electricity capacity is 3322 MW as depicted in Table 78.

The generation mix comprises Hydro, Geothermal, Wind Thermal, Solar, Biomass, and Off Grid as shown in the table below

Table 78: *Sources of energy*

	Installed	Captive power licensees	Total	Share
Hydro	838.5	29.04	867.54	25.50%
Geothermal	950	3.7	953.7	28.04%
Thermal	681.9	21.33	703.23	20.67%
Wind	436.1	-	436.1	12.82%
Solar	212.6	53.71	266.31	7.83%
Bioenergy	2	89.48	91.48	2.69%
Imports	200	-	200	-
Waste Heat	-	83.5	83.5	2.45%
Total	3,322	280.76	3,601.76	100.00%

Source: EPRA

Electricity market share

KenGen, which is the largest power generator in the country currently, accounts for 1944MW of installed capacity with a further 50MW of capacity installed by REREC at Garissa Solar. The Independent Power Producers (IPPs) account for 1,128MW of capacity with a further 200MW being imported from Ethiopia. Isolated grid generation under the Rural Electrification Programme (REP), implemented by REREC (formerly REA), accounts for less than 1%. Figure 174 represents the capacity share between IPPs and public institutions (including imports).

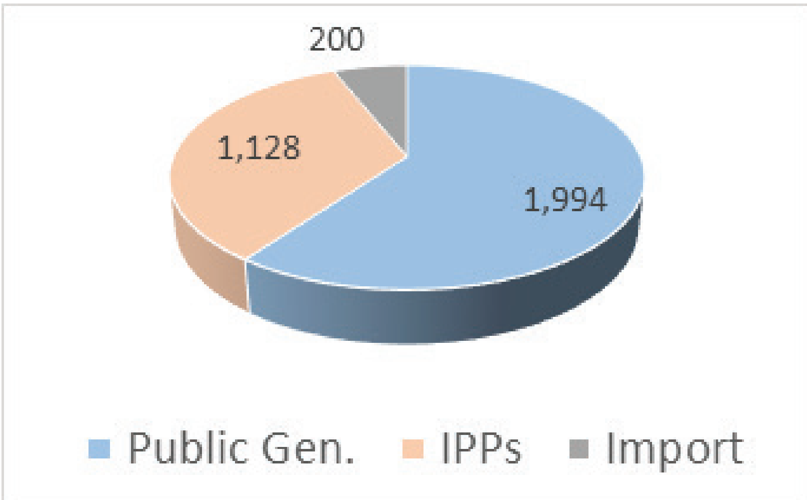


Figure 174: Capacity share between IPPs and public institutions
Source: EPRA

Geothermal Energy

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

Currently, geothermal 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

Geothermal Development in Kenya

Exploration for geothermal resources in Kenya started in the 1950s and gained momentum in the 1960s 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 01karia. The studies identified Olkaria as the most prospective area Leading to the construction of the first geothermal power station between 1981and 1984.

(Source : KenGen,2019)

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 harnessed for water heating and electricity generation for households and telecommunications facilities in isolated locations.

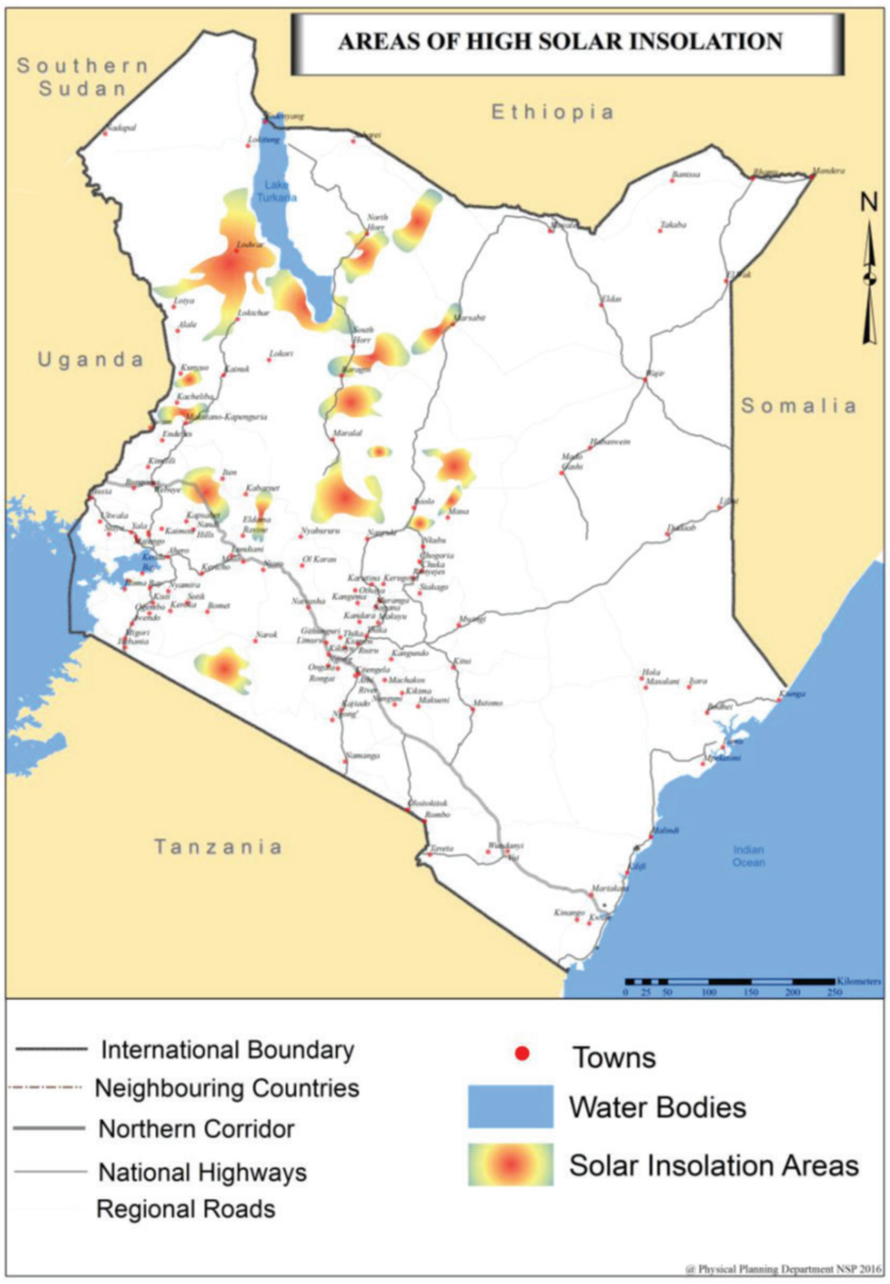


Figure 175: Areas of high solar insolation

Plate 102: Solar wind farm in Eldoret

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. The total installed large hydropower capacity as of June 2022 was 838 MW. Kenya has an estimated small hydropower potential of 3,000 MW which remains unexploited.

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 (22SMW), Kindaruma (72MW), Kiambere (168MW), Tana (20MW), Wanjii (7.40MW), Sagana (l.SMW) and Mesco (0.43MW), Sondu Miriu (60MW), Turkwel (106MW), Sangoro (21MW), Gogo (2MW) and

Sosiani(0.4MW) (Source: KenGen,2019).

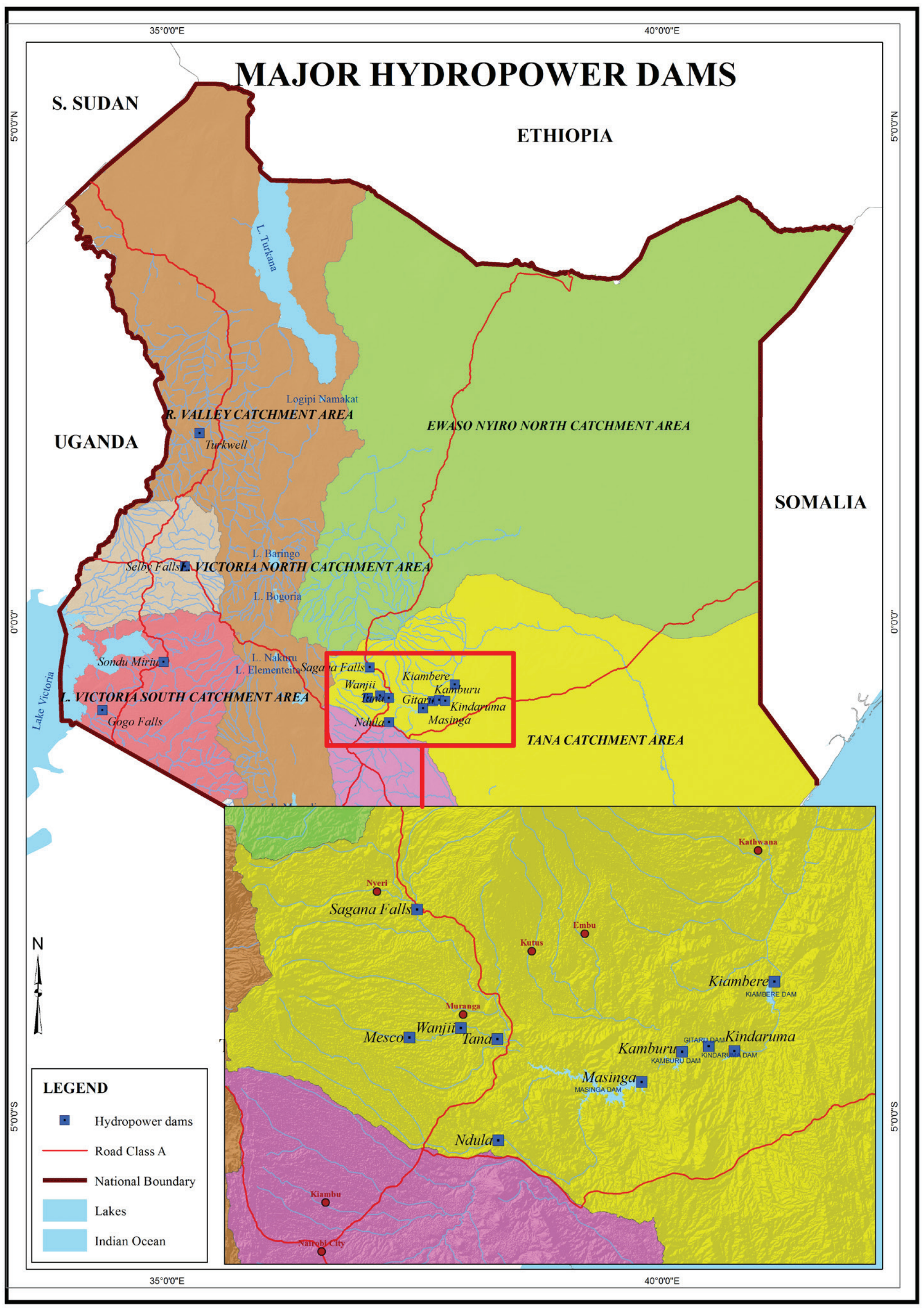


Figure 176: Major hydropower dams

Wind power or wind energy is the use of air flow through wind turbines to generate electricity. Wind power is a sustainable 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 100 meters above ground level. Of this, 28,228 sq. km experiences wind speeds of between 7.5 – 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 435.5 MW. 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 have also installed 310MW and 100MW respectively of reliable, low-cost wind power to the Kenya national grid. The wind farm site is located in Loiyangalani, Marsabit County. The Best wind sites in Kenya are located in Marsabit, Samburu, Laikipia, Meru, Nyeri Nyandarua, and Kajiado counties. Other areas of interest are Lamu, offshore Malindi, Loitokitok at the foot of Kilimanjaro, and Narok plateau. On average the 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 northern 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 mean annual wind speed of 9.27m/s and minimum 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 underdeveloped, yet they support the energy needs of the people of Kenya.

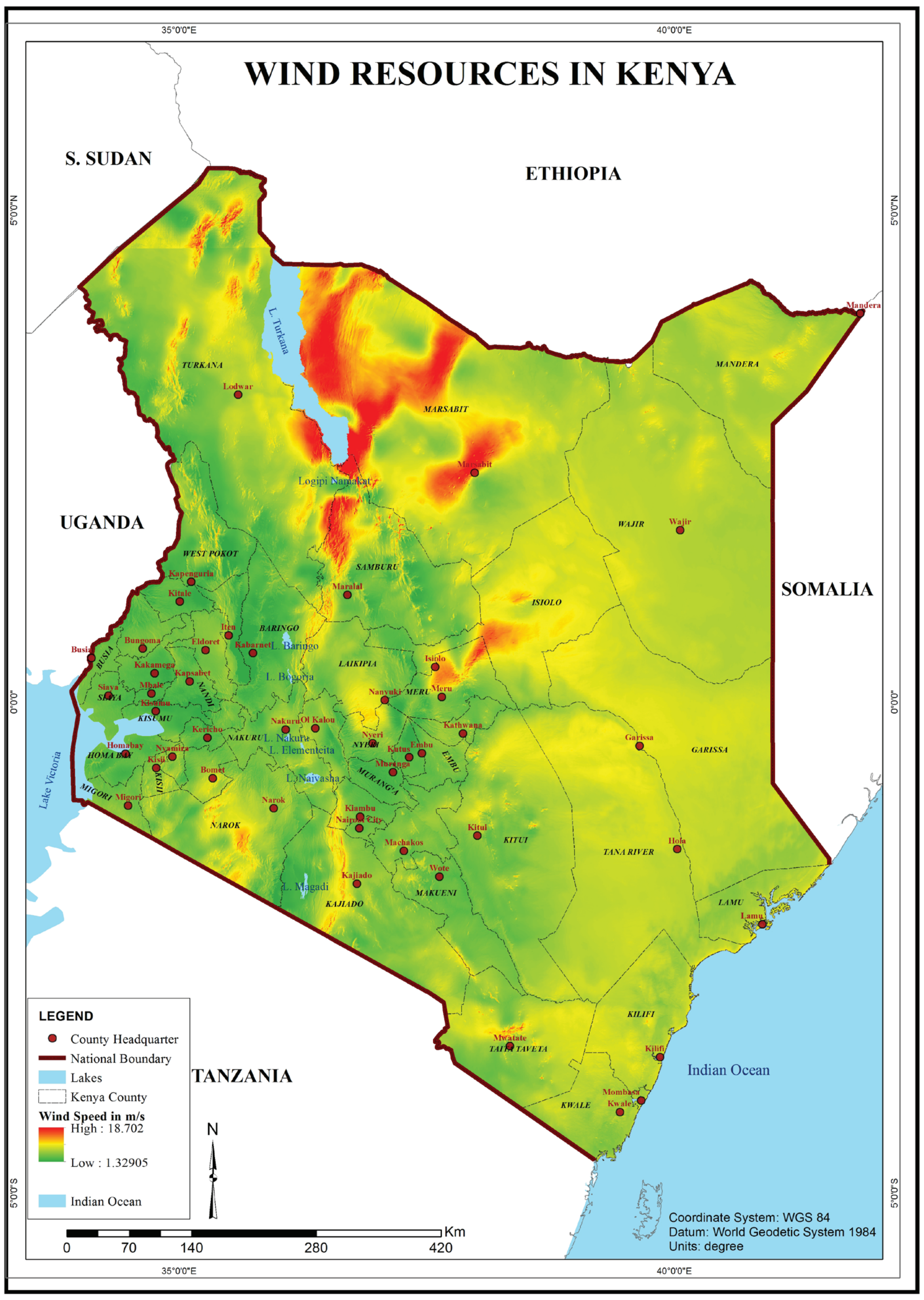


Figure 177: Wind resources in Kenya

Table 79: *Hydropower potential by catchment areas*

Catchment area	Area (Km2)	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

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 with challenges in opposition to its use due to strong environmental impacts namely pollution due to the emission of sulphur dioxide, and release of heavy metals, and the production of greenhouse gases

In Kenya, local coal reserves of a substantial depth of up to 27 meters have 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.).

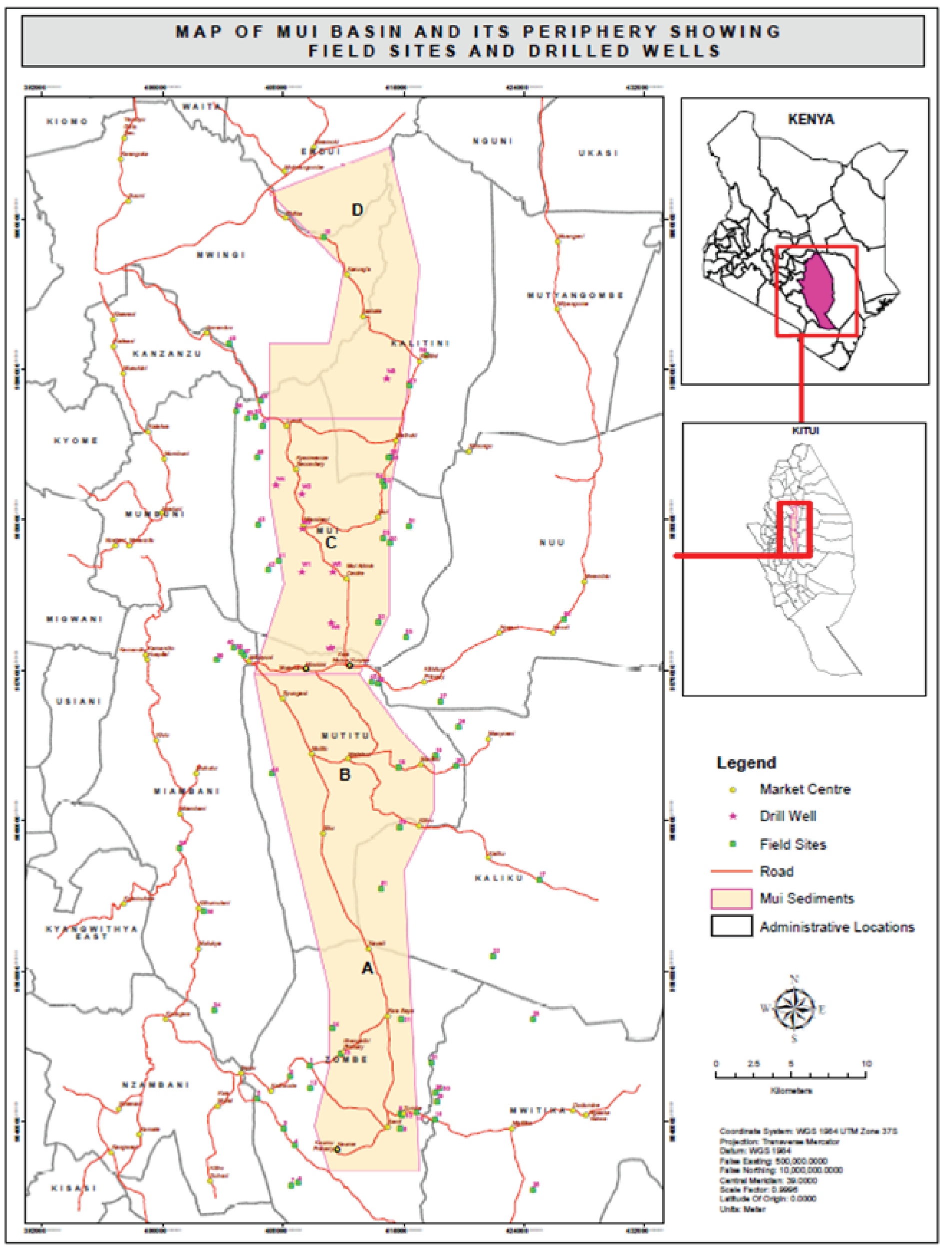


Figure 178: Map of Mui basin and its periphery showing field sites and drilled wells

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.

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 northeastern Kenya. An appraisal plan to follow up on 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 is 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 a 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

Biomass is flexible renewable energy from sources such as wood and wood residues, 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 in 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 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 separately 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. Currently, Nairobi County is exploring the generation of Municipal waste from the Dandora dump site.

Energy Transition

According to the World Bank, only 71% of Kenyan households had access to electricity by 2020, against a global average of 90%. With 29% of the Kenyan population not connected to electricity, this means difficulties in basic needs like lighting and more use of carbon-emitting fuels like firewood and charcoal. An important recall is that the country's goal is to attain 100% access to electricity for all households by 2030. However, the fundamental issue is the source of our electricity generation and how clean it is concerning carbon emissions.

According to the Ministry of Energy and Petroleum, 73% of our electricity is generated from clean, renewable sources, mainly hydro and geothermal. This is significantly higher than most Western countries, with the United States of America at 20%, the United Kingdom at 50%, and China at 48% as of 2021. However, about 29% of Kenya's electricity comes from diesel-powered generators, which the country plans to reduce to zero by 2030 by upscaling geothermal, solar, and wind as clean power sources.

National Climate Change Policy and Energy

Kenya has developed a National Climate Change Action Plan To further Kenya's sustainable development by providing mechanisms and measures to achieve low carbon climate resilient development in a manner that prioritizes adaptation. Ensure an electricity supply mix based mainly on renewable energy, an electricity system that is resilient to climate change promotes energy efficiency, and encourages the transition to clean cooking.

i. Promote clean, affordable, and quality alternative renewable energy sources.
ii. Enhance electricity network expansion and improvement, as well as electricity access in grid and non-grid areas.
iii. Promote clean cooking fuels and technologies.
iv. Promote geothermal energy for alternative (direct) uses.
v. Climate-proof energy infrastructure

This National Climate Change Action Plan 2023- 2027 (NCCAP 2023-2027) presents the detailed priority actions that Kenya will embark on to address climate change during the 2023-2027 medium-term planning period. These actions aim to address the impacts of climate change, which include increased frequency and magnitude of extreme weather events in Kenya Increasing energy efficiency could likewise reduce sector emissions by 10% by 2030, compared to business-as-usual. A complete transition to 100% renewable electricity by 2030 will contribute an additional 24% to building sector emissions reductions compared to business-as-usual.

This long-term strategy (LTS) sets out Kenya's strategy to realize a fair and cost-effective course for ensuring a transition towards a competitive, resilient, and carbon-neutral economy by 2050.

Despite its negligible share of global emissions, Kenya is committed to decarbonizing key economic sectors in pursuit of net zero. Kenya will target becoming a net zero economy by 2050. This builds upon her previous commitments to achieve a 32% reduction in emissions against BAU by 2030, as set out in the December 2020 updated NDC.

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; and 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 the 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, concerning 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 to establish a durable and sustainable system of development including water protection, secure 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.

Concerning 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.

The Energy Act spells out how the licensee shall pay a royalty on the value of Royalty. at the wellhead of the geothermal resources extracted.

Challenges in the energy sector

i. Lack of clear and agreeable formula for benefit sharing between the national government, county government, and local community.

ii. Land access for the development of renewable energy and way leaves for the transmission lines

iii. High upfront investment costs in the exploration and development of energy resources

iv. The relatively long lead time of between 5-7 years from conception to production of electricity

v. Heavy investment in transmission and other support infrastructure due to long distances to existing load centers.

vi. Land and water use conflict.

vii. Climate change impacts on hydropower development

viii. Community conflict in terms of relocation and resettlement of affected persons to create room for the construction

ix. Weak enforcement of the legal and regulatory framework for sustainable production, distribution and marketing of biomass.

x. Issues of Biodiversity threats in potential areas for energy resources like wind, hydro and geothermal plants

xi. Inadequate R&D in renewable energy technologies

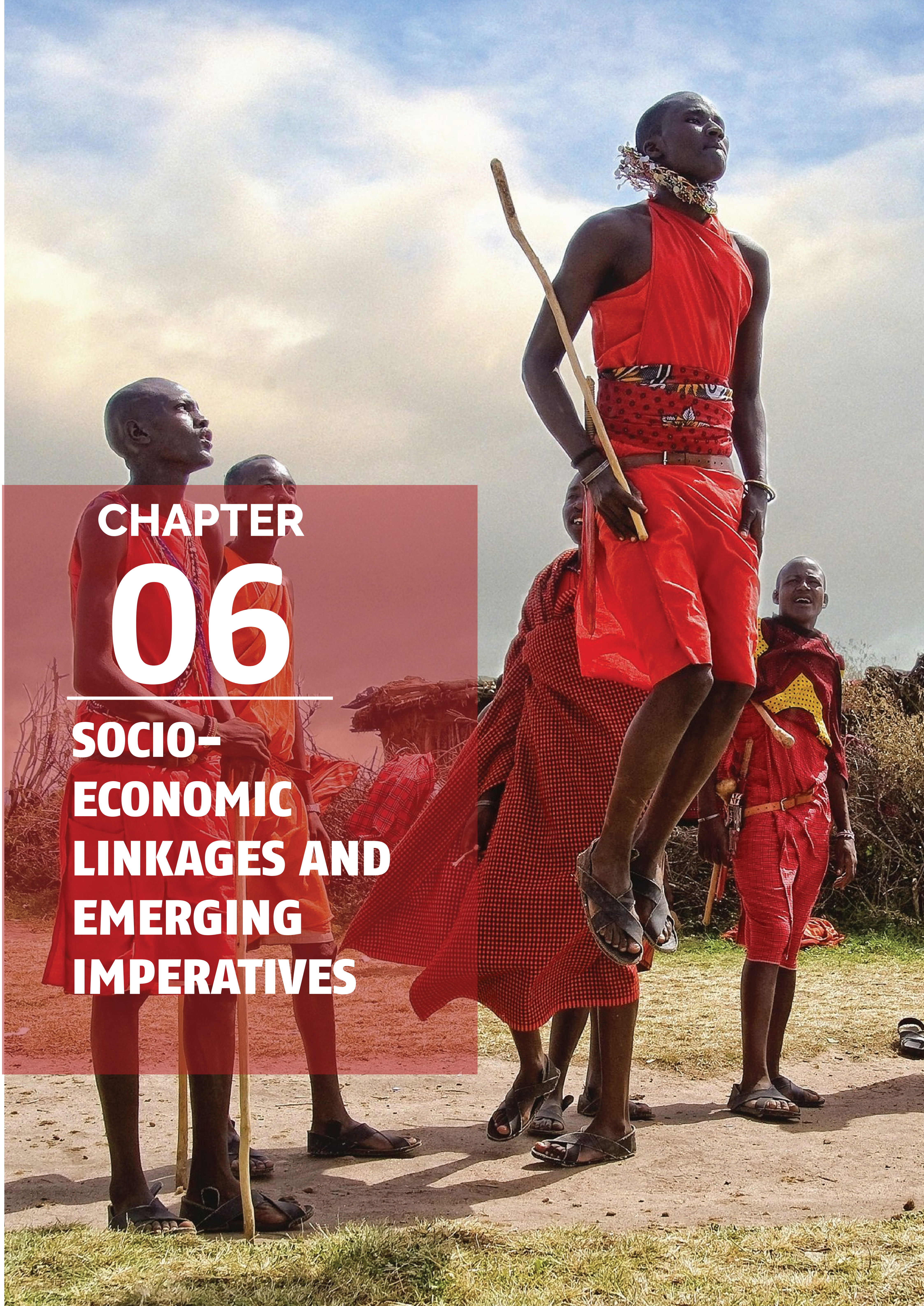
xii. Lack of a framework for management of cross-county energy resource areas

KEY MESSAGE

The energy sector plays a significant role as an enabler of socio-economic development by providing secure, affordable, and reliable energy at the least cost geared to meet national and county needs while protecting and conserving the environment. Access to electricity rose considerably over the last 10 years, from approximately 30% in 2012 to above 70% in 2021, mainly through initiatives by the Government in special projects including the Last Mile Electricity Connectivity Project, GPOBA, and enhanced street lighting. The Big 4 Agenda initiative by Government in 2017, identified manufacturing, universal healthcare, food security, and affordable housing as high-priority areas of focus to strengthen the economy, progress industrialization and create jobs as earlier envisioned in the Vision 2030 national economic blueprint.

In Article 5 of the Energy Act, 2019, the Cabinet Secretary in charge of Energy, in consultation with other relevant stakeholders, is required to develop, publish, and review the Integrated National Energy Plan (INEP) concerning coal, renewable energy, and electricity through consolidation of National Energy Services Provider plans and County Government plans to ensure delivery of reliable energy.

The development of an Integrated National Energy Plan framework has been necessitated by the requirement in Section 5 of the Energy Act, 2019. The framework will be the basis for the development of INEP and will also facilitate the development of energy plans. The framework sets out coherent and systematic guidelines to facilitate the development of energy plans by the Ministry of Energy (MoE), National Energy Service Providers, and County Governments that will eventually feed into the development of INEP as envisioned in the Act.



CHAPTER

06

SOCIO-ECONOMIC LINKAGES AND EMERGING IMPERATIVES

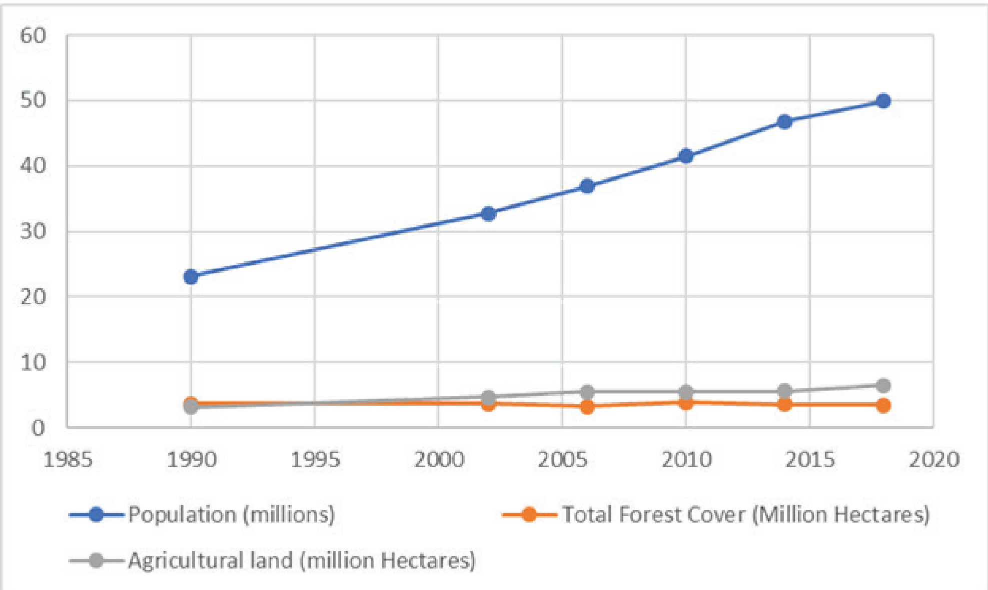
People's livelihoods are intimately linked to the natural resources within territories and even beyond. Natural resources constitute a fundamental and integral beacon for people's survival and well-being, especially in the current context of changing climatic regimes. Socio-cultural practices, beliefs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

Kenya, has 46 officially recognized ethnic communities (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 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.

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 has 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 time are more exposed to natural disasters. Poverty- environment-health linkages must be buttressed in the context of natural resource management agenda.

Table 81: *capacity share between IPPs and public institutions*



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 an urgent need for deliberate policy action in relation to social inclusion on maters land and natural resources.

Kenya Population and Housing Census (2019) report 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, namely the elderly and children, in sustainable land management and conservation practices.

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 such as a 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 negotiations, burials, 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 animal skins and hides, twigs, sisal, among others. Other communities use forests, caves 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 live around gazzetted forests and water towers such as Mt. Elgon, Mt. Kenya, Aberdare (locally known as Nyandarua) 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.

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 in the UNESCO World Heritage Sites enhances their protection and sustained conservation.

Of the rich cultural heritage in Kenya seven have been inscribed in the UNESCO World Heritage List (Fort Jesus, Lake Turkana National Parks, Mount Kenya National Park and Forest, Lamu Old Town, The Sacred Mijikenda Kaya Forests, The Kenya Lake System in the Great Rift Valley and Thimlich Ohinga Cultural landscape). In addition five Intangible Cultural Heritage (ICH) of some communities have also been inscribed (insikuti dance of the Isukha and Idakho of western kenya, Enkipaata (Plate 103), Eunoto and Olng' esher male initiation ceremonies of the Maasai., rituals and practices associated with Kit Mikayi shrine and success stories promoting food and safeguarding traditional foodways of Kenya.

Additionally, there are other sites on the tentative World Heritage list (including Gede national monument), and 400 gazetted sites and monuments. Many world-famous sites such as Olorgesailie, Enkapune ya Muto, Lomekwi and Gede have produced unique artefacts that significantly contribute to our understanding of human evolution and technological development. These cultural heritage resources are largely conserved for recreation, education and research.

Plate 103: 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 makaya, of the Mijikenda people. The makaya (singular, kaya), created in the 16th century for the Nine Villages' during their migration from Somalia 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 in the UNESCO World Heritage List in 2008. The Coastal Forest Conservation unit (CFCU) was constituted by NMK to oversee the conservation efforts of these sacred forests. They represent more than thirty surviving Kayas, which began to fall out of use in the early 20th century.(Plates 104-107)

Plate 104: Kaya – Mijikenda Sacred Forest Photo courtesy of NMK

Plate 105: Kaya Kambe Sacred Forest /Photo courtesy of NMK

Plate 106: Kaya Bomu Sacred Site/ Photo courtesy of NMK

Plate 107: Kaya elder inspects memorial posts 'Vigango' at Kaya Kauma/ Photo courtesy of NMK

Kaldera Island

The El Molo, one of Kenya's smallest communities, treasure 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 droughts and more 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 hardly desecrate it even in times of conflict(Plate 108).

Plate 108: Kaldera Island on Lake Turkana /Photo courtesy of NMK

Gede National Monument

Gede contains the remains of a typical ancient Swahili Town, dating to the twelfth century but was rebuilt with new town walls in the fifteenth and sixteenth centuries, by which time it is thought to have accommodated 2,500 inhabitants. Located in Kilifi County, Gede lies 16km south of Malindi Town. Gede's wealth is evidenced by the presence of a conglomeration of mosques; a magnificent palace and houses all within in its 45 acre space with primeval forest. By the first half of the seventeenth century, however, the town was abandoned due to the drying up of its wells, Wazimba raid in 1589 and the removal of the Sheikh of Malindi and the Portuguese to Mombasa in 1593 as well as threats from the pastoral Oromo.

Gazetted as a historical monument in 1927, Gede was declared a protected monument in 1929 and a National Park in 1948, by which time a Warden was appointed (Plate 109). In 1969, the Museum Trustees took over its administration and todate the Monument remains under the care of the National Museums of Kenya. Gede is not only an important archaeological site, its indigenous forest remaons sacred to the surrounding community, who use it for their traditional rituals and sacrifices. It is an important site for research and tourism owing to its amazing ruins and wildlife that includes monkeys and various birds like the Turacos, Malachite Kingfishers, Paradise flycatchers and African Harrier Hawks. Gede was re-gazetted as a National Monument in 1970 and the NMK is hopeful that the monument will soon become a World Heritage Site owing to its universal value and authenticity and its inclusion in UNESCO's Tentative List

Plate 109: Gede National Monument/Photo courtesy of NMK

Vasco da Gama Pillar (Padrao)

The Portuguese brought pillars (or padraos) (Plate 110) with them in their trade explorations and placed them at prominent points, which they then claimed as belonging to Portugal. Of different shapes and sizes, all these collums with cosses bore the coat of arms of Portugal. Wherever the explorers landed on the African coast, they erected such columns in prominent spots on the shoreline using local stones or mortar carried on board their ships. Each column was topped by a Cross. The Malindi padrão is the only surviving such pillar erected along the African coastline in its original location. The pillar symbolises many things to different people. The Mijikenda, consider it a symbol of a curse that brought poverty and exploitation. To Christians, the pillar represents spiritual inspiration. Others see Vasco da Gama as the father of globalisation and the pillar as a tourist attraction.

When the Portuguese explorer, Vasco da Gama, landed in the harbour of Mombasa on 7 April 1498 on his way to India, the Arabs in Mombasa did not welcome him and attempted to sink his ships. The hostility prompted him to sail northwards, arriving in Malindi on 14 April 1498. The Sheikh of Malindi, welcomed da Gama and his entourage, giving them fresh water and food. The Sheikh gave da Gama a pilot sailor, Ibn Majid, to guide him to India. On his return from India in 1499 – da Gama built the pillar, now known as Vasco da Gama's Cross, or the Padrao. It consists of a cross and the Portuguese coat of arms. Initially built next to the Malindi Sheikh's Palace, in 1512 the Padrao was moved to the seafront. Vasco da Gama explained to the Sheikh that the pillar marked his successful discovery of the sea-route to India. It also gives sailing directions – India is to the east, and Malindi to the west of the pillar. The Sheikh allowed da Gama to set up the pillar further away from his palace as it was an evident mark of Christendom and by 1512 the Portuguese had made Malindi their northern headquarters. Today, the pillar is visible from far away in the high sea, serving as a sailing control tower, even without any light on it. It is one of the oldest European monuments in Africa.

The Pillar was gazetted monument in 1935 and is currently under the National Museums of Kenya. It is one of the historical attractions at the Kenyan Coast and is popular with local and foreign tourists, researchers, teachers and students who visit the site every year. However, today the monument faces severe threats from the rising sea level as result of climate change. The NMK has carried out restoration measures to forestall the eroding headland on which the Pillar stands by reinforcing the existing sea wall, paved the once sandy access road with cabro blocks and built an ablution block within reachable distance to enhance tourist/visitor experience at the monument

Plate 110: The Padrao in Malindi/Photo courtesy of NMK

Krapf Memorial Monument, Rabai

This monument monument lies at Mkomani in Nyali Sub-County, Mombasa as a historical testimony (the cradle) of Christianity in East and Central Africa (plate 111). The monument is named after Rev. Dr, Johann Ludwig Krapf (11 January 1810 – 26 November 1881), the renowned CMS (Church Mission Society) missionary, explorer and scholar born in 1810 in Germany. Krapf studied at the famous Eberhard Karls University of Tübingen from 1829 to 1834, when he graduated.(owandwhere.co.ke/outdoorskenya/johann-ludwig-krapf-monument-of-mkomani/). The first Protestant missionary to East Africa and a pioneer in the study of East African ethnology, geography and linguistics, Krapf is celebrated today with monuments, memorials and museums. 25km north-west of Mombasa at Rabai Mpya is St. Paul's Church, built in 1846, whose architecture testifies to the British and European missionary effort. The original church building houses a small museum (established in 1994). The Rabai Missionary Cemetery is located nearby. Considered the Father of the Anglican Church in Kenya, Krapf was pivotal in the establishment of the Methodists in Kenya as well. Europeans remember him as the founder of Swahili studies for his Swahili dictionary and his name appears in African ethnology and linguistic research as well as geographical studies, where he and Johannes Rebmann are credited as the first Europeans to see the snow-capped Mt. Kilimanjaro and Mt. Kenya (http://thinkgospel.com/was-ludwig-krapf-as-monumental-as-the-monuments-suggest) His contribution in the country are enlivened since the Memorial's unveiling in 1849 (Ngurumi , 2016)

Krapf arrived in Mombasa in 1844 with his wife, Rosine Dietrich Krapf, who gave birth to their second daughter, who, unfortunately died a few days later (that same year in July his wife also passed away). Both were buried Mkomani and their graves are directly opposite the splendid Monument, whose beautifully landscaped gardens with indigenous trees and flowers remain attractive to a variety of local as well as international visitors (https://www.facebook.com/TourismMombasa/posts/krapfs-monument-the-krapf-memorial-located-in-mkomani-nyali-sub-county-mombasa-w/1278836718952631/). The Krapf Memorial Museum gives recollections of monumental events that happened during the advent of early missionaries and are told nostalgically today. Krapf also played a major role in emancipation of slaves in East Africa.

Ngurumi, Andrew Waithumbi (2016). Conservation of Monuments in Kenya: A Case for a Living Heritage Approach in Heritage Legislation. LL.B Dissertation, Strathmore University.

Plate 111: Krapf Merorial monument, Rabai

Mnarani National Monument

Located on a step, overlooking the Kilifi creek, Mnarani is a fascinating historical and archaeological site (plate 112). Mnarani is a Swahili site founded in the early 14th Century. Mnarani is derived from the Swahili word, 'Mnara'. meaning a minaret or pillar. Its unique octagonal pillar has grown to engulf the whole of the immediate town 'Mnarani'. Archaeological research indicates that the site had some settlement until the late 17th Century when it was completely abandoned, most probably due to the drying up of the wells. However, the history of Mnarani ruins extends beyond the Swahili settlement as it provides a chance to learn about the major contributions made by Islam on the development of secular education and the rich cultural heritage of the local Mnarani community including the rituals performed at the great baobab tree within the site. Mnarani's amazing indigenous forest offers unique experiential opportunity within the site's cool nature trails with sounds of insects and birds. Some of the trees have high medicinal and sacred values. Mnarani Ruins were gazetted in March 1929 as "Ruins of Mnarani" and later confirmed as monuments. (https://museums.or.ke/mnarani)/

Plate 112: Mnarani National Monument, Kilifi/Photo courtesy of NMK

The Takwa national monument, with interpretive displays for the public, was opened at the beginning of 2015 (plate 113). Originally gazetted in 1982, the Takwa ruins, located in the Shela area of Lamu County, the relatively well preserved remains of a thriving 15th and 16th century Swahili trading town. The site has a unique Friday mosque with a large pillar atop the qibla wall that faces Mecca, among other notable features. The residents of Takwa abandoned the site in the 17th century due to salination of the water and endless conflict with the rival settlement of Pate (Chebet, 2015, p. 12).

Plate 113: Takwa Ruins in Lamu county/Photo courtesy of NMK

Siyu Fort

Siyu Fort is located in Pate Island in Lamu County(plate 114). Situated opposite Siyu town, some 25km to the North East of Lamu town and can be reached by boat from Lamu, up a long mangrove lined creek which is only navigable at high tide. Siyu is one of the Swahili settlements in the Lamu archipelago, dating from the 15th Century CE. The present village of Siyu is still known for its well established leather craft, including sandals, belts and stools. It became famous in the late 19th century, when it resisted Omani domination, culminating in the building of a Fort as an effort by the Omani Arabs to subdue the residents of Siyu. Apart from the impressive fort, which is open to the public, Siyu also hosts the remains of numerous magnificent tombs and mosques.

Siyu is the only town that built a fort of its own, unlike Mombasa and Lamu whose forts were built by foreigners. Tradition indicates that Siyu Fort was built by one of its leaders, Bwana Mataka (Mohammed Ishaq bin Mbarak bin Mohamed bin Oman Famau) in the 19th century to safeguard Siyu residents from Omani domination. Siyu was gazetted in 1958 as anational monument and is under the care of the National Museums of Kenya (https://museums.or.ke/siyu-fort/).

Plate 114: Siyu Fort National Monument, Pate Island, Lamu County/Photo courtesy of NMK

Lamu Old Town

Lamu Old Town is the oldest and best-preserved Swahili settlement in East Africa, retaining its traditional functions and relevance to date (Plate 115). Built-in coral stone and mangrove timber, the town is characterized by the simple structural forms enriched by courtyards, verandas, and elaborately carved wooden doors reflecting a richconfluence of Arabic, Indian and European cultures. Lamu has hosted major Muslim festivals since the 19th century and has become a significant centre for Islamic and Swahili studies. Lamu Old Town was enlisted in the UNESCO World Heritage Sites in 2001. Every November each year since 2001, Lamu has celebrated a Cultural Festival attracting over 30,000 visitors. The Lamu festival celebrates Swahili heritage born of cross-cultural influences over 1000 years. The festival is a tribute to the people of the Lamu Archipelago who have continued to ensure the survival and integrity of their culture in the face of social, economic and political changes (Chebet, 2015: 12).

Plate 115: Lamu Old Town/ Photo courtesy of NMK

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 Island, over a spur of coral rock (Plate 116- 117). 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 Arab influence. This historical site was inscribed to the UNESCO World Heritage list in 2011.

Plate 116: Fort Jesus World Heritage Site/ Photo courtesy of NMK

Plate 117: Ocean facing view of Fort Jesus World Heritage Site / Photo courtesy of NMK

Thimlich Ohinga

Thimlich Ohinga Cultural Landscape, situated in Migori County, was gazetted as a national monument in 1981 and added to the UNESCO World Heritage List in 2018 (plate 118). Thimlich Ohinga refers to a “frightening dense forest” in the Dholuo ; the Luo are a Nilotic community who occupy the Lake Vistoria region. The unique dry stone walling enclosure reaches four metres high in some sections and two metres wide covering fifty two acres of land, with smaller inner enclosures that were probably cattle kraals. The stone structure is well over 500 years old and was constructed using dry stones meticulously arranged without use of mortar. At Thimlich Ohinga three massive enclosures are interlinked: Kochieng, Kakuku and Koluoch.

Plate 118: Thimlich Ohinga World Heritage Site in Migori County/Photo courtesy of NMK

Kenyan intangible cultural heritage (ICH)

Kenya has a rich intangible cultural heritage (ICH) which have been inscribed in World Heritage List. The intangible cultural heritage elements are described herein:

Rituals and practices associated with Kit Mikayi shrine, 2019

The Rituals and practices associated with Kit Mikayi shrine concern the Luos of western Kenya. Legend has it that Kit Mikayi Shrine is associated with the good fortunes of the Seme people and other Luo ethnic communities who live around the shrine enclave. People access the shrine for many different reasons, including praying, taking oaths, undertaking rituals and associated practices, and enjoying its natural beauty. During times of catastrophe like hunger and famine, Luo elders would conduct rituals at the shrine and rain and bounty harvests would follow. Elderly men and women of excellent social standing would guide the rituals; while men would partake in activities such as slaughtering the animals, women did the singing, dancing and cooking of the foods accompanying the rituals. For generations, the community has relied on the shrine as a sacred site, where they could visit and commune with the Deity. However, the element is now threatened by various factors, including the decreased frequency of its enactment, ageing bearers and practitioners, and encroachment upon the surrounding cultural spaces. The fact that the last major rituals and practices at the shrine date back to 1987 illustrates the risk of their disappearance, with a lack of knowledge triggering a movement towards the devaluation and defilement of the shrine as a sacred space for the community.

Plate 119: Seme community elder, Benjamin Outa, saying a traditional prayer at Kit Mikayi shrineNMK 2015

Enkipaata, Eunoto and Olng'esherr, three male rites of passage of the Maasai community, 2018

Enkipaata, Eunoto and Olng'esherr are three interrelated male rites of passage of the Maasai community: Enkipaata is the induction of boys leading to initiation; Eunoto is the shaving of the morans paving the way to adulthood; and Olng'esherr is the meat-eating ceremony that marks the end of moranism and the beginning of eldership. The rites of passage are mainly practised by young Maasai men aged between fifteen and thirty, but women also undertake certain tasks. By educating young people about their future role in Maasai society, the rites serve to induct them first to moranhood, then as young elders, and finally as senior elders. Respect and responsibility, safeguarding of the lineage, transfer of powers from one age set to the next and the transmission of indigenous knowledge, such as in relation to livestock rearing, conflict management, legends, traditions and life skills, are some of the core values embedded in those rites. However, while the rites still attract relatively sizeable crowds, the practice appears to be rapidly declining due to the fast emergence of agriculture as a main source of income, reforms of the land tenure system and the impact of climate change that affects the survival of cattle.

Plate 120: Initiates heading back to the Manyatta accompanied by elders for the Enkipaata Ceremony , NMK, 2017

Isukuti dance of Isukha and Idakho communities of Western Kenya

The Isukuti dance is a traditional celebratory performance practised among the Isukha and Idakho communities of Western Kenya. It takes the form of a fast-paced, energetic and passionate dance accompanied by drumming and singing. An integral tool for cultural transmission and harmonious coexistence between families and communities, it permeates most occasions and stages in life including childbirths, initiations, weddings, funerals, commemorations, inaugurations, religious festivities, sporting events and other public congregations. The dance derives its name from the drums used in the performance, played in sets of three – a big, medium and small drum – and normally accompanied by an antelope horn and assorted metal rattles. A soloist leads the dance, singing thematic texts in tandem with the rhythm of the drumbeats and the steps of the dancers, arranged in separate rows for men and women. Transmission of Isukuti dance is presently weakening and the frequency of performance is diminishing. Many bearers are elderly and lack successors to whom they can pass on their knowledge. Lack of funds and the necessary materials to make the instruments and costumes also present an obstacle. Finally, many composers prefer to work in more commercial genres, and audiences frequently substitute contemporary entertainment for traditional Isukuti dances.

Plate 121: Isukuti Dance Performance at the Ikhonga Murwi (Crying Stone) site Department of Culture, 2013).

Safeguarding traditional foodways in Kenya

In Kenya, traditional foodways were under threat due to historical factors and the pressure of modern lifestyles. Local foods were looked down upon and were associated with poverty and backwardness. Understanding that a decline in food diversity and knowledge would have serious ramifications on health and on food and nutrition insecurity, in 2007 Kenya committed to safeguarding related practices and expressions. Two main initiatives were launched, in collaboration with scientists and community groups. The first involved inventorying traditional foods, with a focus on traditional vegetables. About 850 indigenous plants with local names were recorded. This was followed by the detailed documentation of use and related indigenous knowledge (including recipes) and practices (such as ceremonies). Finally came rigorous promotion of the foods. For the second initiative, UNESCO in partnership with the Department of Culture and the International and National Museums of Kenya, and in consultation with community leaders, initiated a pilot project to identify and inventory traditional foodways in partnership with primary school children to raise awareness about the threat to traditional foodways.

Plate 122: Members of the Isukha community and pupils of Muraka and Shihuli primary schools, Kakamega country, marching to create awareness on traditional foodways (Patrick Maundu, Kenya, 2012)

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. Cultural trade and exportation of our traditional artefacts is one major challenge that the current dispensation on restitution is hinged on.

Plate 123: Celebrating the return of Vigango from the USA , Source: NMK

Emerging Imperatives

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

- Climate Change and Environmental Stewardship
- Technology and Technological Advancements in Natural Resource Management
- Emerging Jurisprudence
- Weaponization of Nature (also called Bio-terrorism)
- Migratory Pests
- Meaningful Consultation and Public Participation
- Benefit-sharing from Natural Resources
- Blue Economy (Marine Spatial Planning (MSP)
- Natural Disasters and the urge for Compensation
- Pressure on and the need to Degazette Public Forests
- Natural Resource Accounting /Valuation
- Traditional and Indigenous Knowledge Systems in Conservation
- Rights and Security of Land Tenure
- Effects of Community Land Registration on Natural Resources
- Soil, Water Contamination and the direct impact and Link to Food Safety and Human Health.

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 worldwide (IPCC, 2013). 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, deforestation and 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 the 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 unprecedented drought that resulted from five consecutive below average rainy seasons that begun at the end of 2020.

Plate 124: Drought related mortality in wildlife/Photo Credit: National Geographic. This photo shows KWS rangers preparing to move the carcass 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 have been evident in the country (Plate 125-127).

Plate 125: Lake Baringo rising water levels affecting learning institutions

Plate 126: Lake Bogoria impact after rising water levels

Plate 127: Lake Baringo submerging Soi Safari lodge

Kenya has made significant efforts and progress towards addressing climate change by having a robust regulatory framework both at the national and county levels. The Climate Change Act, of 2016 is the main legislation guiding Kenya's climate change response. Additionally, Kenya has 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. Further, the country's Constitution has set out a legal commitment to attain ecologically sustainable development, hence providing a firm basis to address the challenge of climate change while striving to attain the development goals set out in Kenya Vision 2030.

Globally, Kenya has supported the United Nations Framework Convention on Climate Change (UNFCCC) process, ratifying the Kyoto Protocol in 2005, and contributing to continental and regional climate change initiatives. Being a signatory to this agreement, Kenya has made tremendous endeavors and progress including building resilience through its National Adaptation Plan (NAP) and by engaging its Council of Governors (CoG) and county governments in the process of establishing County Climate Change Funds (CCCFs) and mainstreaming climate information (e.g., data on risks, hazards, vulnerabilities, and adaptation actions) into County Integrated Development Plans (CIDPs).

Further, as part of taking the lead in the engagements at global and regional levels, Kenya hosted the inaugural Africa Climate Summit (ACS), where African Heads of State and Government, gathered to discuss sustainable solutions for climate change across the continent where the following commitments were agreed upon:

Focusing on economic development plans for climate-positive growth, including expansion of just energy transitions and renewable energy generation for industrial activity, climate-aware and restorative agricultural practices, and essential protection and enhancement of nature and biodiversity;

Strengthening actions to halt and reverse biodiversity loss, deforestation, and desertification as well as restoring degraded lands to achieve land degradation neutrality;

Taking the lead in the development of global standards, metrics, and market mechanisms to accurately value and compensate for the protection of nature, biodiversity, socio-economic co-benefits, and the provision of climate services;

Strengthening early warning systems and climate information services, as well as taking early action to protect lives, livelihoods and assets and inform long-term decision-making related to climate change risks. further emphasis on the importance of embracing indigenous knowledge and citizen science in both adaptation strategies and early warning systems

Kenya has adopted the following strategies to reduce emissions of greenhouse gases:

- Carbon credit trading; and
- Introduction of electric mobility.

Carbon credit trading

Carbon Credits and Offsets (Fig 181) are tools used to minimize greenhouse gas emissions into and out of the atmosphere. Carbon Credits are instruments that give the right to emit whereas Carbon Offsets are projects that cancel out carbon produced from the removal of greenhouse gas emissions from the atmosphere. The Energy Act, 2019 outlines carbon credit trading as one of the actions to promote development and use of renewable energy, and this could include afforestation and reforestation. Carbon credits are intended to mitigate the impacts of climate change through emission reductions. The carbon markets describe a market that is created from the trading of carbon emission allowances to enhance countries and companies to limit their carbon footprint as well as provide valuable conservation co-benefits for people and nature. Although carbon trading programmes are well-intentioned, it is important to note that the information on the subject is limited particularly to the public. Carbon credit and the market are dotted with numerous challenges related to pricing, and this scheme encourages pollution of the environment through emissions. Similarly, there are issues relating to soil, land and tree tenure in the climate change and carbon credit schemes.

There is also a general concern regarding the threshold for qualification to benefit from voluntary carbon markets through the approved certification/ accreditation processes.

As part of institutionalizing the carbon trade, Kenya has amended the Climate Change Act 2016 and drafted the Carbon Credit and Benefit Sharing Bill 2023. The bill has been done against the backdrop of the Climate Change Amendment Act (2016) which provides a legislative framework for Kenya's participation in the domestic and international carbon markets. The Bill emphasizes the need for a framework to strengthen policies on climate action and also provides for regulations that underpin clean energy standards through strict compliance by all stakeholders seeking to establish a regulatory framework for Carbon Credits Trading and Benefit Sharing in Carbon Trading as well as inclusion of the marginalized and indigenous communities in the transition to a low carbon economy through climate change justice. Further, it provides for the registration and regulation of the carbon credit trading business and for connected purposes.

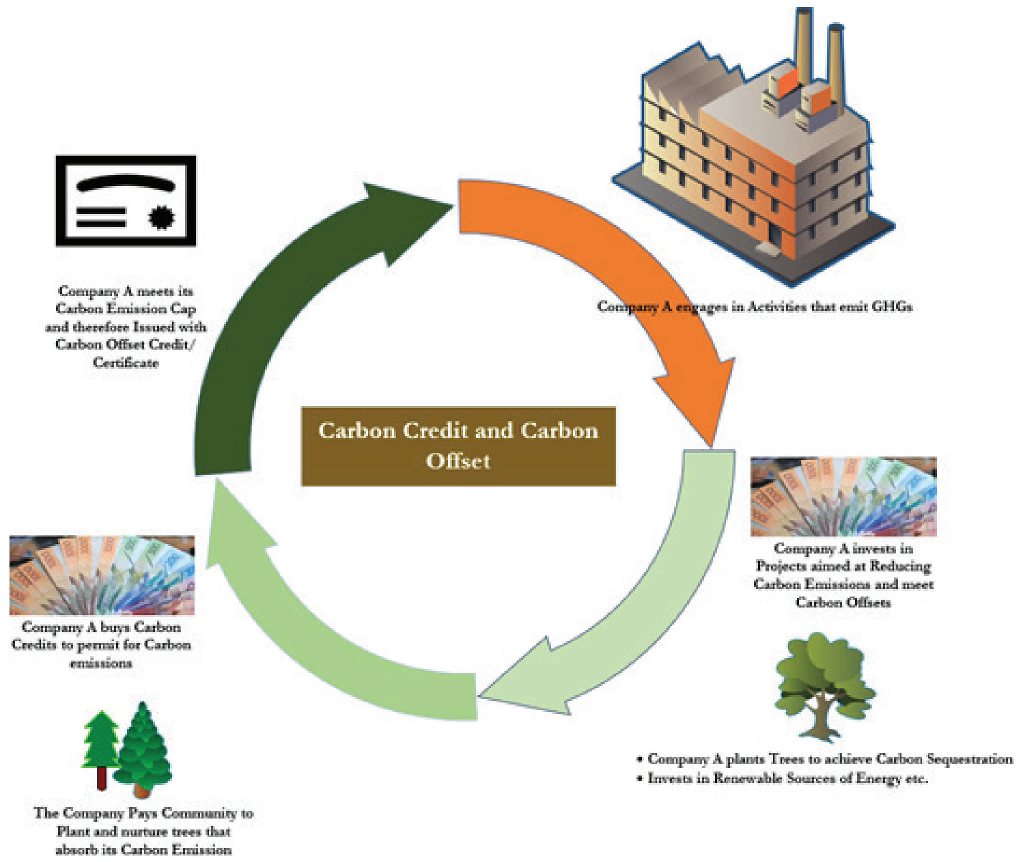


Figure 181: Carbon Credit meets Carbon Offset (Source:NLC)

Introduction of electric mobility

The transport industry is growing rapidly in Kenya as it is globally. While supporting economic growth and social connectivity, the present transport scenario also brings about many problems such as air and noise pollution, congestion, increased demand for petroleum imports and consequent greenhouse gas (GHG) emissions. As part of the efforts to create a sustainable transport system and achieve the country's targets in the National Climate Change Action Plan (NCCAP), the government has laid out plans for a Bus Rapid Transit (BRT), Light Rail Rapid Transit (LRRT) systems, extension of the Standard Gauge Railway (SGR). Significant emphasis is also being put on electrification of the vehicle fleet in the country. This is crucial due to its minimal footprint on the environment. One solution is electric mobility. Electric mobility also known as e-mobility is the use of electricity to power the transport infrastructure as an alternative to fossil fuels (Page, 2023). This electricity is preferably from renewable energy sources such as hydro, geothermal, wind and solar to minimize overall emissions.

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. The emergence and proliferation of Schistocerca gregaria or the Desert Locusts were associated with climate change. These destructive migratory pests threatened the stability of Kenya's natural resources in the recent past.

The locusts migrated into Kenya from Somalia and Ethiopia. They 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). Other examples of migratory pests in Kenya include Spodoptera frugiperda or fall armyworms and red-billed quelea birds.

Technology and Technological Advancement in Natural Resources

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. Some of these technologies include technological aspects 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 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). This is big data, which upon analysis can inform decision-making in the management of natural resources.

Similarly, cloud computing can be used to make decisions relating to sustainable management of natural resources. Rather than buying the costly computing power, agencies, organizations and policymakers/decision-makers involved in the management of natural resources can capitalize on cloud computing to rent this power. Cloud computing allows access to various computing products and solutions including servers, databases and hard drives that store critical natural resources data, software and applications and data analytic tools among others. Cloud computing can provide an extensive array of benefits to managers of natural resources including, but not limited to, speed access and analysis of data, scalability advantages, reduction of IT overhead costs, reliability and improved performance. Figure 182 shows the applicability of cloud computing in natural resources management.

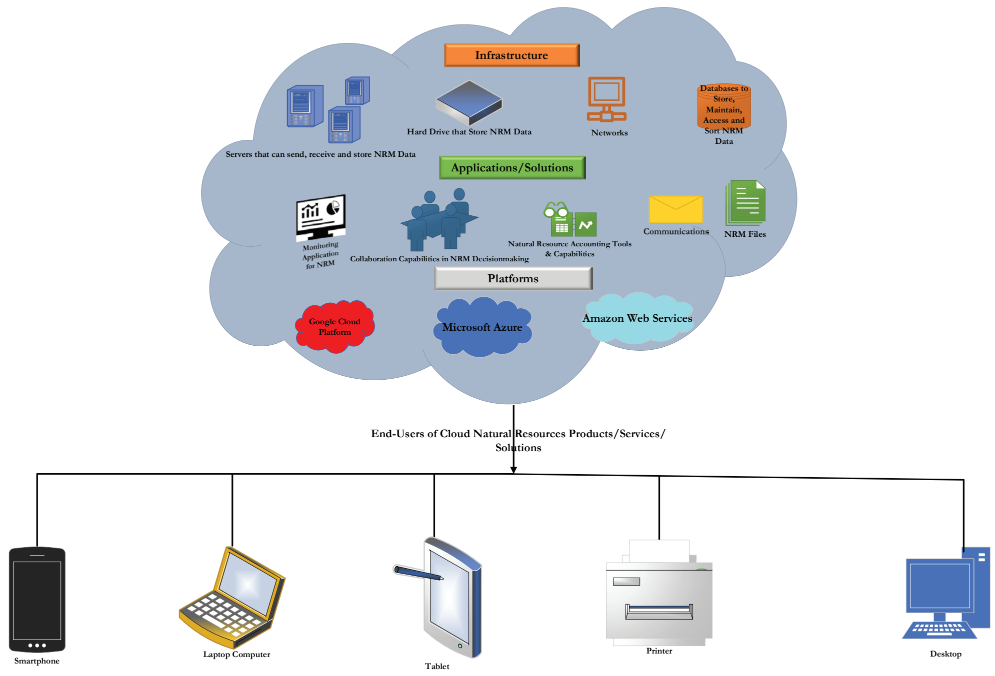


Figure 182: Cloud Computing Depiction in Natural Resources: Image Courtesy of NLC

Emerging Jurisprudence

Kenyan Courts have pronounced themselves on various matters of natural resources including riparian reserves; riparian rights; land gained by sea; competing community land rights versus forest conservation; weaponization of nature; standards for due diligence in land administration; meaningful public participation/consultations; and effects of community land titling on projects among others. Some of the landmark rulings that have a bearing on policy, legislative development and alignments are summarized in table 82:

Table 82: *landmark rulings that have a bearing on policy, legislative development and alignments*

Riparian Reserves		
Case Title	Summary of the Case	Summary of the Ruling
ELC Petition No. 61 of 2018: Riparian Reserve between Milimani Splendor Management Limited v National Environment Management Authority and 4 others.	The Case related to the threshold on what constitutes a riparian reserve as a result of contradicting legislations	That the measurement of the riparian reserve should be based on the high and low watermarks and not the centre of the river in conformity with the definition of the high and low watermarks under the Regulations made under EMCA as well as Article 62 of the Constitution.
Riparian Rights		
Case Title	Summary of the Case	Summary of the Ruling
The Environmental and Land Court (ELC) in Case No 222 Of 2014, by Seventh Day Adventist Church (East Africa) T/A Solace Lifestyle and Wellness Resort Vs. County Government of Kilifi & Others	The Case related to the exclusive entitlement to the riparian rights	The Court ruled that riparian rights are generally reserved for land abutting a natural watercourse. therefore, it means that an ocean, lake or sea would not classify as riparian rights but as littoral rights.
Land Gained by Sea/Lakes		
Case Title	Summary of the Case	Summary of the Ruling

ELC Civil Case No.219 of 2014, by Tukero Ole Kina & another v. Tahir Sheikh Said (also known as TSS) & 5 others [2015] eKLR.	The Case related to acquisition of interest in land gained by sea/lakes.	The Court ruled that land that is created as a result of seawater recession within the riparian areas of water bodies, still is regarded as public land and that these do not constitute private lands.
Competing Community Land Rights Versus Forest Conservation Goals		
Case Title	Summary of the Case	Summary of the Ruling
African Commission on Human and Peoples' Rights (ACHPR) v. Republic of Kenya Application No. 006/2012	The Case related to the indigenous (Ogieks) rights to inhabit the Greater Mau Forest Complex	African Court on Human and Peoples' Rights made rulings in the favor of Ogieks
Land Case No. 288 of 2018 by Kiptarus Tabot v. Attorney General; Kalimbula Investments Limited (Interested Party) (Environment & Land Case 288 of 2018) [2023] KEELC 16846 (KLR)	The Case related to the right to settle on gazetted forests (the Mau Forest complex)	The Court ruled that plaintiffs should not be allowed to back into Mau Forest because of their invalid title deeds and their continuous degradation of the ecosystem
Standards for Due Diligence and shifting paradigms regarding the burden of proof in Land Administration and Management including the concept of innocent purchaser of value		
Case Title	Summary of the Case	Summary of the Ruling
Civil Appeal No 239 of 2009 (Munyu Maina V Hiram Gathiha Maina (2013) eKLR	The case related to the fraudulence acquisition of title over property.	The Court ruled that it is not enough to dangle a title when this is the subject being challenged/disputed. In this case, the Court of Appeal held that "when a registered proprietor's root of title is under challenge, it is not sufficient to dangle the instrument of title as proof of ownership.
ELC No. 137 of 2015 for Daniel Kipruto Metto V Chase Bank (Kenya) Limited (2018) eKLR.	The Case was about the extent to which banks should do due diligence when accepting title as a collateral to issue loans	The Court held that banks must be more diligent when dealing with properties to be charged or mortgaged because some titles are fraudulently acquired.
ELC Civil No. 128 of 2011 regarding Esther Ndegi Njiru V Leonard Gatei (2014) eKRL	The Case related to the circumstances under which land title can be impugned.	The court acknowledged that the law protects and upholds the sanctity of title but at the same time, the law provides the circumstances under which a title because it cannot be absolute and indefeasible
National Land Commission V Afrison Export Import Limited & 10 others (2019) eKLR	The Case was about the extent to which one should go in due diligence	The Court ruled that the burden to know the law and comply with it never moves, within the principle of nihilo nihil fit
Petition No. 8 (E010) of 2021 Dina Management Limited Vs County Government of Mombasa, The Chief Land Registrar and 4 Others	The Case was about a beach plot allocated to the former President, late Daniel Arap Moi by the Commissioner of Lands in Nyali	The Court ruled that the plot was illegally and irregularly allocated and, therefore, reverted it to State.
Rights to Privacy		
Case Title	Summary of the Case	Summary of the Ruling
Constitution Petition No 6 Of 2022, between Mohammed Ahmed Abdalla and 6 Others Vs Khansa Developers Limited And 3 Others	The Case regarded the Proposed Development of 18 Floors Storey Building on Plot Number Mombasa/Block XXVI/595 and in the Matter of Violation of Articles 10, 40, 42, 47 And 69 of the Constitution of Kenya	The court ruled in the favor of controlled development to protect the rights to privacy.

Weaponization of Nature (also called bio-terrorism)

Nature is emerging as a new battle space and micro-organisms such as bacteria, viruses, fungi, prions, protozoa and algae are increasingly being used as bioweapons due to the advanced technologies. For instance, the 2001 Anthrax Attack, where Bacillus anthracis was the bioweapon, resulted in the death of five people and the sickening of 17 others in the United States (Federal Bureau of Investigation, 2016). This was a confirmed case of a bioweaponization of Nature. Other examples of micro-organisms that can be used as bioweapons are outlined in table 83.

Table 83: *micro-organisms that can be used as bioweapons*

S/No.	Possible Biological Weapon/Organism	Result of the Bio Attack
1.	variola virus	Bio-terrorists can possibly use it to cause Small Pox
2.	SARS-CoV-2 virus	The virus can be used as a bioweapon for causing COVID-19
3.	Karenia brevis	The algae species can be used to carry out bioattacks that lead to respiratory irritations
4.	Candida albicans	Bio-terrorists can use this fugal species to cause and spread Candidiasis.
5.	African trypanosomiasis	This protozoan parasite can be used by attackers to transmit sleeping sickness

Visibly, bioterrorists have so much bioweapons at their disposal to execute possible bioattacks.

Meaningful Consultation and Public Participations

Article 10 and section 4 of the Constitution of Kenya (CoK) 2010 and the Land Act 2012, demand for people's participation, transparency, good governance and sustainable development as foundational values and principles of governance. Further, Article 35 of CoK,2010 embeds public participation as a requirement for any policy and governance processes through right of access to information held by the State. Recently the Court of Appel in Kisumu stipulated what entails a meaningful consultation.

In the Court of Appeal at Kisumu (Coram: Kiage, Tuiyott & Joel Ngugi Jj.A) Civil Appeal No. E059 Of 2022, a case by Prof. Francis Angawa Okere & Prof. Isaiah I.C Wakindiki Vs Public Service Commission Cabinet Secretary & 7 Others, the court interpreted and clearly elaborated what public participation and consultations entails. The court ruling formed an important guidance on good governance.

Benefit-sharing from natural resources

Equitable benefit sharing can be defined as the access to benefits that accrue from natural resources by stakeholders including indigenous communities. The international recognition of the right to benefit from natural resources wealth may be predicated upon such recognized rights of communities as the right to self-determination, right to development and the right of peoples to freely dispose of their wealth and natural resources. The principle of equitable benefit sharing is acknowledged in several international environmental and natural resources law instruments. The guiding principles of benefit sharing is as outlined in figure 183.

Figure 183: Guiding principles of benefit sharing

Article 69 (1) (a) of the Constitution requires the state to ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits. Further, the National Land Commission (NLC) is empowered under Section 12

(4) of the Land Act 2012, to ensure that investments in the land benefit local communities and their economies.

Kenya is in the process of developing an Act of Parliament- The Natural Resources (Benefit Sharing) Bill, 2020- to establish a system of benefit sharing in natural resource exploitation between resource exploiters, the national government and the county government. The bill has proposed formation of institutions that will co-ordinate the preparation of benefit sharing agreements between an affected county and an affected entity.

Marine Spatial Planning

The European Commission (2017) defines Marine Spatial Planning (MSP) as the tool used in managing the coherent use of seas and oceans and ensuring that human activities take place efficiently, safely and sustainably. According to the State of the Ocean Report 2022, MSP was launched in 2006 during the first International MSP Workshop, which was convened by the Intergovernmental Oceanographic Commission (IOC) of UNESCO (UNESCO, 2022). MSP has gained considerable global popularity with various countries and territories using it to sustainably manage the use of their marine spaces and conserving biodiversity in oceans and coastal areas. The most recent statistical facts show that 38 countries have so far approved MSPs while more others, including Kenya, are at the plan development stage (UNESCO, 2022). MSP follows a ten-step approach shown in figure 184(UNESCO, 2009).

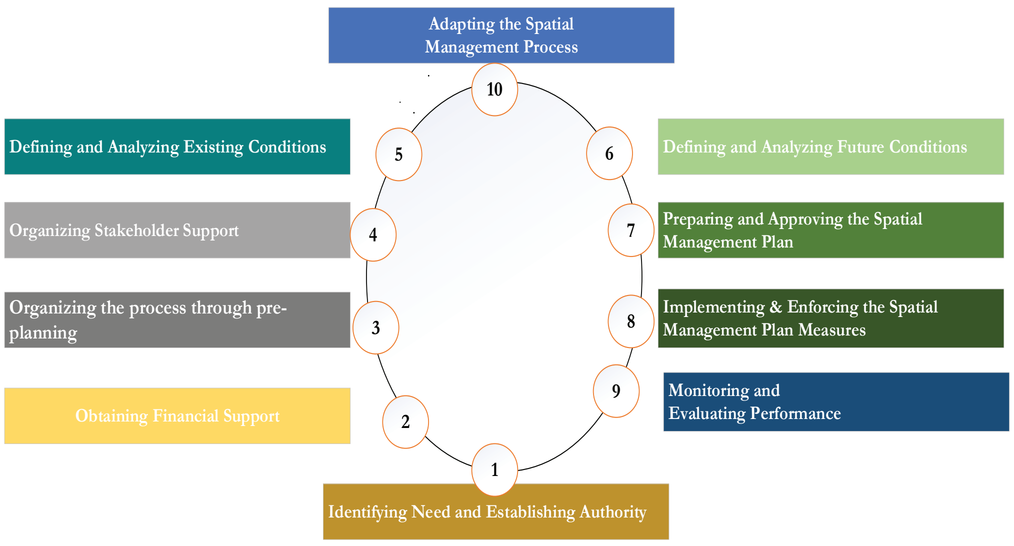


Figure 184: The Ten-step Approach to Marine Spatial Planning

Natural Disasters and the urge for compensation

Natural disasters can have devastating effects on communities, leading to a strong urge for compensation and assistance. This urge arises from the recognition that these disasters often result in significant losses, including loss of life, property damage, economic hardship, and disruption of livelihoods.

As per The Emergency event database EM-DAT there 432 disastrous events related to natural hazards all over the world (Centre for Research on the Epidemiology of Disasters [CRED], 2021). These disastrous events resulted in 10,492 deaths in addition to affecting approximately 101.8 million people both directly and indirection (CRED, 2021). Economically, the events led to a loss of approximately US$ 252.1 billion. Kenya experiences a number of natural hazards, the most common being weather related, including floods, droughts, landslides, lightening/thunderstorms, wild fires, and strong winds. The level of destruction has also become more severe with more deaths of people and animals, loss of livelihoods, destruction of infrastructure among other effects.

According to the State Department of ASALs and Regional Development (2019), the Arid and semi-arid lands (ASALs) make up more than 80% of Kenya's landmass and host 36% of the total human population. ASALs are prone to harsh weather conditions rendering the communities within this region vulnerable to natural hazards, mainly droughts. Drought is the most prevalent natural hazard in Kenya affecting mainly Eastern, North Eastern, parts of Rift Valley and coast Provinces. Floods seasonally affect various parts of the country especially along the flood plains in the Lake Victoria basin and in Tana River while landslides are experienced during the long rains season running from March to May especially in Murang'a district and areas surrounding the Mount Kenya region (Fig 185).

From the Natural Resources Management perspective, one of the emerging issues is natural disasters and compensation in Kenya where communities are suing the government for compensation due to natural disasters. In 2022, members of Ilchamus and Tugen communities living on the shores of Lake Baringo in Kenya displaced by floods sued the government of Kenya for failing to act to mitigate the adverse effects of climate change (Wangui, 2020). In the suit filed at the Environment and Lands Court in Kabarnet, the residents claim that as a result of the government's failure to integrate and mainstream climate change actions, they have been rendered to abject poverty (Wangui, 2020).

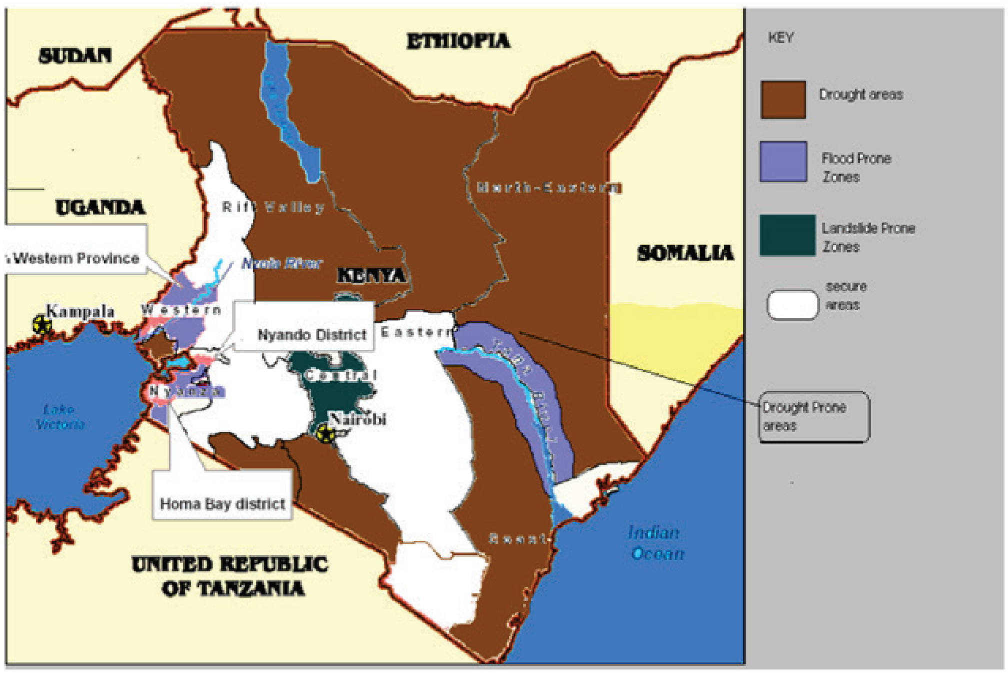


Figure 185: Kenya Hazard Map (Updated Static Map to be generated by Mr. Ouko)

Pressure on and the need to Degazette Public Forests

The pressure to degazette public forests is on the increase to pave way for development projects. Several petitions have been submitted to the National Assembly requesting for degazettement of portions of public forest lands in different parts of the country. It is emerging that forests are the most vulnerable to degazettements unlike other conservation areas. The public view forests as idle lands that need to be converted for agricultural production and settlements. Table 84 shows some of the public forests that have been targeted for degazettement.

Table 84: *:Forest Excisions and De-gazettements (Source: National Assembly)S/N*

S/ No.	Forest Name	Location	LR. No	Size (acres)	Allotees	Status	Responsible Member of Parliament
1	Kuresoi Forest	Kuresoi North	LR. No. Sitoton Com-partment Block 7	10	Kuresoi Divisional Headquarters	Lapsed	Hon. Moses Cheboi
2	Kitalale Settle-ment Scheme	Saboti	LR. No.3023 LR. No.2996 LR. No.2070/		Residents who are currently living on the land as squatters and Sango Vocational Training Centre, Sango Primary and Secondary Schools situated on the land	Pend-ing	Hon. Caleb Luyai
3	Kapolet Land	Cheranga-ny Constit-uency		1,153.43	Sengwer Com-munity in 1997 with a view of registering it as community land and availing it for settlement of members of the community	Pend-ing	Hon. Joshua Kutuny
4	Kodera Forest	God Agulu Beat and Lidha Beat		10,100	the community living along God Agulu Beat and Lidha Beat in Kasipul.	Lapsed	Hon. Charles Ongondo
5	Ngong Hills	Kajiado West		0.08	Settlements	Pend-ing	Hon. George Sunkuyia
6	Ngong Hills	Lang'ata		34	Variation of boundaries of Ngong Road For-est land	Pend-ing	Hon. Nixon Korir
7	East Mau Forest				Resettlement of East Mau Forest		Mr. John Njogu Njoroge

Natural Resource Accounting (NRA) and valuation

Natural Resources Accounting (NRA) is a critical element of sustainable development whose idea is to quantify bases of natural resources and the rate and pace of their usage with respect sustainability and environmental aspects. NRA aims to promote prudent and controlled use of natural resources to reduce the risks of environmental degradation, which results in climate change and its adverse effects. Additionally, NRA aims to reduce or even eliminate the overexploitation of natural resources for the sake of the future generations. The Failure to place monetary value on environmental goods and services has detrimental impacts including posing threats to Ecologically Sensitive Areas (ESAs) (Costanza et. al 1997).

NRA is based on the benefits that natural resources give up as they depreciate and deplete. This is the depletion expense as natural resources are exploited or removed.

There are several facts that should be considered when calculating depletion charge. These facts include the initial cost of acquisition of natural resources, the direct costs for developing the natural resources, expected residual value, and estimated value of these resources in tonnes (Walther, 2010). Based on this information, the formula for calculating depletion charge is:

$$\text{Depletion Charge} = \frac{\text{(Initial Cost of Acquiring Natural Resources+Development Cost-Residual Value)}}{\text{(Estimated Quantity (in tonnes) of Natural Resources to be Produced)}}$$

From the above formula, depletion charge, which is the periodic charge on exploitation of natural resources, is based on value in terms of money per tonne (Walther, 2010).

Traditional and Indigenous Knowledge Systems in Conservation

Traditional and indigenous knowledge systems play an instrumental role in the conservation of natural resources. However the local/indigenous materials have not been documented in the legal education and practice. Notably, the use of traditional knowledge to manage Natural Resources is still being used by the pastoral Communities, especially the use of traditional medicines drawn from the plants to treat people and livestock. For instance, livestock that suffer from blotting are treated by smearing dung around the blotted stomach. The use of specific plants as indicators of high-water tables while others are indicators of suitability of soils, are interesting cultural imperatives. Therefore, utilization and documentation of traditional knowledge is imperative toward sustainable use and management of these resources.

Rights and Security of Land Tenure

According to Article 260 of the Constitution of Kenya, Land includes, among others, natural resources completely contained on or under the surface. The property rights to land within Kenyan societies are defined land tenure. Therefore, land tenure is about the manner of access to land, including the ways in which we hold it and interests and rights granted. Different interests grant different rights and limitations. All these vary, creating different tenures. In Kenya we have Four main land tenure regimes though there are other Tenure regimes as shown in Figure 186.

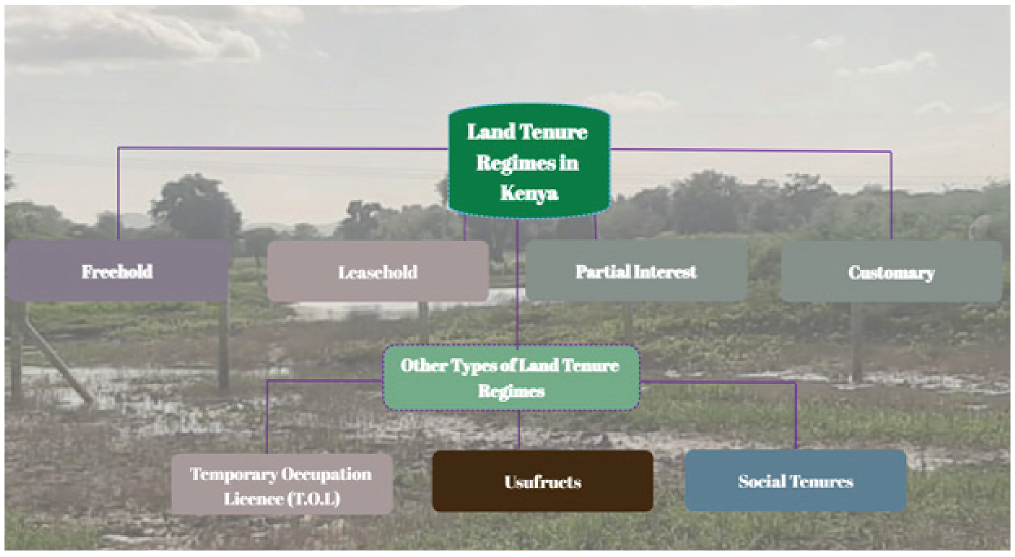


Figure 186: Land Tenure Regimes in Kenya: Photo Courtesy of NLC

Customary tenure is the most prevalent and it's secured by social recognition than by title. Tenure Security (TS) is dynamic, interpreted differently, perceived differently, in response to adaptation, organization and strengthening of people live around these aspects. The scenarios that revolve around security of tenure are:

- Land Titling Vs Social Recognition;
- Title Holding; and
- Security of Tenure as a Psychosocial Concept.

Land Titling Vs Social Recognition

Land is a natural resource that people don't own, but hold recognizable interests in and well-defined rights. Recognition of such interests and rights by the people is what the law registers and issue a title for. Recognition that defines ownership lies in the popular knowledge and later in law. Customary laws, though not recorded, are recognized by the people and the constitution.

Security of tenure is more of recognition rather than a having the title deed document. The more you occupy land or the more you associate with it without any interruption, the more you build popular recognition as the owner of that Land. Popular recognition is also recognized by courts. Jurisprudence has continuously challenged the principle of indefeasibility of a title. Instead, several titles to land have been impugned by the Courts in a bid to restore sanity and promote transparency and rule of law regarding land governance. Article 40 (6) of the Constitution of Kenya provides the ground and exception under which a title can be impeached.

Security of tenure is stronger when based on three pillars illustrated in Figure 187.

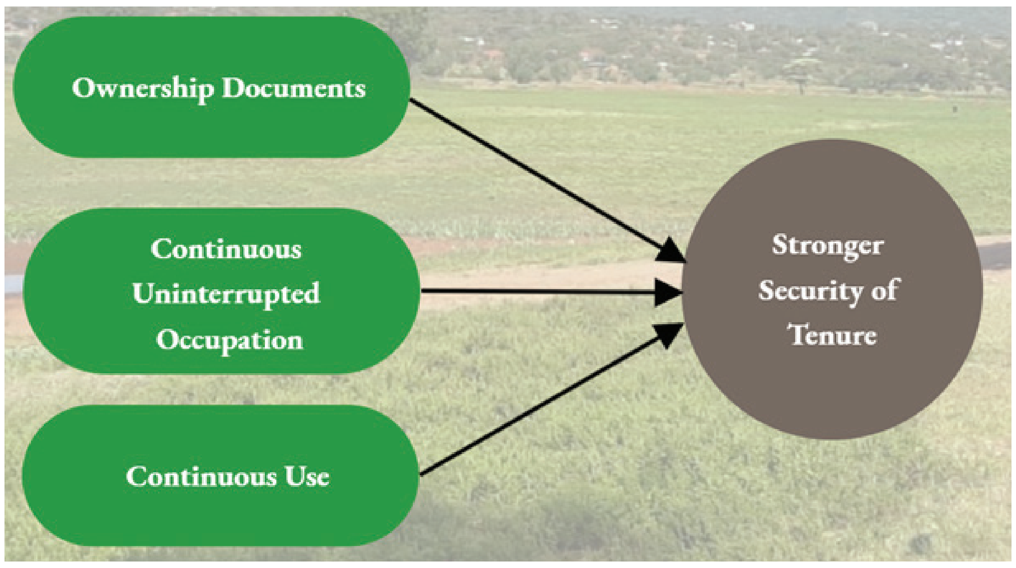


Figure 187: Pillars of a Stronger Security of Tenure. (Source: NLC)

Title Holding

Tenure rights exist and many people hold title deeds, but the government lacks the will or capacity to enforce such rights. Therefore, the government need to secure tenure security for its citizens.

Land tenure and the nexus with politics

Politics influence several aspects of land tenure. Figure 188 illustrates how politics is involved in either positively or negatively influencing the security of land tenure.

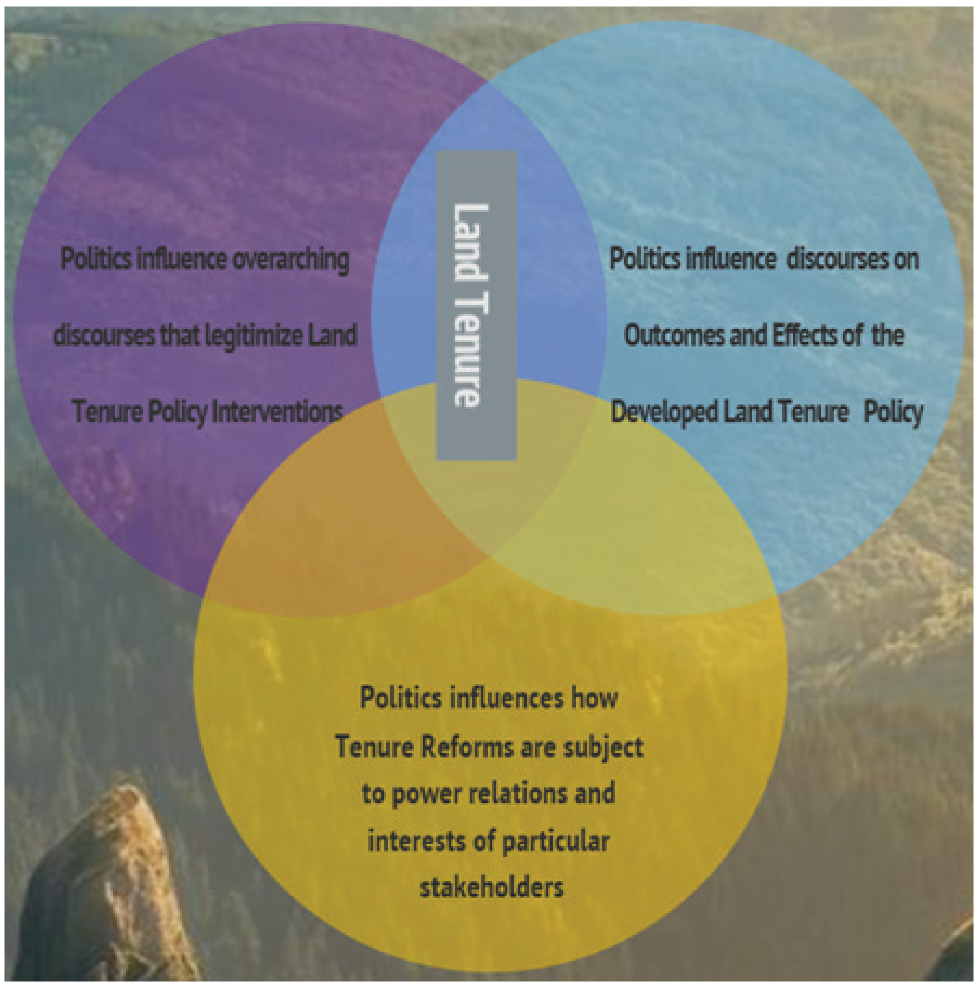


Figure 188: Politics-Land Tenure Security Nexus: (Source NLC)

Security of Tenure as a Psychosocial Concept

Security of tenure has foundations in the minds of the people. Secure tenure rights are questionable. In scenario, where individuals have titles but they can't occupy land due to perceived insecurity and those who own land and property within slums have tenure rights yet their land is occupied by slums dwellers. This implies that none of them have security of tenure psychosocially.

Effects of Community Land Registration on Natural Resources Management

Community land constitutes approximately 65% of Kenya's landmass, majorly found in Kenya's dry areas/ASALs (Mokku, 2021). Currently, they are undergoing registration in order to pave way for secured land rights and tenure in these natural-resource rich lands. However, the community lands play host to vital wildlife and biodiversity resources that need to be protected and safeguarded to provide homage for livestock and wildlife within the precincts of landscape level connectivity. There is therefore an urgent need to delineate, map, and secure these critical natural assets to support socio-economic and ecological development as well as resilience-building.

Ownership, adjudication and change of use, are some of the issues affecting wildlife conservation and management. In order to curb against further degradation of these fragile landscapes, a presidential directive was issued on 24th July 2023(OP/CAB-26/1/34), including among others; that the National Environment Management Authority (NEMA) to stop issuance of licenses and permits in key wildlife conservation areas, stoppage of any further land sub-division and change of land use in the wildlife conservation areas until conservation policy is done, the Ministry of land to fast-tract the implementation of the community Land 2016, and finally need to review National Land Use Policy and Physical Land Use Act, 2016 to include conservation as a land use category in the country.

There have been In the Environment and Land Court at Meru ELC Case No.163 of 2014 Formerly Nairobi ELC No.1330 of 2014, a matter by Mohamud Iltarakwa Kochale & 5 Others (suing on behalf of the residents of Laisamis Constituency and Karare Ward Marsabit County) Vs Lake Turkana Wind Power Ltd, Marsabit County Government & 10 Others. 16th Day of January, 2023. In the Ruling by Hon. Justice P.M Njoroge, Hon Lady Justice Grace Kemei & Hon. Justice Yuvinalis Angima, in their judgment, the court held that: Lake Turkana Wind Power (LTWP) project in Loiyangalani, Marsabit County has morphed into a full-blown crisis whose Sh80 billion worth of investment is in limbo after the local community won a second round of a court battle to take back the 150,000-acre piece where the project sits.

The land is now set to revert to locals after a one-year window issued in 2021 to regularize the deal lapsed. The High Court handed the firm its second blow after it rejected an application for an extension of time to regularize the process of acquisition. A bench of three judges of the Environment and Land Court threw out the plea by LTWP for more time and a review of the decision issued in November 2021, nullifying title deeds to the land, thereby reverting the land to the communities. This implies that decisions about land administration directly affect natural resources initiatives.

Soil, water contamination and the direct impact and link to food safety and human health;

Soil and water contamination can have significant direct impacts on food safety and human health. Contamination of these environmental resources can introduce various pollutants and pathogens into the food chain, affecting the quality and safety of the food we consume, and potentially causing adverse health effects in humans.

Pollution of the environment by heavy metals emanating from rapid economic growth and improper waste and effluent disposal is a major concern (Shen et al., 2017). This is a clear demonstration of weak governance. Industrial growth and urbanization coupled with high population growth have led to an increase in sewage water generation in cities and towns around the world.

In Kenya, millions of small-scale farmers in urban and peri urban areas depend on urban streams, which are the recipients of urban effluent, for irrigation of crops and vegetables for urban markets. This poses a direct risk as the pollutants in wastewater affect both the environment and human health.

Among the pollutants in wastewater are heavy metals and there is a global concern due to their toxicity, through bioaccumulation in food chains and persistence in the aquatic ecosystems. Although heavy metals in the environment could be due to natural processes, the same in urban environments particularly in Kenya have to a greater extent been attributed to industrial development, transportation and marketing of goods. According to Feng et al (2017), atmospheric deposition can also significantly elevate the level of heavy metals in soils. Elevated levels of heavy metals have been reported in areas having long term use of treated and untreated wastewater.

Contamination of vegetables by heavy metals and other pathogens is a key aspect of food quality assurance given the importance of vegetables in the human diet. The use of polluted urban stream water for irrigation contributes significantly to the heavy metal content in soil and subsequently, to the vegetables, which poses health risks to consumers of the vegetable commodities.

Plate 128: Arrowroots and other Vegetables grown along Raw Sewage in Dandora, Nairobi. Photo Credit: Nation Media Group (2023)

According to the 2023 bioindicator report by the Centre for Environment Justice Development (CEJAD), there are high levels of highly toxic chemicals namely persistent organic pollutants (POPs) in Kenya's free-range chicken eggs (CEJAD, 2023). The Report identified e-waste and plastic waste from Dandora dumpsite, the largest dumpsite in Nairobi, and its environs as the main source of POPs. Shockingly, the Report found that eggs of free roaming sampled chickens, which fed within Dandora dumpsite had 111 times higher concentration of POPs than the European Union (EU) regulatory limits (CEJAD, 2023).

These startling findings justify the need for empowering the urban poor economically, with knowledge and consciousness for environmental conservation and its relationship with food safety and human health. Similarly, tackling the inherent governance challenges in relation to wastewater management and re-use for food production by the urban poor, is important. Thus, development of key guidelines and standards for waste water re-use for urban agriculture as well as bolstering capacity for enforcement and surveillance are critical, in addition to enhancing accountability by both the duty-bearers and rights holders

It is thus essential to monitor, regulate, and take preventive measures to reduce contamination and protect both the environment and public health.

KEY MESSAGE

The profound linkage between the natural resources and people wellbeing cannot be gainsaid. The natural resources provide services and goods that are utilized by the society for sustenance, social wellbeing good and economic gain. The need to protect and conserve these resources for perpetuity is paramount especially in the current context of human threats and climate change. Additionally, socio-cultural practices, beliefs and traditional systems and knowledge contribute and are directly to natural capital. In addressing the natural resources challenges, there is need to acknowledge the changing trends including climate change and technological advancement.

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