KENYA'S NATURAL CAPITAL

A Biodiversity Atlas

Ministry of Environment Natural Resources and Regional Development Authorities

AFRICAN CONSERVATION CENTRE

DANIDA INTERNATIONAL DEVELOPMENT COOPERATION

KENYA'S NATURAL CAPITAL

A BIODIVERSITY ATLAS

This is a Government of Kenya Publication,
For bibliographic and reference purposes this publication should be referred to as:
“MEWNR (2015).Kenya Biodiversity Atlas*
Ministry of Environment Natural Resources and Regional Developement Authorities
P.O.Box 30126 -00100, Nairobi, Kenya

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Printed by: Resources International

This report was prepared using funds provided by the Government of Kenya and the Government of Denmark with technical support from various national and international institutions.

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MINISTRY OF ENVIRONMENT NATURAL RESOURCES
AND REGIONAL DEVELOPEMENT AUTHORITIES

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ACKNOWLEDGEMENT

This Atlas is the result of the contributions of many institutions, organizations and individuals. The Ministry of Environment Natural Resources and Regional Development Authorities is indebted to the many institutions and persons that contributed with great enthusiasm to the accomplishment of the task. The policy and technical contributions from the Ministry were led by the Cabinet Secretary and the senior staff whose efforts are acknowledged and greatly appreciated.

The Ministry extends its gratitude to the African Conservation Centre under the leadership of Dr. David Western for an outstanding job in not only putting together a consortium of experts but also guiding the process on a day-to-day basis as well.

In addition, the Government of Kenya acknowledges the generous financial and technical support by the Government of Denmark through the Natural Resource Management Programme funded by DANIDA through the Royal Danish Embassy in Nairobi.

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Cover design: Resources International
Financial Support: Ministry of Environment Natural Resources and Regional Development Authorities; and NRMP-DANIDA

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ACRONYM LIST

ACC	African Conservation Centre
ASARECA	The Association for Strengthening Agricultural Research in Eastern and Central Africa
AWF	Africa Wildlife Foundation
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CC	Closed-Canopy
CDC	Conservancy and the Conservation Development Center
DANIDA	Danish International Development Agency
DEFRA	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
DNA	Deoxyribonucleic acid
DPSIR	Drivers, Pressures, Status, Impact and Responses
DRSRS	Department of Resource Surveys and Remote Sensing
EARPO	Eastern Africa Regional Programme Office (World Wildlife Fund)
EBA	Endemic Bird Area
EC	European Commission
EEA	European Environment Agency
EMCA	Environmental Management and Coordination Act
ESPA	Ecosystems Services for Poverty Alleviation
FAO	Food and Agriculture Organisation
FEWSNET	Famine Early Warning Systems Network
FRA	Forest Resources Assessment
GBM	Greenbelt Movement
GBO	Global Biodiversity Outlook
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GOK	Government of Kenya
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communications Technology
IIED	Institute for Environment and Development
IISD	International Institute for Sustainable Development
ISRIC	International Soil Reference and Information Centre
ILRI	International Livestock Research Institute
IRWS	International Recommendations for Water Statistics
IUCN	International Union for Conservation of Nature
KES	Kenya Shilling
KFS	Kenya Forestry Service
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
KNBSAP	Kenya National Biodiversity Strategy and Action Plan
KSS	Kenya Soil Survey
KWS	Kenya Wildlife Service
LANWRUA	Lake Naivasha Water Resources Management Authority

LPI	Living Planet Index
MDG	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MEMR	Ministry of Environment and Mineral Resources
MENRW	Ministry of Environment, Natural Resources and Wildlife
MODIS	Moderate Resolution Imaging Spectroradiometer
MUIENR	Makerere University Institute of Environment and Natural Resources
NASA	National Aeronautics and Space Administration
NBSAP	National Biodiversity Strategies and Action Plans
NCC	Narok County Council
NCCRS	National Climate Change Response
NEAP	National Environment Action Plan
NEMA	National Environment Management Authority
NES	National Environmental Secretariat
NMK	National Museums of Kenya
NRT	Northern Rangelands Trust
NTSG	Numerical Terradynamic Simulation Group
PCAST	President's Council of Advisors on Science and Technology
PES	Payment for Ecosystem Services
PET	Potential Evapotranspiration
RCMRD	Regional Centre for Mapping and Resources for Development
SA	Secondary Bird Area
SEEA	System of Environmental-Economic Accounts
SEEA-Water	System of Environmental- Economic Accounts for Water
SEUCO	South Eastern University College
SOK	Survey of Kenya
SRTM	Shuttle Radar Topography Mission
TCC	Trans-Mara County Council
TEEB	The Economics of Ecosystem Services and Biodiversity
TEV	Total Economic Value
UK NEA	United Kingdom National Ecosystem Assessment
UN	United Nations
UNCSD	United Nations Conference on Sustainable Development
UNDP	United Nations Development Fund
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WB	World Bank
WCED	World Commission for the Environment and Development
WCMC	World Conservation Monitoring Centre
WRI	World Resources Institute
WWAP	UN World Water Assessment Programme
WWF	World Wildlife Fund

FOREWORD

Kenya has a large complement of biological diversity of immense value which is used, valued, and protected by local communities as well as a variety of institutions. While communities have strived to use biological diversity sustainably and live in harmony with nature, the intensity of extraction and exploitation has increased while ecosystems are negatively affected by development initiatives.

Cases of over exploitation, habitat loss and conversion remain a major threat the sustenance of biodiversity compromising our ability to derive continued benefits. Mostly, the causes of loss of biological diversity arise as secondary consequences of activities within various economic sectors, such as urban development, transportation, energy, water supply, forestry, tourism, fisheries, mining, and agriculture. This is particularly so for those activities that focus on short-term benefits rather than long-term sustainability.

In the Rio+20 outcome document "The future we want" world leaders called for urgent action on unsustainable patterns of production and consumption where they occur. Such actions remain fundamental in addressing environmental sustainability, and promoting conservation and sustainable use of biodiversity and ecosystems, regeneration of natural resources, and the promotion of sustained, inclusive and equitable global growth.

In 2012, ten African Heads of State met in Gaborone, Botswana and agreed on the Gaborone Declaration for Sustainability in Africa. The objective of the Declaration is to ensure that the contributions of natural capital to sustainable economic growth, maintenance and improvement of social capital and human well-being are quantified and integrated into development and business practice.

Preparation of the Atlas of Kenya's biological diversity as a first step is therefore in line with that Declaration. The compilation of Kenya's natural capital that has led to the production of the Atlas of our Biological Diversity is an attempt to present, in a visual form, the current extent, status, threats, trends, interventions and potential sustainable use opportunities of our biological diversity. Efforts have been made to collate the available data and information of the country's biological diversity and present it in form of maps, photos and diagrams that are easy to understand.

It is my expectation that the Atlas will re-invigorate stakeholders to act on the knowledge, institutional, policy, technological and economic development challenges highlighted in the Atlas. In the same vein, I encourage all of us to take up the opportunities for sustainable use and economic activities highlighted in the Atlas. I invite development partners, private sector, academia, researchers and all relevant stakeholders to increase their efforts and contribution towards achievement of conservation and sustainable use of biological diversity, while improving the well-being of Kenyans through the creation of wealth as envisioned by the vision 2030.

The Government of Kenya is fully committed to ensuring that a full and comprehensive valuation of our natural capital is undertaken and integrated and mainstreamed into all national socio-economic development processes.

In conclusion, I wish to most sincerely thank all the experts who worked tirelessly to gather and assemble the data and information that made it possible to produce the Atlas. I also extend my appreciation to Government of Denmark for partnering with the Government of Kenya and providing the financial resources necessary for this important initiative.

Prof. Judi Wakhungu, PhD,

CABINET SECRETARY,

MINISTRY OF ENVIRONMENT, WATER AND NATURAL RESOURCES

MESSAGE FROM THE PRINCIPAL SECRETARY

Natural capital is the wealth of natural assets comprising both living and non-living, and the interactions within and between them, resulting in a wide range of goods and services. These include goods such as medicines, food, fuel wood, water, clean air and services such as climate regulation, food regulation, carbon storage and pollination of crops. Other indirect yet invaluable benefits include aesthetic values such as be beautiful scenery and landscapes as well other cultural and religious values.

The medicines, food, fuel-wood, water, clean air, to mention a few, that human beings use are primarily provided by our wealth of ecosystems. Less obvious ecosystem services include climate regulation, flood control by trees, carbon storage and pollination of agricultural crops. Even less appreciated are the aesthetic values such as enjoyment of scenery and wildlife as well as religious and cultural values.

In spite of all the benefits human kind derives from natural capital, there is increasing evidence that human beings are utilizing the stock of natural capital in an unsustainable manner and run the risk of tipping the balance beyond repair.

Just like in business where continued use of existing stock without replenishments leads to collapse of the business due to lack of stock, continued unsustainable use of ecosystem goods and services could lead to degradation of ecosystems to catastrophic levels after which the ecosystems are no longer able to provide those essential goods and services.

There is no denying that unsustainable utilization is the major cause of loss of biological diversity resulting in degradation of ecosystems and the services they provide. It leads to loss of productivity, weak resilience and inability to sustain economic activities and local communities' subsistence. There is evidence that in degraded areas there often is food shortage, conflict over scarce resources, and often displacement (migration) of populations to other areas leading to internally displaced persons also referred to as environmental refugees.

The Ministry of Environment, Natural Resources and Regional Development Authorities recognizes that the country's biological diversity and ecosystems underpin the socio-economic wellbeing of the entire population and the country's development in general. The Ministry therefore enlisted support from a consortium of national and international experts coordinated by the African Conservation Centre (ACC) to collate and document data and information on the biodiversity component of the country's natural capital. The initiative has started with compilation of available data and information on the extent, status, trends, challenges as well as interventions made by the Government and other stakeholders in response to some of the challenges. In addition, efforts have been made to highlight the immense economic potential that our natural capital offers through sustainable use activities such as ecotourism and organic farming among many others.

It is from this compendium of data and information that this Atlas has been prepared as a first step towards comprehensive documentation. The Ministry expects the Atlas to inspire all relevant stake holders to use the information contained in the Atlas to develop programmes and projects that will contribute to the Ministry's goal of attaining full valuation of our biodiversity and ecosystem services and their contribution to the cultural, social and economic development of Kenya.

I believe that this initiative will contribute greatly to the achievement of Vision 2030 and the fulfillment of the Government's obligation under the Constitution of Kenya 2010 as well as commitments to international agreements and processes.

In conclusion, I invite all Kenyans to internalize the reality that the quality and sustainability of our livelihoods is directly tied to the status of our natural capital. We all have a role to religiously safeguard our environment in order to continue deriving from it all the benefits it confers to us.

Richard L. Lesiyampe (Phd), Mbs

PRINCIPAL SECRETARY,

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REGIONAL DEVELOPMENT AUTHORITIES

PREFACE

Natural Resources form the foundation of Kenya's social, cultural and economic wellbeing. Plants, animals and the ecosystem services they provide play a key role in the lives of communities throughout the country.

Kenya is blessed with a wealth of biological diversity consisting of a large complement of diverse micro-organisms, plants and animals that co-exist in different formations leading to a wide range of ecosystems of varying composition.

From this wealth of biological diversity, communities directly derive food, energy, building materials and medicinal herbs among other key goods. They also provide essential services such as water and air purification, climate regulation, habitats, and cultural and spiritual sites.

On the economic pillar, biological diversity provides goods and services that support industries through the provision of raw materials for industrial processes as well as scenic sites that are the cornerstone of the country's tourism sector. Biological diversity is therefore one of the central resources for the attainment of Vision 2030 and the future we want as envisioned by the global community as it embraces the Green Growth initiatives.

Despite the immense value of biological diversity to Kenya's socio-economic development there are numerous challenges that threaten its continued existence.

Low levels of appreciation of the immense wealth provided by biological diversity and its potential to drive socio-economic development to higher levels is a key concern.

The Biodiversity Atlas of Kenya is a visual presentation of this treasure. It presents a representative complement of the variety of microbes, plants, animals and ecosystems in a reader-friendly language.

Efforts have been made to show the status, threats, interventions, potential for sustainable use and the future of biological diversity in the country.

The Atlas will be a valuable document that will contribute to the knowledge base on the conservation and sustainable use of biological diversity in Kenya. It should be seen as a first step in the process of establishing the full complement of the country's natural capital, in particular, the biodiversity component including its valuation and inclusion in national accounts.

It is my hope that this Atlas will spur stakeholders to make progress, especially by investing more in sustainable utilization of biological diversity to accelerate the achievement of Vision 2030, bringing about creation of wealth and improvement of the standard of living in the country.

H.E. Geert Aagaard Andersen

THE AMBASSADOR OF DENMARK TO KENYA

MESSAGE FROM AFRICAN CONSERVATION CENTRE

Kenya's Natural Capital: A Biodiversity Atlas was commissioned by the Ministry of Environment, Water and Mineral Resources and produced by the many institutions and individuals who gave their time and expertise so freely.

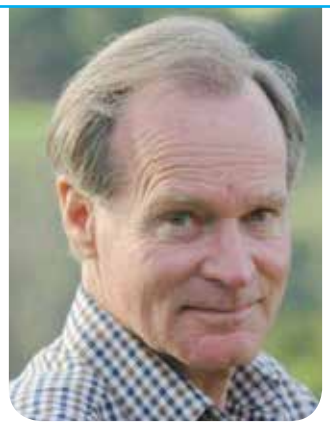
We give our special thanks to the former Permanent Secretary of the Ministry of Environment, Dr. Ali Mohammed, and the staff of the Multilateral Environmental Agreements Department for their commitment to publishing a biodiversity Atlas of Kenya and their tireless support in the course of its production. We also thank the current Cabinet Secretary, Prof. Judi Wakhungu, the Principal Secretary, Dr. Richard Lesiyampe, and the staff of the Ministry for their full support in the final preparations of the Atlas. The Danish Embassy funded the compilation and production of the Atlas and gave unstinting support.

The list of institutions that contributed to the production of the atlas is listed in the acknowledgements. Special mention goes to the National Museums of Kenya, the Department of Remote Sensing and Regional Surveys, Kenya Wildlife Service, the International Livestock Research Institute and the World Resources Institute for their inputs to the Atlas at all stages.

The synthesis team played a seminal role in steering and overseeing the production of the Atlas. The editorial and production teams worked tirelessly and graciously on many drafts to produce the final Atlas.

Special thanks go to the staff of the African Conservation Centre for all the work it put in to see the Atlas through from conceptualization to completion. Preetika Hirani and Umulqer Adam gave their time fully and freely to fulfilling ACC's secretarial role in coordinating and producing the Atlas.

The contributors to the Atlas submitted more information than could be included in the final volume on the understanding that the additional material would be compiled in a digital database and made available as a Biodiversity Compendium on CD and on the website of Kenya's Natural Capital (www.kenyanaturalcapital.or.ke). The Natural Capital Atlas of Kenya will be produced in electronic form freely available online. A digital platform of the data will form the basis of an electronic platform of Kenya's biodiversity that can be continuously expanded and updated for public use and applications to biodiversity and natural resource planning.



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EXECUTIVE SUMMARY

CHAPTER 1: NATURAL CAPITAL IN NATIONAL PERSPECTIVE

Kenya is renowned for its spectacular wildlife, but the grandeur and diversity of its landscapes are often overlooked. The constellation of climates and tapestry of landforms make Kenya a biodiversity hotspot of the African continent and among the richest regions on earth for the diversity of its mammals, birds and other vertebrates. Here, in the cradle of humankind, indigenous and immigrant peoples down the ages introduced and developed crops, animals, husbandry skills, livelihoods, cultures, religions and languages, raised the productivity of the land and supported a diverse and growing population.

Kenya survived ancient and modern waves of extinctions around the world to retain its wildlife and biodiversity relatively intact. The first steps to conserve Kenya's heritage were taken in the late 1800s. Forests were protected as state land in 1902, the Game Department was established in 1906 and Kenya National Parks in 1947. At independence Kenya declared its natural heritage as the foundation of its economic growth and wellbeing. Despite the conservation measures, a burgeoning population and rising consumption despoiled lands and depleted natural resources. Forest and wetlands shrank, rangelands degraded, erosion climbed, wildlife numbers fell and effluents polluted waters, air and soils.

At first the environmental cost of economic growth was overlooked in the rush for development. By the late 1960s the fallout raised the first voices of concern. Homegrown responses included community-based conservation, the Wildlife Clubs of Kenya and the Greenbelt Movement (GBM). Kenya contributed to a new paradigm, linking development to environmental sustainability, when the National Environmental Secretariat (NES) was set up in Nairobi in 1971. Kenya also ratified the Convention on Biological Diversity (CBD) that underscores biodiversity conservation as the foundation of human development and wellbeing, and the Kyoto Protocol on Climate Change. The Environmental Management and Coordination Act (EMCA) of 1999 domesticated Kenya's international treaty obligations to conserving biodiversity.

In 2010 Kenya's commitment to conserve biodiversity was indelibly embedded in the constitution, declaring that every Kenyan has the right to a clean and healthy environment and a duty to protect it. A raft of new policies and legislation is incorporating these fundamental rights and responsibilities into law.

Kenya's Natural Capital: A Biodiversity Atlas documents the wealth of biodiversity, its many values, the status of species and ecosystems, the threats they face and the gaps that remain in conservation policy and practice. This chapter underscores the link between biodiversity, ecosystem services, sustainable development, and Kenya's goal of adopting natural capital as the pillar of development alongside human and economic capital.

CHAPTER 2: A WEALTH OF ECOSYSTEMS

Kenya's rich biodiversity has been shaped by geology, topography, soils, climate and hydrology, and moulded by the forces of evolution and time to create a diversity of environments modified by rising human activity. The varied environments created distinctive eco-climatic zones each with a characteristic assemblage of plants and animals adapted to geography and climate—making up distinctive ecosystems. The major ecosystems range from forests to grasslands, shrublands, woodlands, wetlands, deserts, lakes, rivers, montane and afro-alpine highlands and marine environments.

Each ecosystem provides a range of services and values that have shaped and sustained livelihoods and enriched the cultures of Kenya's peoples down the ages. Each ethnic group has a unique heritage based on husbandry practices, and plants and animals adapted to seasons, harsh conditions and hard times. Although traditional peoples transformed Kenya's landscape andecology over time, they caused few animal or plant extinctions.

A modern Kenyan landscape now overlays natural ecosystems and traditional lands. The distinctive associations between eco-climatic zones, plants, animals, livelihoods and culture are fast disappearing, replaced by plantations, greenhouses, irrigation, commercial farms and urban consumer societies. In recent decades, burgeoning human activity has transformed Kenya's natural landscape to such an extent that human-modified and human- manufactured landscapes have supplanted natural ecosystems. Despite the environmental transformation Kenya's economy and society is still heavily rooted in and shaped by the environment. How efficiently and sustainably Kenya uses its biodiversity and ecological services for economic development and human wellbeing depends on sound knowledge and wise husbandry of its natural capital.

CHAPTER 3: A WEALTH OF SPECIES

The rich tapestry of Kenya's environments and ecosystems explains the wealth of its animals and plants. Although Kenya is not among the richest nations in terms of total species, ten of the world's fourteen biogeographical regions are found within its borders. Together with neighbouring Tanzania, the variety of ecosystems makes Kenya the richest vertebrate region in Africa and places it in the top rank worldwide. Most notable of all is the region's renowned abundance and variety of large herbivores and carnivores that have made Kenya a wildlife Mecca.

The Convention on Biological Diversity gave global recognition to biodiversity, highlighting its fragility and underscoring its importance to sustainable development. The Convention calls for accurate and up-to-date data on species, their current status, the threats they face, the actions being taken to protect them and the gaps that remain in conserving biodiversity.

A Wealth of Species provides the first compilation of Kenya's biodiversity. It also gives an overview of the distribution of plants and animals; biodiversity hotspots; endemic, endangered and threatened species, their value to society and the threats they face. Kenya's list of species exceeds 30 000 but is far from complete due to the paucity of biodiversity surveys and collections.

The main threats to biodiversity arise from land-use change, habitat destruction and over-harvesting. Pollution, invasive species and climate change pose new and growing threats. Protected areas are important conservation safeguards yet give inadequate conservation coverage to Kenya's biodiversity and leave out many of the biodiversity hotspots, especially of plants.

CHAPTER 4: STATUS, THREATS AND RESPONSES

Global diversity has dropped sharply in in the last 35 years. Forests are degrading, coral reefs are deteriorating, wildlife populations are declining and a quarter of all plant species are threatened with extinction. Global benchmarks set for biodiversity conservation have not been met and the shortcomings are mirrored on national and local scales across Kenya.

Population pressure and poverty combine to put unsustainable demands on natural resources and the environment. Agriculture, the mainstay of the economy, led to dwindling landholdings, growing pressure on land, accelerated erosion and declining soil fertility over much of Kenya. Divergent value systems, human-animal conflicts, and cultural and religious beliefs also threaten biodiversity and natural resources.

In this chapter, a DPSIR Drivers, Pressures, Status, Impact and Responses approach is used to assess the standing of biodiversity and natural capital in Kenya's main ecosystems: the rangelands; forests; lakes, rivers and wetlands; the coastal and marine ecosystems; and the moorlands and afro-alpine meadows. The state of natural resources is analysed in terms of wildlife, forests, biomass energy and fisheries. The responses to the threats are reviewed, including policies and legislation, protection, participation in international environmental treaties, and public outreach and engagement. The concluding section identifies the main gaps in conservation, the need for a more comprehensive approach to valuing ecosystem services and for a national auditing and monitoring systems for Kenya's natural capital.

CHAPTER 5: VALUATION OF BIODIVERSITY AND ECOSYSTEM SERVICES

Gross Domestic Product (GDP) measures national economic growth but ignores the ecological services provide by natural capital and the costs of overuse and depletion. This chapter details the importance of ecological services and provides examples that take ecological, social and economic factors into account in planning and management. It also considers a range of new tools for natural capital accounting based on environmental assets and losses. Many countries are beginning to value environmental health and sustainability in their national accounting. Kenya, one of the first signatories to the *Communiqué on Natural Capital Accounting,* has pledged to value and sustain its natural capital. Some of the tools for doing so, including Payment for Ecosystem Services (PES) and Total Economic Value (TEV), are considered. Such comprehensive valuations allow decision-makers to weigh the value of precautionary conservation action and the cost of inaction. Fully valuing nature's services also identifies the benefits and beneficiaries of natural capital to ensure its equitable and sustainable use. Although few quantitative studies have been conducted in Kenya to date, examples given in this chapter, including Payment for Watershed Services in Lake Naivasha and Payment for Wildlife Habitats in the Mara Ecosystem, illustrate the benefits of fully valuing ecosystem services.

The adoption of natural capital accounting is essential to the achievement of Kenya's Vision 2030, but has yet to be incorporated into the national planning processes. This chapter ends with policy and regulatory recommendations to introduce natural capital accounting for Kenya—as the basis for bridging economic growth and the wellbeing of its people.

CHAPTER 6: CONSERVING BIODIVERSITY FOR SUSTAINABLE DEVELOPMENT

A decline in biodiversity and erosion of natural capital is not unique to Kenya. None of the eleven targets for conserving global biodiversity set by the Convention on Biological Diversity in 2002 were met by 2010. Despite some progress in arresting the trends, loss and degradation of species, habitats and ecosystems continues worldwide. The failure is due to focus on proximate solutions such as protected areas and species survival rather than the root causes of loss—the social and economic problems standing in the way of a fair and sustainable use of ecosystem services and natural capital. Priority should be placed on convincing decision-makers to ensure that biodiversity is fully valued and embedded in the national development agenda.

Development goals have been equally elusive. The United Nations (UN) Rio+20 summit of 2012 identified the main setbacks to achieving the Millennium Development Goals (MDGs) and called for setting Sustainable Development Goals for incorporation into the MDGs after the 2015 implementation deadline. Such goals must link social and economic targets. They must not only meet the needs of the present without compromising the ability of future generations to meet their needs. They must also safeguard earth's life support systems on which the welfare of all generations and all life depends.

This chapter outlines the steps Kenya has taken towards policies and practices that sustain development and conserve biodiversity. It also identifies the gaps that stand in the way of linking the two—in line with Vision 2030 and the Constitution of Kenya 2010. Priorities for conserving Kenya's rich and unique biodiversity are also identified. The need to fully value ecological services and adopt natural capital accounting mechanisms is explained and illustrated with examples from Kenya's economic planners.

In line with new constitutional goals and mandates, Kenya is committed to identifying and addressing threats to biodiversity and opportunities for development and wellbeing. It does so by strengthening national and county administration. The main emphasis will shift from central management and enforcement policies to devolved voluntary environmental management based on incentives and opportunities. Policies will shift from costly restorative environmental measures to thrifty conservation practices reflecting national aspirations—and will be built into planning, development and investment processes.

Kenya's commitment to sustainable development and conserving biodiversity calls for valuing and monitoring natural capital within a national economic and social framework. This chapter concludes with steps that Kenya will take to establish natural capital as a foundation of development alongside human and economic capital.

CHAPTER

01

Natural Capital in NATIONAL PERSPECTIVE

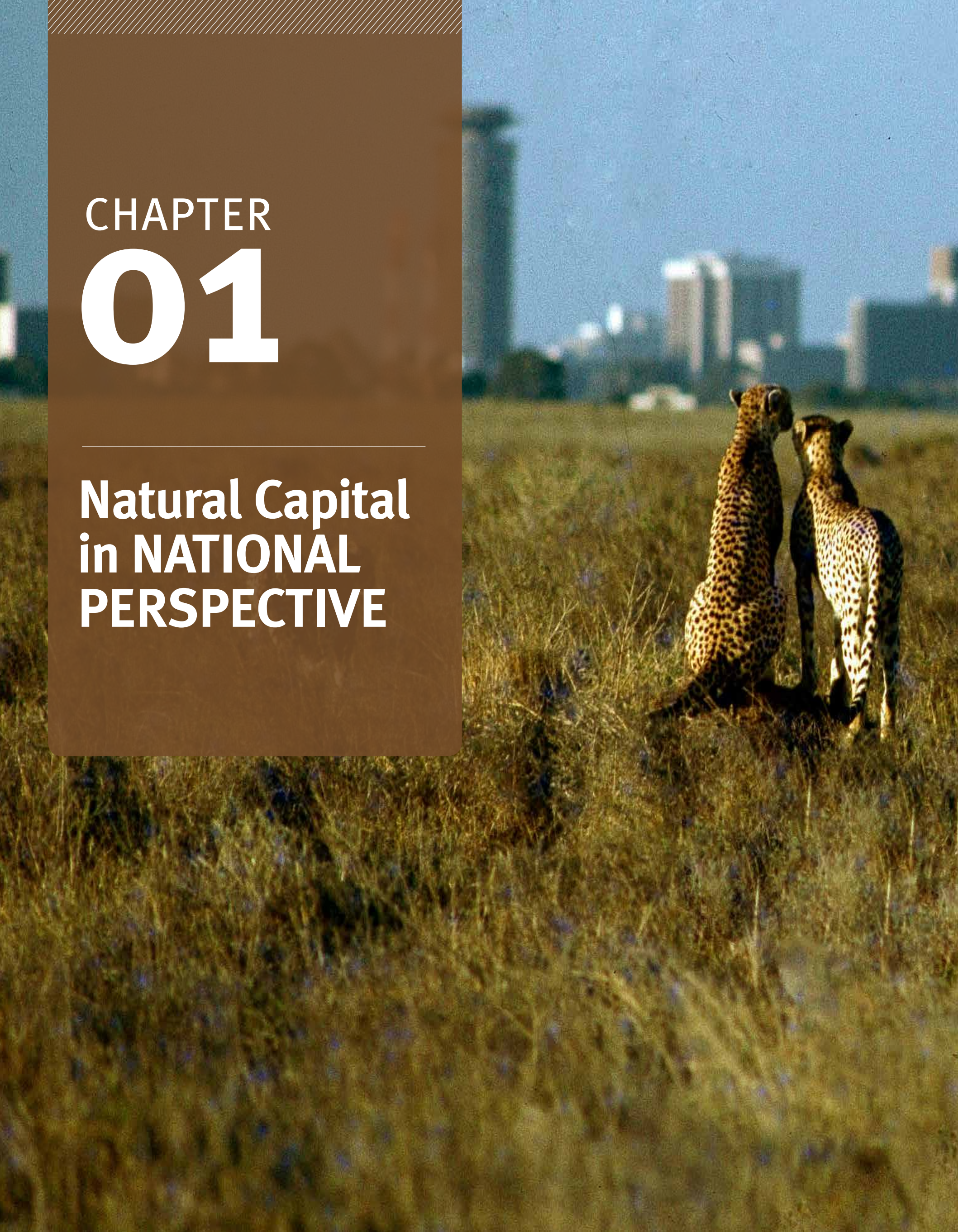


PLATE 1.1: Cheetah at Nairobi National park with Nairobi City as the background. © *Camerapix Ltd.*

BOX 1.1: NATURAL CAPITAL DEFINED

Natural Capital is world's stocks of natural assets which include geology, soil, air, water and all living things.

Natural capital is thus the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future. For example, a stock of trees or fish provides a flow of new trees or fish, a flow which can be indefinitely sustainable. Natural capital may also provide services like recycling wastes or water catchment and erosion control. Since the flow of services from ecosystems requires that they function as whole systems, the structure and diversity of the system are important components of natural capital.

Source: The Encyclopedia of Earth.

WHAT IS NATURAL CAPITAL AND BIODIVERSITY?

It is from this Natural Capital that humans derive a wide range of services, often called ecosystem services, which make human life possible. Ecosystem services are the benefits that the environment provides to humans, benefits that we have traditionally viewed as free and would have to supply for ourselves if our surroundings ceased to furnish them. The environment provides direct services, including air, minerals, food, water and energy. It furnishes regulating services such as the purification of water, carbon sequestration, climate mitigation, waste decomposition and detoxification, crop pollination, and pest and disease control. The environment supplies support services including nutrient dispersal and cycling, as well as seed dissemination. The environment also yields cultural benefits, such as intellectual and spiritual inspiration, recreation, ecotourism, and scientific discovery.

PLATE 1.2: Reconstruction of a Pleistocene ecosystem.
Over a million years ago our human ancestors emerged in the African savannahs and co-evolved with a rich assemblage of wild herbivores and carnivores. © Jay Maternis. *Source: National Museums of Kenya*

ORIGINS OF KENYA'S BIODIVERSITY AND PEOPLES

Kenya is known as the safari capital of the world. A place where rhinos, lions, giraffe and zebra stroll by tourists vehicles within sight of bustling downtown Nairobi. Less publicized is Kenya's majestic scenery. The nation's rich collage of landscapes range from the Chalbi Desert in the north to the snow-clad peaks of Mt. Kenya, from the white beaches of the Indian Ocean to the shores of L. Victoria, and from the rolling plains of Maasai Mara to the floor of the Great Rift Valley.

Kenya is also the foundry of varied cultures and lifestyles rooted in the productivity and diversity of its landscapes. Over forty ethnic groups spanning hunter-gatherers, herders, farmers, fishermen, artisans and traders have depended for eons on the providence of the land, soils, waters, plants and animals.

Kenya's indigenous peoples trace their roots to the dawn of humankind. The fossil beds of Olorgesailie reveal our humble origins in the African savannah over a million years ago and trace our emergence to fully modern humans. Over this timespan our forbearers rose to ecological dominance and shaped Kenya's ecosystems through the use of fire, tools and husbandry practices.

Over the last hundred thousand years modern humans spread out of Africa and colonized first Europe and Asia, then the New World, and finally the remotest of islands. The extreme age of Africa's human ancestry is reflected in the richness of its cultures and the far greater genetic diversity and phonal richness of its languages than any other peoples'.

Over the last 5 000 years, Kenya became the crossroads of migrating peoples within and around the African continent (Andrew Fedder, 1979). From Central and West Africa came Bantu farming peoples, bringing with them new crops, iron smelting and metallurgy. From the north came Cushitic hunters and Nilotic pastoralists introducing cattle, sheep, goats, donkeys and camels. Borne by the Monsoon Trade Winds of the Indian Ocean came people from the Near East, Far East and Europe—each with new skills, knowledge, livelihoods, lifestyles, cultures, religions and languages. The peoples of coastal Kenya bridged the interior and exterior worlds of Africa, developing the trading language, Kiswahili, and a rich cosmopolitan culture (Kesby, 1977).

The quickening change at the cultural crossroads of Kenya brought new domesticated species of plants and animals, as well as new tools and skills to the region's ancient cultures, reshaping the landscape once more. To indigenous crops such as sorghum, millet and melons were added more

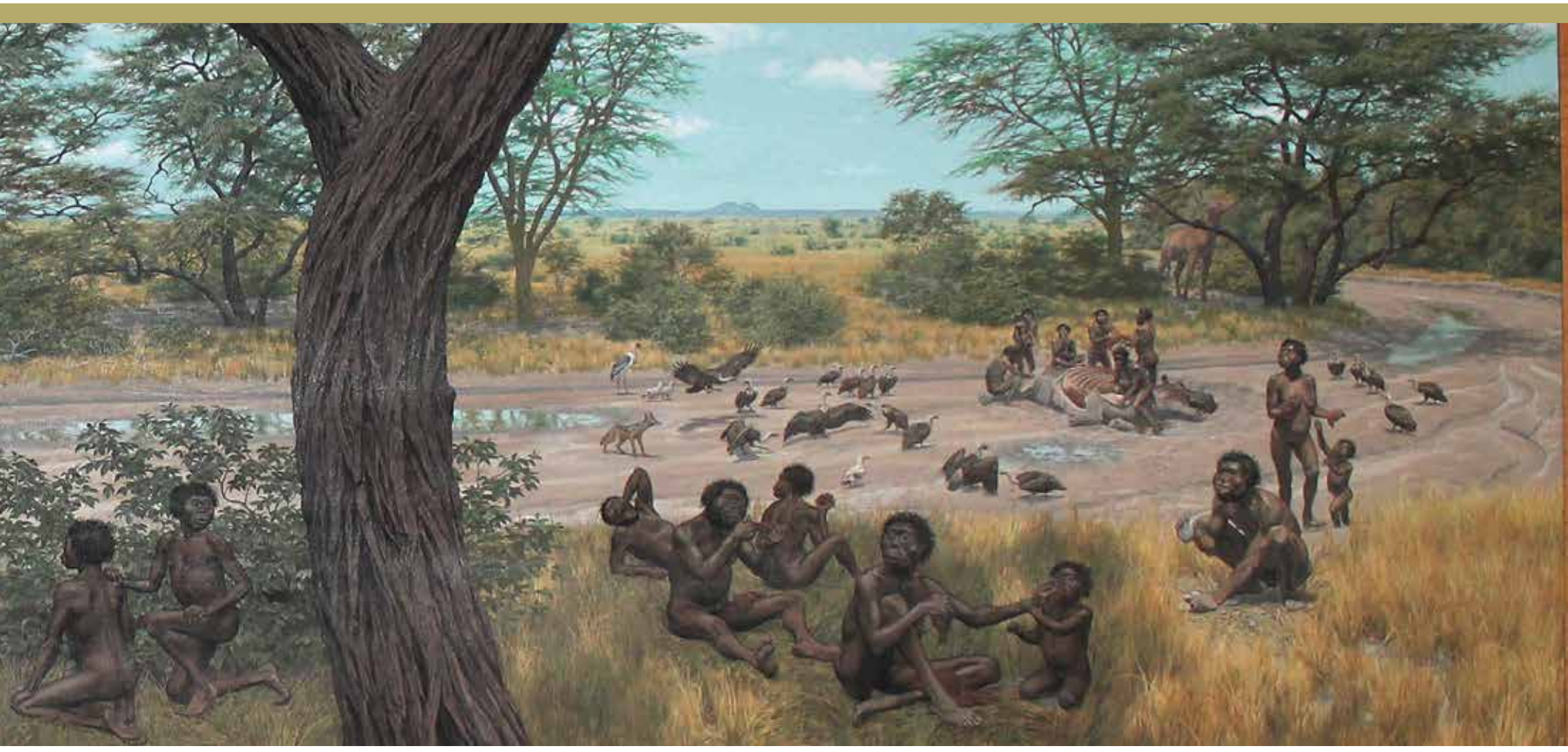
Biodiversity represents the foundation of ecosystems that, through the services they provide, affect and critically contribute to human wellbeing. Kenya, ranks among the world's richest biodiversity nations (IUCN & UNEP 1986, Groombridge 1992, Rathbun 2009) and hosts over 35 000 species, which collectively support the livelihoods of over three-quarters of its population. Biodiversity underpins Kenya's national development, particularly in the agricultural, tourism, industrial and health sectors. In the agricultural sector alone, biodiversity through the ecosystem services it supplies, supports the livelihoods of 70% of the 38.6 million rural Kenyans. Wildlife-based tourism, the third largest foreign exchange earner after tea and horticulture, makes up 10% of Kenya's GDP (National Tourism Policy, 2006). The three largest foreign exchange earners are all the product of healthy productive ecosystem. In the power sector, hydropower driven by Kenya's rivers generates 51% of the country's electricity (Kenya Vision 2030) and over 80% of Kenyans rely on plants as a primary source of medicine.

BOX 1.2: BIODIVERSITY DEFINED

Biodiversity is the variability among living organisms from all sources including, inter-alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Source: The Convention on Biological Diversity.

Without fully accounting for natural capital, Kenya risks losing the foundation of its economy. Full accounting calls for quantifying, mapping and valuing the services provided by nature, assessing the many benefits it provides and building the capacity and institutions to ensure the efficient and sustainable use of natural capital



productive cash crops such as maize, beans, rice and bananas. To traditional bushmeat such as buffalo, eland and giraffe were added domesticated cattle, sheep, goats, camels and chickens. Populations grew rapidly with new husbandry practices, leading to the establishment of large villages, towns and, along the coast, small cities such as Mombasa, Malindi, Lamu and Pata (Abungu, 1998).

The hybridization of ancient hunting and cultivation practices with new farming, herding and trading cultures led to a wide variety of lifestyles, livelihoods and cultures reflecting Kenya's varied environments and climate. Spliced onto the rich indigenous knowledge of the land and management of its natural resources, the new crops and livestock raised the productivity of indigenous husbandry practices and diversified diets. New varieties of crops and livestock adapted to local conditions added genetic richness to indigenous breeds such as the red-headed sheep and short-horn zebu cattle.

Despite a growing population, and perhaps due to a long history of husbanding scarce resources in the face of harsh droughts and climate changes, Kenya's cultures learned to collaborate in managing the land and conserving resources. In the process, Kenya's peoples achieved what few have done: sustained biological diversity into modern times. Whereas in the last 50 000 years Europe, Asia, the Americas, Australia, New Zealand and Madagascar lost most of their native large animals to hunters and land transformation, few went extinct in Africa. Kenya's biological diversity survived a second wave of extinctions as colonial powers spread around the world and across Africa with modern weapons and technology.

The survival of biological diversity in a modern industrializing state is a legacy few countries can claim and most envy. Here, in the cradle of humankind, a view across the herds of wildebeest in Maasai Mara looks much as it would have done to our ancestors 350 000 years ago. Europe is famous for its great cathedrals and citadels and America for its natural monuments such as the Grand Canyon and Yosemite but Eastern Africa alone can celebrate a wildlife legacy from the Pleistocene Age. The annual migrations of Mara and Serengeti are known as the Eighth Natural Wonder of the World and attract a pilgrimage of visitors each year.

KENYA'S CONSERVATION MOVEMENT

Kenya was fortunate to be colonized so late and to have established hunting regulations so early. At the dawn of colonialism in the late 1800s, the first steps were taken to stem the slaughter that had wiped out the great herds of bison in America and blaubok, quagga and springbok in southern Africa.

The Game Department was established in 1906, the first national park, Nairobi, in 1947, followed shortly by such parks and reserves as Tsavo, Mara,

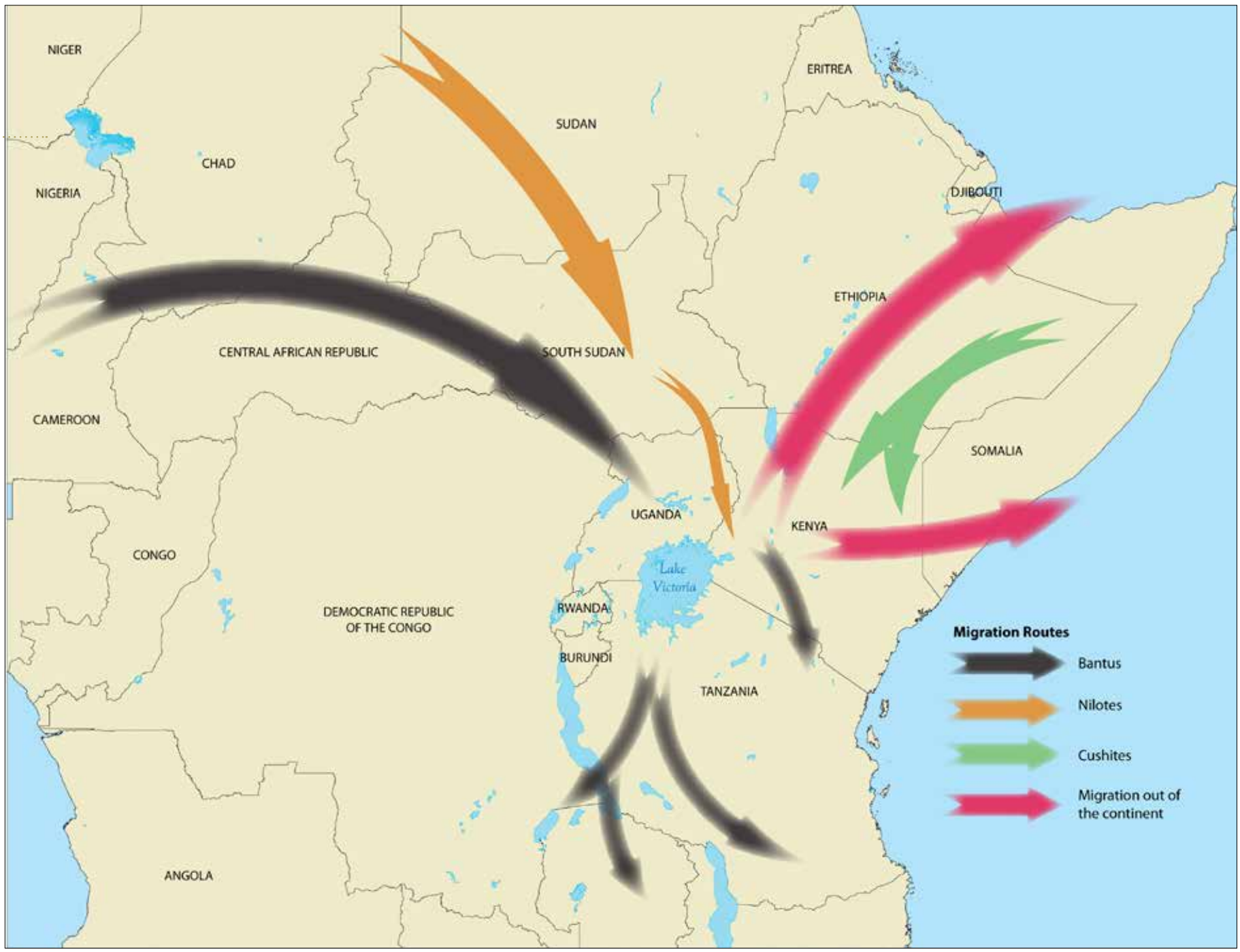


FIGURE 1.1: A diversity of cultures.
Kenya lies at the crossroads of many ethnic groups migrating from within and beyond Africa. Over 46 ethnic groups give modern Kenya a diversity of cultures and livelihoods that have helped shape the landscape and biodiversity. *Source: National Museums of Kenya*

Amboseli and Samburu (Kenya Wildlife Service, 1997). In parallel with wildlife regulations and wildlife reserves, the Kenya Forest Services established similar regulations governing forests and reserves. Regulations to restrict overfishing, soils and water catchments soon followed.

The importance of Kenya's wildlife and natural resources was recognized by its founding president, Jomo Kenyatta:

resources of this country; its wildlife h an attraction to visitors from all the beautiful places in which these e mighty forests which guard the t areas so vital to the survival of man and beast, are priceless heritages for the future. The Government of Kenya, fully realizing the value of its natural resources, pledges itself to conserve them for posterity with all the means at its disposal."

Jomo Kenyatta, founding president of Kenya, 1963

BOX 1.3: EARLY CONSERVATION REGULATIONS AND SENTIMENTS

The first hunting licenses and game quotas to restrict hunting in Kenya were instituted in 1885.

"It would be melancholy to think that such glorious creatures as the eland, the kudu, the sable antelope and zebra were passing into extinction when they might be saved and perpetuated by our making a little effort in the right direction."

Sir Harry Johnston, Special Commissioner to Uganda, 1894.

In 1899 the Northern and Southern Reserves were established to protect wildlife and the rights of indigenous peoples.

In 1901 the first game ranger was employed in Kenya to protect wildlife, especially in the reserves.

In 1902, to curb destruction, forest lands were declared property of the state.

"We owe the preservation of the interesting and valuable and sometimes disappearing types of animal life as a debt to nature and to the world. The reserves exist not for the gratification of the sportsman, but for the preservation of … animal life."

The Secretary of State in Britain, 1906.

Kenya's natural heritage was seen as the foundation of economic growth in the newly independent nation. The future lay in boosting crop and livestock yields from the nation's rich arable farmlands and sprawling rangelands, and in the growth of the forestry, fisheries and wildlife sectors. Newly independent Kenya drew up strong legislation and earmarked development and research funds to boost production from natural resources without depleting water supplies, soils, nutrients, forests and pasture.

The increase in production from Kenya's natural resources bolstered a rapid demographic and economic transition in the country. The population grew from 8.6 million at independence to 43 million in 2013, GDP grew from $793 million to $37 billion in 2012; the number of universities from 1 to 35. Agricultural output rose with inputs of fertilizers and pesticides, and the securing of domestic and export markets. Farmers and herders migrated to towns and cities, spawning the growth of industry, transportation and commerce.

With rapid population growth and rising consumption, there were soon heavy demands on land, water and energy to feed Kenya's growing numbers and rising wealth. Natural resource extraction outstripped Kenya's investment in conservation and extension services. Forest and wetlands shrank, rangelands degraded, erosion climbed and wildlife numbers fell rapidly. Adding to the growing impact was a new source of environmental threat to Kenya—pollution caused by industrial and commercial activity. As levels of pollution in the air, water and soils rose, they posed a growing threat to human as well as environmental health.

Until the late 1960s the environmental costs of development were viewed as inevitable. The economic mantra was: first create wealth then repair the damage. Governments and development agencies alike heavily discounted the cost of environmental damage to future generations and overlooked the point that prevention was far less costly than repairing the damage in future.

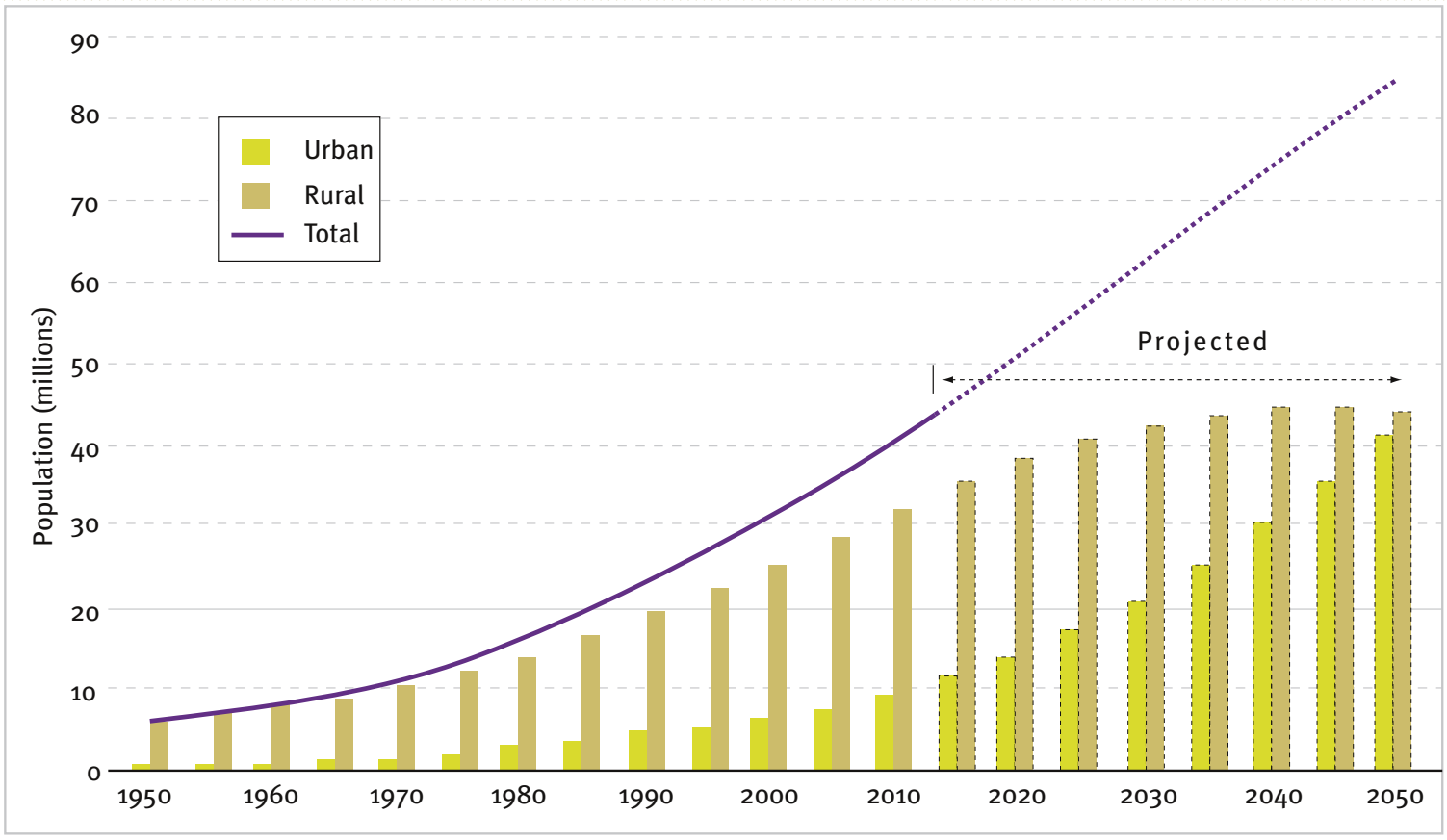


FIGURE 1.2: A growing population.
Kenya's population has grown fivefold since independence, placing heavy demands on natural resources. Internal migration will see half the population in cities by 2050 and rural numbers leveling off and starting to fall. *Source: UNDP, 2014. http://esa.un.org/wpp/*

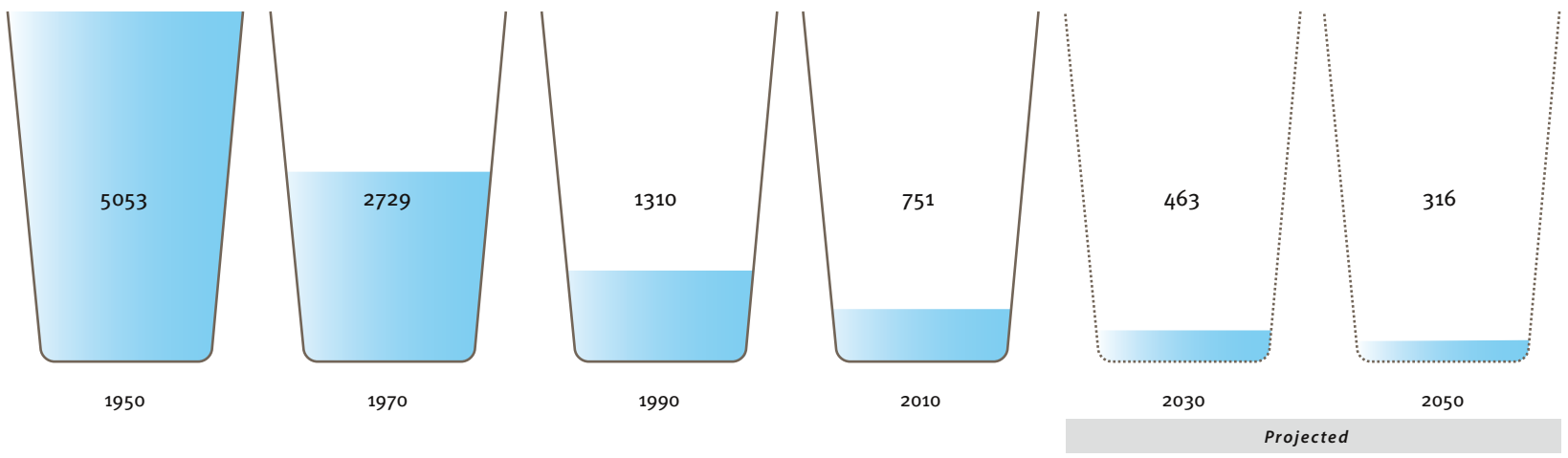


FIGURE 1.3: A growing human population and rising per capita use of resources is depleting water supplies in Kenya. Highly efficient water conservation and management will be needed to avoid extreme shortfalls in supply projected by 2030 and 2050.
Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2012 Revision. http://esa.un.org/unpd/wpp/index.htm

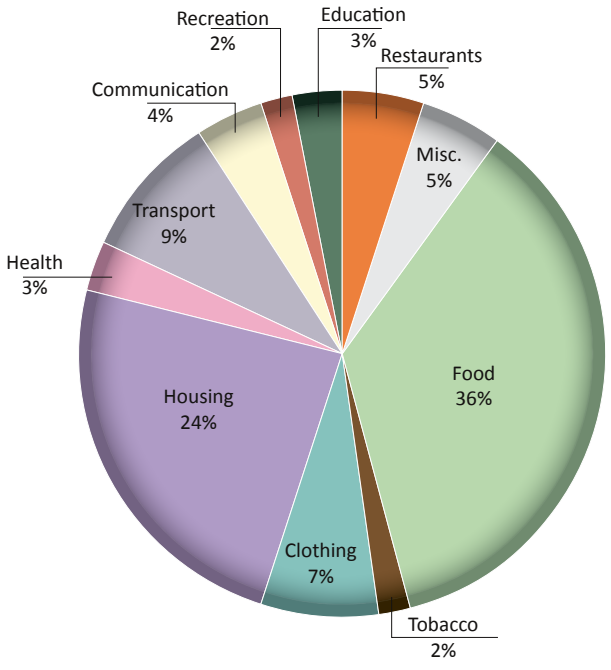


FIGURE 1. 4: Changing trends of per capita expenditure.
Per capita expenditures have shifted with development: from most of family income being spent on food to two-thirds on other activities and products. The growth in material consumption and affluence has widened human impact on the environment.
Source: GoK (2010d). Kenya Population and Housing Census, Vol 1B. Population Distribution by Political Units. Kenya National Bureau of Statistics (KNBS) Government Printer, Nairobi.

By the late 1960s ecologists were raising alarm over the cost of runaway population growth and development to forests, farmlands, air, water and soils around the world. In western nations, a young generation rallied behind a growing environmental and civil rights movement to protest the damage. For the first time, the opposition between development and environment was brought to light.

Kenya was at the forefront of the new environmental sensibility. The Wildlife Clubs of Kenya, founded in 1968, marched in the streets of Nairobi to save wildlife. Wangari Maathai, the first person ever to win a Nobel Prize for the environment, formed the Greenbelt Movement, which rallied women and children to save forests and plant trees.

Ecologists, natural resource economists and the media alerted Kenyans to growing environmental woes. By the mid-1970s elephant and rhino populations were in freefall, jeopardizing Kenya's lucrative tourism industry. Even as Kenya built dams on the Tana River to generate electricity for the national grid, studies showed erosion from the upper catchment washing away farmers' top soil, silting up the dams, jeopardizing fishing in the rivers and coral life at the coast.

The growing environmental awareness in Kenya raised the prospects for a new development paradigm linking economic and social development to environmental health.

> *"Activities that devastate the environment and societies continue unabated. Today we are faced with a challenge that calls for a shift in our thinking, so that humanity stops threatening its life-support system. We are called to assist the Earth to heal her wounds and in the process heal our own."*
>
> *Prof Wangari Maathai, 2004 Nobel Laureate*

CONSERVATION AND DEVELOPMENT

The first steps towards the new linkage came in 1971 with the founding of the National Environmental Secretariat (NES), housed in the Ministry of Natural Resources, and later the Office of the President (United Nations Environmental Programme, 2001). NES' first task was to prepare for the UN Conference on Human Environment in 1972. Kenya's strong participation at the conference persuaded the international community to locate the United Nations Environmental Program (UNEP) in Kenya. Established in Nairobi in 1973, UNEP would give Kenya a strong international voice for balancing environmental health with development goals.

Kenya's Development Plan for 1979 to 1983 included *'The Policy Framework'*, a section that made provisions for environmental protection. The provisions included a National Land Commission, policies for land-use and soil erosion control, and the setting aside of land for forestry, wildlife, flood abatement and other conservation measures. The *'Environmental Management Policy'* section explicitly stated that the prevention of harmful effects was cheaper than correction (United Nations Environmental Programme, 2001).

Rising environmental concerns prompted civil and government action. Kenya was a strong voice at the Stockholm Conference, which first drew the attention of world leaders to the perils of unregulated development to humanity and the planet. Kenya also backed the sustainable development principles drawn up by the Bruntland Commission and adopted by the World Commission for the Environment and Development in 1987 (WCED, 1987).

Kenya played an equally strong role in the Earth Summit of 1992, which brought to the attention of world leaders the importance of biodiversity (Convention on Biological Diversity, 1992). The CBD sets three primary goals: 1) the conservation of biological diversity; 2) the sustainable use of the components of biological diversity and 3) the fair and equitable distribution of the benefits of biodiversity. It also spells out the role of governments

PLATE 1.3: Grassroots tree-growing initiatives.
Overuse and destruction of forests in Kenya has prompted grassroots tree-growing initiatives such as the Greenbelt Movement launched by Nobel Laureate Wangari Maathai.
Source: Green Belt Movement.

BOX 1.4: WHAT IS SUSTAINABLE DEVELOPMENT?

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own (WCED, 1987).

in setting rules to guide the use of natural resources and developing National Biodiversity Strategies and Action Plans (NBSAPs). The CBD underscored the need to integrate national plans for environment and development—particularly in the case of sectors such as forestry, agriculture, fisheries, energy, transportation and urban planning.

In the years following the Earth Summit, the value of biodiversity in sustaining economic development on one hand, and human wellbeing on the other, has been recognized and adopted internationally. The values and costs of business-as-usual development became all the more apparent when scientists showed, in the 1980s, that rising greenhouse gases, emitted by burning fossil fuels, were warming the planet and changing global climate and weather patterns. This new and untold threat to sustainable development, human health and the environment arose from greenhouse gas emissions spewed into the atmosphere by 150 years of industrial activity, and rapid poorly-regulated economic activity worldwide. The Kyoto Protocol, aimed at setting internationally binding emission reduction targets, was adopted in December 1997 and entered into force on February 2005.

Kenya, in addition to ratifying the CBD and the Kyoto Protocol, supported and adopted many other international conventions dealing with environmental protection, including the Convention on International Trade in Endangered Species, The Wetlands Convention and the Migratory Species Convention.

To integrate its development plans with environmental sustainability and domesticate its obligations to international treaties, Kenya drew up the Environmental Management and Coordination Act of 1999 (Environmental Management Coordination Act, 1999). EMCA subscribed to the principles of sustainable development and set up the legal framework and institutions to ensure all developments were regulated accordingly.

The Kenya National Biodiversity Strategy and Action 2000, produced by the Ministry of Environment and Natural Resources after extensive public consultation, laid out Kenya's goals and plans for conformity with the CBD. Kenya has made a good deal of progress in fulfilling the goals of the convention and submitted regular national reports to the Conference of Parties of CBD.

BOX 1.5: STEPS TOWARDS CONSERVING BIODIVERSITY (CBD, 1992)

- Identifying and monitoring the important components of biological diversity that need to be conserved and used sustainably.
- Establishing protected areas to conserve biological diversity while promoting environmentally sound development around these areas.
- Rehabilitating and restoring degraded ecosystems and promoting the recovery of threatened species in collaboration with local residents.
- Respecting, preserving and maintaining traditional knowledge of the sustainable use of biological diversity with the involvement of indigenous peoples and local communities.
- Preventing the introduction of, controlling, and eradicating alien species that could threaten ecosystems, habitats or species.
- Controlling the risks posed by organisms modified by biotechnology.
- Promoting public participation, particularly when it comes to assessing the environmental impacts of development projects that threaten biological diversity.
- Educating people and raising awareness about the importance of biological diversity and the need to conserve it.
- Reporting on how each country is meeting its biodiversity goals.

VALUING NATURE'S SERVICES

Only once the threats of human activity at a global and local scale were highlighted by the Millennium Ecosystem Assessment in 2000 (Millenium Ecosystem Assessment, 2005) did the connection between environmental health and human wellbeing raise hard questions. What is the link between biodiversity and the goods and services it provides humankind with? How fragile and imperiled is biodiversity? What are the consequences for present and future generations if the ecological services provided by biodiversity are unrecognized, undervalued and lost?

The Millennium Ecosystem Assessment brought the significance of biodiversity to sustainable development and human wellbeing into focus. A new field of economics, Sustainable Economics, aimed at valuing nature's capital once taken for granted, gave definition to ecosystem services and showed the many unrecognized and economically discounted values of biodiversity.

The ecological services Kenya derives from biodiversity are the bedrock of Kenya's agricultural production, livestock economy, fisheries and forestry industries, and wildlife economy. Biodiversity also buffers humans, crops and livestock from drought, floods and disease.

BOX 1.6: THE MILLENNIUM ECOSYSTEM ASSESSMENT

The Millennium Ecosystem Assessment (MEA) commission by the UN and compiled by over 1 000 scientists, looks at the status of the Earth's major ecosystems. Released in 2005 the report concludes that humanity has a large and growing impact in degrading biodiversity and the ability of ecosystems to recover. The report recognizes natural resources as our life support, providing a range of ecosystem services. Of 24 ecosystem services nature provides, only four have shown improvement in the last half century, fifteen are in serious decline, and five are stable but threatened in many areas. The report offers summaries and guidelines for decision-makers. (Millenium Ecosystem Assessment, 2005)

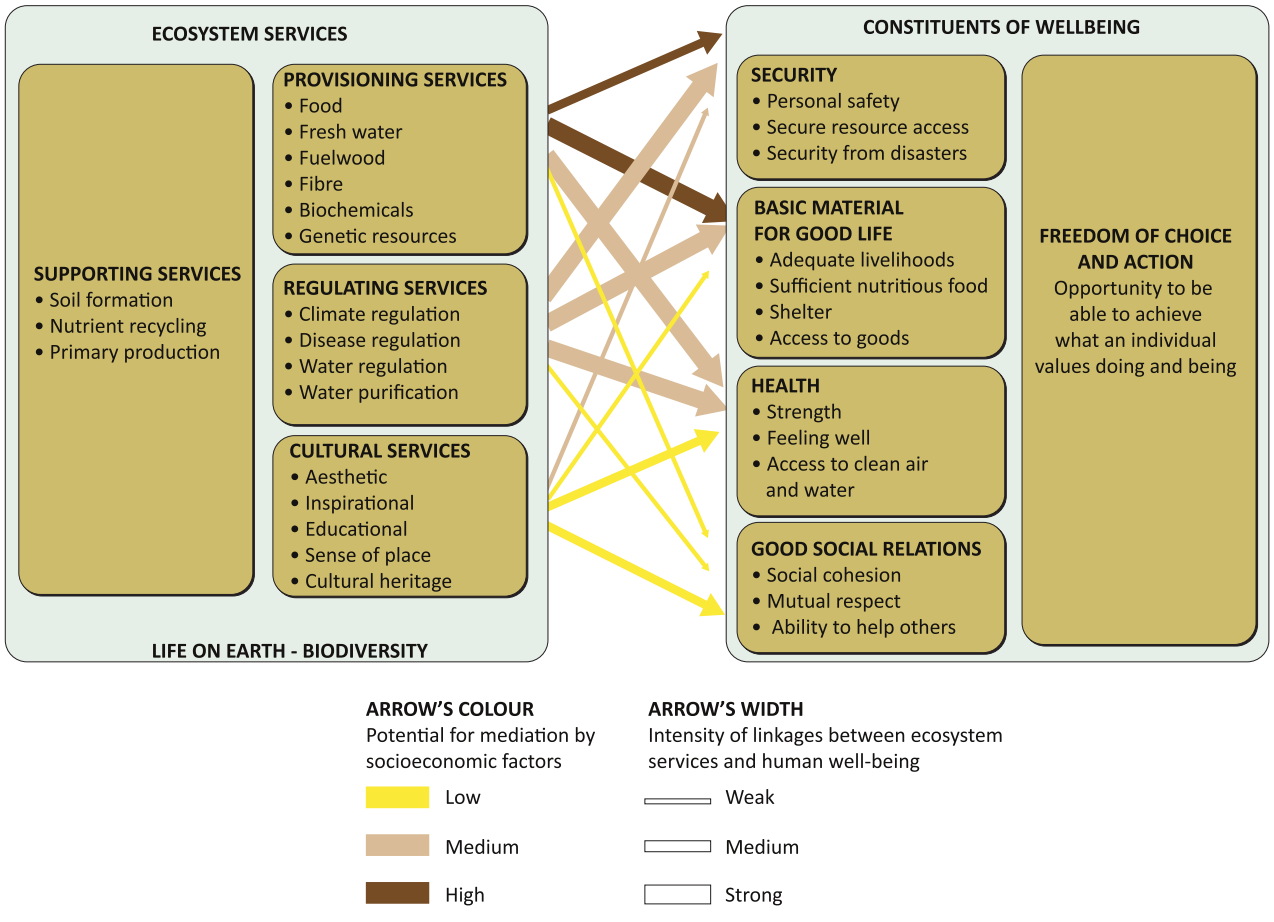


FIGURE 1.5: The range of ecosystem services.
The range of ecosystem services: At an ecosystem scale, ecosystem services govern hydrological and nutrient cycles, contain erosion and boost soil fertility. At a global scale, they regulate carbon and geochemical cycles and, in so doing, buffer the atmosphere and oceans from extreme oscillations. At a personal level, biodiversity connects our ecological and cultural values and provides spiritual, aesthetic and recreational outlets for our wellbeing. *Source: Millennium Ecosystem Assessment 2005. http://www.millenniumassessment.org/documents/document.765.aspx.pdf*

We are still at a rudimentary stage of recognizing, valuing and quantifying the many ecological services biodiversity provides us with. Few countries have mapped their biodiversity fully, let alone evaluated its services. Fewer still have compiled the sum of all their biodiversity and begun to audit and monitor this natural capital as a pillar of development.

Kenya's Vision 2030 aims at becoming a middle-income industrial economy by 2030 (Kenya Vision 2030, 2007). It aims to do so, on the basis of a green economy rather than fossil fuels. The vision is founded on the premise that sustainable development can be best achieved by using Kenya's renewable natural resources and energy, and sustaining environmental health in the process.

In 2010 Kenya took the far more radical step of embedding environmental standing and rights in its new constitution (Constitution of Kenya, 2010).

Article 42 under the Bill of Rights states:

BOX 1.7: ARTICLE 42 OF THE CONSTITUTION OF KENYA

Every person has the right to a clear and healthy environment, which includes the right to have the environment protected for the benefit of present and future generations through legislative and other measures. The constitution further mandates that the State shall ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources; ensure the equitable sharing of the accruing benefits; protect genetic resources and biological diversity, establish systems of environmental impact assessment, environmental audit and monitoring of the environment; eliminate processes and activities that are likely to endanger the environment; and utilize the environment and natural resources for the benefit of the peoples of Kenya.

BOX 1.8: WHAT IS AN ECOSYSTEM?

An ecosystem is a dynamic complex of plant, animal (including human), and microorganism communities interacting with their physical environment (including soil, water, climate and atmosphere) as a functional unit (MEA, 2005). An ecosystem broadly composes primary producers, the plants that gather sunlight, water and nutrients to manufacture organic matter; secondary consumers, the animals that feed on other organisms; and decomposers than break down and recycle dead and decaying matter through the food chain.

The constitution has prompted a raft of new policies and legislation aimed at incorporating these fundamental rights and responsibilities into law, and setting up the institutional framework to ensure a clean and healthy environment.

BOX 1.9: WHAT ARE ECOSYSTEM SERVICES?

Ecosystem services are the processes and services provided by ecosystems. Ecosystem services supply us with food, clothing, shelter, fuel and medicines; the recycling of natural and human by-products; and pollution abatement. Ecosystems also regulate natural perturbations such as floods, storms, erosion and mudslides, and buffer humans from environmental threats and hazards (MEA, 2005).

TOWARDS A NATURAL CAPITAL ASSESSMENT

In 2010, following the strong commitment expressed in the Constitution of Kenya to sustainable use of natural resources, the Ministry of Environment, Water and Natural Resources convened a public international conference titled *Biodiversity, Land Use and Climate Change.* The conference celebrated the UN *Year of Biodiversity* and aimed at addressing the CBD recommendation that each signatory nation "conduct surveys to find out what biodiversity exists, its value and importance, and what is endangered. On the basis of these survey results, governments can set measurable targets for conservation and sustainable use. National strategies and programmes need to be developed or adapted to meet these targets".

The preliminary maps presented at the conference showed the Kenya–Tanzania borderlands to be the richest site for vertebrate diversity in Africa and among the most important worldwide. The conclusions called for a national audit and monitoring system for tracking and sustaining Kenya's natural capital (Towards a National Biodiversity and Conservation Framework, 2010).

Kenya's Natural Capital: A Biodiversity Atlas is a national endeavor commissioned by the Ministry of Environment, Water and Natural Resources to document the natural wealth of Kenya. The Atlas presents provisional maps of Kenya's biodiversity. It explains what accounts for the richness of its ecosystems and the survival of its unique mega fauna into the 21st century. The Atlas also looks at the status and threats of Kenya's biodiversity; the values it affords society; the steps taken to protect it; and the challenges ahead. It further points to the need for Kenya to fully value its natural capital and provides a framework and case studies for how to do so.

Finally, the Atlas points to a new vision and strategy for how Kenya can incorporate natural capital as one of the pillars of its national development, alongside the economic and political pillars on which Vision 2030 is founded. It is intended, above all, to give Kenyans in all walks of life an Atlas that recognizes and values the rich biodiversity of our country—and lays the foundation for a sustainable future rooted in conservation and efficient use of natural capital.

CHAPTER

02

A Wealth of ECOSYSTEMS

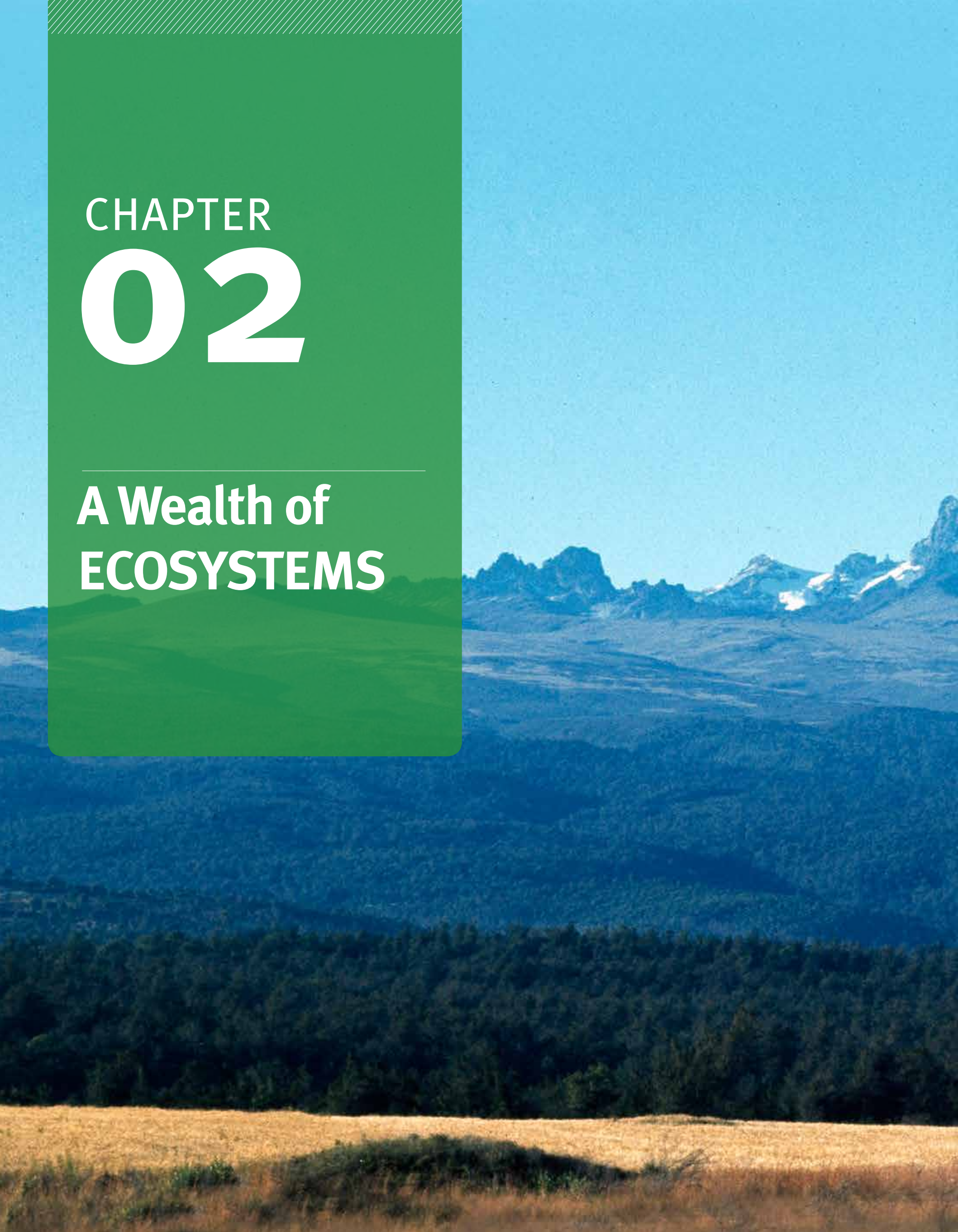


PLATE 2.1: Ice glaciers and cliffs on 17 058-foot-high Mt. Kenya and the variety of habitats. © *Camerapix Ltd*.

Introduction

Kenya owes it rich biodiversity and natural capital to a diversity of environments, fashioned by topography and episodic changes in climate and habitat. No less important are the evolution, migrations and growing impact of humans on the landscape. Kenya's environment today is an amalgam of natural, modified and manufactured landscapes. By unEarthing the forces that shaped the habitats, plants, animals and cultures we gain a deeper understanding of the living realms that underpin the economy and society of modern Kenya.

The sections that follow start with the geological strata and topographical features of the physical landscape of Kenya—the template on which the interplay of climate, soils and hydrology create distinctive eco-climatic zones. Each eco-climatic zone has a characteristic assemblage of plants and animals adapted to its geography and climate. Eco-climatic zones merge into each other along rainfall and altitudinal gradients. This notwithstanding, they are still useful in describing the range of Kenya's physical and biological environments, as well as the traditional livelihoods and land-use potential of each region.

Within each eco-climatic zone variations in topography, soils, hydrology and human activity create locally distinctive ecosystems. Rivers draining the highlands create riverine woodlands and wetlands in the eastern lowlands of Tsavo, for example. Freshwater lakes such Victoria collect in shallow basins with outlets to the sea, and saline lakes such as Nakuru and Bogoria form in closed drainage systems such as the Rift Valley. Mountains such as Marsabit rise above the surrounding eco-climatic zone into cooler atmospheres, capturing rainfall and creating wetter microclimates that attract and support plants, animals and land-uses typical of moister regions. Rivers such as the Tana discharge into the ocean, creating tidal estuaries. The volcanic alkaline soils of Amboseli create open grasslands in a sea of surrounding bushland. The plants, animals and peoples within eco-climatic zones interact to form distinctive human-modified ecosystems such as the coral-reef and fishing communities of the coast; the patchwork of small farms, forest and woodland of the highlands; and the migratory wildlife populations and pastoral lifestyles of savannah ecosystems such as Maasai Mara and Samburu.

Kenya's modern landscape of farms, ranches, indigenous and plantation forests, natural and irrigated wetlands, national parks and rangelands, scattered villages and crowded towns cannot be understood without taking account of the growth and activity of Kenya's people in recent decades. Neither can the nature, growth and shape of Kenya's economy and society be understood or managed properly without taking account of its diverse environments and ecology. How efficiently and sustainably Kenya uses and maintains its biodiversity and natural capital for economic development and human wellbeing depends on our knowledge and husbandry of Kenya's varied environments.

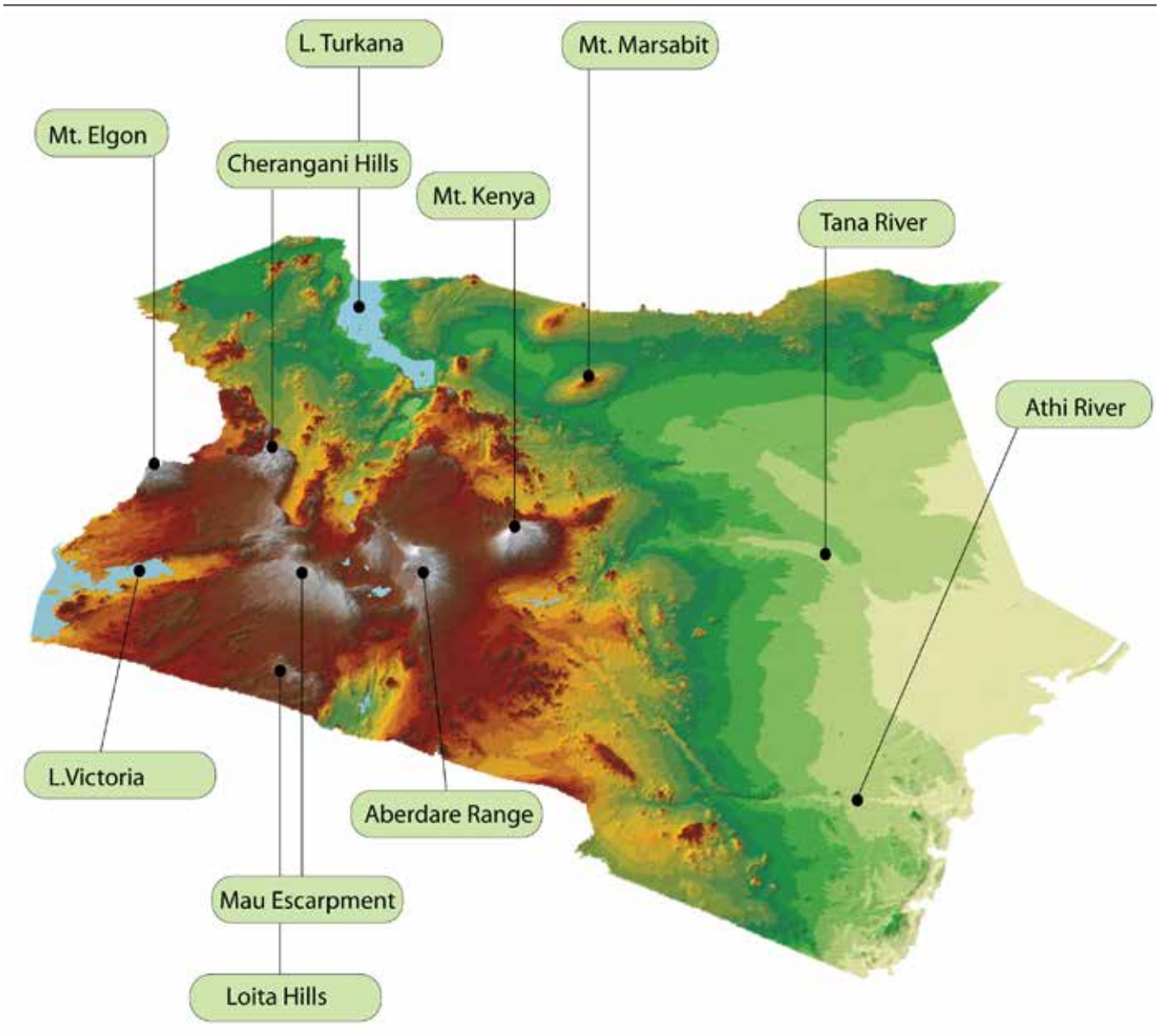


FIGURE 2.1: The topography of Kenya.
Kenya's topography ranges from coastal reefs to high mountains, lake basins, expansive plains and desert. One of the most spectacular features of Kenya is the Great Rift Valley running north-south from the Middle East to Mozambique. Other outstanding features include the 5 199m snow-capped summit of Mt. Kenya; the upland massifs of the Mau Escarpment, Cherangani Hills and the Aberdares; the Rift Valley lakes of Naivasha, Nakuru and Baringo; the great lakes of Victoria and Turkana; Kakamega, Mau and Arabuko Sokoke forests; the great plains of Amboseli and Samburu; the Chalbi Desert; the coral reefs and mangrove swamps of the coast; and the many wetlands scattered across the lowlands of Kenya. *Source: SRTM*

THE PHYSICAL LANDSCAPE

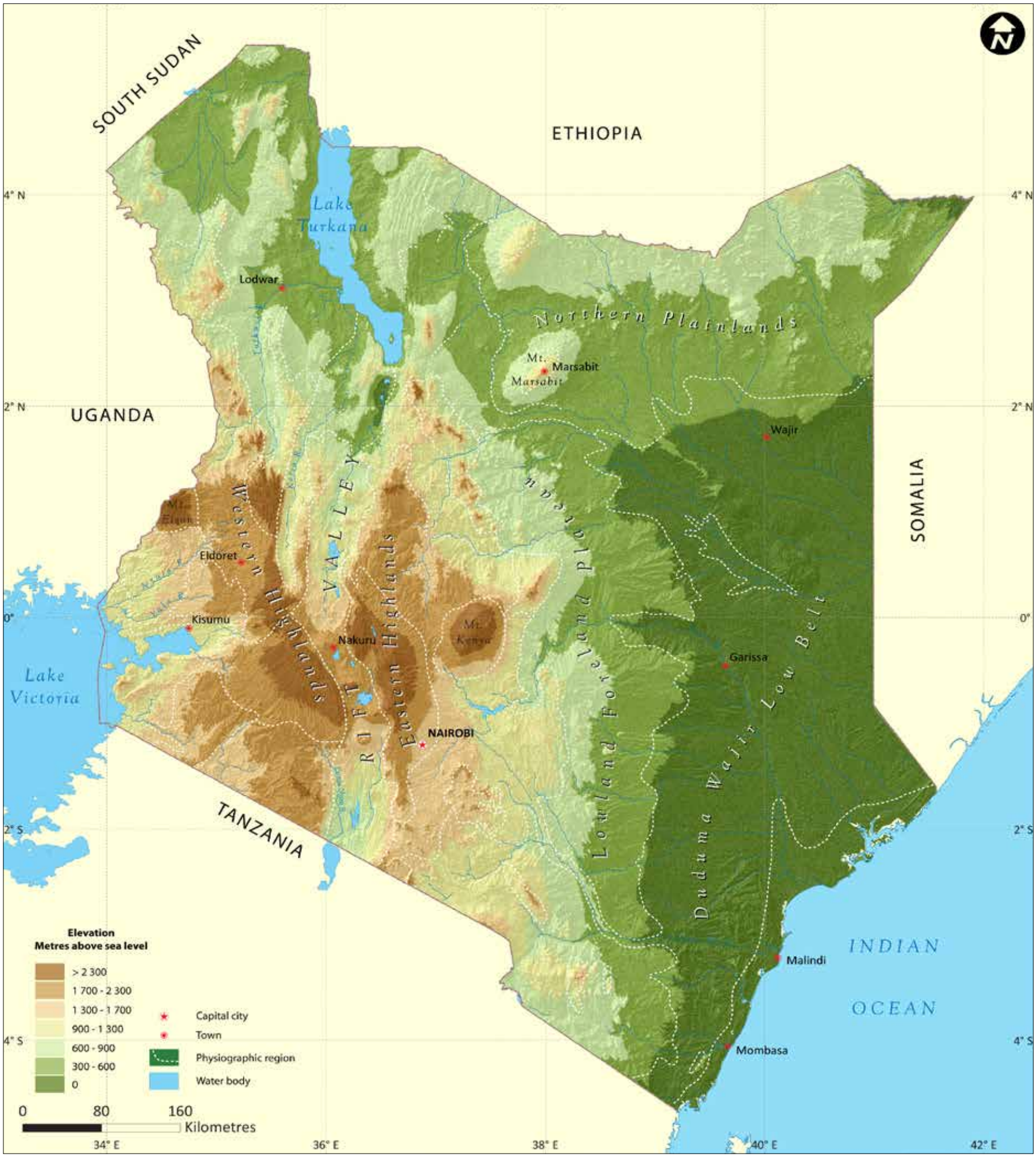


FIGURE 2.2: The physical landscape of Kenya
Kenya has a land area of 582 646 km^2. The varied landscapes have been moulded by ancient tectonic forces, as well as rifting, faulting, uplifting and dissecting of the landscape. The upwelling of magma from the Earth's core has produced volcanoes such as Longonot and Suswa, ash fallout and lava flows on a grand scale.
Source: DRSRS, SRTM/MODIS/NASA.

BOX 2.1: VALUE AND IMPORTANCE OF LANDSCAPES

Mountain, hills, plateaus and plains, because of their aesthetic value, are important tourist attractions. Mountains and hills also regulate river flows and prevent flooding; help recharge ground-water tables; improve soil fertility; help regulate local climate conditions; are part of cultural ceremonies and form sacred groves or sites; harbour forests; and are important as wildlife habitats (flora and fauna) and watersheds. Tourism contributed US$ 1.2 billion in 2011 (KNBS 2012) and provides employment to 300 000 Kenyans.

GEOLOGY

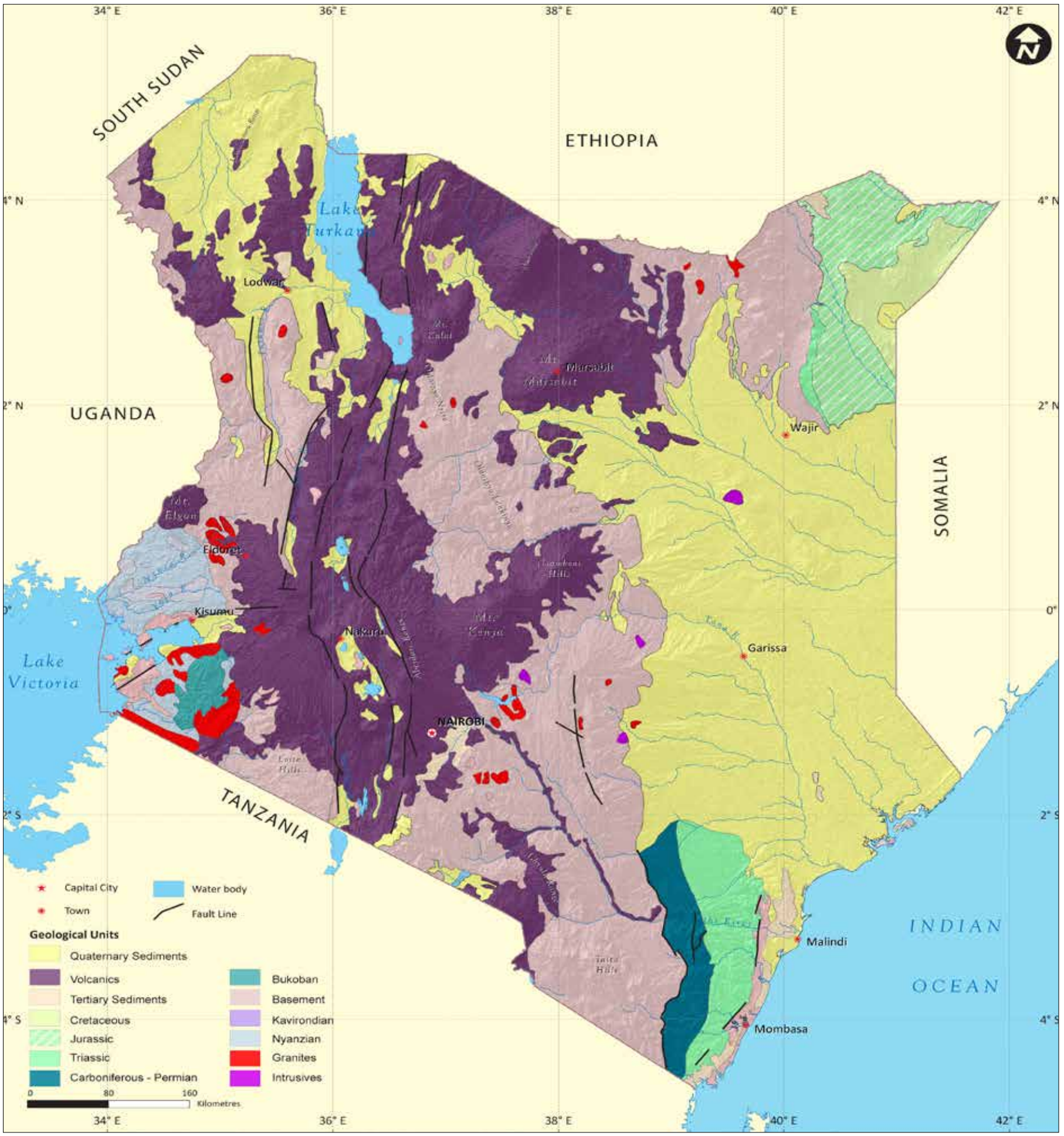


FIGURE 2.3: The geology of Kenya
Kenya's landscapes were formed by tectonic Earth movements, volcanic activity and mountain building. The main geological features include the Great Rift Valley; sedimentary, metamorphic and volcanic rocks; and ancient marine uplifts. The rocks and sediments are sources of many precious minerals. Petroleum deposits have recently been discovered in the sedimentary basins of northern Kenya. *Source: SOK 2003.*

BOX 2.2: VALUE AND IMPORTANCE OF GEOLOGY

Soil formations, coal (a primary source of energy), and hydrocarbons (gas, petroleum) were discovered in Kenya in 2012. Fossil fuels (petroleum) make up 23% of Kenya's energy supply, and sands, clays, sandstones, shale, marble, granite and limestone are used in the construction industry. Some rocks also host a variety of precious minerals such as garnets, ruby, gold, iron ore and amethyst. Groundwater is stored in the old weathered surfaces between the lava flows and the older formations. Volcanism is the source of geothermal energy. Some features such as the Rift Valley and volcanic formations like craters and calderas are major tourist attractions.

SOILS

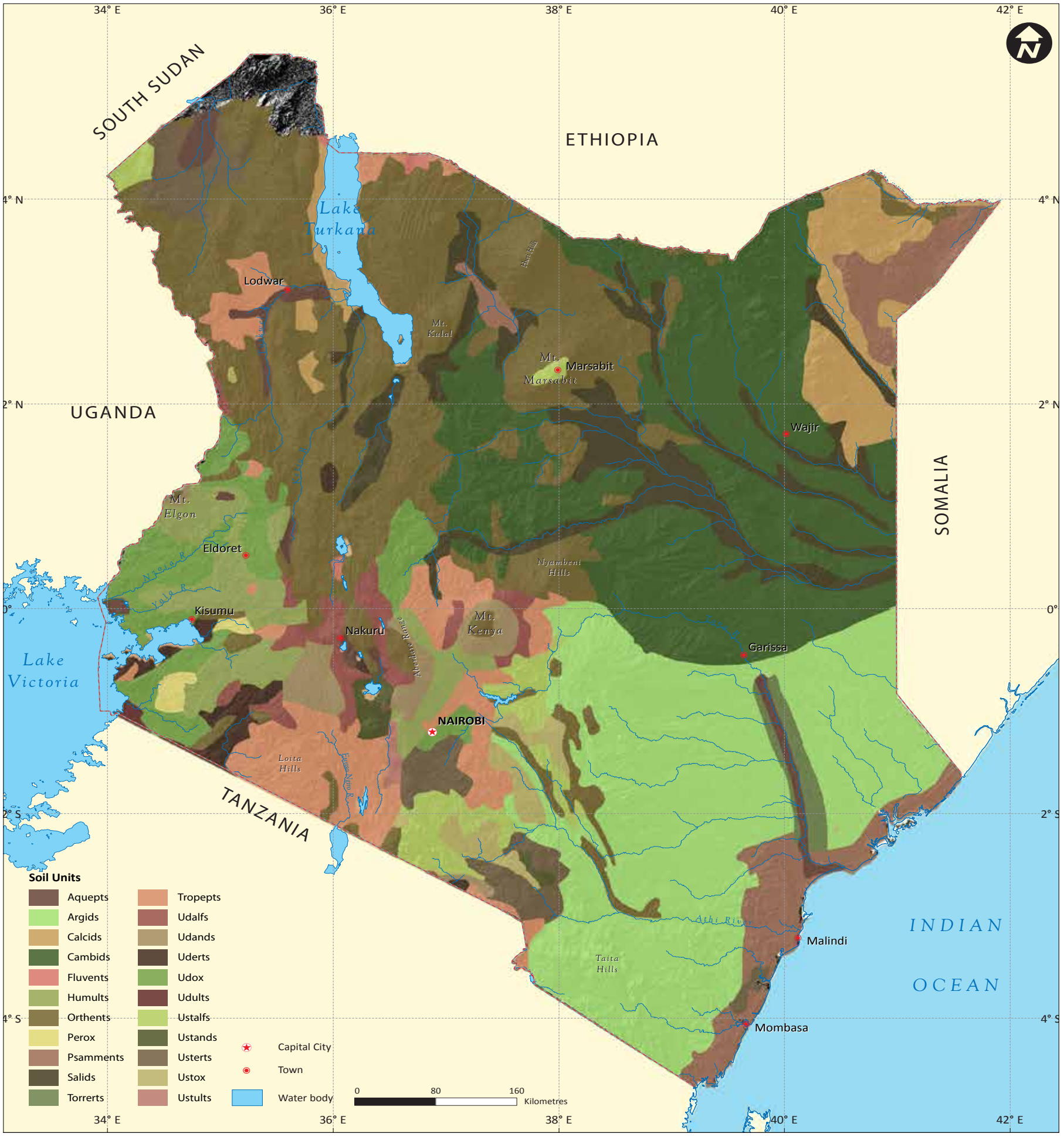


FIGURE 2.4: The soils of Kenya
The varied topography and geology of Kenya, modified by hydrology, climate, vegetation, and animal and human impact, creates a diversity of soils that in turn influence the biological properties of ecosystems.
Source: FAO 1990

BOX 2.3: VALUE AND IMPORTANCE OF SOILS

Soil is a very important resource that sustains human wellbeing and other forms of biodiversity. Soils provide nutrients for plant growth, crop production and animal production; hold vegetation in place; allow percolation of rain water; help in construction by forming the foundation of buildings; act as carbon reservoirs and sinks; and preserve underground biodiversity.

WATER AND DRAINAGE BASINS

FIGURE 2.5: Water and drainage basins of Kenya
Climate overlaid on topogaphy has created Kenya's major rivers, lakes and the five major drainage basins—L. Victoria, Rift Valley, Athi, Tana and Ewaso Ng'iro. Major lakes include Victoria, Turkana, Naivasha, Baringo and Nakuru. Many rivers arise and traverse the five drainage basins, amounting to 2% of Kenya's land area. Average annual water availability per capita is 647m^3, far below the recommended UN threshold of 1000 m^3/year. Per capita availability is expected to decrease to 359 m^3 by 2020 with population growth. *Source: DRSRS, WRI et al 2007.*

BOX 2.4: VALUE AND IMPORTANCE OF WATER RESOURCES AND WETLANDS

Water is used for various purposes including domestic use, agricultural production (livestock, crops, both rainfed and irrigated), industrial use, energy generation , wildlife habitat (flora and fauna), food production (e.g. fish), mangrove habitat, corals, tourism, transport, climate regulation, grazing, flood control and erosion control.

CLIMATE

Temperatures across Kenya vary with relief, season, rainfall and cloud cover. The northern and eastern lowlands reach maximum average temperatures in excess of 35° C and the central highlands of less than 18° C. Temperatures in the afro-alpine zone of Mt. Kenya drop below freezing every night.

Potential Evapotranspiration (PET) across Kenya varies with rainfall, temperature, altitude and the proximity of water bodies. Evapotranspiration determines the amount of water available for plant growth, whether natural vegetation, farms or forests.

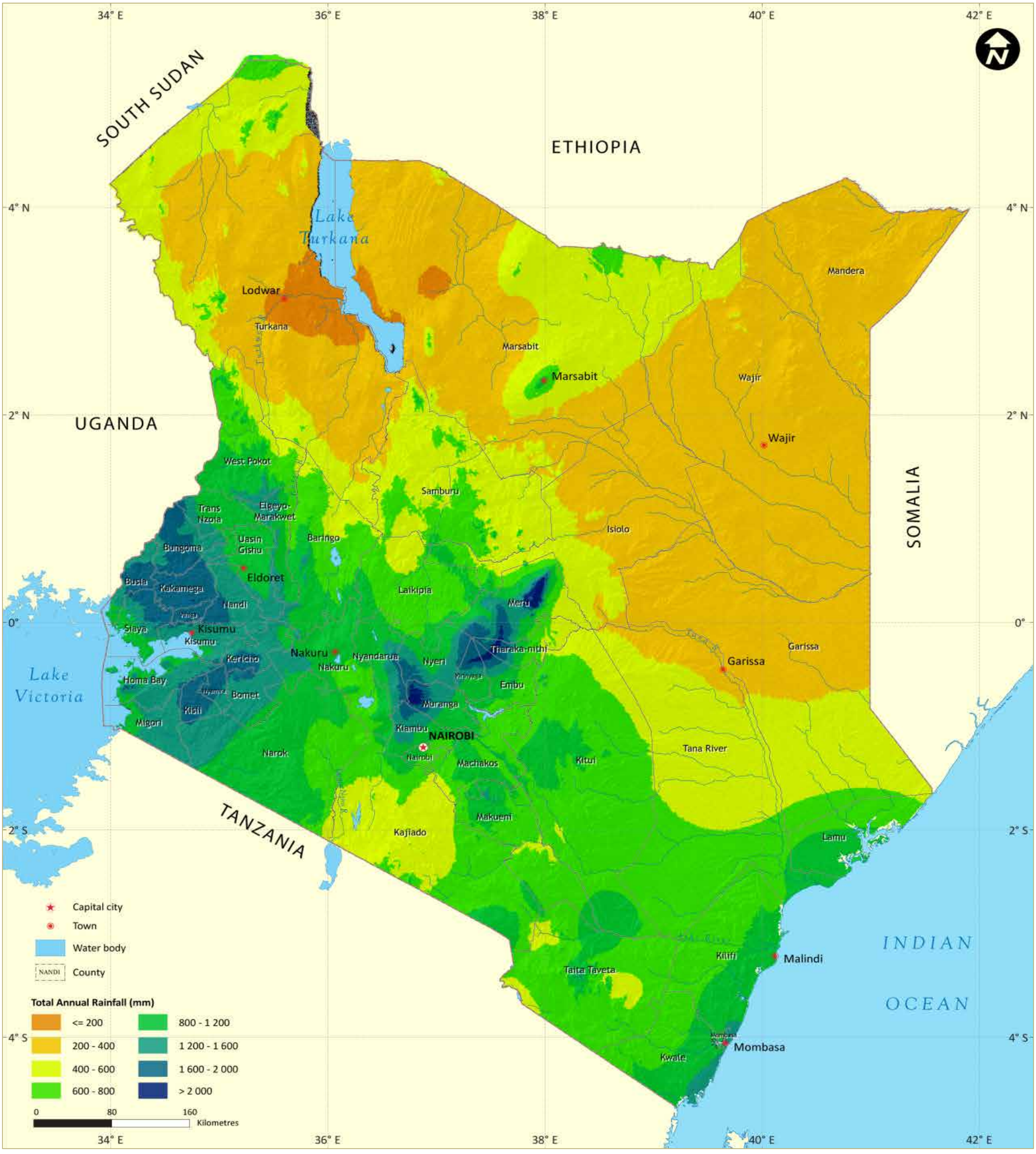


FIGURE 2.6: The climate of Kenya
The climate of Kenya is heavily influenced by its equatorial position, the Indian Ocean to the east, L. Victoria to the west and the central highlands. The sun passes over the equator twice a year— moving northward until June and southward until December. The Inter-Tropical Convergence Zone, following the wake of the sun's migration, brings two rains each year, the short rains from October to December, and long rains from March to May. Average annual rainfall and seasonality varies widely with altitude and proximity to major water bodies. *Source: Kenya Meteorological Department.*

EVAPOTRANSPIRATION

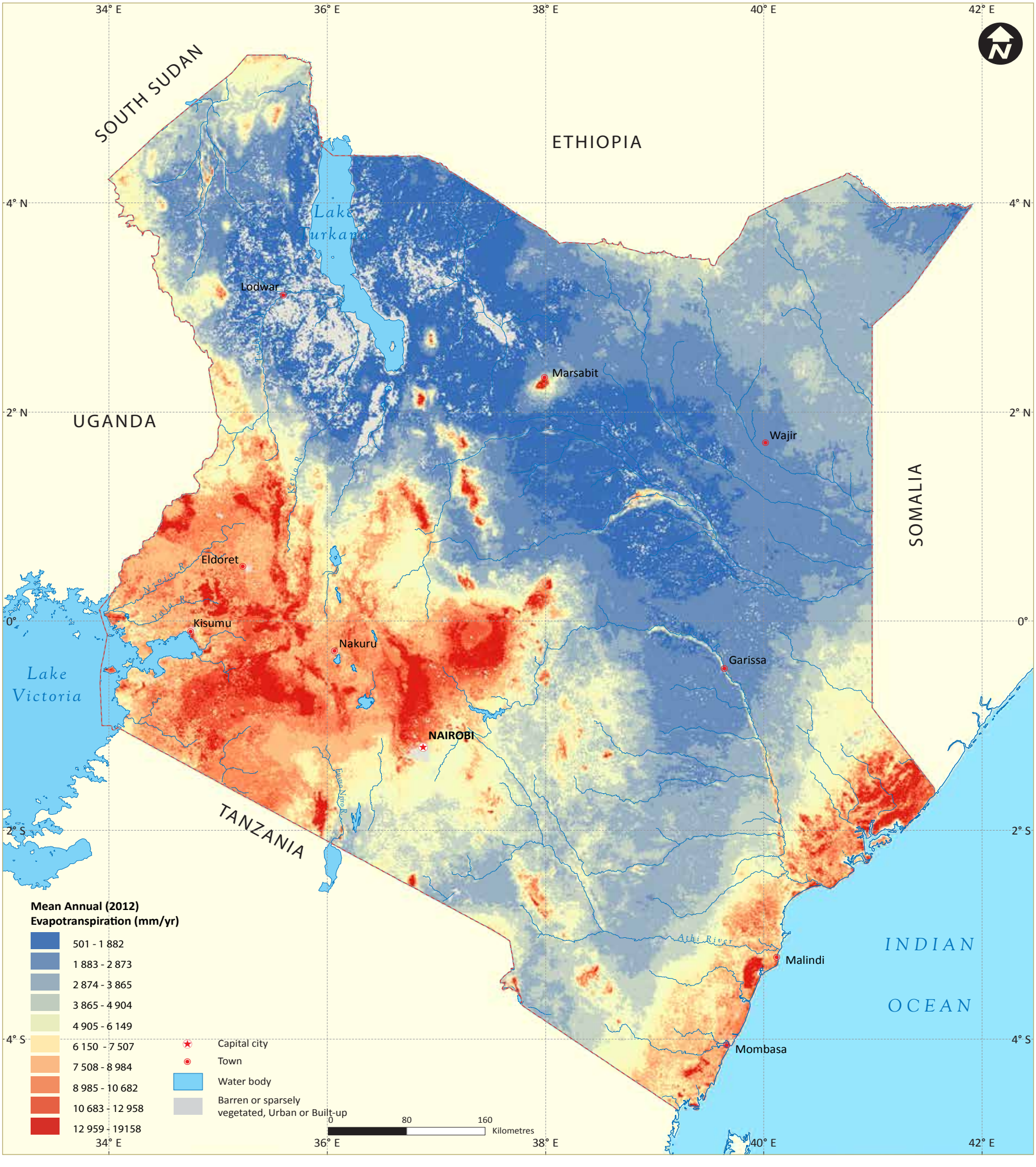


FIGURE 2.7: Evapotranspiration

Altitude and rainfall are the main determinants of evapotranspiration, the drying power of the air. The higher drying power of low hot elevations reduces the effectiveness of rainfall, and thereby plant and crop production relative to the highlands. *Source f: NTSG 2014.*

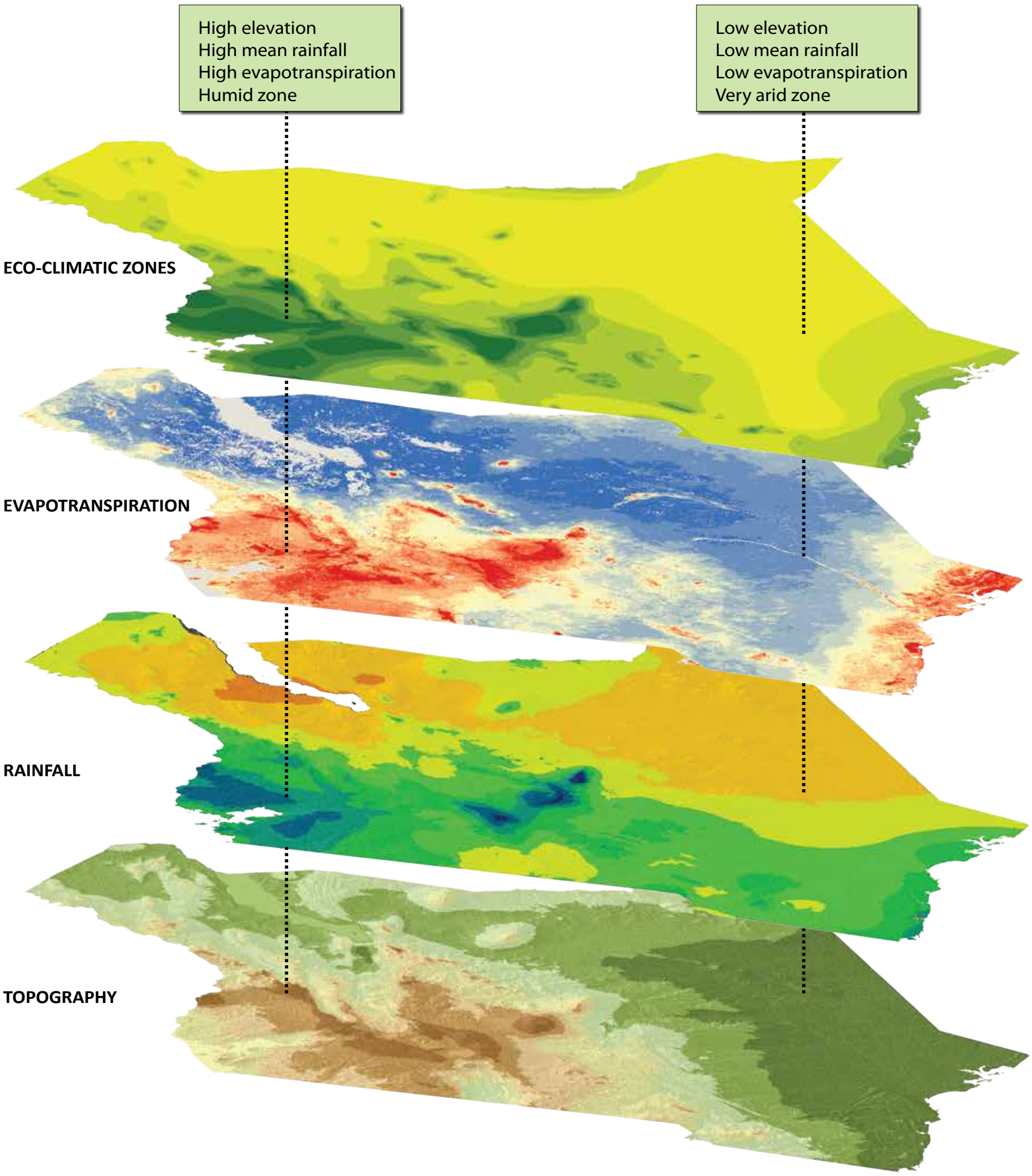


FIGURE 2.8:
Rainfall distribution overlaid on Kenya's varied soils and topography, and modified by evapotranspiration and other factors including drainage, account for the wide range of eco-climatic zones countrywide.
Source: DRSRS, NEMA 2011.
Evapotranspiration - NTSG 2014.
Rainfall - Kenya Meteorological Department.
Topography - SRTM.

THE ECO-CLIMATIC ZONES

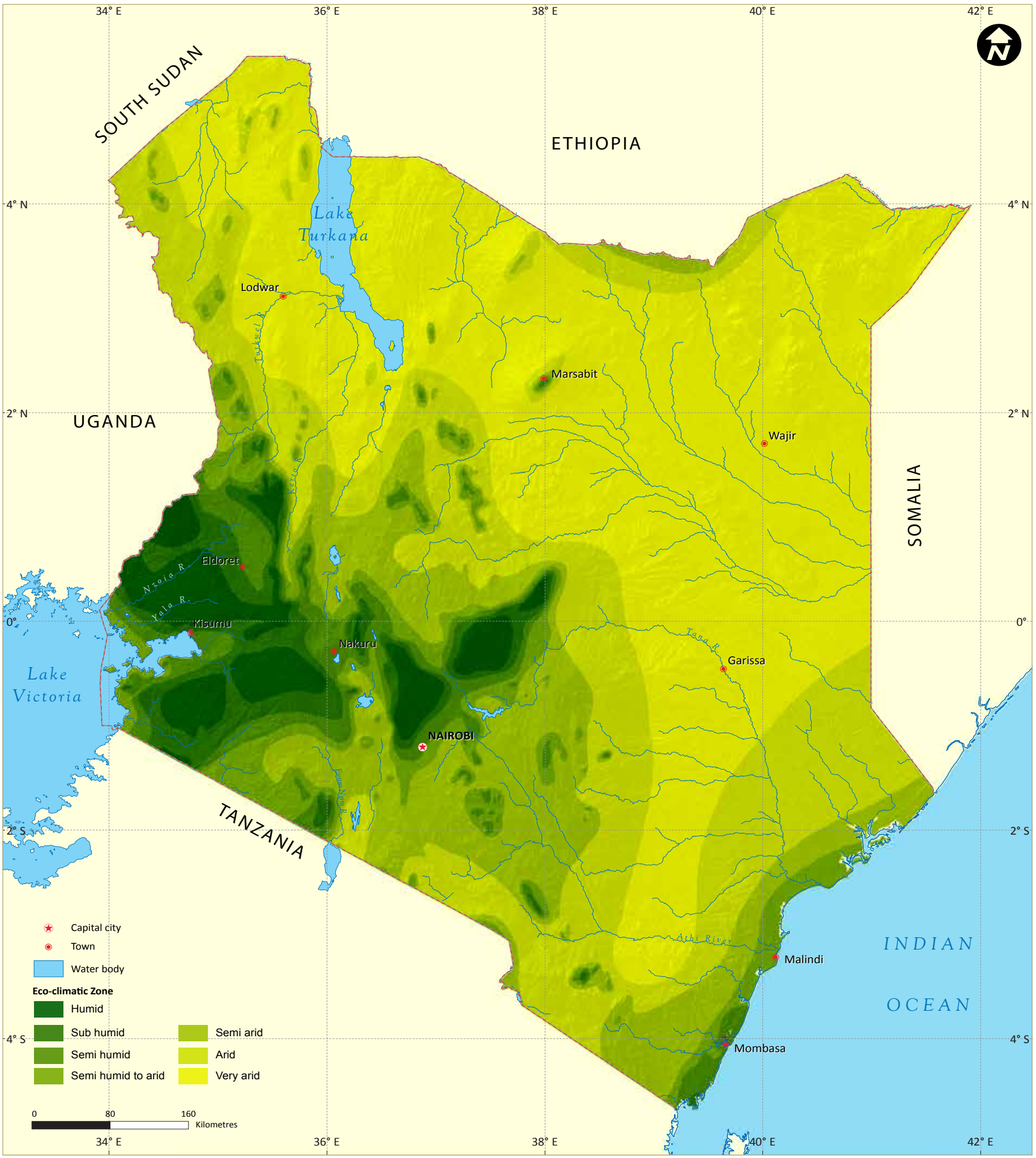


FIGURE 2.9: The eco-climatic zones of Kenya
The eco-climatic zones of Kenya reflect annual patterns of rainfall, temperature and evapotranspiration, influenced by topography and proximity to large water bodies. The steep topographic gradients produce a wide variety and tight mosaic of eco-climatic zones and account for Kenya's range of lifezones and ecosystems. *Source: DRSRS, NEMA 2011.*

TABLE 2.1: **THE ECO-CLIMATIC ZONES ARE SHAPED BY RAINFALL, TEMPERATURE AND EVAPOTRANSPIRATION, WHICH AFFECT VEGETATION, LAND-USE AND AGRICULTURAL POTENTIAL**

Biome/ Ecosystem	Area (%)	Major geological structure	Major Soils	Landform	Average rainfall (mm)		Average temperature (°C)		Population density/ km^2)
					Min.	Max.	Min.	Max.	
Forest	2.7	Pyroclastic and ultrabasic igneous	Eutricplanosols, mollicandosols, and humicnitisols	High-gradient montane, plain and ridges	600	2 400	14	28	50
Woodland	3.2	Marine and ultrabasic igneous	Eutricplanosols	Plain, high-gradient hills and mountains	260	2 200	14	29	20
Shrubland	22.3	Marine and ultrabasic igneous, Gneiss, mignetite , pyroclastic, sandstone	Gleyicsolonetz, haplicsolonetz and rhodicferrasols, Calcaricregosols, ferralicsolonchaks	Plain, high-gradient hills and mountains, plateau, and medium gradient mountains	250-270	1 900	14-16	29-32	10-30
Grassland/ Savannah	47.1	Gneiss, magnetite and sandstone	Calcaricregosols, calcic solonetz and haplicsolonetz	Plain, plateau, and high gradient mountains	200	1 900	18	32	5
Desert/Dunes/ Bare	1.0	Basalt and clastic sediment	Calcaricregisols, calcic solonetz and ferralicsolonchaks	Plain	200	2 000	18	33	5
Waterbodies/ Wetland	4.5	Pyroclastic and limestone other carbonate rocks-Sandstone, olian and fluvial	Haplicsolonetz, eutricfluvials and eutricvertisols	Plain; plain and ridges	200	1 600	14-17	29-33	10-30
Cropland	19.2	Gneiss, mignetite	Rhodicferralsols and humicnitisols	Plain, ridges, and medium-gradient hills	250	2 000	13	29	200
Urban	0.1	Basic Igneous and pyroclastic	Eutricvertisols and humicnitisols	Plain and ridges	600	1 600	13	28	5 500

Source: Sombroek et al 1982, Pratt et al 1966, Woodhead 1970, Pratt and Gwynne 1977, Jaetzold et.al. 2009.

BOX 2.5: VALUE AND IMPORTANCE OF CLIMATE

Kenya is blessed with abundant climatic natural capital that include solar insulation and sunlight, which can be tapped for solar energy; wind that can be harnessed for wind energy; air that is essential for survival and sustenance of biodiversity; and rainfall that brings the water so vital to our socio-economic development in sectors such as agriculture and industry. Sunshine received in abundance throughout the year makes it possible to harness solar energy, which presently contributes one per cent to the national electricity supply, which provides six per cent of Kenya's energy needs (NEMA 2011). Kenya's warm and hospitable tropical climate is a major tourist attraction. Climate also contributes to soil formation.

PLATE 2.2: Highlands in the Rift valley in Kenya
Source: P. Kariuki/SEUCO.

PLATE 2.3: Dry landscape in Samburu County
Source: P. Kariuki/SEUCO.

Major Ecosystems

Many methods are used to classify landscapes. These include lifezones, biomes, ecozones, ecosystems, land cover and land-use classes. Terminology varies with purpose of mapping and the degree of human modification. In Kenya the major natural vegetation zones grade into each other along topographic and rainfall inclines corresponding to the ecoclimatic zones. Moist closed-canopy (CC) forests grade into woodlands and shrublands of varying height and composition, depending on local rainfall, soils, nutrients, and animal and human disturbance. Shrublands are broken up by open grassland, depending on soils, drainage and fires. Open shrublands and grasslands give way to barren deserts in the driest regions of northern Kenya.

The gradations, patchiness and modification of vegetation by humans complicate classification. Savannah ecosystems in the semi-arid areas of East Africa include a mixture of grasslands, shrublands, woodlands and wetlands. This mosaic is shaped by local variations in topography and drainage—modified by wildlife and human activity. Burgeoning human activity in recent decades has transformed the natural landscape to such an extent that mapping must take into account human-modified ecosystems.

In describing Kenya's wealth of ecosystems, we highlight the most distinctive ecosystems—the forests, woodlands, shrublands, grasslands, deserts, wetlands, lakes and rivers, montane, afro-alpine and marine. Using ecosystems based on such recognizable and distinctive habitats and land features draws attention to the ecological functions of the plants and animals, the services they provide and the uses we make of them. Ecosystems are also a convenient way of looking at the threats faced by biodiversity and how to address them. They have the added advantage of applying equally to natural areas as to human landscapes such as cities and croplands.

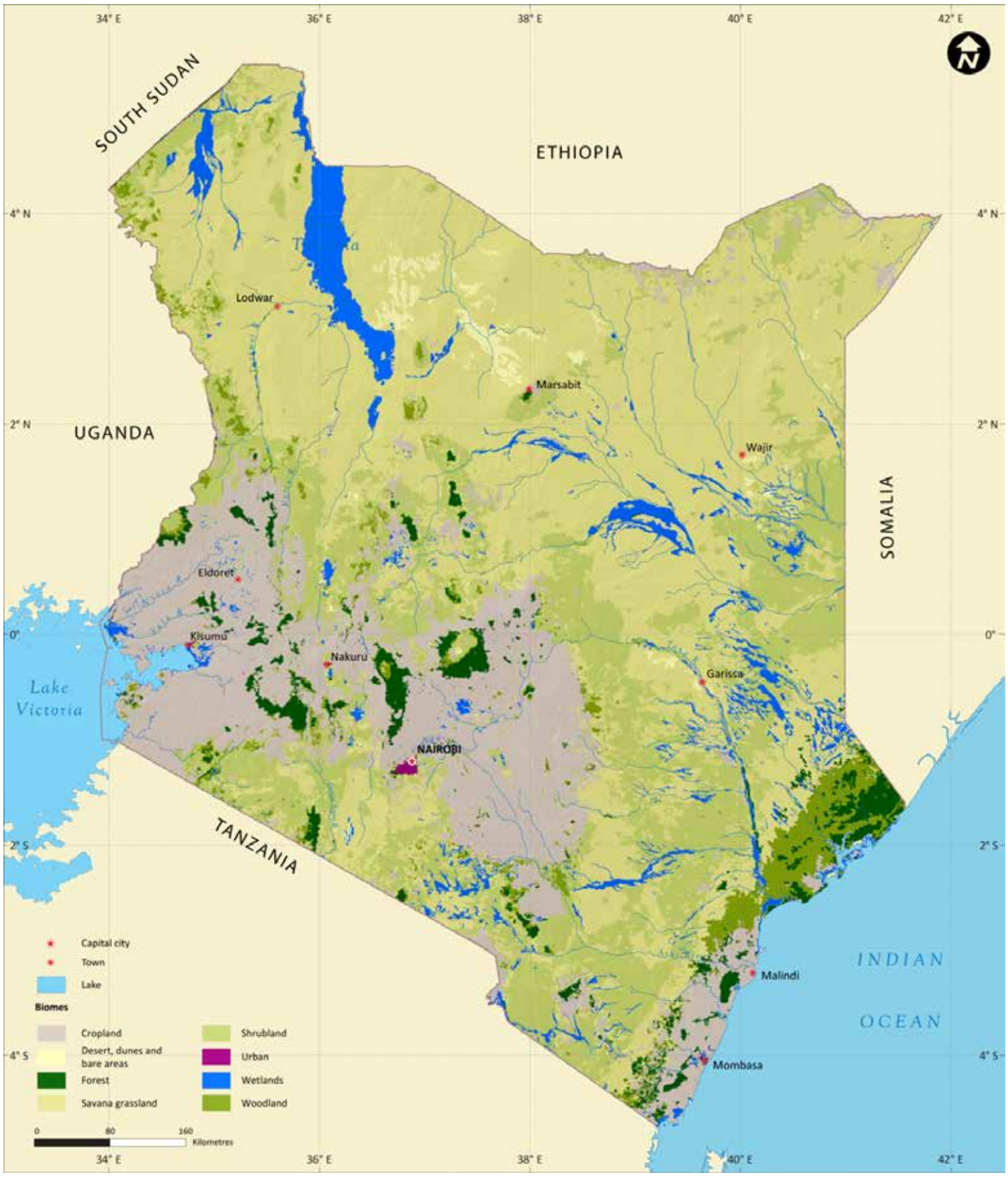
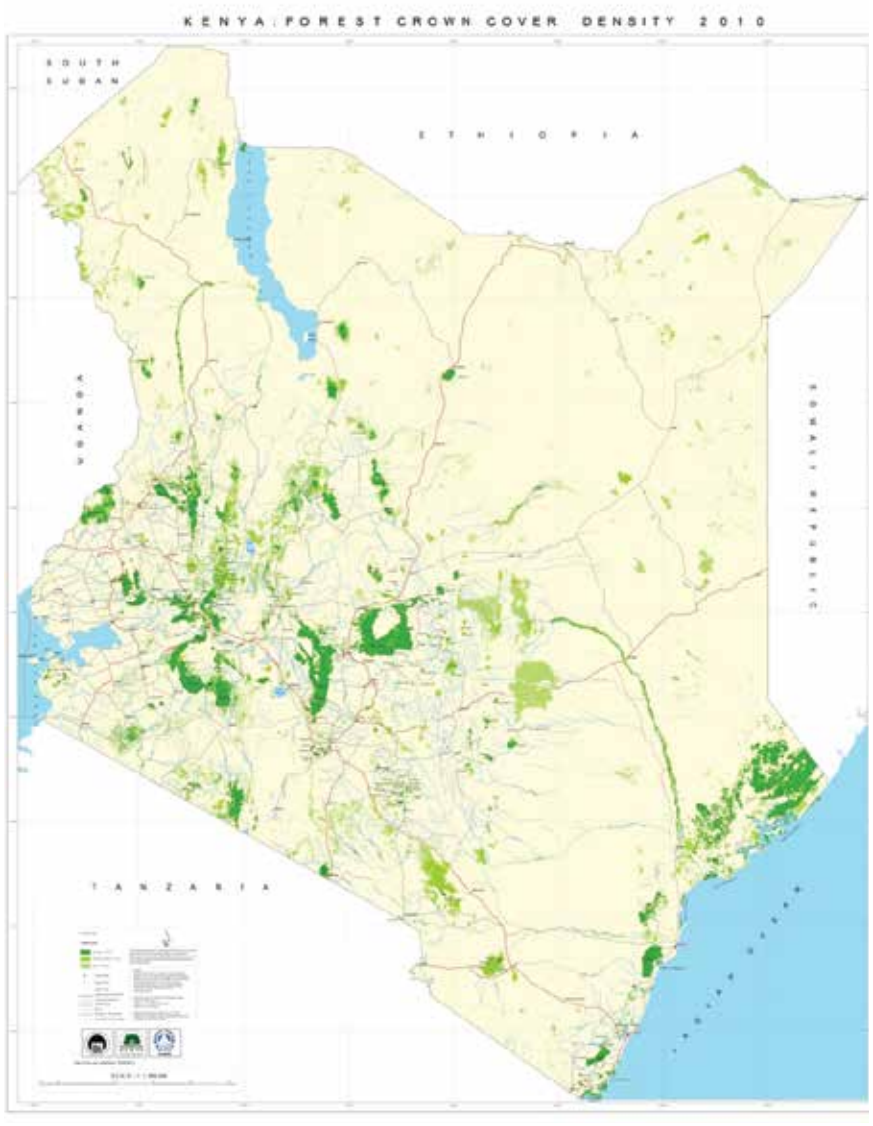


FIGURE 2.10: The structure and distribution of Kenya's major ecosystems reflect local climate, topography, soils and biota, modified by human activity.
Source: FAO 2000, WR et al 2007, modified for this study.

FORESTS



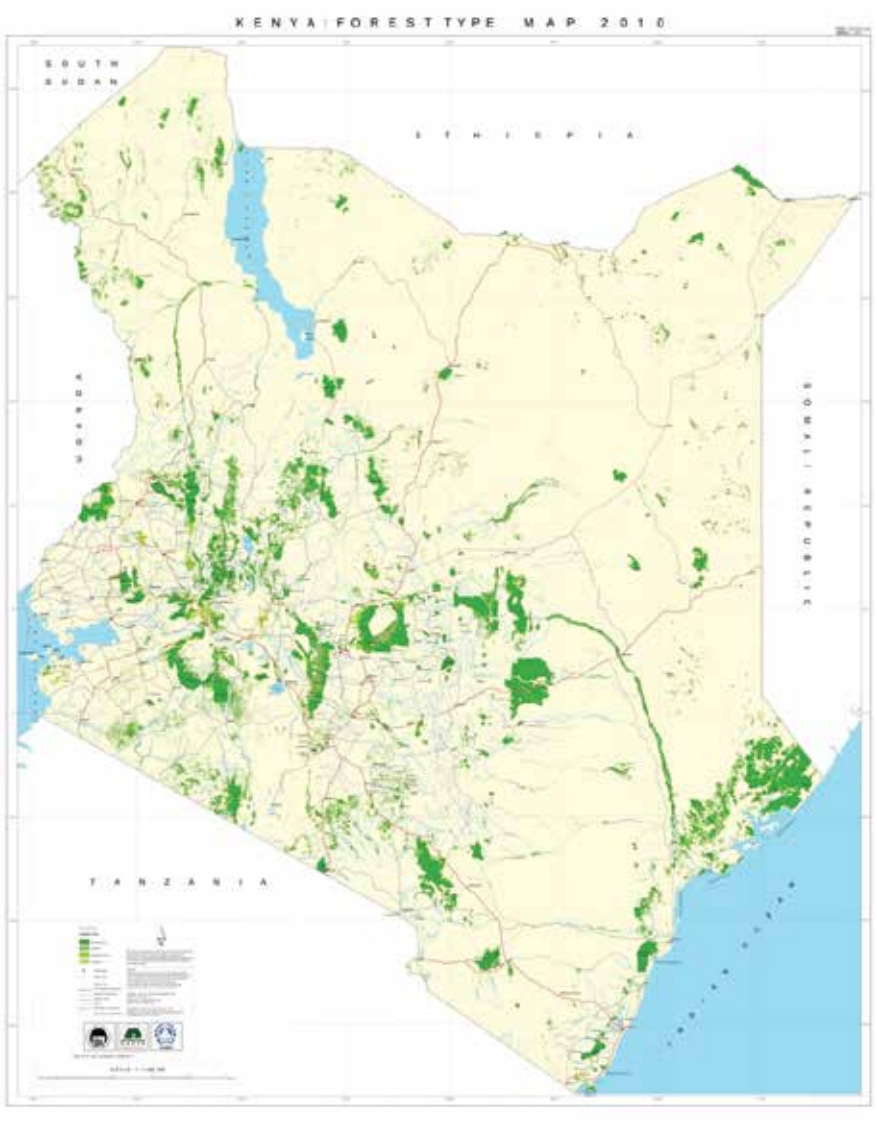


FIGURE 2.11: Types and crown cover density of forests in Kenya.
Closed canopy forest makes up less than 3% of Kenya's vegetation cover (UNEP 2001). The range of forest types include coastal, highland, equatorial, mangrove, bamboo and plantation. *Source: RCMRD and KFS 2010.*

Forests are distinguished by tall trees and a closed-canopy. Little light penetrates to the forest floor in mature stands, resulting in a fairly sparse understory of plants. Kenya has several types of forest, including coastal, mangrove, mountain and upland, bamboo, the equatorial forests of Kakamega and plantation forests. Forests vary not only in composition but also cover, as shown in the Table 2.2 below.

TABLE 2.2: **FORESTS BY TYPE AND COVER BASED ON 2010 SURVEYS**

FORESTS BY TYPE AND COVER	AREA IN HECTARES
Moderately Dense 40–65% CC	***976 275.30***
Bamboo	8 552.41
Mangrove	116.15
Natural Forest	926 603.62
Plantation Forest	41 003.14
Open 15–40 %CC	***1 272 840.89***
Bamboo	744.60
Mangrove	5 692.09
Natural Forest	1 247 614.18
Plantation Forest	18 790.02
Very Dense > 65 % CC	***1 980 900.34***
Bamboo	76 395.70
Mangrove	42 719.91
Natural Forest	1 728 179.68
Plantation Forest	133 605.05
Grand Total	**4 230 016.56**

Source: RCMRD and KFS.

Coastal forests occur in small remnant patches such as Shimba Hills and Arabuko Sokoke Forest. Typical trees include *Cynometra, Afzelia, Brachylaena* and *Brachystegia*. Most highland moist forests range between 1 500m and 3 000m and include genera such as *Podocarpus, Olea, Juniperus* and *Newtonia.* Kakamega Forest is the easternmost relic of the Guineo-Congolean rainforests.

Tropical forests are the most biologically diverse of all ecosystems, containing some quarter of the world's known species. Kenya's forests are no exception and are especially rich in plant and invertebrate species many of them endemic. Kakamega is a renowned hotspot for butterflies, the Aberdare and Mt. Kenya for bongo and the giant forest hog, and the Tana River riverine forests for its two endemic subspecies of primates, the Tana River Mangabe and Red Colobus. These distinctive animals are remnants from earlier wet periods when the equatorial forest spread across much of Kenya.

Kenya has 3.5 million ha of forests, including indigenous forests, open woodlands, and plantations, and an additional 24.6 million ha of 'bushland'. These are highly fragmented and degraded forests patches. An estimated 10 per cent of the original wet montane forest remains. Much of the forest cover was lost in the early stages of expanding human cultivation that began some 2 000 years ago and accelerated with the fivefold increase in population, and extensive agricultural expansion since the early 1900s. The demand for timber, fibre and fuelwood spawned by Kenya's economic growth over the last half century, coupled with an insufficient forest plantation, settlement schemes, and illegal farming and herding, greatly accelerated forest loss and degradation.

PLATE 2.4: Mau Forest on the western Rift Valley escarpment is the most expansive in Kenya but has been extensively cleared and felled by settlement in recent decades. *©s P. Wargute /DRSRS.*

BOX 2.6 :THE IMPORTANCE OF FORESTS

Forests provide important ecological services in the way of water catchment, spring and river flow, regulation of nutrient cycling, and erosion and flood abatement. Forests have been called the lungs of the Earth and account for a quarter of all carbon capture that, in an age of fossil fuel combustion, is important in moderating global warming.

Forests are the richest of all ecosystems in terms of plant and animal species, accounting for a quarter of all biodiversity. Kenya's forests are not only rich in species, but also harbour many endemic animals and plants.

Food, building materials, fuelwood, medicinal plants and animals, a refuge from drought for pastoralists and a place of spiritual, cultural and ceremonial significance are some of the many values ascribed to forests. The Mijikenda of coastal Kenya conserve *kayas*, forest patches of special ancestral and spiritual importance to their identity. As a nation, Kenya has placed a high value on forests as water catchments and symbols of its commitment to conservation and climate change mitigation. The constitution sets a goal of attaining 10 per cent forest cover countrywide. Forests have also become important to Kenya's tourism industry and to meet the growing demand for outdoor recreation, nature walks, education and research.

PLATE 2.5 : Woodland in the Aberdare Ranges, Nyeri County.
Most of Kenya's woodlands are a patchwork of habitats, ranging from heavy tree cover to fragmentary woodland patches and invasive bushlands and grasslands. *© P. Wargute /DRSRS.*

WOODLANDS

The woodland ecosystems of Kenya cover some 15 per cent of the land surface lying along the rainfall and altitudinal gradient between moist forests and dry savannahs. Woodlands include trees of lower stature and more open canopy, allowing light to penetrate to the ground and support a rich understory vegetation. Woodlands cover a wide range of habitats, from the dry coastal Boni dwarf forest to upland savannahs, and riverine and ground-water woodlands. By far the most extensive woodlands fall within the moist coastal belt, around mountain bases and in the medium altitude uplands. Typical species of trees include *Crotons* and the larger Acacias —*Terminalia, Combretum, and Brachystegia*. Woodlands vary greatly in canopy cover due to local variations in topography, drainage and soils. Most woodlands have been heavily shaped and modified by large herbivores, including giraffe and elephants, which along with baboons are important agents of seed dispersal. Kenya's woodlands have also been heavily influenced by human activity—livestock impact, shifting settlements and fires in pastoral regions, and clearance for farms and villages in the highlands and at the coast.

Woodlands are nonetheless among the richest of Kenya's ecosystems in terms of species, given that they are a bridging habitat between forest and savannahs and support a wide variety of species from wet and dry climates. Many of Kenya's most important bird areas and some of its richest wildlife populations are found in woodlands and associated mixed habitats.

BOX 2.7 :THE IMPORTANCE OF WOODLANDS

Woodlands, because of their extensive cover and high woody biomass, provide many ecological services. These include carbon capture, reducing surface heat, regulating water and nutrient cycles, and abating winds, floods and erosion. Woodlands support a rich variety of animals and plants, bridging as they do wet and dry habitats. Woodlands also supply food, water, fuel, clothing, building materials and medicines to traditional communities, and feature prominently in culture, heritage and ceremonies. They support some of the largest and economically diversified rural populations in Kenya due to their interface between herders, farmers, hunter-gatherers and fishing communities. In recent decades woodlands have perhaps disappeared faster than any habitat in Kenya as a result of overharvesting for the fuelwood and charcoal that supply two-thirds of household energy countrywide. Woodlands are of growing importance to tourism and the recreation industry. Planted private and community woodlots are playing a growing role in providing farmers and herders with fuel, building materials, fodder, shade and windbreaks.

SHRUBLANDS

Kenya's shrublands are not uniform but rather a mixture of habitats occupying the semi-arid lands dominated by low trees and shrubs, and scattered grasslands. Trees are typically short due to low soil moisture and canopy cover is sufficiently spare that the herb layer is usually far more productive than the canopy layer. The characteristic shrubland appearance is due to predominance of small trees such as Acacias, Commiphora species, Combretum and abundant shrubs.

The biodiversity of shrublands is dominated by arid-adapted species of plants and is particularly rich in endemic aloes and euphorbias. The extensive semi-arid lands cover over half the surface area of Kenya and are by far the most extensive of wildlife and pastoral populations. The salient ecological feature of these drylands are the regular seasonal migrations and periodic large-scale movements to evade drought. The pastoral peoples and their livestock have occupied drylands for over 4 000 years and have heavily shaped the structure of plant and animal communities through the impact of livestock, fire, waterholes and shifting settlements.

In recent years the shrublands have been subdivided and settled by pastoralists and immigrant dryland farmers. Subdivision, sedentarization, range fragmentation, heavy continuous grazing by livestock, and sand and rock harvesting are among the many threats to the shrubland areas of Kenya. Over the last two decades the charcoal industry has mushroomed and stripped much of the semi-arid lands within commercial distance of large towns and cities of their large- and medium-sized trees, adding to rangeland degradation.

BOX 2.8 :THE IMPORTANCE OF SHRUBLANDS

Shrubland ecosystems cover over half of Kenya and, by area alone, are the most important ecological region in terms of carbon sequestration, water capture and primary productivity. The condition of the rangelands has a large bearing on the countrywide volumes of run-off, erosion, nutrient loss, flooding and carbon emissions arising from bushfires. Though not rich in biodiversity within any single location, the size of the rangelands accounts for a large share of Kenya's biodiversity. More important, the rangelands—including grasslands and woodlands—support the most abundant wildlife herds on Earth. The majority of protected areas, which form the backbone of Kenya's US$1.3 billion tourism industry, are located in the rangelands.

The rangelands have shaped the nature, productivity and diversity of Kenya's pastoral economies and cultures. The pastoral regions support over half the national livestock herd. Though many pastoral communities still practice seasonal livestock migrations and subsist on their herds, a growing portion have taken up commercial livestock production and supply a large portion of Kenya's meat industry.

The rangelands hold important cultural values for pastoralists whose dress, settlement structures, social systems, customs and ceremonies have all been moulded to the austere environment. Recently the rangelands have acquired new values in terms of biodiversity, wildlife conservation, tourism, recreation, wilderness and aesthetic appeal.

PLATE 2.6 : Shrubland in Kajiado
© P. Wargute /DRSRS.

GRASSLANDS

Grassland ecosystems are, like the woodlands and shrublands, a mixture of habitats, depending on topography, drainage and soils. Grasslands unbroken by other habitats are a rarity in Kenya, confined largely to areas of volcanic soils such as the Athi Plains, ancient lakebeds such as Amboseli, floodplains such as the ox-bows of the Galana River, and estuaries and deltas such as the lower Tana River. In most respects the grasslands and shrublands occupy similar climatic and ecological zones, with the grasslands being distinguished as areas where grass cover exceeds shrub and woody cover, giving the appearance of open savannahs. The grasslands range from the sparse short grasses of low rainfall areas to tall derived grasslands in wetter regions where woodlands have been removed by fire and settlement.

PLATE 2.7: The extensive grasslands of the Maasai Mara-Serengeti ecosystem support the largest population of migratory ungulates on Earth. *© P. Wargute /DRSRS.*

BOX 2.9: THE IMPORTANCE OF GRASSLANDS

Grassland and shrubland ecosystems are commonly combined as the rangelands in terms of livestock production, the dominant land use. Collectively the rangelands cover a quarter of the Earth's land surface and nearly three quarters of Kenya. They are important in carbon and water capture, flood and nutrient regulation, and in erosion control. Grasslands support the bulk of free-range livestock economies, especially cattle, sheep and goats, and some of the largest remaining migratory wildlife populations. Grasslands have played a large role in shaping cowboy, ranching and pastoral economies and cultures, as well as in wildlife conservation, outdoor recreation and adventure tourism. The East African grasslands have come to symbolize not only the birthplace of indigenous peoples, but the cradle of all humankind. The archaeological sites at Olorgesaili and L. Turkana have come to epitomize our common origins in the savannah grasslands.

Due to a double rainfall season and relatively young and fertile soils, Kenya's grasslands are highly productive compared to other semi-arid rangelands. The productivity accounts for the extraordinary abundance of wildlife and livestock in the East African savannahs. The grasslands have been expanding steadily in recent centuries due to growing human activity and livestock production, aided by water development, disease control and habitat conversion.

DESERTS

Deserts are highly water-stressed environments where rainfall is sparse and plant growth limited to small grasses, herbs and shrubs that respond quickly to scattered and infrequent rain. Much of the desert is covered by weathered stone, known as jebbel, or by wind-blown sand dunes. Short, widely-scattered Acacias are the most characteristic vegetation feature of the deserts in northern Kenya. The Chalbi, the driest of Kenya's deserts, is extensively covered by sand dunes.

Desert ecosystems support a low diversity of plant and animal life, highly adapted to water and food deprivation, and high temperatures. Many species of small animals, including rodents and reptiles, evade the desert extremes by burrowing underground and becoming torpid. Large mammals, such as the oryx, gerenuk and gazelle, manage to survive without drinking by conserving water metabolically, feeding on the moistest plants and shading during the hottest periods.

The impact of peoples on desert plants and animals has been the most important factor shaping deserts since the domestication of livestock ten-thousand years ago. In northern Kenya plants and animals have been displaced, hunted down or depleted by camels, sheep and goats. Tree cover has been greatly reduced by a rising human population using ever more material for livestock shelters, fuelwood and, increasingly, a commercial charcoal industry. Heavy browsing and grazing by livestock has depleted groundcover and increased erosion. As a result, livestock herds have fallen and poverty has increased among pastoral societies of northern Kenya in the last three decades.

PLATE 2.8: Chalbi Desert.
Despite low rainfall, deserts are home to many pastoral peoples who have adapted their livestock, lifestyles and customs to the extreme conditions over thousands of years. The Rendille, Borana and Gabra of northern Kenya depend heavily on drought-hardy camels and goats for a living and move regularly to capture localised flushes of vegetation. © *P. Wargute /DRSRS.*

BOX 2.10: THE IMPORTANCE OF DESERTS

Deserts cover less than two per cent of Kenya's land surface and are the least productive ecosystem. Though relatively minor in the league of ecosystem services, deserts are important in supporting a unique array of specialized plants and animals adapted to extreme heat and drought. Windblown desert sands are transported on a global scale and increase the productivity of distant lands, lakes and oceans. Deserts are important homelands to pastoralists, especially camel cultures. Deserts have long been important sources of salt and minerals. The value of deserts is likely to rise as Kenya moves towards a green economy based on renewable energy sources such as the sun and wind, both of which are intense in deserts.

WETLANDS

FIGURE 2.12: The wetlands of Kenya
The wetlands of Kenya covered 3– 4% of the land surface but have shrunk to below 2.5% in recent decades. *Source: NEMA 2004.*

Wetlands are defined as 'areas of land that are permanently, seasonally or occasionally waterlogged with fresh, saline, brackish or marine waters, including both natural and manmade areas that support plants and animals' (National Wetlands Standing Committee of the Inter-Ministerial Committee on Environment—GoK 2008). This definition includes swamps, marshes, bogs, shallow lakes, ox-bow lakes, dams, river meanders and floodplains, as well as riverbanks, lakeshores and seashores where wetland plants grow. The definition covers marine and intertidal wetlands such as deltas, estuaries, mud flats, mangroves, salt marshes, seagrass beds and shallow reefs.

Wetlands cover 3–4 per cent of the land area of Kenya. The size and composition of wetlands formerly varied with climate, expanding greatly in wet periods and contracting in dry periods. In recent decades the impact of human activity has played a far larger role than climate. Wetlands have been drained for farming and settlement, waters have been diverted for irrigation, domestic and urban use, and dams built to harness flows and generate hydroelectric power. Wetlands, like forests, are among the most vulnerable of ecosystems to human transformation due to their freshwater storage capacity. More than any other ecosystem, wetlands are vulnerable to pollution by toxic chemicals, pesticides and fertilizers. In some respects, human activity has created new wetlands, although on a far smaller scale than the natural wetlands lost. So, for example, dams and reservoirs retain large volumes of water that gradually infill with sediments and create local wetlands. The Mwea irrigated rice scheme has created a large, if relatively impoverished, wetland.

BOX 2.11: THE IMPORANCE OF WETLANDS

Wetlands provide a wide range of ecological, economic and social goods and services. Ecologically wetlands form the unique interface between water and land that supports a distinctive community of plants, including floating lilies and sedges, and animals including frogs, fish and turtles. Wetlands buffer the effects of floods, reduce erosion control, capture carbon, filter out and decontaminate pollutants and toxins, recycle nutrients and stabilize stream banks and shorelines. Wetlands store excess water and act as buffers against drought for wildlife, farmers and herders. Wetlands also provide an abundance of plant and animal produce for humans, including food, water, medicine, and material for handicrafts, furniture and construction. In recent decades wetlands have become important in irrigated farming, commercial fishing, hydro-electric power generation, wildlife conservation, tourism and recreation. Wetlands are key assets in sustainable development, poverty alleviation and the improvement of livelihoods.

LAKES, DAMS AND RIVERS

Lakes and rivers are bodies of water localized within a basin and surrounded by land. Lakes are relatively still waters, while rivers are moving waters on or below the land surface. The formation of lakes and rivers has been greatly influenced by the Rift Valley faulting, which divides the drainage basins between east and west in Kenya, and by mountain uplift. Inland waters cover about eight per cent of Kenya's land surface. Freshwater resources, including rivers, lakes and swamps are widely distributed among the five main drainage basins (See Figure 2.13).

The diversity of Kenya's water bodies is as great as the terrestrial habitats and should rightly be considered as several ecosystems. So for example, lakes range from the large freshwater inland sea of L. Victoria to the brackish L. Turkana and extremely saline lakes, Nakuru and Magadi. Highland streams are small, cold, clear and fast-flowing with relatively low suspended organic matter, whereas the lower Tana and Galana rivers are large, warm, sluggish

FIGURE 2.13: Kenya's surface water
In Kenya is contained in lakes, rivers, dams and ponds within five drainage basins: L. Victoria basin, Rift Valley basin, Athi River basin, Tana River basin and the Ewaso Ng'iro North basin. Permanent rivers include Tana, Athi, Mara, Yala, Nyando, Nzoia, Murui, Kerio and Turkwell. *Source: NEMA, 2003; NEMA 2004.*

PLATE 2.9: L. Victoria is celebrated for its richness of its chichlid fish, which have evolved rapidly into many species since the lake shrank to a small remnant some 10 000 years ago.
© P. Wargute /DRSRS.

PLATE 2.10: The Tana River
The Tana River flows from the Mt. Kenya highlands to the coast, creating riverine habitats that run through semi-arid lands and support a large population of pastoralists, farmers and wildlife.
© P. Wargute /DRSRS.

and rich in suspended organic matter. Alkalinity, salinity and chemical composition also affect the properties of lakes and rivers, and thus the abundance and composition of plants and animals.

The large freshwater lakes and rivers are highly productive and support a rich variety of water plants, vertebrates and invertebrates and micro-organisms. The alkaline lakes of the rift valley are also renowned worldwide for their algal productivity and populations of up to three million flamingoes that migrate between the lakes along the length of the rift valley, depending on algal abundance.

BOX 2.12: THE IMPORTANCE OF LAKES AND RIVERS

Collectively, Kenya's lakes and rivers contain some 20 billion cubic meters of water—which has a large bearing on local climate. They capture nutrients and sediments eroded from the land and so sustain a highly productive and diverse assemblage of plants and animals. Freshwater habitats support unique and specialized species, several endemics and many rare or threatened species. Lakes and rivers are important stepping stones for Palearctic migratory birds, flamingoes and shore birds. They also supply the bulk of the water that drives the Kenyan economy, from farming and ranching to industry, commerce and settlement. Freshwater fisheries have, until recently, been dominated by traditional and artisanal fishing communities but now sustain commercial fisheries in L. Victoria and Turkana. Rivers also produce hydroelectric power, filter and provide clear water for human settlement and, together with lakes, provide transport routes for commerce and a range of amenities that attract tourists, outdoor and water-sports enthusiasts.

MONTANE ECOSYSTEMS

Kenya's mountains include some of the most dramatic scenery and important ecosystems in the country. Kenya's largest mountains arise from volcanoes, uplift from faulting of the Rift Valley, hard igneous extrusions, and basement rock left emergent as the surrounding plains were worn out by erosion.

The mountain landscape accounts for 10 per cent of Kenya's land surface and varies in height from 1 500m to over 5 000m above sea level. These sky islands jut high above the plains and create their own climate, which becomes wetter and cooler with altitude until the afro-montane zone. The mountains also create a distinctive zonation of habitats, stratified by altitude and varying with location. The habitats of Mt. Kenya and the Aberdares, for example, stretch from foothill grasslands, through woodlands and forest to the upper moorlands. The plant and animal life in the forests are a mix of equatorial and savannah species and, above the forest, a mix of tropical and temperate species. At high altitude the climate is cold and plant species are temperate in nature, though with rather different growth patterns and adaptations due to the year-round alternation of warm days and cold nights—or 'summer every day and winter every night', as Swedish botanist Olof Hedberg described it. The relative isolation of Kenya's montane ecosystems and extreme climate at higher altitude also explain the rich assemblage of endemic plant and animal species of montane ecosystems. The gradation of life-forms from base to peak of the sky islands makes them the most varied of all Kenya's ecosystems. The windward side of montane ecosystems capture more rain and are considerably richer biologically than the leeward side.

Montane ecosystems are among the most densely settled regions of Kenya. Traditionally the mountains supported a range of traditional herding and farming communities, honey-gatherers and hunter-foragers, all in close proximity and often trading commodities within and beyond the montane regions. The impact of heavy settlement, land conversion, resource extraction and fire has shrunk and modified montane ecosystems over the millennia, most significantly in the lower woodlands and forests. The density of people and diversity of livelihoods has increased with Kenya's rapid population and economic activity since independence—further reducing and modifying montane habitats through intensified farming, resource extraction, timber and bamboo harvesting, commercial plantation forests, and illegal logging and hunting.

BOX 2.13: THE IMPORTANCE OF MONTANE ECOSYSTEMS

Kenya's distinctive mountains thrust upwards from the lowland plateau and act as water towers that capture rainfall and create a system of drainage basins—supplying water across highlands and lowlands. The heavy vegetation cover of montane ecosystems regulates flooding, erosion and nutrient cycles. The most fertile and productive farmlands and ranches are located in Kenya's uplands and around the base of high mountains. The mountain habitats also supply a wide range of forest products, including lumber, bamboo, fuelwood, honey, medicinal plants and traditional foods, and offer a place to shelter from drought. In traditional cultures mountains are places of great spiritual and cultural significance, retreats for special ceremonies, and citadels of wonder, awe and worship. Adding to these ancient services and goods are a range of new values including biodiversity, aesthetics, tourism, outdoor recreation, adventure, wilderness, education, science, climate change amelioration, and carbon capture and credits.

PLATE 2.11: Mt.Kenya permanent glaciers
Mt.Kenya has permanent glaciers despite straddling the equator. Swedish botanist Olof Hedberg described the afro-alpine zone as having summer every day and winter every night. The cold climate supports temperate plant species with growth-forms adapted to the daily flux of temperatures.
© Christian Lambrects.

AFRO-ALPINE

Covering only a mere 1.2 per cent of Kenya's land surface, the afro-alpine ecosystem is the remotest and harshest region for all but a few highly-adapted plants and animals. Lying 3 000 m or more above sea-level, the ecosystem is only found on the highest elevations of Kenya's tallest mountains. The afro-alpine zone is home to cold-tolerant plants and animals. The moorland has several small well-adapted mammals such as the Mt. Kenya Rock Hyrax, the groove-toothed rat and common duiker as well as birds such as sunbirds, alpine chats, starlings and raptors. The high-altitude plants include giant Lobelias and Senecios, several tussock grasses and sedges, *Hagenia abyssinica* and bamboo *Arundinaria alpina*.

BOX 2.14: THE IMPORTANCE OF THE AFRO-ALPINE ZONE

The afro-alpine zone is Kenya's most remote and unique ecosystem. Intensely cold, it supports a specialized variety of plants and animals. Though infrequently visited traditionally, the afro-alpine areas of Mt. Kenya, the Aberdares and Elgon have become prime attractions for tourists, climbers, fly fishermen, hikers and photographers. Culturally, the high-altitude ecosystems feature in traditional societies as places affiliated to god and the ancestors. Today Mt. Kenya has become a national symbol of the nation that has taken its name.

MARINE

Kenya's marine ecosystem links to and is influenced by its coastal forests, mangroves and tidal estuaries. The marine ecosystem itself spans a number of distinctive zones and habitats, including rocky and sandy shorelines, tidal flats or the littoral zone, lagoons, seagrass beds, coral reefs and the open-sea pelagic zone.

Kenya's coastline extends 600 km from Somalia to Tanzania. The continental shelf is relatively narrow, ranging from 5 to 10 km wide, with depths dropping below 200 m. The continental shelf serves as fishing grounds for thousands of artisanal fishermen living along Kenya's coastline.Beyond the continental shelf, the seabed slopes away to depths of over 4 000 m.

FIGURE 2.14: The coastal ecosystems of Kenya
Coastal ecosystems of Kenya include mangrove forests, coastal foreshores, coral reefs and offshore deep-water pelagic zones. *Source: Kenya State of the coasts report 2008.*

PLATE 2.12: Kenya's mangrove forests and coastal wetlands
The mangrove forests and coastal wetlands concentrated on the northern coast of Kenya, around the Lamu archipelago and Tana and Sabaki River estuaries are nutrient-rich environments, as are the smaller clusters along the southern coast. Both serve as nurseries and feeding grounds for fish and invertebrates. © *P. Wargute /DRSRS.*

The north-flowing East African Coastal Current and south-flowing Somali Current create a falling temperature gradient south to north, resulting in poorer coral reefs in the cooler, nutrient-rich waters of the north, and extensive mangrove, seagrass and suspension-feeding communities to the south.

Coral reefs are the ocean's richest ecosystems in terms of biodiversity and productivity. The coral reefs around the equatorial belt show striking similarity in the composition of their plants, animals and micro-organisms due to the circulation of ocean currents and relatively stable and uniform marine environments. Straddling the equator and in the path of currents delivering deep ocean nutrients, Kenya's reefs are particularly productive ecosystems rich in corals, sponges, seaferns, algae, seagrasses, phytoplankton, and an extraordinary variety of invertebrates ranging from burrowing worms and bristleworms to jellyfish, anemones, shrimps, lobsters, crabs, starfish, sea urchins, sea cumbers, giant clams, bivalves, conches, seahares, squids and octopuses. The remarkable array of forms, including stagehorns, gorgonians, and table, brain and mushroom corals along with hundreds of species of fish of varying shapes, sizes and colours form among the most colourful and spectacular ecosystems of all.

Seagrass meadows are composed of submerged flowering plants that colonize shallow marine waters. The meadows settle sediment loads in the tidal zone, buffer the coastline from ocean currents, absorb suspended nutrients and sequester nitrogen. They also offer food and shelter for invertebrates and fish, and are important to the subsistence, commercial and sport-fishing industry of the coast (State of the coasts report 2008).

Offshore behind the fringing reef the seafloor drops away to the continental shelf and beyond, to the ocean abyss of the western Indian Ocean. This deep-sea zone spans two thirds of the planet and has a large assemblage of pelagic fish and squid.

The coral reefs, fringing reefs and inner lagoons of Kenya's coast have supported artisanal fishing for millennia, mainly using dugout canoes and, in the open ocean, jahazi vessels powered by lateen sails. The coastal fishing cultures also developed distinctive traps, techniques, rules and customs to exploit and protect their fishing grounds. Over time, the fishing communities linked up with dhow traders plying the Indian Ocean monsoons, forging a trading culture that gave rise to the Swahili-speaking peoples and making the coastal strip a gateway to the interior and to the outer world.

BOX 2.15: THE IMPORTANCE OF MARINE ECOSYSTEMS

Reefs play an important role in protecting the shoreline, mangroves and seagrasses from wave action, currents and storms. The filter-feeding of corals and sponges ingests particulate matter and improves the clarity of inshore waters. The buffering and cleaning action of reefs is as important to residential homes and commercial centres as it is to biodiversity.

The marine zone has been the backbone of traditional coastal fishing communities for millennia, providing them with food, coral rag, mangrove poles and thatch for building houses, medicines, ornaments and trading goods.

Over the last few decades the coast has spawned Kenya's prime in- and offshore commercial fishing industry. The coast has also become a focal point of a burgeoning tourism industry, based on beach and reef tourism, water-sports, and historical and cultural visitation. The coastal belt has also become a focal point of Kenya's trade, industry, and residential and urban development.

PLATE 2.13: *Tridacna maxima (Elongated giant clam). Source: NMK.*

The Traditional Human Setting

Africa is the most ancient human landscape on Earth. From the time the lineage leading to modern humans split from the apes some seven million years ago, our ancestors have been shaped by the African environment. Once early hominids learned to make tools and to hunt and forage cooperatively, they in turn began to shape the landscapes.

Kenya's human history can be read in its many prehistoric sites. Evidence from butchery sites tells us that by 2.5 million years ago, humans were hunting antelope-sized animals, and in due course the largest species. Around one million years ago early humans learned to use fire and so alter habitats on a large scale. Between 500 000 and 320 000 years ago, early humans made the transition from large Achulean hand-axes, typical of the Olorgesailie prehistoric site in the Rift Valley, to a varied and sophisticated toolkit of small refined blades made of obsidian and chert, often transported from considerable distances. Many of the tools were hafted to form projectile weapons, increasing the ability of early humans to kill prey at larger distances and dispatch larger animals with less risk. The composition of the fauna changed, at much the same time, to the modern assemblage. Many large species, including elephants, sheep and a giant baboon, *Theropithecus,* disappeared. Whether the extinctions occurred as a result of improved hunting tools and skills or climate change is the subject of research at Olorgesailie by the National Museums of Kenya (NMK) and the Smithsonian Museum of Natural History.

Starting 11 000 years ago in Mesopotamia, the domestication of plants and animals led to the emergence of farming and herding communities. Populations grew rapidly and transformed landscapes and ecosystems across North Africa and progressively southwards. Subsistence societies of hunter-gatherers, farmers, herders and fishermen converged in Kenya as Bantu peoples with new crops and iron-smelting technology migrated from Central and West Africa, and pastoralists from the Nile Basin and Horn of Africa migrated south with cattle, sheep, goats, donkeys and camels. Farmers converted large areas of forest and woodland to croplands, pastoralists transformed the savannahs to rangelands, and fishing communities settled heavily along the lakes and coastal shorelines.

By 1 000 years ago Kenya's ecosystems were dominated by human activity. In the following centuries the monsoon trade around the Indian Ocean brought new peoples and opened up commercial trade to Kenya's shores. The trade routes extended ever deeper into the interior, eventually reaching the great lakes. Small coastal villages grew into towns such as Mombasa, Malindi, Lamu and Shimoni, linking the interior world to North Africa, Arabia and India. The iniquities of the trade grew with commercial trade, disrupting and scattering many communities. Yet at the same time new crops, livestock breeds and technologies, including guns, spread inland, boosting populations and the impact of Kenya's peoples on the landscape and wildlife.

Kenya's cultural history is the product of a varied array of some 45 ethnic groups. Each culture has a unique heritage and livelihood sustained by the land and its natural resources. The term 'culture' has many definitions, but in the context of human history, it refers to a system of behaviours, symbols and ways of relating to each other that allows people to live in social groups and meet their needs. Culture incorporates knowledge gained through teaching and experience, bearing on local environmental systems and their resources. In other words, culture cannot be thought of as separate from environment. These biocultures, as they have been called, determine the knowledge people have of their crops, livestock and environment and the skills, tools, practices and governance systems they use to make a living.

BOX 2.16: WHAT IS CULTURE?

The learned behaviours and symbols that allow people to live in groups, the primary means by which humans adapt to their environments. The way of life characteristic of a particular human society.

Nanda and Warms 1998. (From Cronk 1999: 132-133).

PLATE 2.14: Galla Married Woman, painting © Joy Adamson.
Source: NMK

Over centuries, farmers and herdsmen experimented with crops and livestock, eventually developing husbandry practices, cultivars and breeds that allowed them to survive and prosper across the varied landscapes of Kenya. Knowledge about pastures, soils and growing conditions helped communities to manage the changing seasons and environmental conditions. Many communities combined cropping with livestock husbandry, giving them a variety of food sources.

In heavily-forested areas, where ruminants fare poorly, bees substituted as 'livestock' among hunting and gathering as well as farming communities. Hunter-gatherers acquired knowledge about the animals they hunted and the food they gathered. Kenya had many different groups of hunters-gatherers in highland forests as well as coastal lowlands. Today they include the Sengwer, the Ogiek, the Yaaku, the Sanye and Aweer, among others. Each invested in worked traps, weapons and beehives, and stored food such as dried meat and honey for lean times. Honey is particularly important to hunters, providing a source of carbohydrates unavailable in meat. Many hunter-gatherers subsisted on small animals. Others such as the Wata specialized in hunting large animals, including elephants. Most traded honey, animal and other forest products as well as ivory with farmers, herders and traders.

For the last 3 000 years, Kenya's rangelands have been occupied by herders who use fire to create grasslands and fresh grazing land, and to control parasites. The pastoral way of life reshaped the savannahs and largely supplanted hunter-gatherers.

The human imprint of traditional peoples transformed Kenya's landscape and ecology but caused few animal or plant extinctions. One reason is the mobility of subsistence farmers and herders. Agriculturalists rotated and changed crops to suit the seasons, and often grazed their herds away from their farms until the crops matured. Many pastoralists moved seasonally between pastures to increase and sustain milk yields year round. In more erratic environments, pastoralists such as the Turkana became fully nomadic and diversified their diet by fishing and hunting, occasionally growing hardy fast-growing arid-adapted crops such as sorghum and millet. Pastoralists varied their herd composition to adapt to wet and dry periods, achieving higher production and better resilience to droughts. Many communities still practice pastoralism, including the Maasai, Samburu, Turkana, Borana, Burji, Gabbra, Rendille/Ariaal, Somali, Pokot, Wardei and Orma.

BOX 2.17: VARIATONS IN ENVIRONMENT AND PASTORALIST SYSTEMS IN KENYA

The Maasai live in an area with a bimodal rainfall, great diversity of physical environments and localized areas of high pasture production. Traditionally, the Maasai moved their livestock seasonally to access dry-season pastures, water and minerals and to avoid diseases. Such mobility enabled pastoralists to boost milk production and sustain yields for calves and families throughout the year. Many pastoral groups moved up and down altitudinal gradients to counter seasons. Most fenced off pastures around the settlement for calves and reserved robust pastures for late-season forage.

The Ngisonyonka Turkana, who live in the drier erratic rainfall regions of northern Kenya, often face dry seasons of nine months or more. During the driest times, herders forage their herds up to 70 km from family settlements. Their diversified herds include camels, cattle, goats and donkeys, which spreads the range of vegetation consumed, and increases overall herd productivity and adaptability. Such flexibility among pastoral societies reflects the large difference in environment and cultures across the rangelands.

Source: Homewood 2008.

PLATE 2.15: Variatons in environment and pastoralist systems in Kenya

Agriculturalists such as the Kikuyu, Meru, Embu, Pokomo, Kamba, Taita, Tharaka, Kisii, Kipsigis, Luo, Nandi, Teso and Luhya lived in high- or mixed-potential zones, which sustained crops. Pastoralists and agriculturalists have different concepts of land 'ownership' and user rights, which shape their governance of land and natural resources. Pastoral governance revolves around mobility of herds, whereas farming cultures are more concerned with securing land tenure to ensure crop production. Like pastoral communities, land-use patterns and practices among farming communities vary with the environment.

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

Because of infertile soils, Kenya's coast has low arable potential despite its rainfall. As a result, coastal peoples supplement farming with other livelihoods, including fishing and trading, linked to the monsoon winds. Over centuries, the coastal communities acquired a deep knowledge of the

BOX 2.18: SPECIALIZED LANDHOLDING PATTERNS FOR CHALLENGING ENVIRONMENTS: THE TAITA

The people living in the Taita Hills came from different directions and with different skills, and range from pastoralists and farmers, to hunter-gatherers. The Taita communities adapted their husbandry practices to the exigencies of geography and microclimate in the Taita Hills, whether high or low, steep or shallow, or located in storm tracks or rain shadows. The three broad ecological zones range from dry low-lying plains and moist uplands to cool, wet, foggy mountain tops. The Taita combined land tenure systems stretching up the mountains to accommodate altitudinal and seasonal differences. The farmers also shifted cattle between upland and lowland pastures, and between fields. These diversified and flexible husbandry practices, gave the Taita—like the pastoralists—higher production and resilience to drought. Skills and knowledge were built up over years of experience, and shared within cultures.

Source: Bravman 1998.

winds, tides and seasons, and developed productive and adaptable fishing customs. Limitations of technology and seasons rested fish stocks naturally, but there are remnant practices that hint at sustainable management practices built around closed fishing times, limited access to landing sites, restrictions on the size of fish taken, and sacred restricted sites. Some fishing communities were resident year-round, others migratory, reflecting the monsoon dhow trade that plied up and down the coast and expanded around the Indian Ocean in the 16th century.

During the 20th century traditional artisanal practices gave way to mechanized and commercial fishing in response to colonialism, immigration, tourism, demographic and economic transition, and changing beliefs. The increased exploitation and impact on ecosystems has depressed fish stocks, cleared mangrove forests and damaged reefs. More farmers are supplementing their income with fishing, putting pressure on stocks and depriving traditional fishing communities (McClanahan *et al*., 1997; Versleijen & Hoorweg 2008; Fulanda *et al*., 2009).

Kenya's lake communities also have a long history of fishing, often supplementing agro-pastoralism and hunting practices.

BOX 2.19: CHANGING LIVELIHOODS IN RESPONSE TO CHALLENGING CIRCUMSTANCES

Traditional livelihood practices reflect local environmental conditions and limitations, and show flexibility and resilience in the face of droughts, warfare, disease outbreaks and other disruptions. Communities switched livelihoods in response to shortages and reverted to traditional practices in better times. So, for example, pastoralists temporarily took up cultivation, fishing, hunting and gathering when their herds died. Among the Maasai, wildlife was regarded as second cattle, only to be hunted in extreme times such as drought and the rinderpest pandemic of the 1880s. The *Il Chamus,* near L. Baringo, retained their language when taking up irrigated farming and fishing to offset livestock shortages, easing the reversion to nomadic pastoralism.

In other cases, traditional subsistence cultures switched livelihoods permanently in the face of opportunity or duress. The Yaaku (also known as Mukogodo) were hunter-gatherers living in the Laikipia area and heavily-reliant on territorially-defined beekeeping. Honey was an important food source, a tradable commodity and dowry in negotiations for a bride. In the mid-1920s the Yaaku shifted to pastoralism as they intermarried with the Maasai and adopted their language and lifestyle. As their herds grew, the Yaaku abandoned the Mukogodo Forest and built Maasai corrals and houses. Their traditional territories lapsed as they foraged and became mobile herders.

Source: Cronk 2004, Bernsten 1976, Homewood 2008

BOX 2.20: TRADITIONAL FISHING PRACTICES IN L. VICTORIA: THE LUO

Early Luo migrated into Kenya from the Sudan in the late 14th century. These early agro-pastoralists settled near L. Victoria close to grazing and water for their livestock and good farming areas. They learned fishing from established communities, diversified their economy, and traded and adapted their practices to local and seasonal variations. By the 1880s the Luo developed institutions and practices to manage fish stocks. Fishermen understood lunar cycles and seasons, and their effects on fish behaviour and abundance. Elders controlled beaches and regulated access to and timing of fishing activities. Breeding areas were protected, and in some heavily-fished areas, bans imposed. Nets were made of papyrus and mesh sizes were regulated. The harvesting of certain species was also controlled. The Luo culture incorporated rules and customs, rites performed before fishing, and taboos. Fishermen cooperated in setting of traps, sharing canoes and catches, and often distributed them to the unlucky, orphans and the destitute.

Source: Opondo 2011

PLATE 2.16: Fishing in L. Victoria

Pastoralists, agriculturalists, hunters and fishers often traded produce, and occasionally livelihoods. The flexibility of traditional practices and varied food sources lowered the risk of droughts, diseases, social conflict, invasions and warfare. Historically, pastoralists without livestock turned to hunting or cultivation until they were able to make up their losses and acquire livestock. Traditional hunters, such as the Yaaku, became pastoralists. As land pressure forced farmers off the land, they often took up fishing. Fisherman no longer able to make a living turned to farming to diversity their income (Versleijen & Hoorweg 2008).

BOX 2.21: VALUE AND IMPORTANCE OF CULTURE AND INDIGENOUS KNOWLEDGE

Used in conservation and sustainable utilization of natural resources including biological diversity. Traditional knowledge is mainly of a practical nature and spans such fields as livestock, agriculture, fisheries, health, forestry and environmental management in general. Kenya's rich cultural resources have aesthetic and eco-tourism value; and are important in spirituality, research and education.

A Changing Nation and Changing Environments

TRANSFORMATION OF THE ENVIRONMENT

At the dawn of the colonial era, Kenya's population stood at approximately three million. During the 20th century, Kenya saw a rapid increase in population with the transformation from subsistence to market economies, the introduction of modern medicine and healthcare, education, social services, technology, and new modes of transportation. New industries, such as manufacturing, cash crops, agro-industry, horticulture, wildlife and tourism, changed ancient ways of life and homelands. By independence Kenya's population had increased to five million. By 2013 it had breached 40 million.

Kenya has shifted from subsistence to market economy in a few decades, driven by land-use intensification, rising resource extraction and technology. To manage the transition and raise land and resource production, Kenya developed policies, legislation and institutions to regulate and sustain its natural resources of water, soils, forestry, fisheries, wildlife and energy.

The modern Kenyan landscape now overlays, and has transformed, natural ecosystems and traditional lands. 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. New lakes are collecting behind dams in drylands. Fish farms are spreading across farmlands and ranches. Mobile pastoralism has given way to sedentary ranching, smallholdings and dairy farms. Kenya's rangelands are being privatized, subdivided and built up with rural homes, towns, cities and industrial estates.

This new landscape is creating human-dominated ecosystems and wholly manufactured landscapes. New agrarian and urban ecosystems divert most of the sun's energy, captured and distributed through complex foodwebs made up of thousands of species of plants and animals. These human-dominated ecosystems boost the production of foods and materials with fossil fuels and so disguise the strong dependence Kenya still has on its natural environment.

In the chapters that follow, the richness and importance of biodiversity will be mapped, its benefits quantified and the threats it faces highlighted to underscore the dependence Kenya still has on its natural capital for the majority of its production, for sustainable development and for the welfare and wellbeing of its people.

CHAPTER

03

A Wealth of SPECIES

PLATE 3.1: Variety of Birds in Kenya.
©Theo; *Source: D. Western/ACC.*

Kenya's Biodiversity in Global Perspective

The Earth Summit held in Rio de Janeiro, Brazil in 1992 marked a turning point for conservation. For the first time biodiversity was recognized as underpinning sustainable development and given a central place on the global agenda. The summit called for action to arrest the loss of biodiversity. But what should be the priorities globally, given a rising tide of extinctions, limited funds and lack of information on biodiversity? Little was known about the number, distribution or importance of endangered species. Estimates at the time put the number of species between five and one hundred million, with extinction as high as a 25 per cent species loss within a decade. Species were disappearing faster than they could be described and mapped. Rapid survey methods were devised to locate biodiversity hotspots based on the concentration of species and the level of threat.

There are many ways to map and measure the importance of biodiversity other than the abundance of species. Methods include global priorities, crisis regions, centres of endemism and plant diversity, ecoregions and the last of the wild. One of the biggest hurdles to classifying and mapping biodiversity is the enormous variety of environments worldwide, ranging from the polar ice caps to forests, deserts and coral reefs. A number of classifications have been developed to capture the characteristics of plant and animal communities, and climatic conditions such as temperature, precipitation and evapotranspiration, which affect animals and plants. Biomes, ecoregions, major ecosystems and Holridge Life Zones are four classifications commonly used to map the world's major biogeographic regions. The eco-climatic zones of Kenya are based on a similar methodology (chapter 2) and have proved their worth in mapping land-use and land-use potential as well as biogeographic zones.

Mapping lifezones, biomes and major ecosystems helps us understand the physical environment and ecology of Earth's most distinctive bioclimatic regions. Each region has a characteristic assembly of plants and animals adapted to its climate and geography. Each assembly includes species that have evolved adaptations to capture energy, water and nutrients efficiently and to withstand the rigors of local climate and geography. Species in a biome make up the community of plants and animals that account for the productivity and resilience of a region.

Kenya's most distinguishing biogeographic feature is that ten of the world's fourteen biogeographical biomes are found within its borders. Together with neighbouring Tanzania, Kenya is the richest biotic region in Africa and amongst the richest of nations worldwide. The range of biomes reflects not only the far greater richness of species in the tropics compared to temperate regions, but also Kenya's array of lifezones spread along altitudinal gradients from the coast to the snow-clad peaks of Mt. Kenya, towering over 5 000m above sea level. This wide range of altitudinal eco-climatic regions parallels

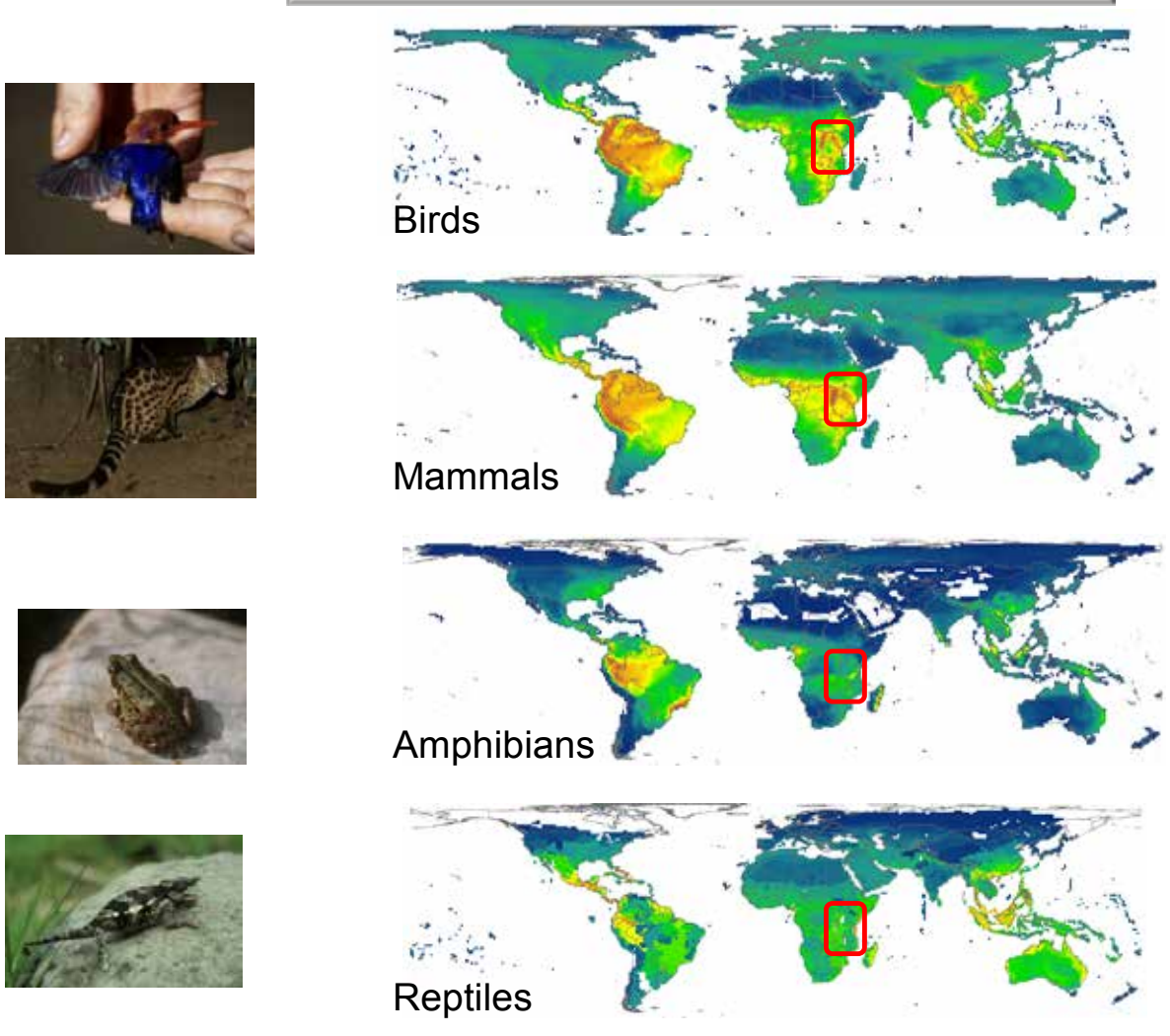


FIGURE 3.1: Vertebrates richness patterns
Viewed in Global perspective, eastern Africa is biodiversity-rich in terrestrial vertebrates, especially mammals and birds. Eastern Africa is shown in the red box. Orange and red areas indicate areas of high species richness, green and blue areas of low richness. *Source: Walter Jetz.*

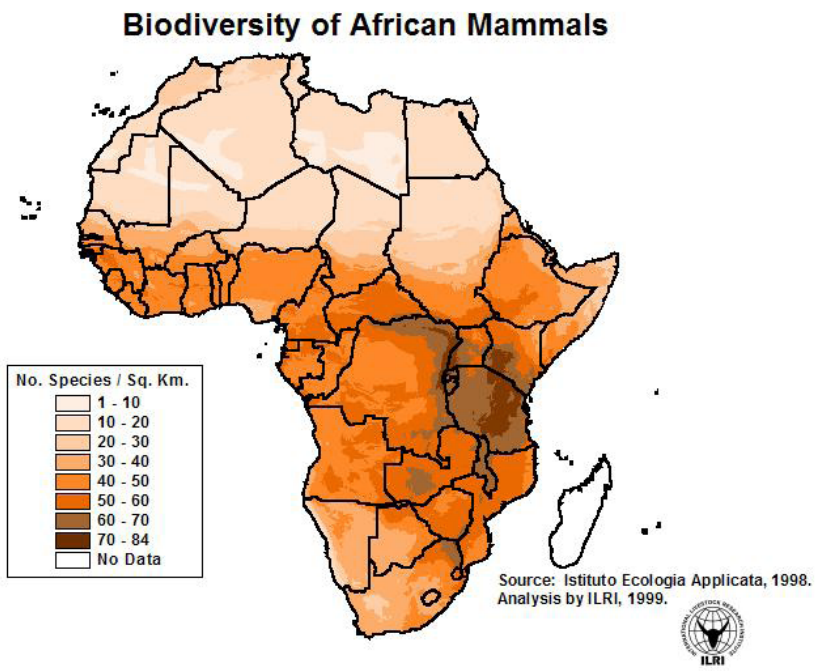


FIGURE 3.2: The Kenya–Tanzania borderland stands out on the African continent for its wealth of mammals. *Source: ILRI*

the major lifezones stretching from the tropics to the poles (Chapter 2).

In addition to its overall biotic richness, Kenya has a number of distinctive biomes of global significance. They include the East African coastal biome; the coastal forests of Arabuko Sokoke and the lower Tana River; the afro-montane forests of Mt. Kenya, the Aberdares and Mt. Elgon; Kakamega Forest, the eastern-most outlier of the Guineo-Congolian equatorial forests; the Somali-Maasai zone; the expansive afro-tropical grassland and highlands biome; the Victoria Basin biome; and the Sudan and Guinea Savannah biome. These biomes contain high levels of animal species diversity and genetic variability, and have many endemic, rare, endangered and threatened species.

Yet another distinctive feature of Kenya's biodiversity is the richness and abundance of its terrestrial vertebrates, especially its world-renowned large mammals and their spectacular seasonal migrations.

Large mammals that dominated all the major continents and land masses until the late Pleistocene suffered a wave of extinctions starting 50 000 years ago. Largely due to advances in human weaponry, hunting skills, farming, herding and settlement, the trend accelerated with the Industrial Revolution and colonialism. East Africa is exceptional for retaining its megafauna relatively intact (Chapter 1).

This unique legacy of the Pleistocene Age of the mammals, as is often called, combined with the large migratory populations of herbivores and a wealth of carnivores, are a global attraction at the centrepiece of Kenya's vibrant tourist industry. The wealth of mammals and birds at an African scale identifies Kenya and neighbouring Tanzania as having the richest concentration of species on the continent making these countries and a high priority for conservation.

Global and continental biodiversity mapping directs international attention to the world's richest and most vulnerable regions. Yet global maps are far too coarse for a national biodiversity assessment and ignore the special and unique features of each country. Global maps also overlook the landscape, ecological and human factors that shape biodiversity and determine conservation threats, options and priorities. Recognizing the limitations, the Convention on Biological Diversity (CBD) calls for each country to conduct a national biodiversity assessment and map the variety and distribution of species—as the basis of drawing up conservation goals, strategies and plans.

The sections that follow compile a broad overview of Kenya's wealth of species, their importance and status.

A Diversity of Plants

Underpinning and providing the foundation for Kenya's vertebrate diversity is the richness and abundance of its plant life. A total of 29 614 vascular plant species are known from Africa, including 706 ferns, 44 gymnosperms and 28 864 angiosperms. The East African region has a documented 12 317 species: this is the highest plant diversity per unit area across mainland tropical Africa. Of these at least 7 004 (57 per cent) are found in Kenya, though this number is likely to change as new species are recorded, existing data is collated and taxonomy changes. For the analysis presented here a total of 4 623 species across 1 387 genera are available. There are, in addition, 766 species of bryophytes, 511 ferns and 2 071 species of fungi and lichens (Figure 3.3).

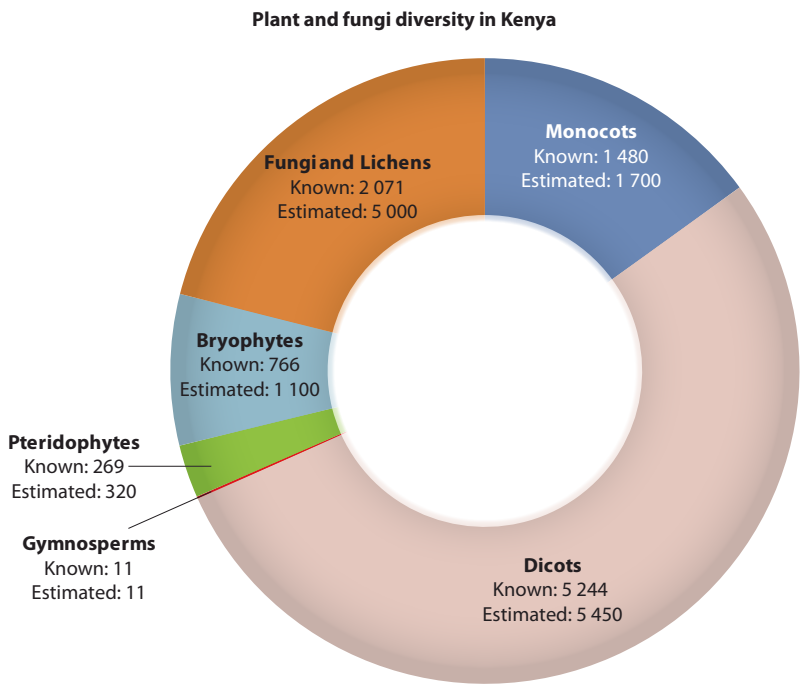


FIGURE 3.3: Plant and fungi diversity in Kenya
Kenya's 7 004 vascular plants comprise 1 720 genera and 240 families. The plant families are dominated by angiosperms (flowering plants), most of which are legumes (708 species) and grasses (576 species). Other species-rich families are the Compositae (494), Euphorbiaceae (341), Rubiaceae (330), Orchidaceae (249), Acanthaceae (225), Labiatae (218) and Cyperaceae (211). *Source: NMK*

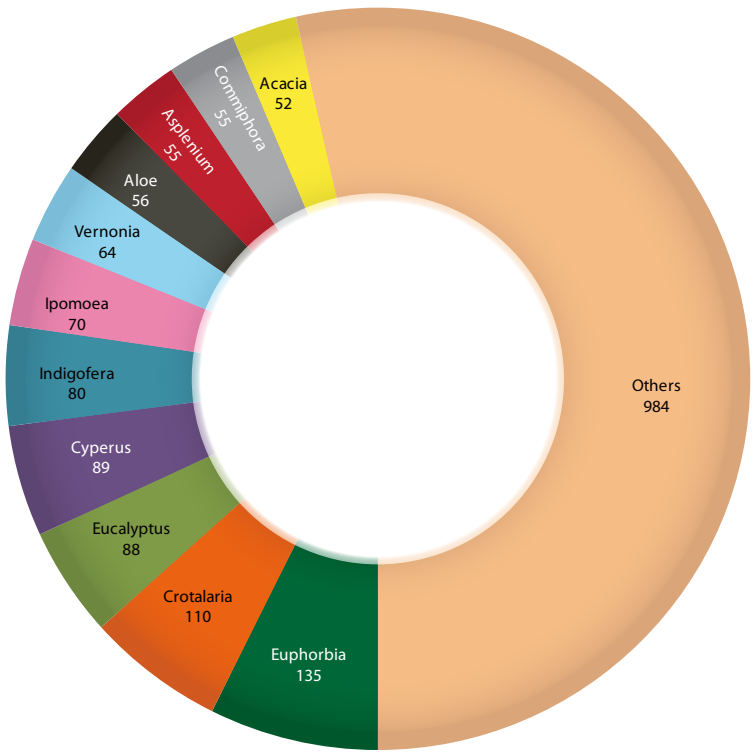
BOX 3.1: A DEFINITION OF SPECIES, GENUS, FAMILY AND ORDER

A Species is one of the basic units of biological classification and a taxonomic rank. A species is often defined as the largest group of organisms capable of interbreeding and producing fertile offspring.

A Genus is a category of biological classification ranking between the family and the species, comprising structurally or phylogenetically related species or an isolated species exhibiting unusual differentiation, and being designated by a Latin or latinized capitalized singular noun.

An Order is a taxonomic group containing one or more families.

A Family is a taxonomic rank fitting between order and genus in the hierarchy of classification.



Others (Genera with less than 50 species)

Genus	Number of Species	Genus	Number of Species
Eragrostis	48	Helichrysum	30
Hibiscus	48	Senecio	30
Cyphostemma	46	Sansevieria	30
Habenaria	44	Leucas	30
Sporobolus	39	Plectranthus	30
Rhynchosia	38	Polystachya	30
Justicia	36	Oldenlandia	29
Ficus	36	Eulophia	28
Solanum	36	Hyparrhenia	27
Panicum	35	Polygala	27
Phyllanthus	33	Combretum	26
Vigna	33	Pavetta	26
Psychotria	32	Barleria	25
Brachiaria	31	Abutilon	25
Tephrosia	31	Pavonia	25

FIGURE 3.4: The diveristy of species by genera.
The diveristy of species varies greatly within genera. The richest generus is Euphorbia found mainly in dry regions. *Source: NMK.*

MUSHROOMS

A mushroom (or toadstool) is the fleshy, spore-bearing fruiting body of a fungus, typically produced aboveground on soil or on its food source. Edible mushrooms are frequently harvested from the wild for consumption, as well as for sale, especially in western Kenya and in the coastal forests. Termitomyces mushrooms associated with termite mounds, are an important seasonal food in the arid and semi-arid areas of eastern Kenya.

Among the most important mushrooms are those that form mycorrhizal associations with plants, allowing nutrient flows and subsequent plant growth. Mushrooms are widespread in Kenya and common in all ecosystems. They are also a major source of food and medicine.

PLANT HOTSPOTS

BOX 3.2: BIODIVERDSITY HOTSPOTS

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans. To qualify as a biodiversity hotspot, a region must contain at least 1 500 species of vascular plants (⇢ 0.5 % of the world's total) as endemics, and must have lost at least 70 per cent of its original habitat. In this section we discuss plant hotspots within the Kenyan context. These are areas that are rich in plant species and are under great threat of anthropogenic habitat loss.

TOTAL PLANT DIVERSITY

The highest diversity of species is found in eco-climatic zones 1 to 4. The highest diversity per unit area, is found in eco-climatic zone 3 (Figure 3.5), extending through the central highlands and some coastal forests. Eco-climatic zone 6 has more species than eco-climatic zone 1, but they are widely distributed over a large area of northern and eastern Kenya. Three key areas with high plant diversity are Mt. Elgon, Nairobi and the coastal forests, with 650 to 950 species per 0.5 degree square. The hotspots partly reflect the intensity of plant surveys and collections but also correspond with the steep environmental gradients from highland to lowlands.

PLATE 3.2: *Fernandoa magnifica.*
Plants of Kenya. *Source: NMK*

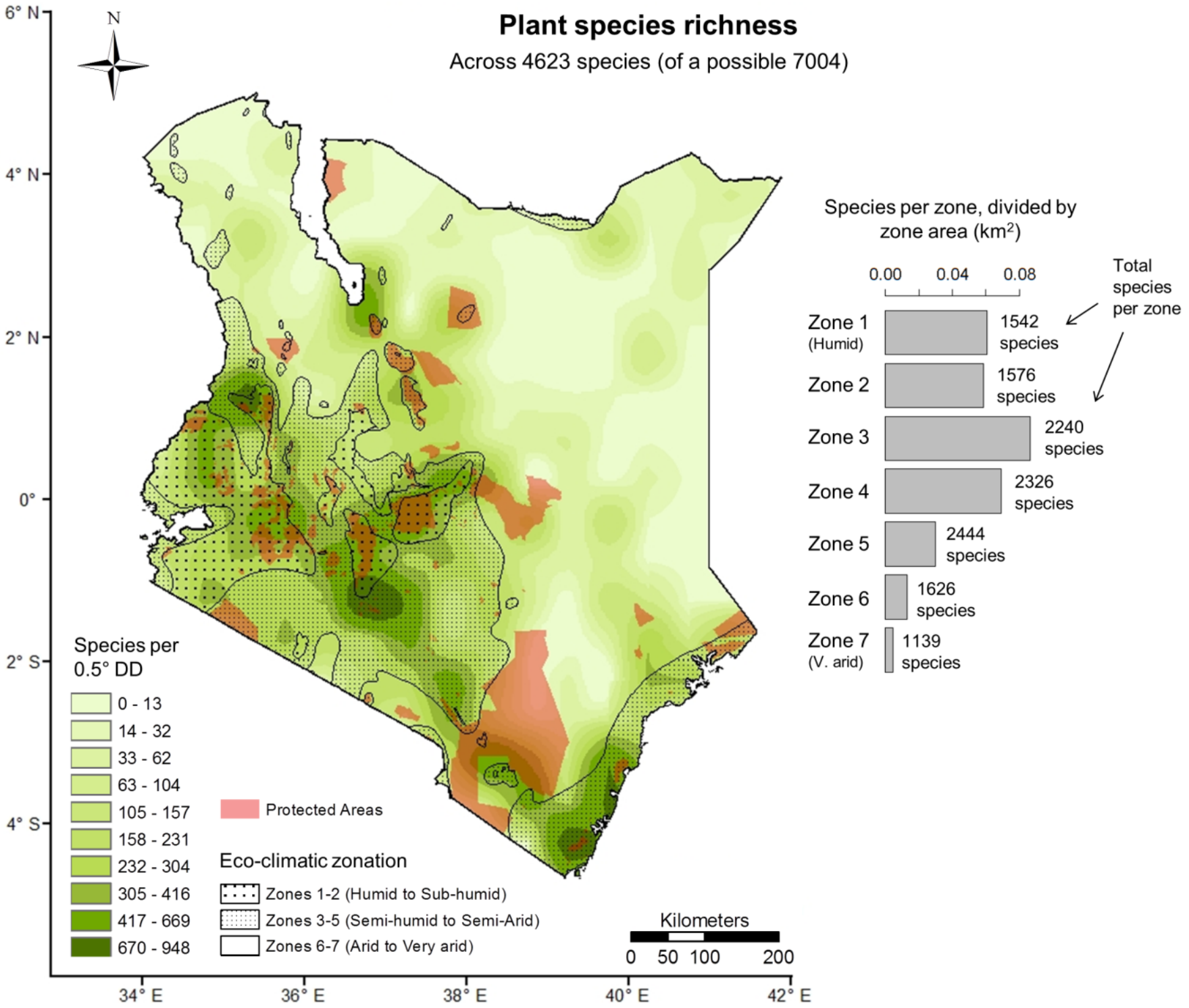


FIGURE 3.5: The diversity distribution of plants across Kenya in relation to eco-climatic zones. *Species records provided by the National Museums of Kenya, Missouri Botanical Garden, and Henk Beentje (Royal Botanic Gardens, Kew)*

PLATE 3.3: *Aloe ukambensis*
Plants of Kenya. *Source: NMK*

PLATE 3.4: *Psychotria kirkii*.
Plants of Kenya. *Source: NMK*

PLATE 3.5: *Huernia keniensis var nairobiensis*.
Plants of Kenya. *Source: NMK*

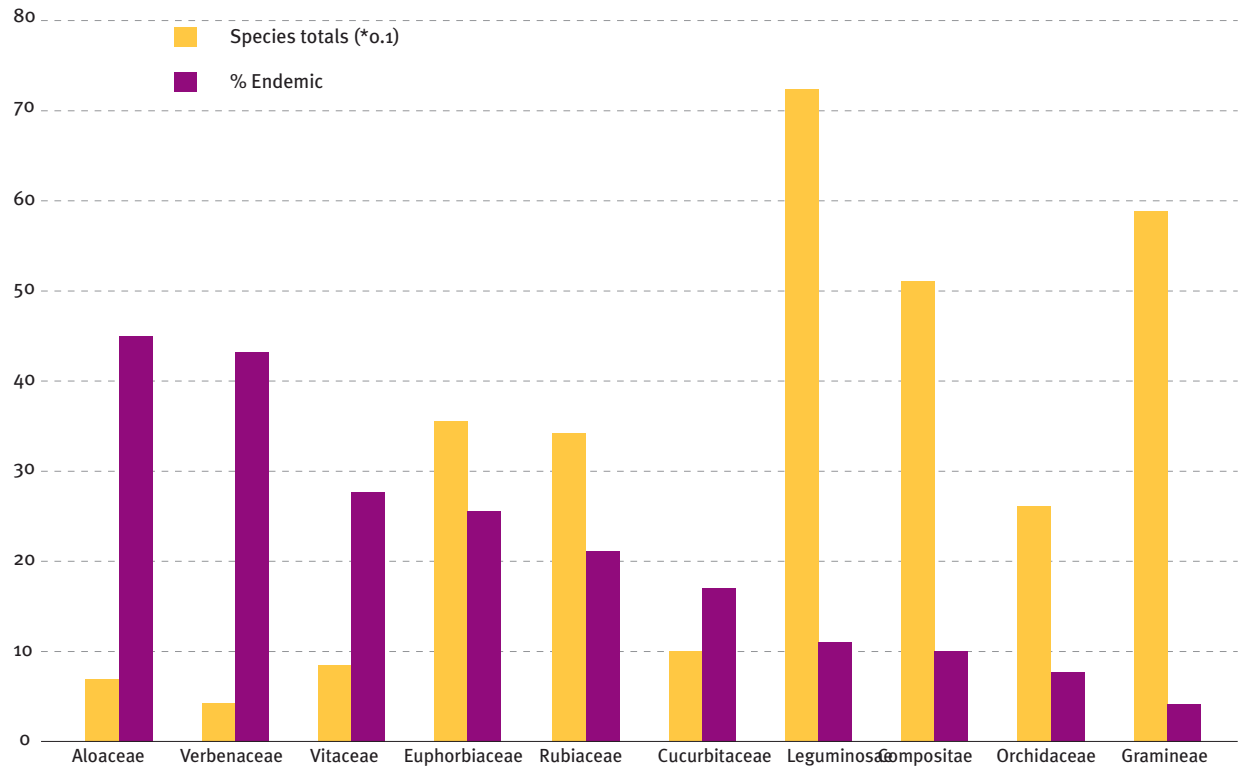


FIGURE 3.6: Endemic plants of Kenya grouped by family.
Source: NMK.

ENDEMIC PLANTS

Of the 7 004 plant species found in Kenya, 577 (some 8 per cent) are endemic. Due to many uncertainties of definition and gaps in collection, the actual figure could lie anywhere between 268 to 1 100. The families of Aloaceae, Verbenaceae, Vitaceae and Euphorbiaceae are particularly rich in endemic plants, indicating their relative geographic isolation and adaptation to Kenya's landscapes.

National centres of endemism for Kenya include the coastal centre of endemism, recognized globally as the Coastal Forests of Eastern Africa Hotspot, and the isolated mountain peaks of the afro-montane forests, recognized as the Eastern Afromontane Hotspot. The two centres account for over 80 per cent of endemic species (Fig.3.7).

BOX 3.3: ENDEMIC SPECIES

Endemism is the ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type. In this section we discuss plant species that are found naturally in Kenya and nowhere else on Earth.

PLATE 3.6: *Thunbergia napperae,* a species endemic to central and eastern Kenya.
Source: NMK.

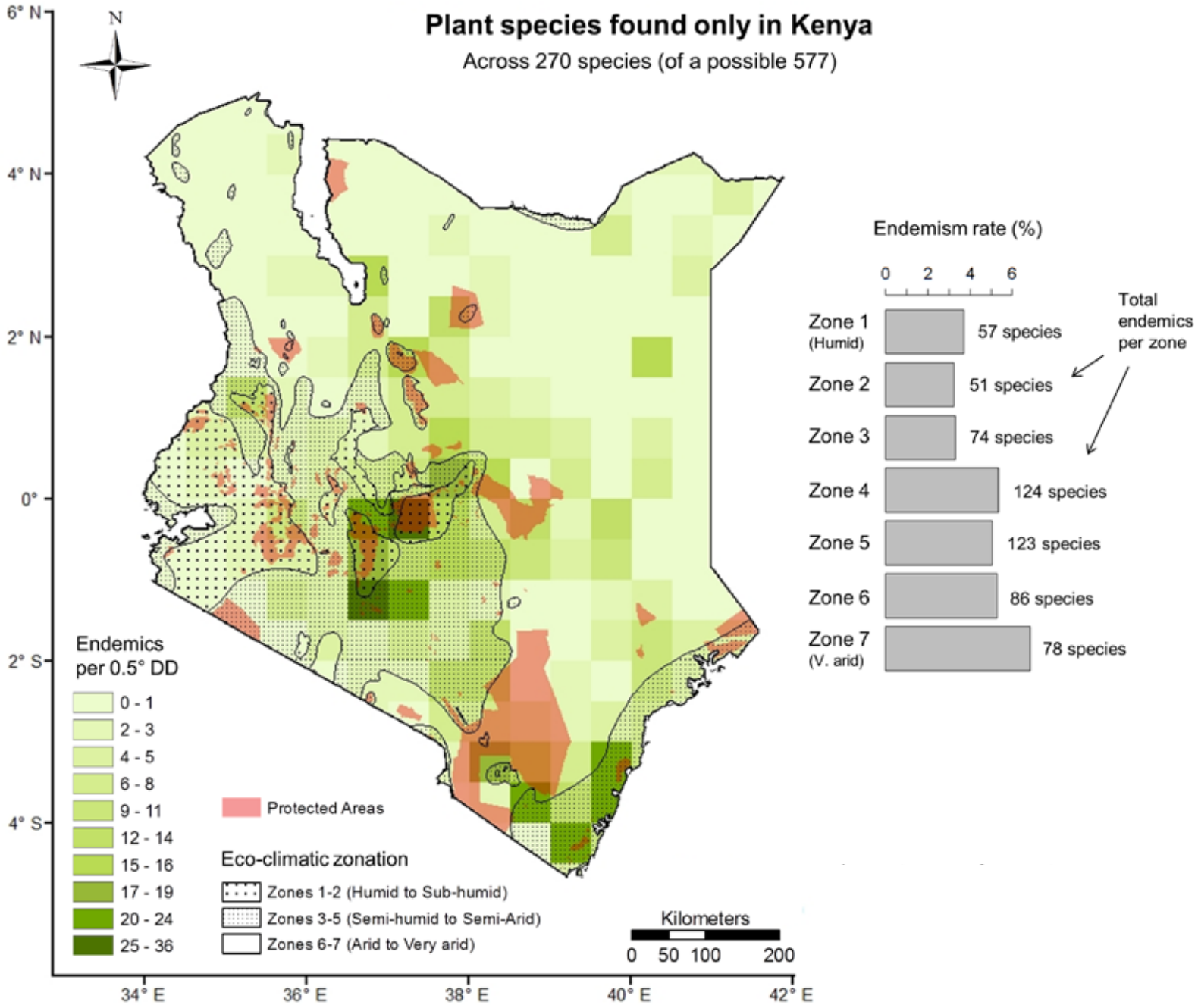


FIGURE 3.7: Endemic plants
The highest diversity of endemic plants is found in the central highlands and the coastal forests. These biodiversity hotspots reflect a combination of the steep environmental gradients and their relative isolation. Mt. Marsabit and Mt. Kulal in northeastern Kenya are similar isolated montane areas with several endemic species. The diversity of endemic plants is fairly evenly spread across eco-climatic zones, with 3–6% of species in each zone being endemic. The highest proportion of endemic plants is found in the most arid environments, which call for special adaptations. *Species records provided by the National Museums of Kenya, Missouri Botanical Garden, and Henk Beentje (Royal Botanic Gardens, Kew)*

ENDANGERED AND THREATENED SPECIES

Threatened species in Kenya were collated from a combination of those classified by the International Union for Conservation of Nature (IUCN)as Vulnerable, Endangered or Critically Endangered, based on the IUCN Red List Categories and Criteria (IUCN, 2001), and a Plant Red-listing workshop held in Nairobi in 2013.

A total of 356 vascular plant taxa (species, subspecies and varieties) in Kenya have so far been classified as Threatened or Near Threatened. Of these, 24 taxa (21 species) are Critically Endangered, 111 are Endangered (83 species), 167 are Vulnerable (128species) and 67 are Near Threatened (56 species). Threatened species are particularly common in the Fabaceae, Euphorbiaceae and Rubiaceae families. The highest number of threatened species, 95 in all, is found in the Coastal Forests Hotspot, mainly because of habitat fragmentation and the extensive loss of the highly-diverse coastal forest ecosystems such as Arabuko Sokoke National Park and the *Kaya* forests.

PLATE 3.7: *Gigasiphon macrosiphon*, a critically threatened tree species
Source: NMK.

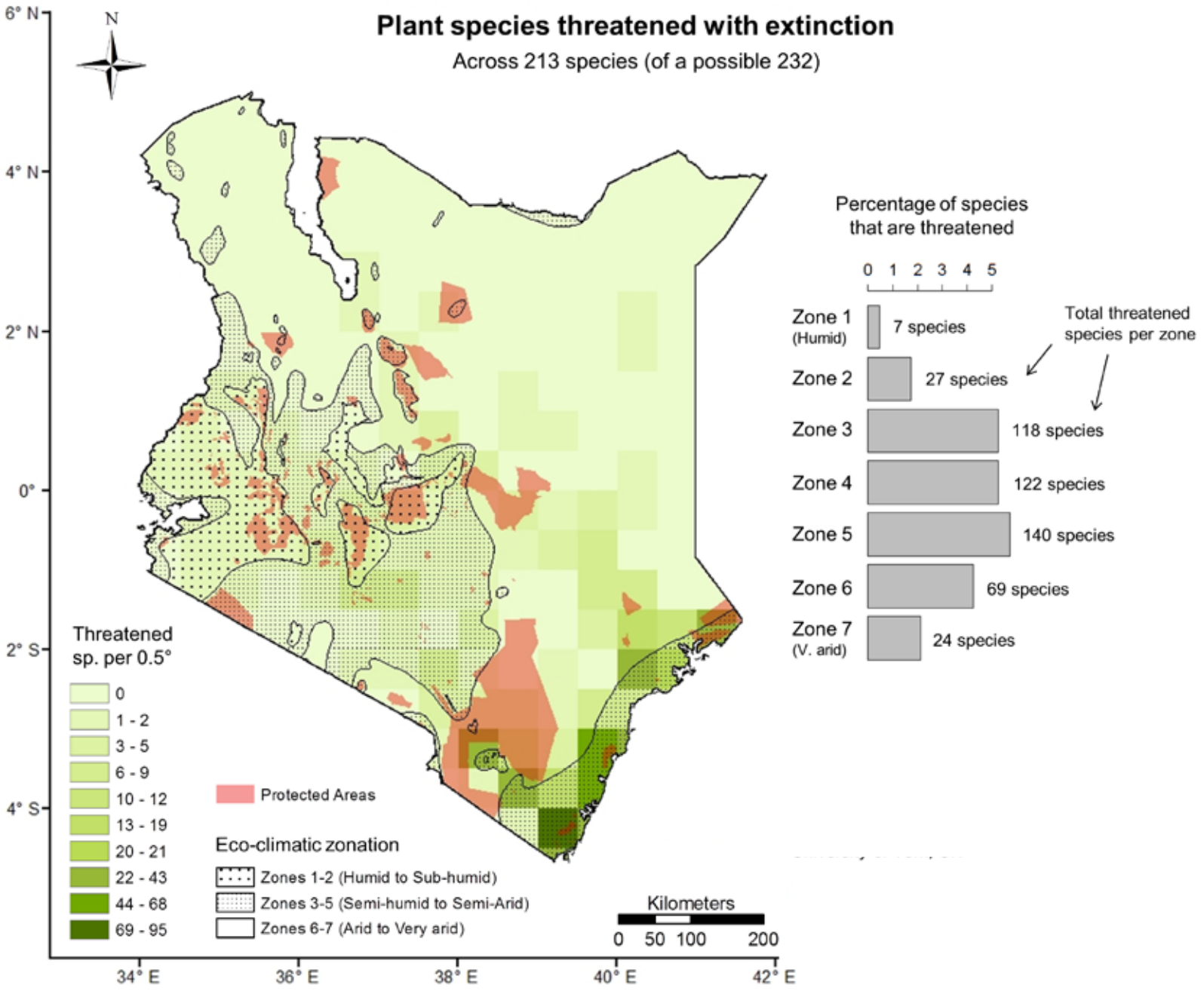


FIGURE 3.8: Plant species threatened with extinction
The distribution of threatened plant species across Kenya and by eco-climatic region. The coastal forest has the highest number of threatened species. *Species records provided by the National Museums of Kenya, Missouri Botanical Garden, and Henk Beentje (Royal Botanic Gardens, Kew)*

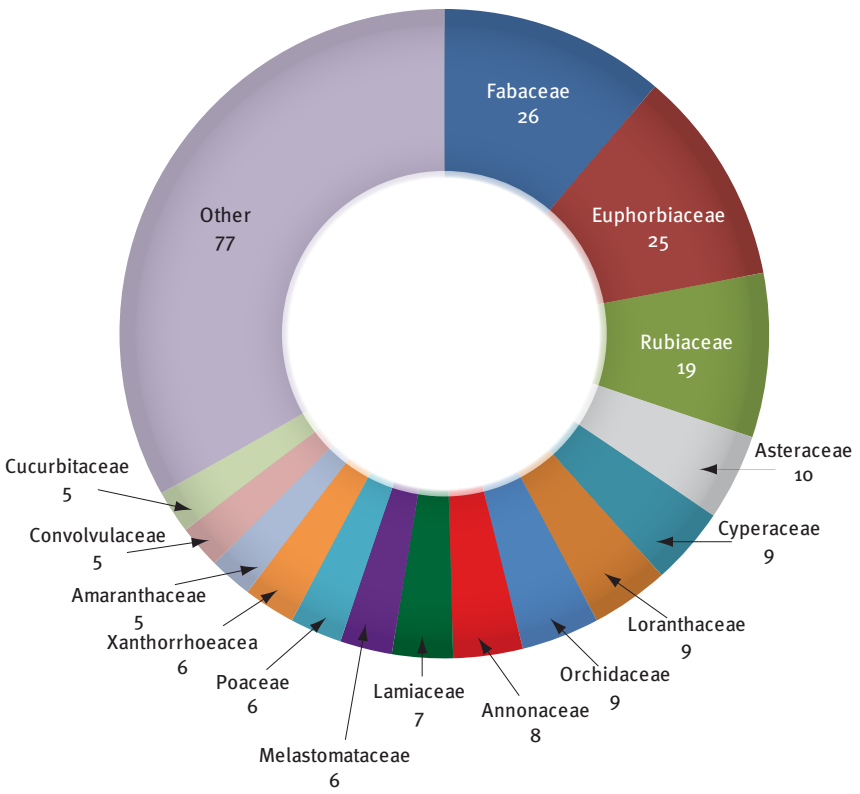


FIGURE 3.9: The number of threatened species by plant family. 'Others' includes families with fewer than five threatened species.
Source: NMK.

BOX 3.4 :THE VALUE OF PLANTS

Plants convert sunlight, minerals and water to organic matter that forms the base of the food-chain for herbivores, carnivores and decomposers. Plants also transpire ground water; humidify the atmosphere; and lower surface temperatures, wind speed and the drying power of the air. Among the many important ecological functions they perform, plants recycle water, atmospheric gases and nutrients; increase rainfall infiltration to the soil; reduce runoff and erosion; and purify air, water and soils polluted by human effluent. At a global level, plant cover is important in reducing the reflectiveness of the Earth and the atmospheric warming resulting from the build-up of greenhouse gases.

Plants are the primary source of human food worldwide, mainly cereal crops, vegetables, fruits and nuts from over 7 000 species. They also provide construction and furnishing materials, pulp, and fibre. Plants have provided the main source of traditional medicines and a quarter of all drugs in the pharmaceutical industry, whether to cure cancer, lower the risk of heart disease or analgesics such as aspirin.

Plants feature centrally in all cultures, as objects of spiritual reverence, beauty, adornments, aesthetics, romance, literature and art. Natural habitats, humanized landscapes, gardens, parks and arboretums play an ever-growing role in urban societies by providing areas of outdoor recreation and enjoyment.

TABLE 3.1: **THREATS TO PLANT SPECIES VARY ACCORDING TO LOCATION AND FAMILY. HABITAT DESTRUCTION AND OVER-EXPLOITATION ARE THE MOST PERVASIVE THREATS TO PLANT SPECIES. INVASIVE SPECIES AND CLIMATE CHANGE POSE GROWING THREATS.**

Taxon	Habitat destruction	Over - exploitation	Invasive species	Pollutants	Climate change
Acacias (family Fabaceae)					
African violets (family Gesneriaceae)					
Aloes (family Xanthoraceae)					
Boabab (family Malvaceae)					
Bryophytes (mosses and liverworts)					
Giant senecio (family Asteraceae)					
Cycads (family Cycadaceae)					
Ocotea					
Orchids (family Orchida-ceae)					
Prunus Africana (family Rosaceae)					
Pteridophytes (ferns)					
Wild coffee (family Rubiaceae)					

Low Intermediate High

Source: NMK.

CONSERVATION STATUS AND THREATS

The maps of plant diversity, endemic and threatened species show that current protected areas give poor coverage, even before threats posed by climate and land-use change are considered. Large protected areas, such as Tsavo, fall in between the high-diversity plant areas. The coastal forest protected areas are especially important in plant conservation but better protection is needed.

TABLE 3.2: **ORDERS OF MAMMALS**

Order		No of Family	No of species
1.	Primates(Non-human)	3	20
2.	Chiroptera(Bats)	9	108
3.	Afrosoriscida (Tenerecs, golden moles)	2	2
4.	Macroscellidea(Sengis)	1	6
5.	Tubulidentata(Aardvark)	1	1
6.	Hyracoidea (Hyraxes)	1	3
7.	Proboscidea (elephant)	1	1
8.	Soricomorpha (shrews)	1	36
9.	Erinaceomorpha (hedgehog)	1	1
10.	Pholidonta(pangolins)	1	3
11.	Sirenia(dugong, sea cows)	1	1
12.	Perissodactyla (odd-toed Ungulates)	2	4
13.	Artiodactyla(Even-toed Ungulates	4	43
14.	Cetacea(whales, Dolphins)	5	23
15.	Carnivora	7	34
16.	Lagomorpha	2	4
17.	Rodentia	11	109

The main threats to plants vary with taxa, as shown in Table 3.1. Overall habitat destruction and transformation, closely followed by over-harvesting, pose the most universal threats to plants. Climate change will pose an ever growing threat in the coming decades (Chapter 4). Invasive species pose a more localized significant threat most commonly associated with human settlement. Pollution, especially eutrophication from fertilizers leached from farmlands, poses a significant threat to many freshwater plants.

TABLE 3.3: **THE LIST OF ANIMAL SPECIES CURRENTLY RECORDED IN KENYA IS STILL FAR FROM COMPLETE. FAR MORE SURVEY AND TAXONOMIC WORK IS NEEDED, ESPECIALLY ON INVERTEBRATES**

Category	Species
Vertebrate Animals	
Small Mammals	220
Birds	1 100
Reptiles	200
Amphibians	110
Fishes	898
Total Vertebrates	2 528
Invertebrate Animals	
Dragonfiles	194
Butterflies	900
Bees	800
Molluscs	297
Crustaceans	343
Corals	183
Total Invertebrates	2 717
Total Animal Species	5 245

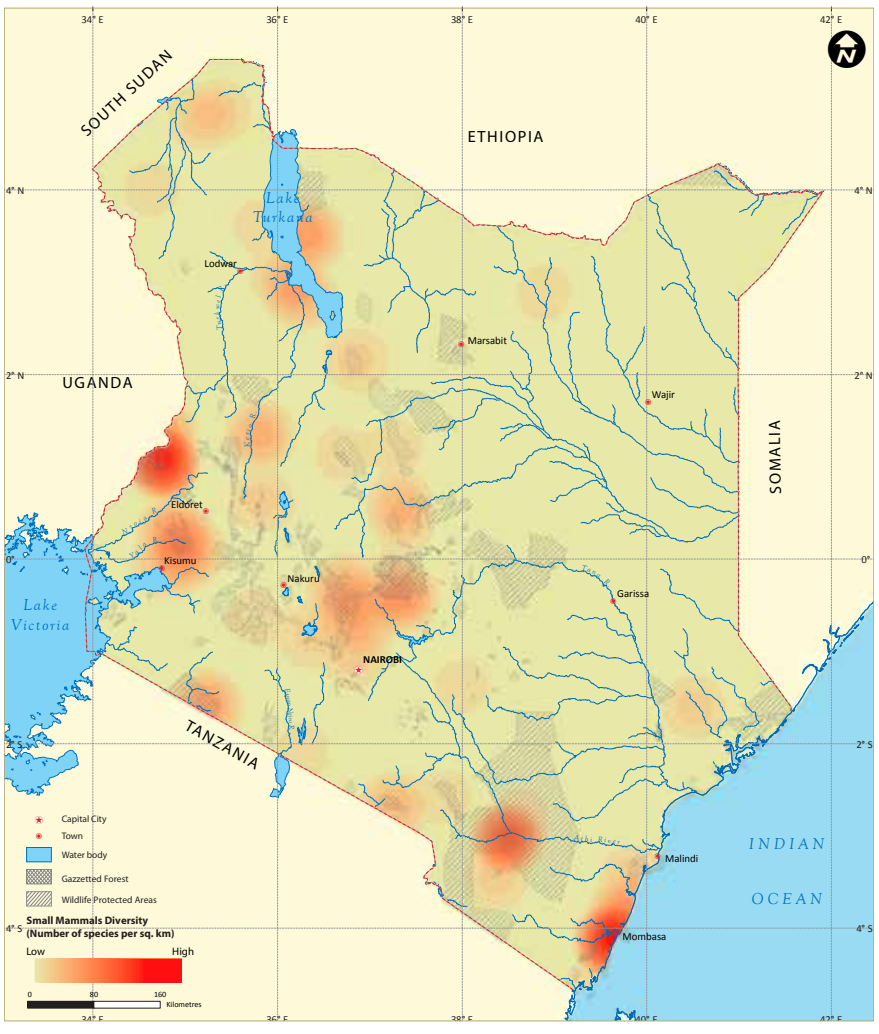


FIGURE 3.10: Refined species-richness map of all vertebrates in relation to protected areas. A large portion of Kenya's vertebrate diversity falls outside and between protected areas. *Source: NMK.*

A Diversity of Animals

Kenya possesses a remarkable variety of globally important and valuable animal species. These include birds, mammals, reptiles, amphibians, fish and invertebrates.

THE VERTEBRATES

The wealth of vertebrate species broadly relates to rainfall and topography, with the richest areas found in the highlands. The distribution does, however, vary among taxa.

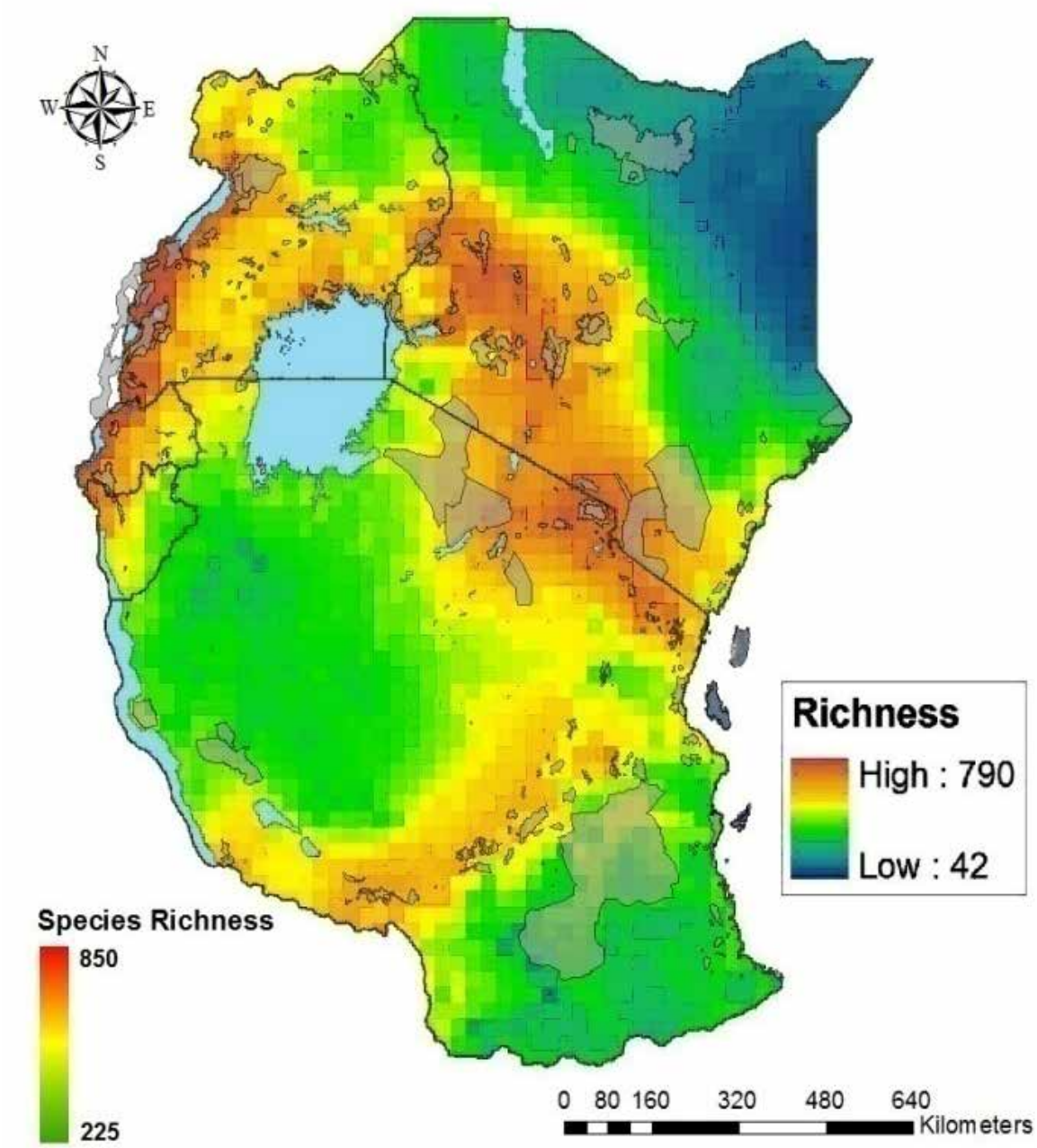


FIGURE 3.11: Species-richness of vertabrates in relation to protected areas. *Source: Walter Jetz.*

THE LARGE MAMMALS

Large herbivores and carnivores are the most visible of animals across the Kenyan landscape, with abundance corresponding to rainfall.

PLATE3.8: The wildebeest annual migration
A herd of wildebeest crosses the Mara River during the great annual migration. Every year, hundreds of thousands of wildlife including wildebeest, zebra, and other migratory herbivores travel along a migratory route between the Serengeti National Park in Tanzania and the Maasai Mara Game Reserve in Kenya. Due to its greatness and uniqueness, this annual crossing has been dubbed the eighth wonder of the world and makes the Maasai Mara Game Reserve a "Tourist Mecca". © *Katie Hunt/flickr.*

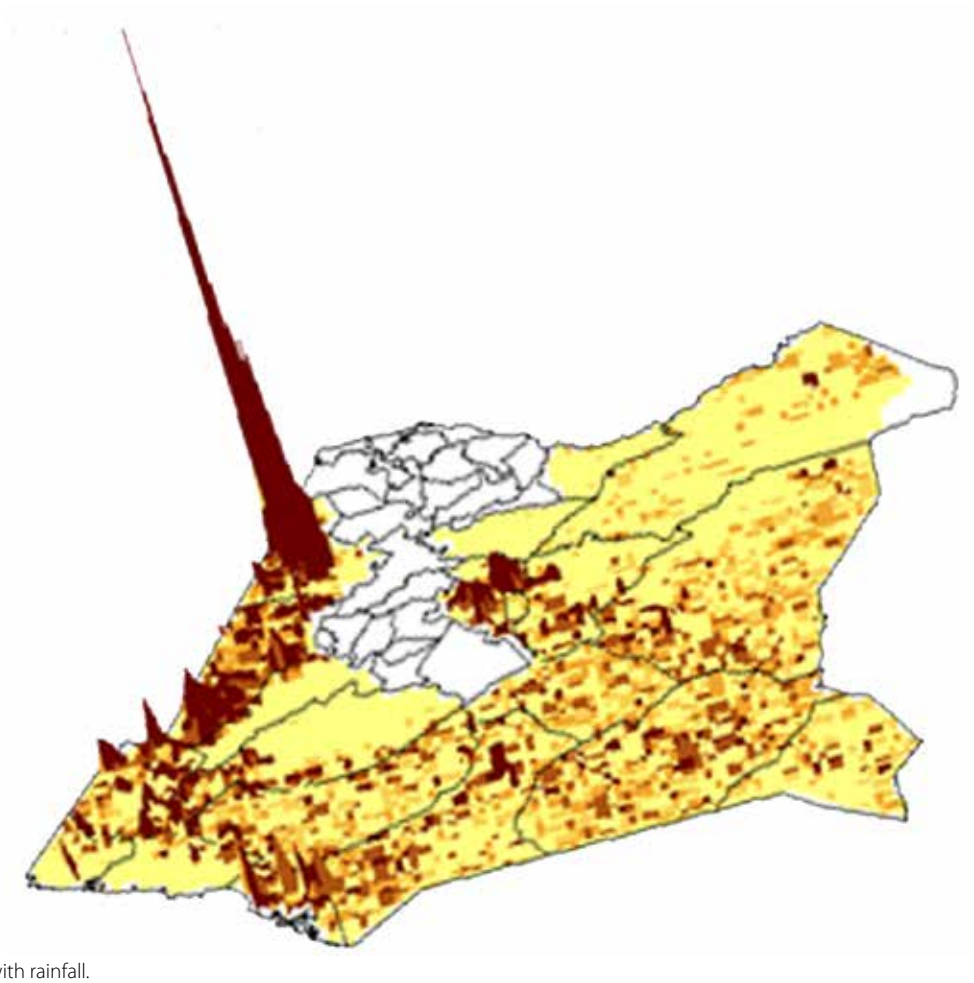


FIGURE 3.12: The abundance of wildlife varies with rainfall.
The abundance of wildlife corresponds to the height of the bars. The greatest abundance is found in the wetter habitats of southern and eastern Kenya, including Maasai Mara, Amboseli, Tsavo and the coast

PLATE 3.9: A leopard perched on a tree. Maasai Mara Game Reserve. © *Christopher Michel/flickr.*

PLATE 3.11: A herd of Buffalo in Maasai Mara Game Reserve. © *Benh LIEU SONG/flickr.*

PLATE 3.10: Zebras in the short grass plains of the Maasai Mara Game Reserve. © *John Schinker/Flickr.*

Kenya's diversity and abundance of **large mammals is world renown** and the main pull behind the **$1.3 billion tourist industry.** A large variety of **herbivores** and **carnivores occupy all terrestrial ecosystems —from desert to forest.**

PLATE 3.12: A female water buck in the bushes of Tsavo West National Park. © *Matt Rudge/flickr.*

PLATE 3.13: An elephant. Amboseli National Park. © *Julian Mason/flickr.*

PLATE 3.14: A Rhino on the shores of Lake Nakuru, Lake Nakuru National Park. © *Ryan Harvey/flickr.*

BOX 3.5: THE IMPORTANCE OF LARGE MAMMALS

Large mammals are the ecologically dominant species in Kenya's terrestrial ecosystems. The sheer abundance, impact and mobility of large herbivores, including elephants, wildebeest and zebra, and carnivores including lion, leopard and hyenas, govern the structure and dynamics of all major habitats from forests to deserts. The savannahs are among the most productive grasslands on Earth due to the diversity of herbivores, their range of feeding habits and resilience to harsh droughts. The patchiness and diversity of habitats in eastern Africa is largely due to the interactions between herbivores and carnivores shifting across the landscape in response to seasons.

The East African savannahs are among the last places on Earth where the large mammals that dominated the Pleistocene era until 10 000 years ago still survive in abundance. Kenya's parks and reserves, including Mara, Tsavo, Amboseli, Samburu and Nakuru are world-famous wildlife attractions. With over one million visitors each year, the tourism industry generates over Kshs.1 300 billion annually, accounting for 11 per cent of GDP and over 300 000 jobs.

THE SMALLER MAMMALS

Kenya has 250 small mammal species distributed in eight orders: Afrosoricida (2 spp.), Macroscelidea (5 spp.), Hyracoidea (4 spp.), Rodentia (95 spp.), Lagomorpha (3 spp.), Erinaceomorpha (1 spp.), Soricomorpha (37 spp.) and Chiroptera (103 spp).

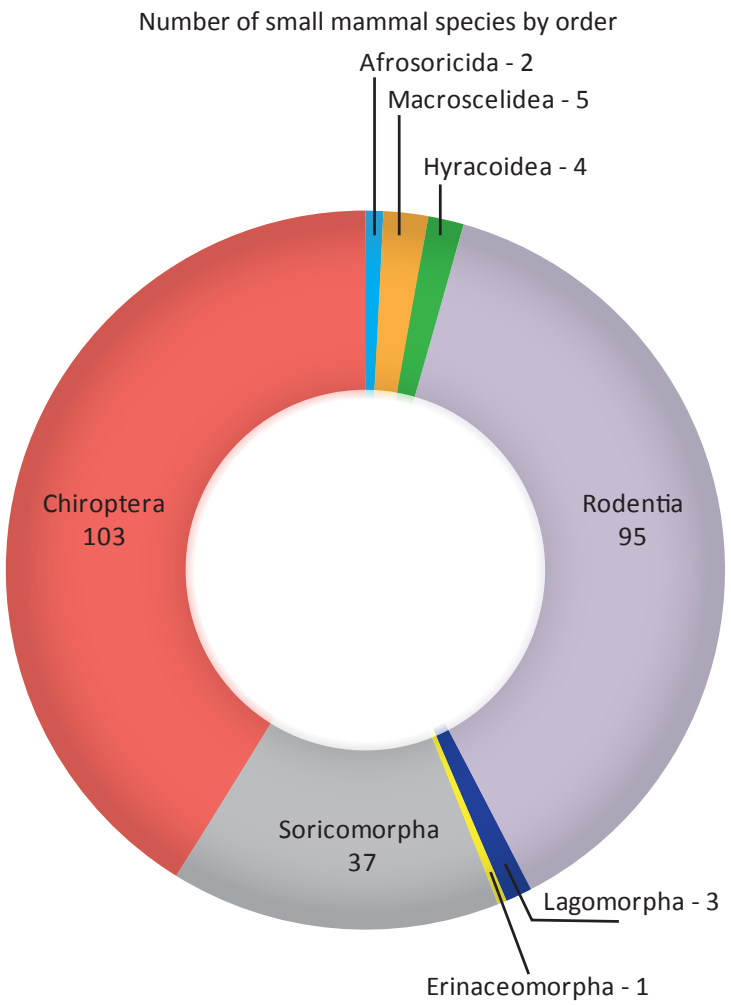


Figure 3.13: Number of small mammal species by order.
Source: NMK.

BOX 3.6: THE IMPORTANCE OF SMALL MAMMALS

Small mammals play crucial ecological roles in the ecosystem and are of economic importance to humans in many ways. Bats pollinate over 300 plant species, including culturally important indigenous species such as the baobab and commercially important agricultural species such as mangoes, guavas and bananas. Bats and small mammals feeding on fruits and nuts, disperse seeds and promote the regeneration and spread of forests, woodlands and shrublands. Rodents are important in spreading grass seeds and diversifying the composition of grasslands. Small mammals are also important in rural economies and traditional cultures. Small carnivores are particularly numerous in Kenya and keep rodent pests in check. They feature prominently in traditional folklore: hares are clever and used to council wisdom, the tortoise patience, and zebras the curbing of greed. Small mammals are also omens—bats of bad times and storks of coming rains. Because of their fast growth and short lifespans, small mammals are also early-warning indicators of environmental hazards such pesticides and toxins.

PLATE 3.15: African dormouse. © *Bernard Agwanda*

PLATE 3.16: Unstriped ground squirrel. © *Martin Odino*

PLATE 3.17: Scrub Hare . © *Simon Musila*

Though less visible than large mammals, **Kenya's small mammals** are **diverse** and **abundant.**

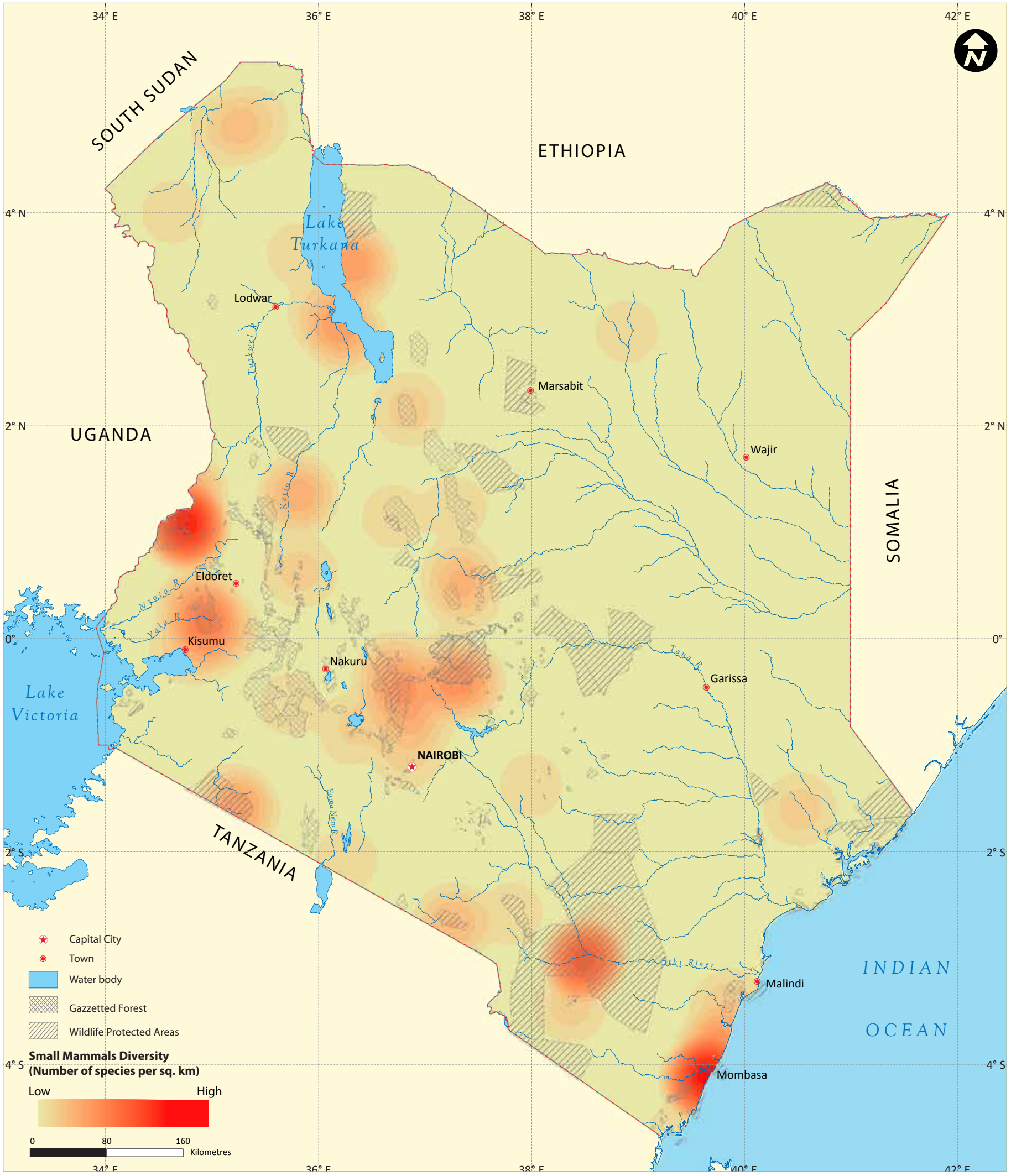


FIGURE 3.14: Estimated geographical range of various small mammal species in Kenya in relation to protected areas.
Source: NMK.

BIRDS

Kenya has one of the richest avifauna diversities in Africa (Fig 3.15), with around 1 100 bird species recorded. Of these, 800 species are year-round residents, 60 species are afro-tropical migrants moving within the continent and 170 are Palaearctic migrants that journey from Eurasia each winter. The major migratory flyways in Kenya include the 550km long coastline with its associated creeks, reefs and beaches, and the chain of lakes stretching along the Rift Valley from Turkana in the north to Magadi in the south.

Some 170 palaearctic migrant bird species migrate south to Kenya from Eurasia for the northern hemisphere's winter. Eleven of these species have local breeding populations that are year-round residents. Around 60 species in Kenya migrate only within Africa, including Madagascar.

The endemic birds of Kenya:

Four globally recognized Endemic Bird Areas (EBAs) are represented in Kenya (Stattersfield *et al* 1998) (Figure 3.16). One other EBA, the Jubba and Shabeelle valleys, is only marginally represented in Northern-eastern Kenya. EBAs are defined as places where two or more bird species with a world distribution of less than 50 000 km² occur together. Kenya has two globally recognized secondary areas of importance—Kakamega and Nandi forests, and the northern Kenya short-grass plains.

TABLE 3.4. **ENDEMIC BIRDS OF KENYA**

	Common name	Scientific name
i	Williams Lark	*Mirafra williamsi*
ii	Sharpes Longclaw	*Macronyx sharpei*
iii	Hinde's Babbler	*Turdoides hindei*
iv	Taita thrush	*Turdus helleri*
v	Taita Apalis	*Apalis fuscigularis*
vi	Aberdare Cisticola	*Cisticola aberdare*
vii	Clarkes Weaver	*Ploceus golandi*
viii	Jackson's Francolin	*Francolinus Jacksoni*

Source: NMK

PLATE 3.18: An African Fish Eagle takes off with a fish. Lake Baringo. © *Yodod/flickr*

PLATE 3.19: Lappet-faced Vulture perched atop an Acacia in the Nairobi National Park. © *Peter Steward/flickr*

PLATE 3.20: A crane. © *NMK*

The **76 raptors** found in Kenya range from **carrion birds such as vultures to eagles, falcons and owls,** making it one of richest birding locations on Earth for sheer numbers and visibility.

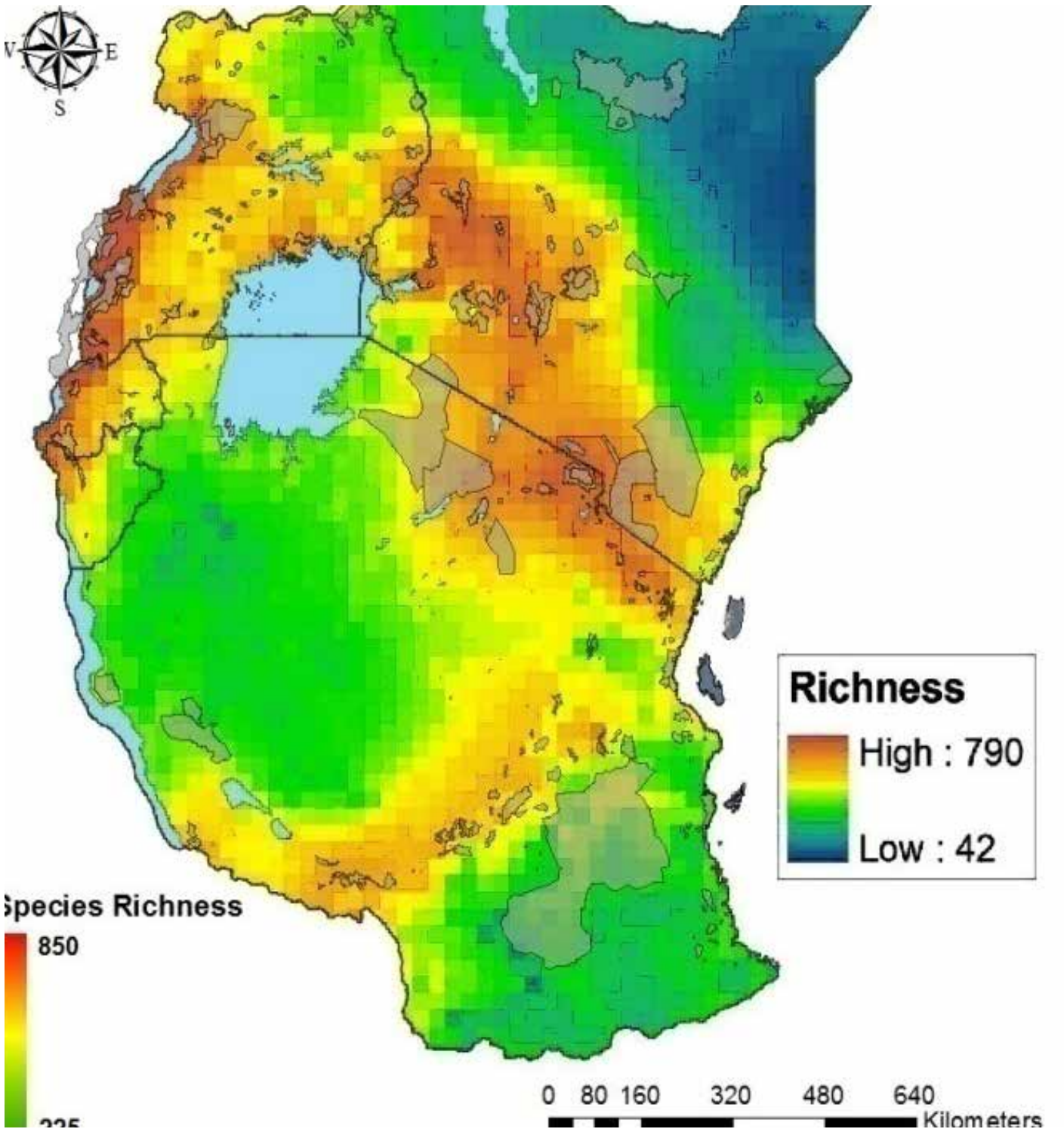


FIGURE 3.15: Species-richness of birds in relation to protected areas.
The distribution of bird richness is similar to mammal biodiversity distribution.
Source: Walter Jetz.

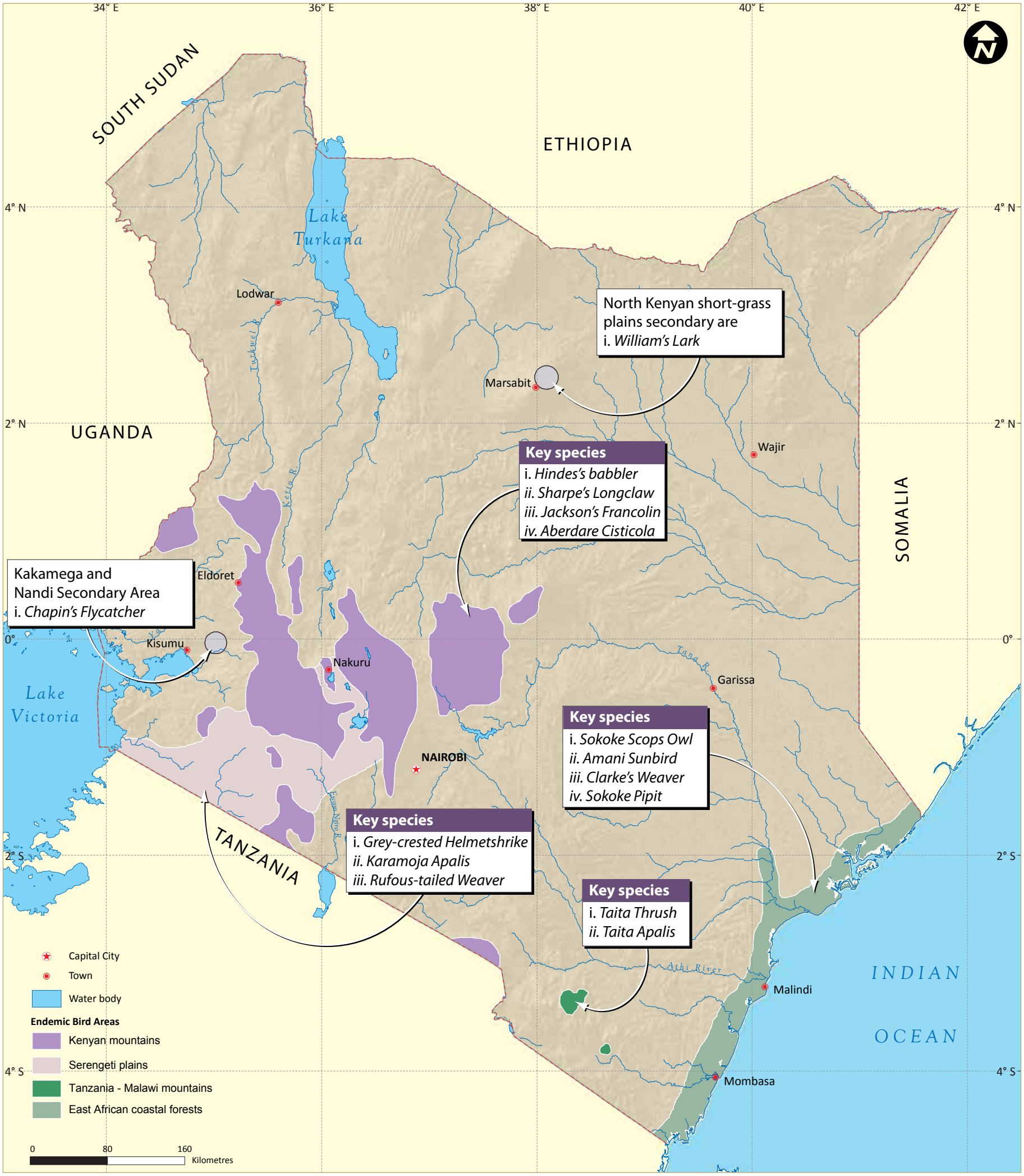


FIGURE 3.16: Map of the Endemic (EBA) and Secondary Bird Areas (SA) found in Kenya and the key species found in each.
Data source for Endemic Bird Areas: NMK. *Source: http://www.wri.org/publication/content/9291.*

PLATE 3.21 : The pink lakes of Kenyan's rift valley

The lesser flamingo is a highly specialised filter-feeder on microscopic blue-green algae, benthic diatoms and small invertebrates found in soda lakes. A population of 1 500 000–2 500 000 migrates between the rift valley soda lakes and pans. The flamingoes' characteristic pink colouring is a result of the beta-carotene in their diet. The species breeds in huge colonies of many thousands of pairs often mixed with the Greater Flamingo Phoenicopterus roseus. The timing of breeding is irregular and varies geographically depending on the rains**.** *© Andries3/flickr.*

Bird distribution by habitats

Avian Biomes in Kenya

There are six avian biomes in Kenya (Fishpool and Evans 2001) (Figure 3.17), all with characteristic bird species. The Somali Masai biome is the most widespread and has the most representative species, (Bennun and Njoroge 1999). The Guinea-Congo Forest biome, though only represented in Kenya by the Kakamega Forest is represented by 43 species in Kenya. The Sudan and Guinea savannah is marginal in Kenya, being at its extreme eastern limit. Most species in this biome are not found elsewhere in the country apart, from Kongelai Escarpment and its environs.

TABLE 3.5. **AVIAN BIOMES IN KENYA AND THE TOTAL NUMBER OF BIRD SPECIES UNIQUE FOR EACH AVIAN BIOME**

Biome	Number of species present in Kenya
Somali-Maasai Biome	92
Afro-tropical Highlands Biome	67
Guinea-Congo Forest Biome	43
East African Coast Biome	30
Lake Victoria Basin Biome	9
Sudan and Guinea Savannah Biome	13

Source:Bennun and Njoroge 1999

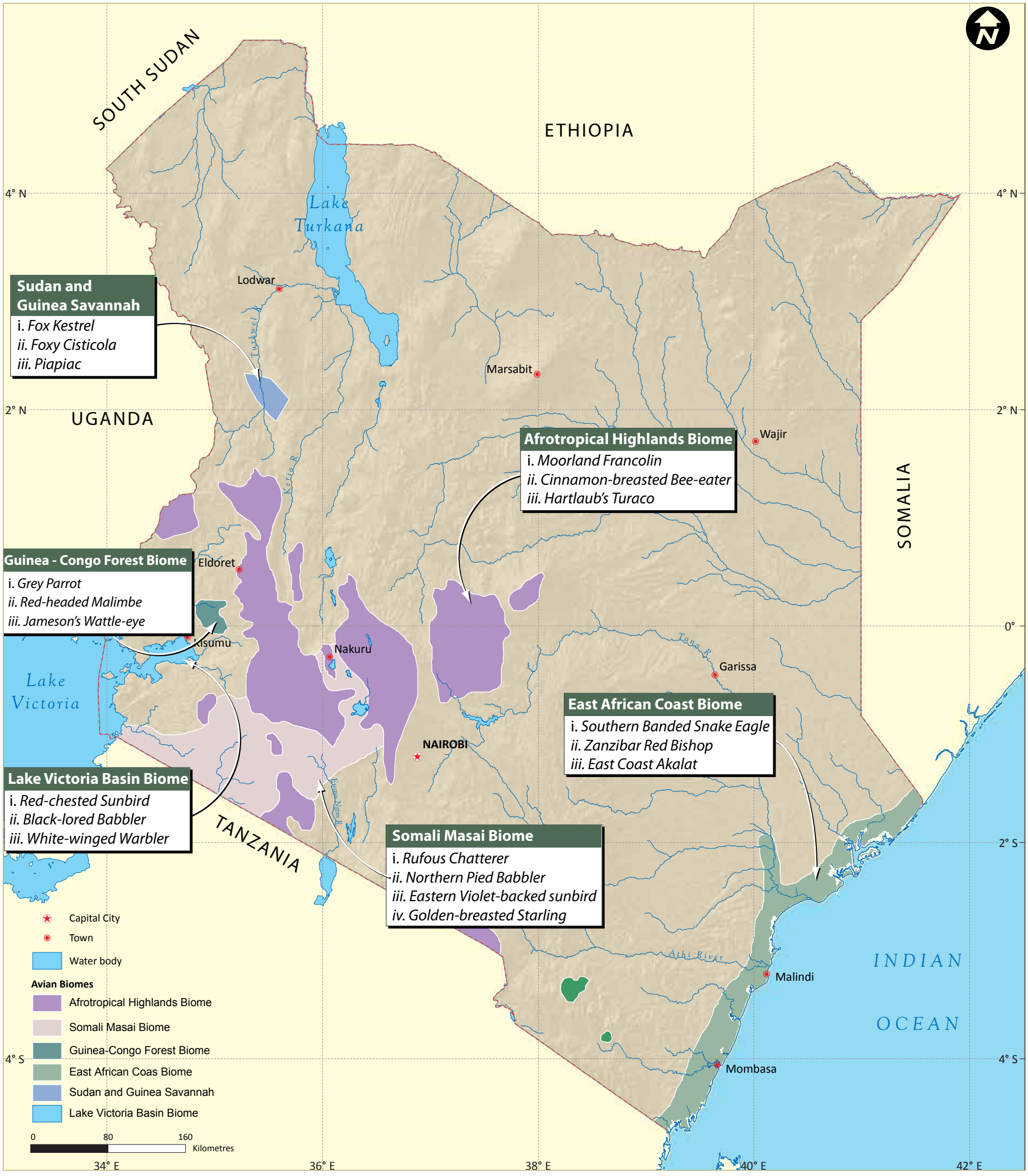


FIGURE 3.17: The six avian biomes in Kenya and representative species for each. *Source: http://www.wri.org/publication/content/9291.*

BOX 3.7 : IMPORTANCE OF KENYA'S BIRDS

Birds play a major role in the functioning of all Kenya's ecosystems as pollinators, seed dispersers, carnivores, scavengers, and seed, fruit and nut-eaters. Birds transport seeds over large distances and play a vital role in plant colonization. Many seed- and fruit-eating species are considered agricultural pests but also are an important source of food for subsistence societies. Kenya's rich and colourful variety of birds is a prime attraction of visiting and domestic tourists.

REPTILES AND AMPHIBIANS

Kenya has over 220 reptile species, including 100 snakes, 100 lizards, 5 marine turtles, 5 tortoises, 5 terrapins and 1 crocodile. The centre of reptile richness in Kenya runs in an arc of habitats ranging from the coastal forests, though the bushes and grassland savannahs of the Kenya–Tanzania borderlands, and into the Rift Valley.

The distribution patterns of snakes and lizards are broadly similar, and point to the fact that the cold-blooded vertebrates prefer warmer lower altitudes but all latitudes on a global scale are suitable.

Amphibians are associated with wetter habitats and tree-frogs mostly with forest and mountain areas. Reptiles and amphibians in Kenya have not received as much taxonomic attention as other vertebrates, so large gaps still occur in specimen collection, mapping, and behavioural and ecological studies.

PLATE 3.22: Von Hohnel's chameleon *(Chamaeleo hoehnelii). © Victor Wasonga*

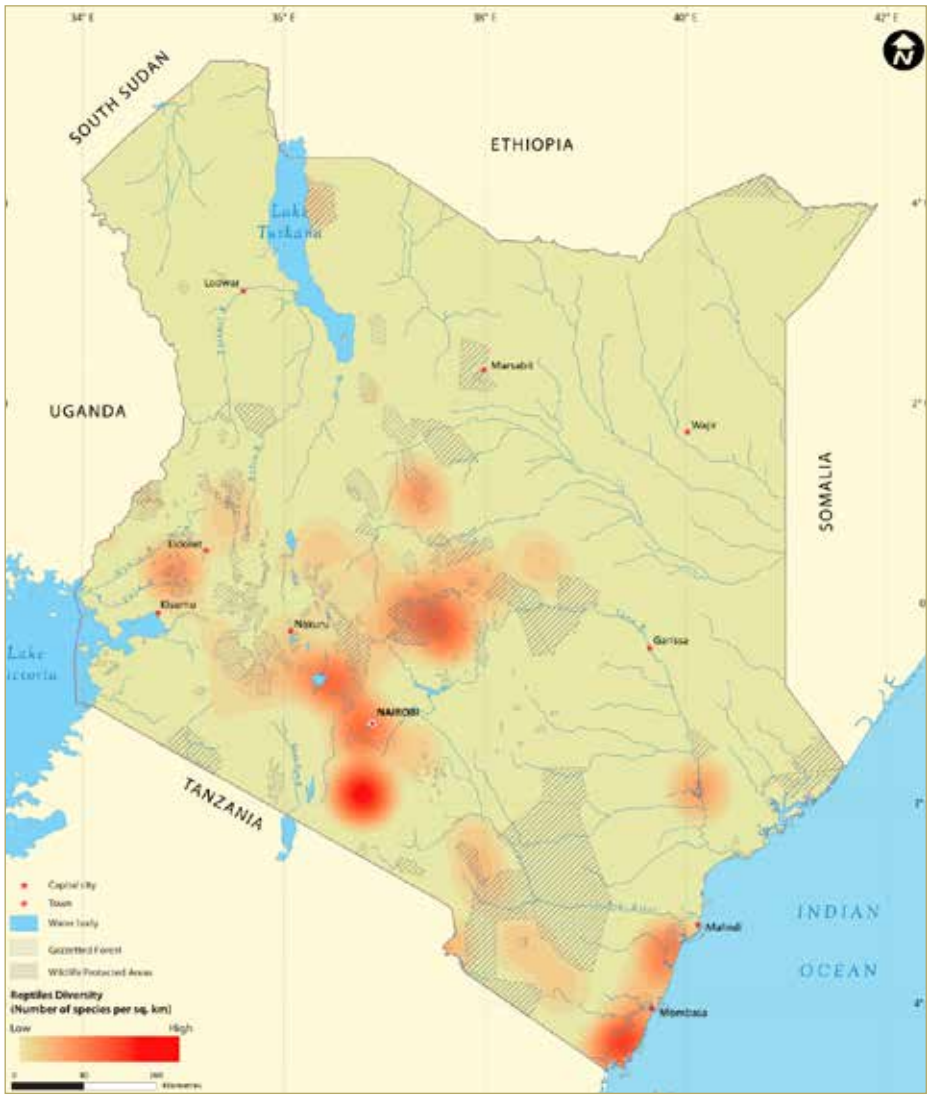


FIGURE 3.18: Species richness of reptiles in relation to protected areas. The richest areas lie outside parks and reserves.
Source: NMK

PLATE 3.23: Kenya sand boa *(Eryx colubrinus). © Victor Wasonga*

PLATE 3.24: Flat-backed toad *(Amietophrynus maculatus). © Victor Wasonga*

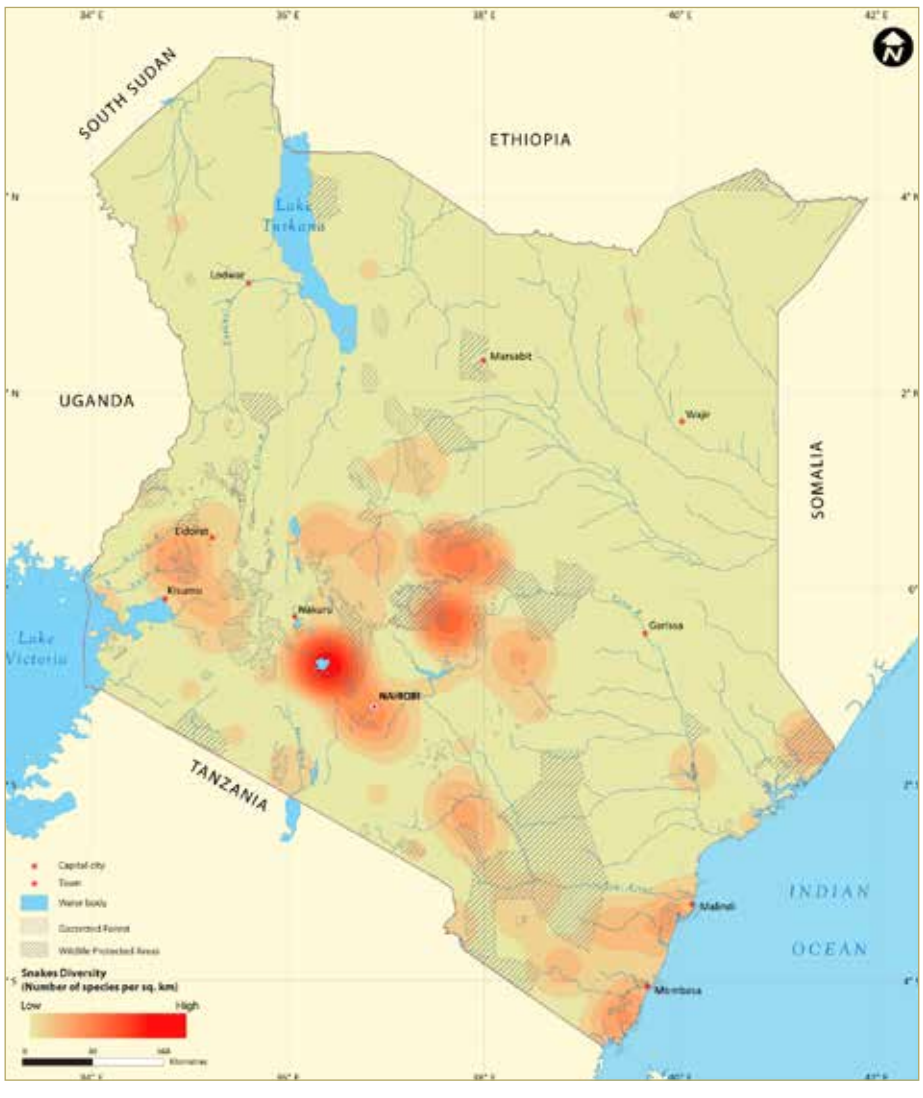


FIGURE 3.19: Species richness of snakes in relation to protected areas.
Source: NMK.

PLATE 3.25: Common egg-eater (Dasypeltis scabra) © *Victor Wasonga*

PLATE 3.26: Argus reed frog (Hyperolius argus) © *Victor Wasonga*

PLATE 3.27: Changamwe ceacilian (Boulengerula changamwensis) © *NMK*

BOX 3.8: IMPORTANCE OF REPTILES AND AMPHIBIANS

Reptiles and amphibians are important second- and third-level consumers in the food-chain, regulating populations of small mammals, birds and invertebrates. This regulatory function has economic importance in controlling rodent and bird pests of crops and granaries. Aquatic amphibians control malaria by feeding on mosquito larvae. Crocodile farms provide sustainably harvested meat to restaurants and leather for goods such as handbags, belts and shoes. Large turtles are important marine herbivores along the Kenyan coast. Poisonous snakes are a threat to human life and may account for more deaths than any other wildlife, but are also a major attraction at snake parks. Snake venom is the subject of immunological and biomedical research. Amphibians are widely used in teaching anatomy and physiology in secondary and tertiary education, and are a sensitive biological indicator of agrochemical pollutants that damage ecosystems and people.

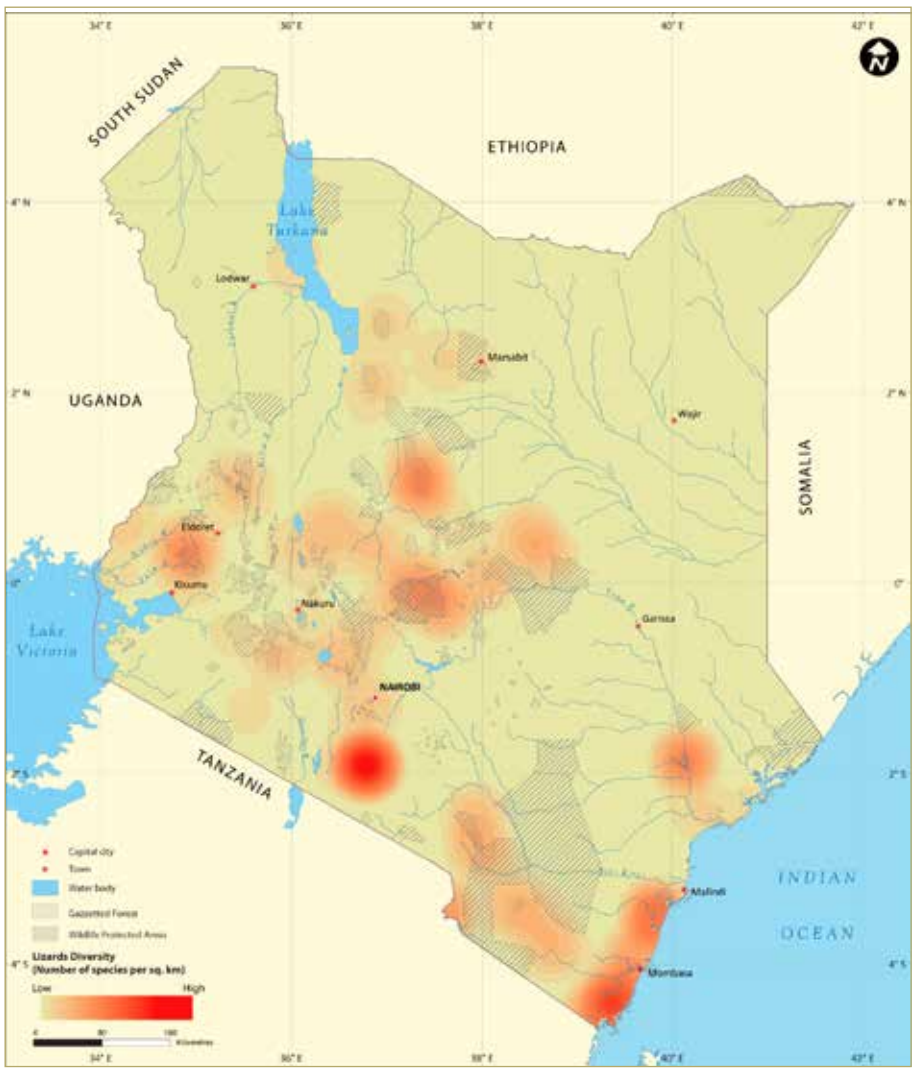


FIGURE 3.20: Species richness of lizards in relation to protected areas.
Source : NMK

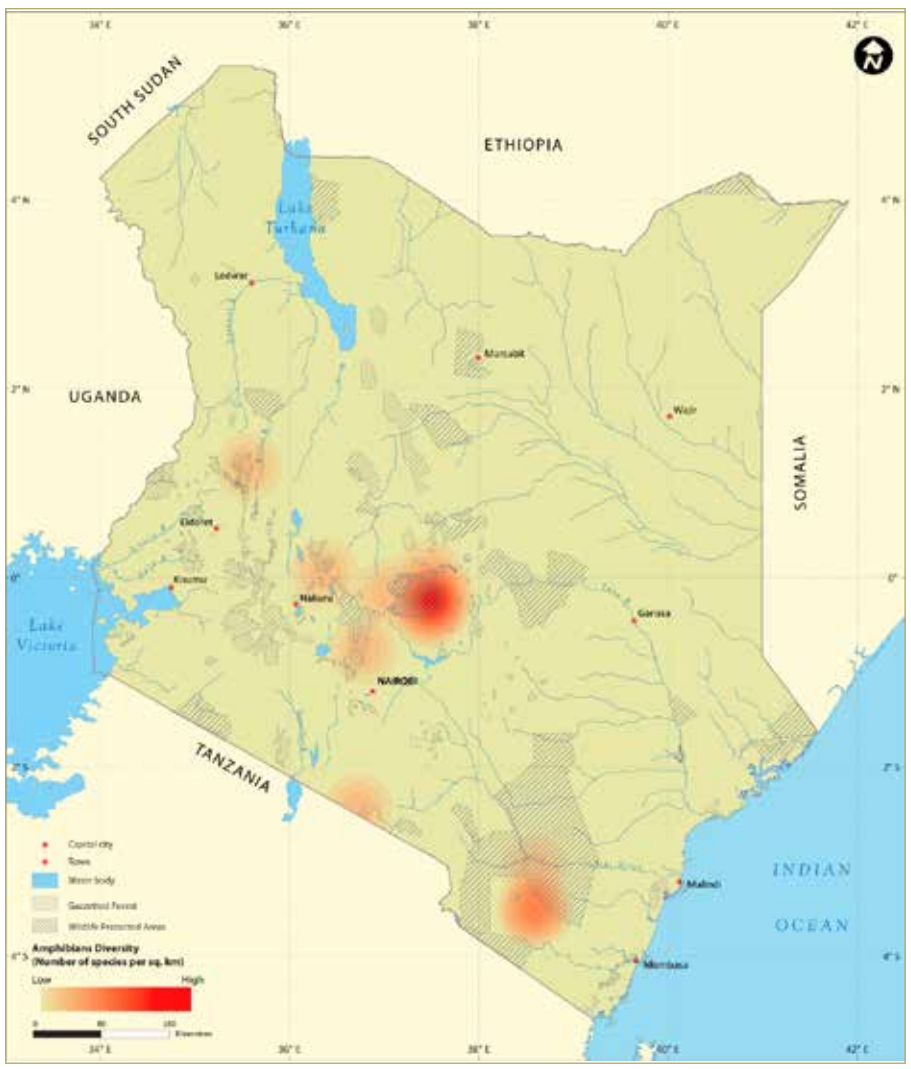


FIGURE 3.21: Species richness of amphibians in relation to protected areas.
Source: NMK

FISH

To date 206 species of fish have been catalogued from Kenyan fresh waters, and a further 18 have been introduced. The distribution of fish in Kenya's drainage systems is determined by the size of the aquatic basin, diversity of aquatic habitats, ability of fish to disperse, temperature, food availability, depth and water movement. Swamps and river habitats are also crucial dryland biodiversity conservation centres. Kenya is known for its high endemism of freshwater fishes, totalling 36 in all.

PLATE 3.28: *Oreochromis niloticus baringoensis (Baringo Tilapia).*
© Dorothy Nyingi/NMK

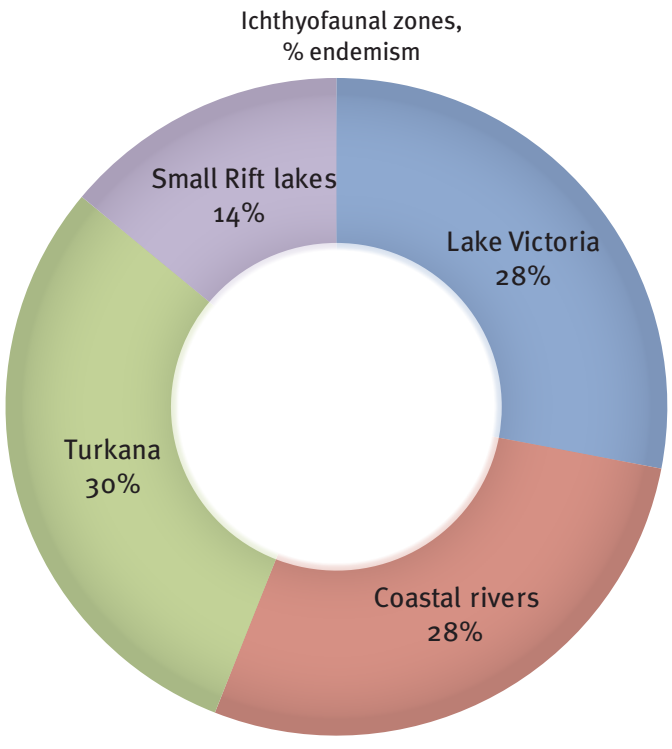


FIGURE 3.22: The percentage of endemism levels across drainage zones.
Source: NMK

PLATE 3.29: *Synodontis manni (Catfish). Photo Credit; Dorothy Nyingi/NMK*

PLATE 3.30: *Rastineobola argentea (Cyprinid). Photo Credit; Dorothy Nyingi/NMK*

PLATE 3.31: *Oreochromis variabilis (Tilapia). Photo Credit; Dorothy Nyingi/NMK*

BOX 3.9: THE VALUE OF FISH

Fish play a fundamental role in the productivity and ecology of freshwater and marine ecosystems. They make up a large portion of the herbivore and carnivore sections of the foodweb, supported by primary producers: plants. Fish have been a mainstay of many traditional fishing communities along the coast and around Kenya's major lakes and rivers. In recent decades commercial fisheries and fish farms have supplied both the domestic and export markets. The fish industry produces some 150 000 metric tonnes annually and accounts for 5 per cent of Kenya's GDP. Fish-oil is increasingly marketed as a heath supplement because of its high Omega-3 content. Economically important freshwater fish include tilapia, nile perch and catfish. Economically important marine species include demersals, pelagic bony fish, sharks and rays.

ENDANGERED AND THREATENED SPECIES

The number of endangered and threatened species of vertebrates has been growing steadily with expanding human activity in the last few decades. Currently some 97 species are classified as critically endangered, endangered or vulnerable, as shown in the table below.

TABLE 3.6: **SUMMARY OF THREATENED SPECIES OF VERTEBRATES, PER TAXA**

Order	Critically Endangered	Endangered	Vulnerable	Total
Mammals	4	11	18	33
Birds	4	12	14	30
Reptiles	2	4	2	8
Fish	7	4	15	26
Total	**17**	**31**	**49**	**97**

Source:: NMK

Vertebrate Conservation Status and Threats

Similar to plants, a large proportion of Kenya's vertebrate species and many of the richest hotspots lie outside protected areas (Fig 3.23). The conservation coverage is relatively good for large mammals but poor for small mammals, birds, reptiles and amphibians. Habitat loss and exploitation are the most imminent threats. In the case of aquatic species, amphibians and fish are threatened by fertilizers, insecticides, chemicals and sedimentation. Birds face a significant threat from herbicides and pesticides in farming and ranching areas. Climate change is likely to pose a growing threat in the coming decades

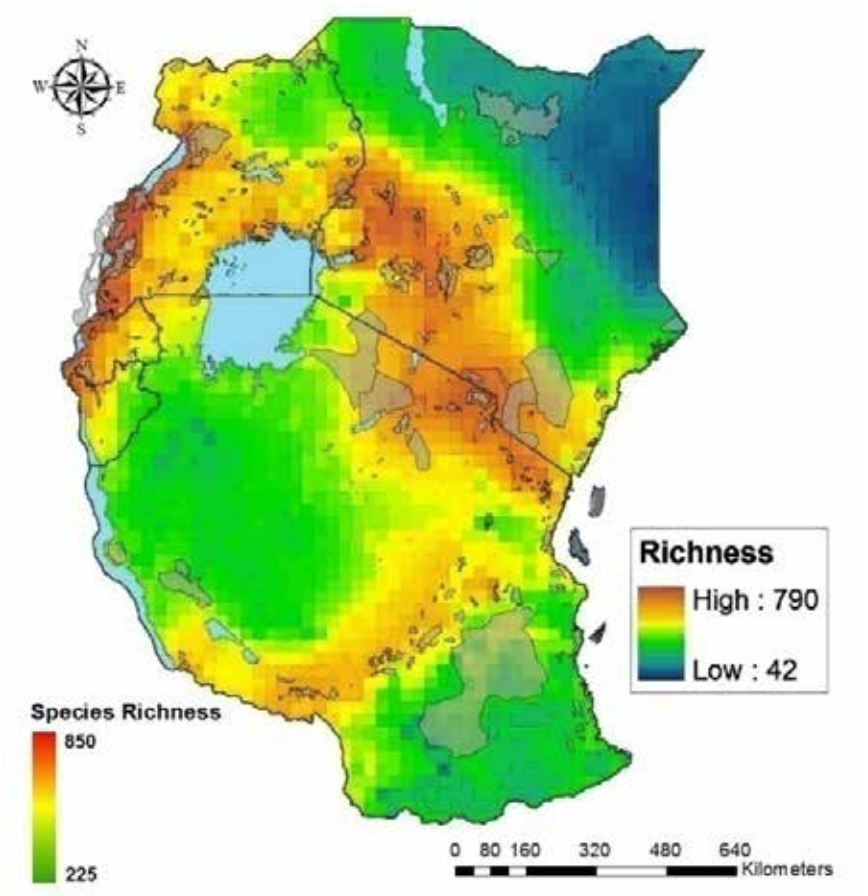


FIGURE 3.23: Refined species-richness map of all vertebrates in relation to protected areas.
Source: : Walter Jetz.

TABLE 3.7: **SUMMARY OF MAIN THREATS TO VERTEBRATES, PER TAXA.**

Taxon	Habitat	Over-exploitation	Invasive species	Pollutants	Climate change
Large mammals	High	Intermediate	Low	Low	High
Small mammals	High	Intermediate	Low	Low	High
Birds	High	High	Low	High	High
Reptiles	Intermediate	Intermediate	Low	Low	Low
Amphibians	High	Intermediate	Intermediate	High	High
Fish	High	High	Intermediate	High	High

Low Intermediate High

INVERTEBRATES

Diversity

Kenya has over 25 000 invertebrates, many of them yet to be described.

Insects are the most diverse group of animals. Some of the major species listed for Kenya include 9 000 beetles, 900 butterflies, 500 bees, 650 ants, 60 thrips but many of these groups have yet to be recorded or described. Insects include flies, wasps, bees, beetles, bugs, mantids, crickets, grasshoppers, ants, termites, lice, fleas, moths and butterflies. They are ecologically significant in every ecosystem and region, and perform important economic and social roles in all human societies. Insects are especially important in the pollination of both wild and cultivated plants ranging from coconuts, mangoes and pawpaws to oil palm. Insects are used as food by indigenous people and have played an important role in the history of human nutrition. Some insects are crops pests and vectors of diseases, while others play a key role in the biological control of pests.

Some 900 species of bees are estimated in Kenya. Most species are poorly understood by farmers with the exception of the honey-bee *Apis mellifera*. Bees pollinate over three-quarters of flowering plants worldwide. They are found in all warm terrestrial areas. The richest bee habitats in Kenya include Kakamega Forest where over 240 bees have been documented, and the coastal forest and savannah ecosystems. Over 90 species of bees have been documented in Nairobi City Park.

TABLE 3.8: **SUMMARY OF INVERTEBRATES IN KENYA**

Invertebrate Animals	Number of Species Present in Kenya
Dragonflies	194
Bees	800
Butterflies	900
Molluscs	297
Crustaceans	343
Corals	183
Total Invertebrates	**2 717**

Source: NMK.

PLATE 3.32: *Coriandrum sativum (*Stingless bee coriander). *© Dino Martins*

PLATE 3.33: *Megachilid Crotolaria (*mason/leaf cutter bee). *© Dino Martins*

PLATE 3.34: Changamwe ceacilian *(Boulengerula changamwensis) ©Dino* **Martins**

PLATE 3.35: *Belenois. ©Dino Martins*

PLATE 3.36: *Amegilla drepanolobium. © Dino Martins*

Over 900 butterfly species are found across Kenya, including 487 in Kakamega Forest alone. The species represents five Kenyan butterfly families namely: Papilionidae, Pieridae, Lycaenidae, Nymphalidae and Hesperiidae. Kenya has many of Africa's most beautiful butterflies, which has spawned butterfly farming and ecotourism. The presence and abundance of butterflies and moths are good indicators of ecological health.

Dragonflies

With a total of 170 dragonfly species, Kenya is home to about a quarter of Africa's total. The majority of species are widespread but the highest diversity is found in western Kenya (Figure 3.24) where the Kakamega Forest retains many of the equatorial forest species.

Marine invertebrates

Marine invertebrates cover many phyla ranging from microscopic bacteria and zooplankton to giant molluscs. The more conspicuous and ecologically important phyla include plankton, corals, flatworms, bristle worms, anemones, jellyfish, insects, echinoderms, crustaceans and molluscs.

Some 343 species of crustaceans have been recorded in Kenya, including crabs, prawns and lobsters.

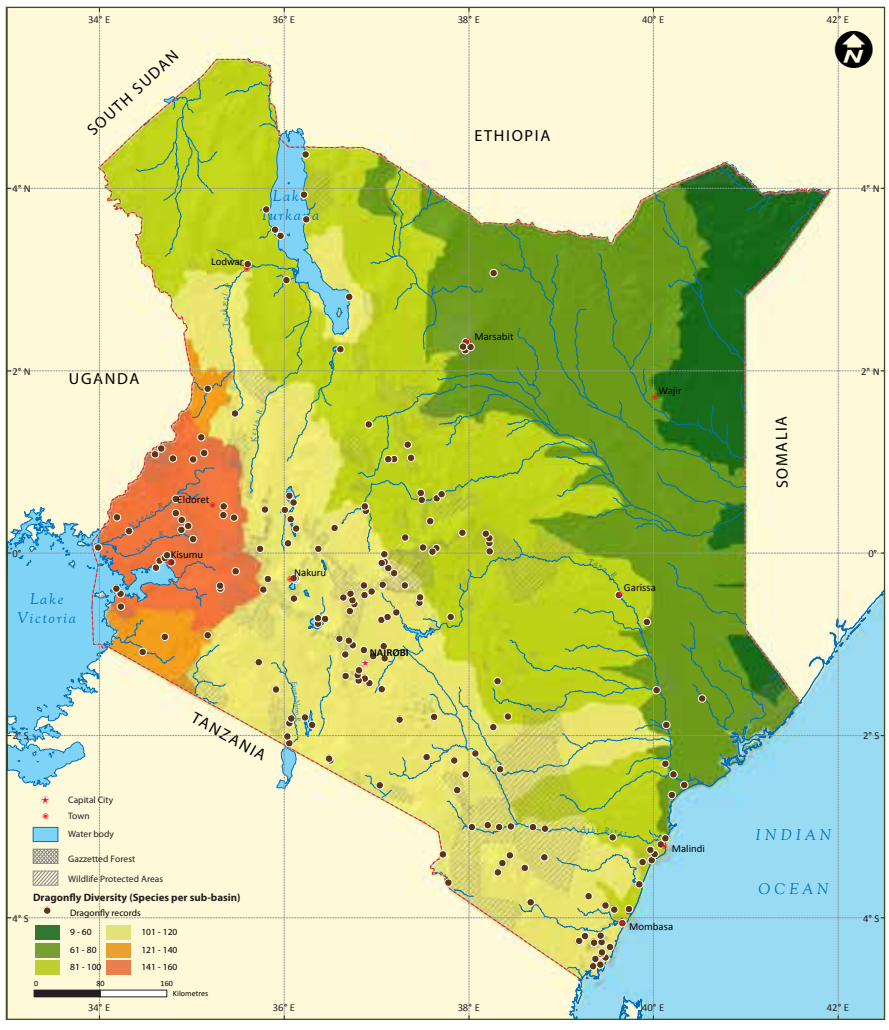


FIGURE 3.24: Dragonfly distribution in Kenya
The point locality of records of dragonflies in Kenya showing species-richness declining from highland and moister areas to lowland and drier areas. *Source: Dr. Viola Clausnitzer.*

Crabs play many important roles including being a source of food for many marine animals and humans, nutrient recycling, turning over soils and playing a keystone role in foodwebs. The Coconut Crab (*Birgus latro*) is one of the largest terrestrial crabs and in Kenya is only found at Kisite-Mpunguti Marine Park. Crabs of the coral reefs, seagrass beds, rocky shores and sandy beaches account for 19 species. Over 36 species are found in the mangrove forests.

PLATE 3.37: *Ozius guttatus* (Mangrove crab).and *Penaeus monodon* (Giant tiger prawn). *Source: NMK*

Important prawn species harvested as food for local and export markets include five penaeid species commonly caught within the shallow continental shelf off Malindi and Ungwana Bay by commercial prawn trawlers, and in estuaries and deltas by artisanal fishermen. Caridean shrimps are caught alongside the penaeid prawns by trawlers in shallow areas. Prawn juveniles utilized estuaries and deltas colonized by mangroves.

Spiny lobsters (palinurid species) are an important source of food and include five common species. Deep-sea lobsters are caught by commercial vessels off Malindi, and several edible slipper or shovel-nose lobsters are caught in Kenyan waters, including Mombasa and Gazi-Bay.

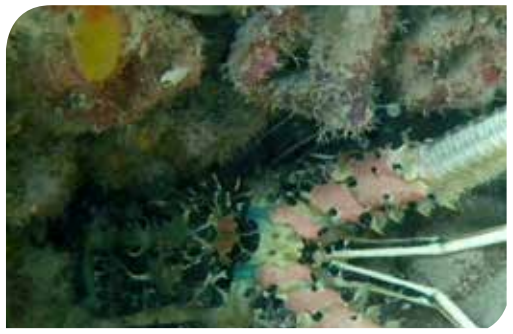


PLATE 3.38: Cooked mud crab (*Scylla serrata*) and flathead locust lobster (*Thenus orientalis*) © *Kochey* **.** Painted *Panulirius* versicolor. © *Midori*

A total of 297 species of molluscs have been recorded in Kenya. Molluscs play a major role in marine foodwebs and in regulating ecosystem functions, including nutrient recycling and predation. Molluscs, especially squids are an important source of food for fish and humans. Over 45 species of shells are traded as curios, including the giant clam Tridacna maxima and Tridacna squamosal. Dangerous molluscs, causing harm to humans, include species of cone shells such as Conus geographus and Conus textile. Nudibranch molluscs are amongst the most dazzling animals of the coral reefs—a great attraction to beach holiday-makers.

PLATE 3.39: *Tridacna maxima (giant clams)* . © *Midori*

The reef-forming corals create a barrier buffering the ocean from the tidal flats and beaches along most of Kenya's coastline. The collecting and recording of corals falls far short of the 183 species likely to be in Kenya. Coral reefs and corals are important in ecosystem functioning, including nutrient recycling, and as the substrate on which other reef-dwelling animals and plants build up one of the most diverse and complex ecosystems on Earth. They also support other critical habitats such as seagrasses and mangroves. Coral reefs provide an estimated US$ 30 000 million worth of goods and services each year to world economies, including, tourism, fisheries and coastal protection.

PLATE 3.40: Coral Diversity, Marine park, Kenya. © *Midor*

PLATE 3.41: *Tripneustes gratilla (above)* and Astropyga radiata (below) sea urchins at *Shelly beach lagoon (© Kochey, 2008)*

BELOW-GROUND MICRO-ORGANISMS

Biodiversity conservation has largely focused on above-ground species. Though the soil comprises a large proportion of the world's biodiversity, the below-ground ecosystems that play a central role in nutrient and water capture and recycling—on which plant production depends—have been poorly studied. The rich biota includes microbial fauna made up of fungi, bacteria and protozoans; mesofauna made up of taxa such as nematodes, mites, ants and collembolans; macrofauna made up of taxa such as arthropods and Earthworms; and megafauna made up of vertebrates such as rodents, moles and lagomorphs—rabbits and hares. Only in the past two decades has research focused on the richness and ecosystem services of below-ground biota. A few examples illustrate the diversity and importance of this world beneath our feet.

Bacteria

Bacterial species dominate the soil fauna. Among the most important, economically, are the rhizobial bacteria that form nodules on leguminous plants and convert inert nitrogen gas in the atmosphere into nitrogen-containing organic compounds essential for plant growth.

Yet another important bacterium is *Bacillus thuringiensis*, which produces proteinaceous spores with insecticidal properties, widely used in controlling pests of agricultural crops.

Microscopic fungi

Trichoderma species are a cosmopolitan fungi that decay wood and recycle vegetable matter. They colonize roots and parasitize other fungi. Nine species have been identified in Embu soils and eleven in Taita soils. Studies have barely scratched the surface of soil fungi and their ecological roles.

Fusarium is another large genus of widely distributed soil bacteria associated with plants. Most species are harmless. Some are severe plant pathogens.

Nematodes

Nematodes are long slender worms that are widespread in all environments. They occur as parasites of plants, animals, humans, bacteria, fungi, algae and other nematodes. They are typically grouped into two broad categories: the pathogenic and the beneficial nematode groups.

A total of 27 genera of nematodes have been recorded in the cotton-growing areas of Kenya, spread across five agroecological zones.

Invertebrates and Micro-Organism Conservation Status and Threats

The conservation status of most invertebrates and micro-organisms is poorly known due to the large number of species, and paucity of surveys. Tentative assessments can only be given for the better studied and economically

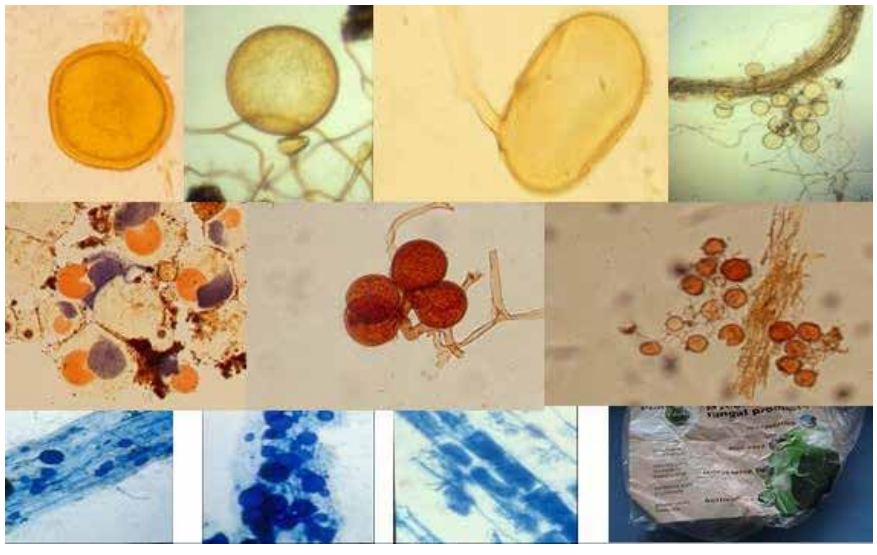


PLATE 3.42: The widespread arbuscular mycorrhizal fungi
The widespread arbuscular mycorrhizal fungi form associations with 80% of all plant species. The microscopic spores in roots are stained blue. *Source: Dr. S. Okoth.*

TABLE 3.9: **SUMMARY OF MAIN THREATS TO VERTEBRATES, PER TAXA**

Taxon	Habitat	Over-exploitation	Invasive species	Pollutants	Climate change
Bees	High	Low	High	High	High
Butterflies	High	Low	Intermediate	High	High
Crustaceans	Intermediate	High	Low	High	Intermediate
Dragonflies	Intermediate	Low	Intermediate	High	Intermediate
Molluscs	Intermediate	High	Low	Intermediate	Low

Low Intermediate High

Source: S.okoth

important taxa such as bees, butterflies, dragon flies, molluscs and crustaceans. Table 3.9 is a first attempt to give a broad assessment of threats to invertebrates by the National Museums of Kenya. No assessment can yet be made for micro-organisms given their cryptic nature and parity of surveys. As with plants and vertebrates, habitat destruction and conversion are the biggest threats. Overharvesting threatens important food species such as molluscs and crustaceans. Pollution is a serious threat to many pollinators, including bees and butterflies, and to aquatic taxa such as dragonflies and crustaceans. Climate change is a moderate but growing threat to a wide range of species.

Conclusion

The number of species recorded in Kenya currently includes 7 004 plants and 5 245 animals, based on a compilation for this Atlas by the NMK. The figure reflects the dEarth of biodiversity surveys undertaken for many taxa and regions. Among the plants, fungi, algae, lichens and bryophytes have been inadequately studied, which calls for detailed research. Among the animals, invertebrates, including insects, crustaceans, molluscs, annelids, round worms, flatworms and micro-fauna have yet to be the subject of systematic biodiversity surveys. In terms of locations, the plants and animals of the arid and semi-arid north and eastern regions of Kenya—as well as the micro-organisms and phyto- and zooplankton of the near and offshore marine zone—call for further survey and taxonomic work.

New species are being recorded, even among well studied taxa such as birds, mammals, reptiles and fish. The current total number of species described worldwide stands at around 1.8 million (Encyclopedia of life). Some with the actual total number estimated to lie between 5 and 7 million, there is far to go in completing an all-species inventory. Kenya faces a large challenge in documenting and classifying its rich biodiversity. Many species will be lost before they are described unless greater investments in biological surveys are made by the NMK, relevant government agencies, universities and conservation organizations—and unless greater strides are made to conserve biodiversity.

The following chapter takes stock of threats to biodiversity, the status of ecosystems and natural resources, and the current conservation responses to slowing and reversing biodiversity loss.

CHAPTER

04

Status Threats and RESPONSES

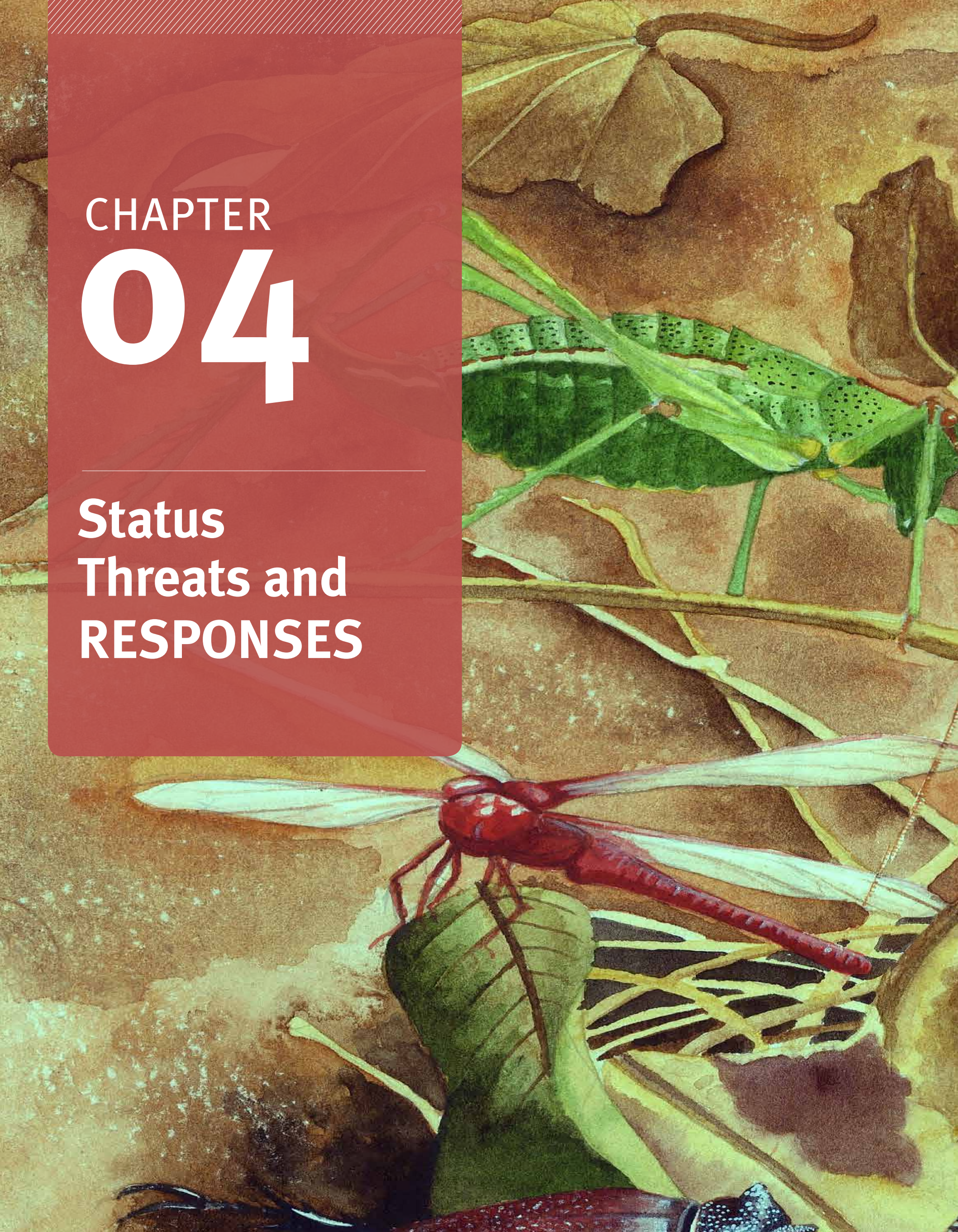


PLATE4.1: Variety of Insects in Kenya. © Theo
Source: Dr. D. Western/ACC

Global Threats to Biodiversity

Globally, ecosystems and biodiversity are in decline. The Millennium Ecosystem Assessment (Millenium Ecosystem Assessment, 2005) concluded that forests were fragmenting and degrading fast on all continents and coral reefs are the ecosystems deteriorating most rapidly. Overall, global biodiversity has dropped more than a quarter in the last 35 years, according to the World Wildlife Fund(WWF, 2006).

The Living Planet Index (LPI), (Living Planet Index, 2006) shows a declining population trend in nearly 4 000 documented populations of wildlife between 1970 and 2005. Species in the tropics and fresh waters, and amphibians as a whole, are most at risk. In addition, one quarter of plant species are estimated to be threatened with extinction. Recent figures point to a sharp increase in extinction risks for mammals, birds and amphibian species used for food and medicine, as well as birds traded internationally (Butchart *et al.*, 2010).

The findings of the RIO+20 report(UNCSD, 2012)and the third Global Biodiversity Outlook (GBO3) concluded that the benchmarks for biodiversity conservation set in 2002 have not been met by 2010. Following that observation, the Convention on Biological Diversity (CBD) focused on five major causal factors behind biodiversity loss.

Despite its globally important ecosystems, endemic, rare and unique species, Kenya has performed no better than the rest of the world in fulfilling its conservation obligations. Global threats to biodiversity are mirrored on national and local scales across Kenya. One way to visualize and prioritize these threats is to use a DPSIR approach. This method identifies the main drivers [D] of change, the pressures [P] they create, current status [S], impacts [I] on ecosystems and species, and the responses [R] to these through the conservation measures in place.

We use the DPSIR approach in this chapter to identify the major drivers and pressures on Kenya's biomes, ecosystems, species and natural resources; the main trends and impacts; and the formal and informal measures in place to contain and reverse losses. A national stocktaking of Kenya's biodiversity and natural capital is a task for many years and continual re-evaluation. Several government and public agencies are appraising the scale and scope of the threats, the status of biodiversity and the conservation measures called for (NBSAP, 2000).

This chapter can do no more than give a sketch of the threats to biodiversity and natural capital, and the responses to those threats, by distilling the findings of the previous two chapters and examples of conservation efforts around Kenya. The chapter concludes by touching on the main gaps and the need for a more comprehensive approach to valuing ecosystem services in moving towards a national conservation framework for sustainable

BOX 4.1: THE MAIN CAUSES OF BIODIVERITY LOSS (CBD 2010)

- Habitat change through conversion to cropland, urban areas and other human-dominated landscapes.
- Overexploitation or unsustainable harvesting of economically valuable species.
- Pollution of the water, land and air.
- Alien invasive species, including pests and disease pathogens.
- Environmental change: for example shifts in climate and increasing intensity of human ecological footprints.

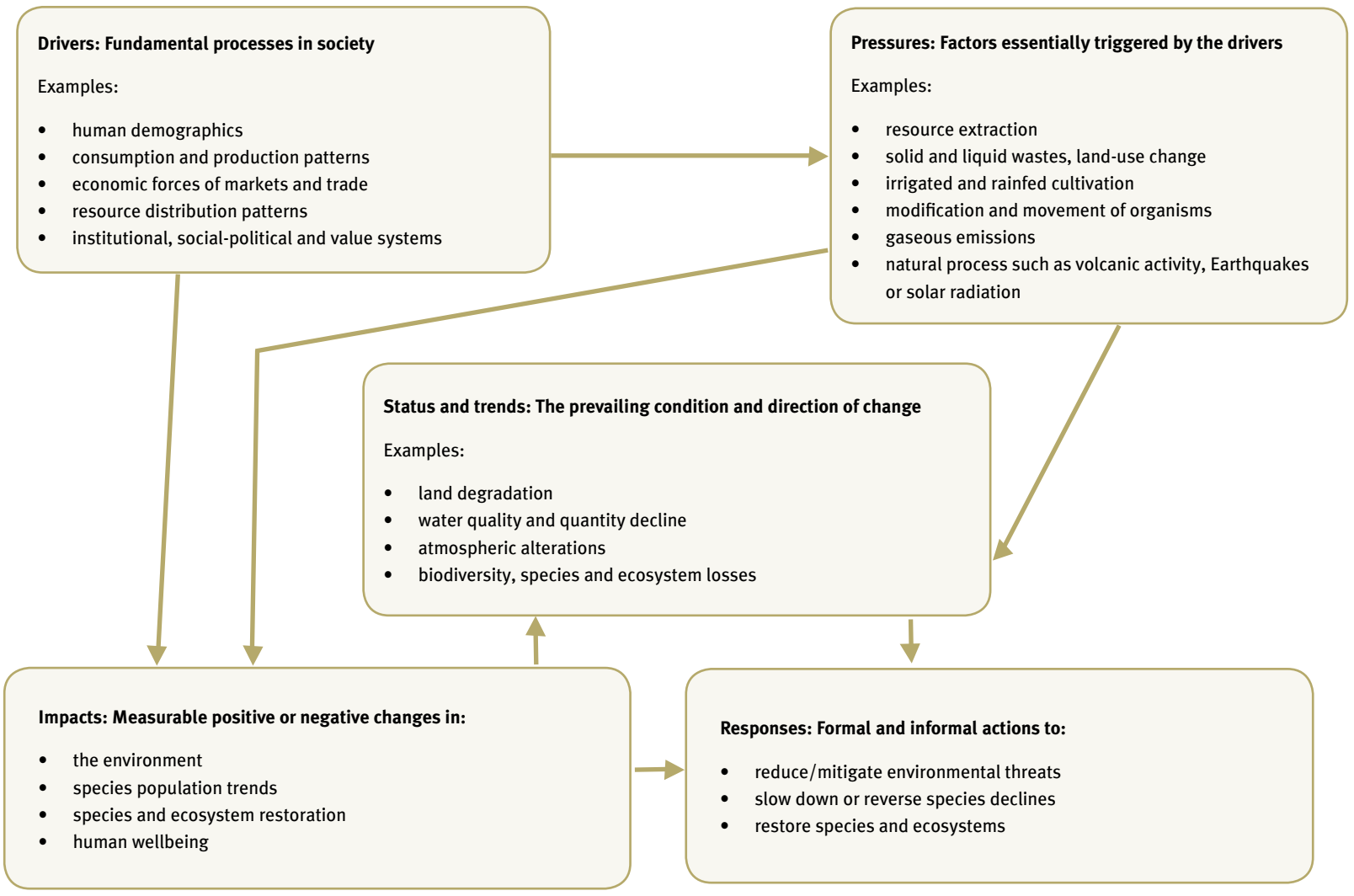


FIGURE 4.1: The DPSIR framework approach helps visualise and prioritise threats to biodiversity. *Source: Adapted from the 4th Global Environment Outlook (GEO4)*

development.

Rapid human population growth

Kenya's population grew from about eight million people in 1960 to 10.9 million in 1969, 15.3 million 1979, 21.4 million in 1989, 28.7 million in 1999 and 38.6 million in 2009. The population now stands at 40 million, a fourfold increase from 50 years ago, with growth continuing at 2.9 per cent per year. Present projections put the population at 51 million by 2025 and 96.9 million by 2050 (UNDP, 2014).

Poverty

Kenya's population growth is compounded by poverty and inequality in access to and consumption of resources. With 46 per cent of its people below the official poverty line, according to the Kenya Integrated Household Budget Survey (Kenya National Bureau of Statistics, 2005–2006), nearly half of Kenya's population is too poor to meet its daily nutritional needs (Figure 4.2). Most of the poor live in rural areas and depend on small farms and pastoralism. Population pressures and poverty combine to put large unsustainable demands on natural resources and the environment. More than half of urban dwellers are also poor, living in informal settlements that lack basic services and heavily pollute rivers and aquatic habitats. The population growth rate and income gap jointly erode gains in education, health, food security and employment. A clean and healthy environment, guaranteed by the constitution as the right of every citizen, is hard for the poor to achieve when needs

PLATE 4.2: Kenya's growing population
A population projected to reach 97 million by 2050 coupled with urban crowding will place heavy pressure on Kenya's natural resources and biodiversity. © *Carlos Fernandez/flickr.*

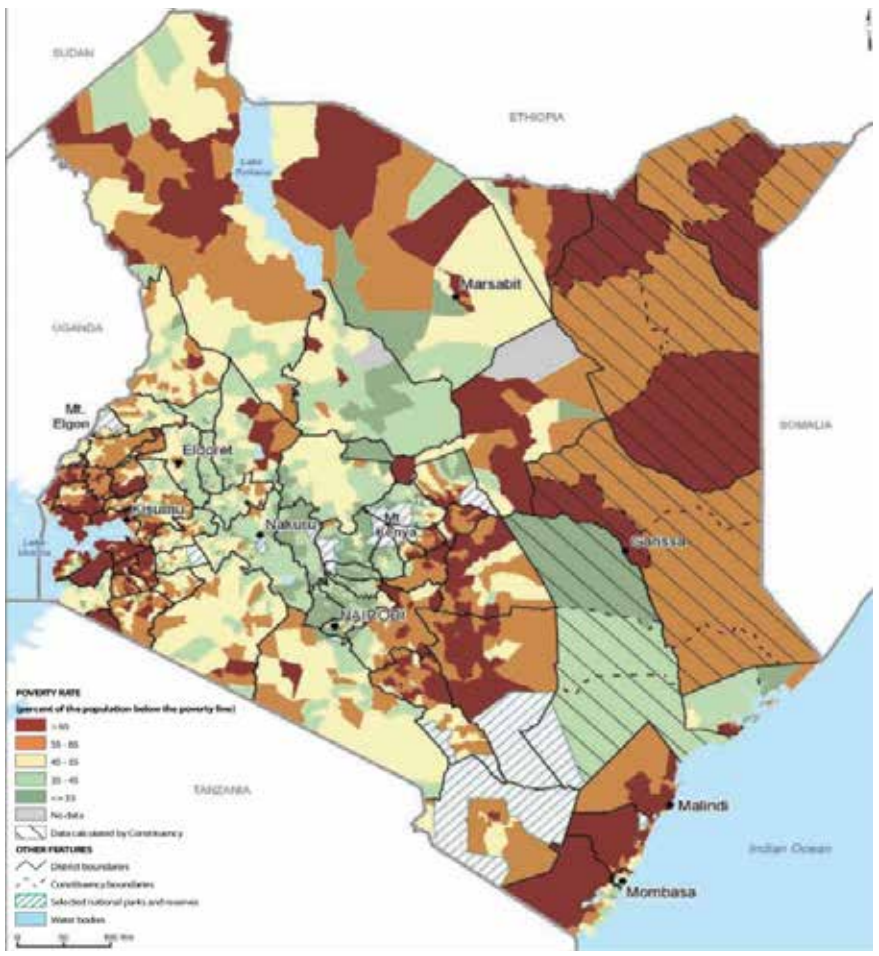


FIGURE 4.2: Spatial distribution of poverty in Kenya
Spatial distribution of poverty rates varies across Kenya with high rates of poverty in the arid and semi-arid lands. (Source: WRI et al. 2007).
Kenya's capital city Nairobi has large densely packed slums. Almost half of Nairobi's population lives in some 100 slums and squatter settlements**.** © *United Nation Human Settlement Program (2008).*

are so pressing and tenure rights and the institutions for sustainable management of natural resources so weak.

Expansion of agriculture and settlement

Crop production and pastoralism remain the main sources of livelihood for the majority of Kenyans. Most of the growth in agricultural production and trade between the 1960s and 1970s stemmed from expansion into marginal lands and from better market access of smallholders, rather than intensification. Irrigation is expanding in the drylands, and water conservation and management are inadequate. Inappropriate crops need large-scale land conversion to make up for low yields. The spread of farming follows the expansion of human settlement driven by population growth in the rural areas.

The upshot of population growth and agricultural spread has seen a steady decline in Kenya's per-capita land base. Population density in high-potential areas is six times the country's average (Figure 4.4). The average landholding of an agricultural household is less than one-fifth of a hectare. The dwindling size of landholdings and growing pressure on the land has led to higher

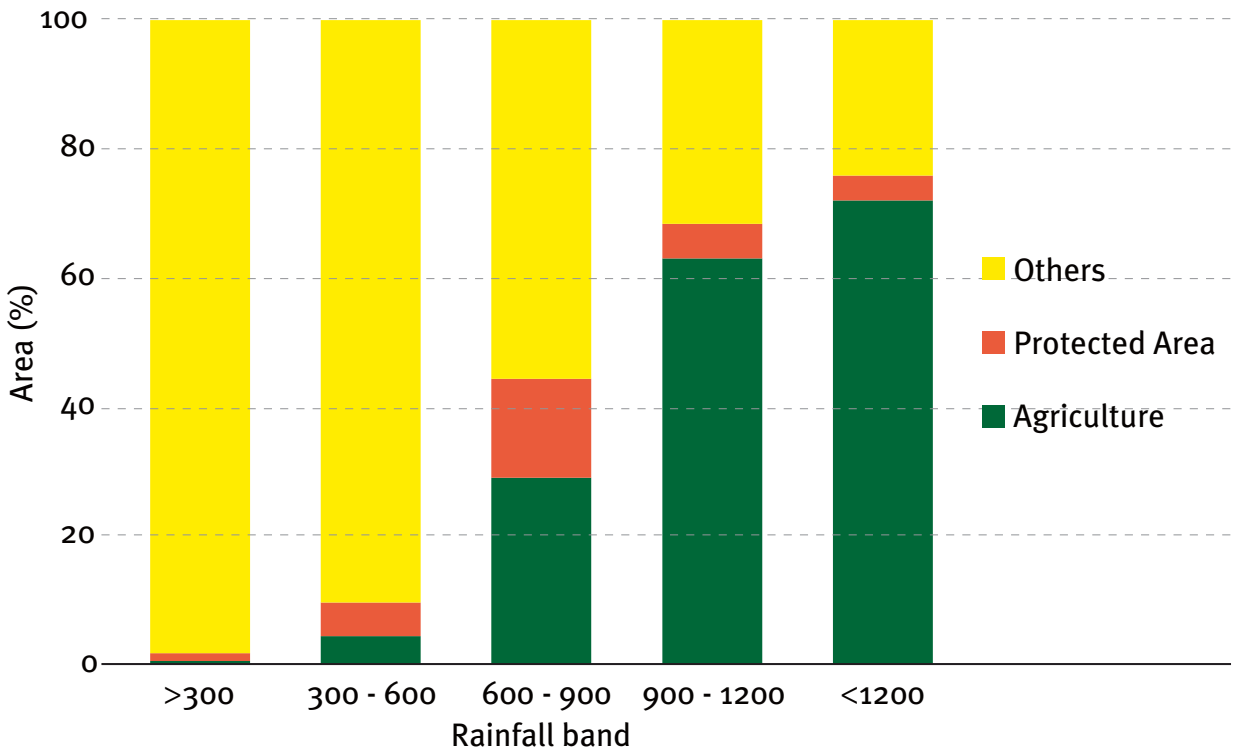
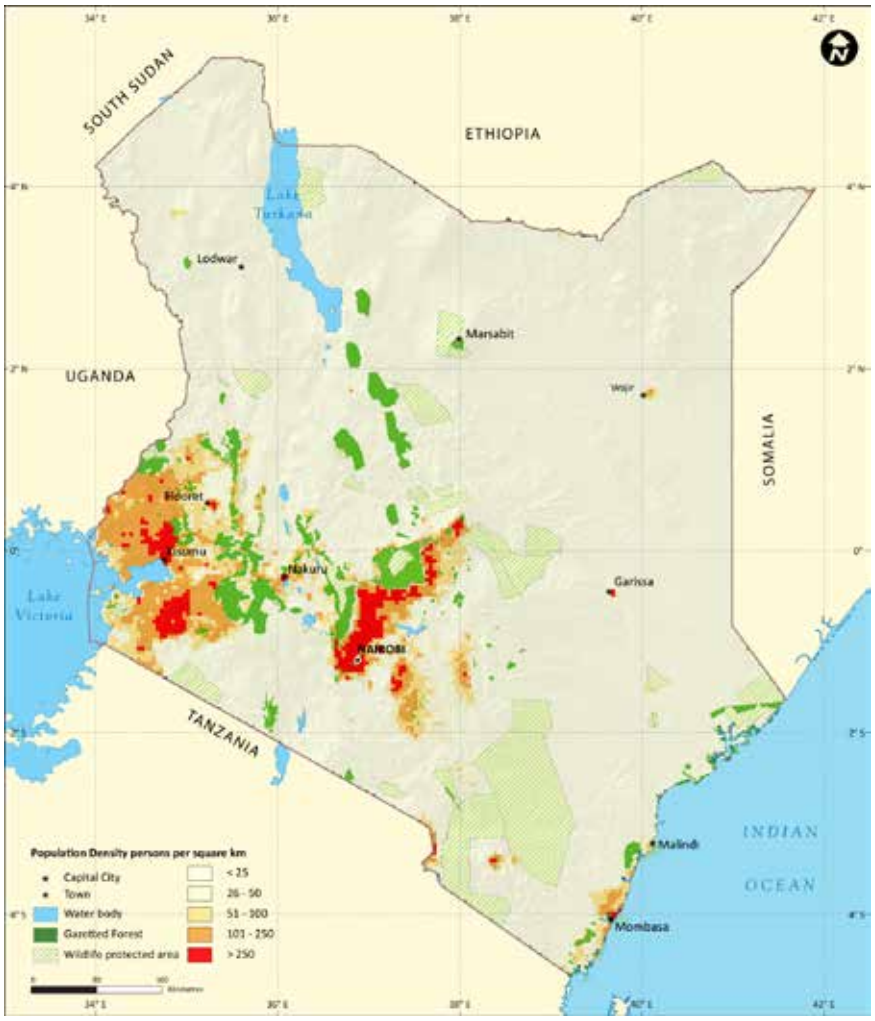
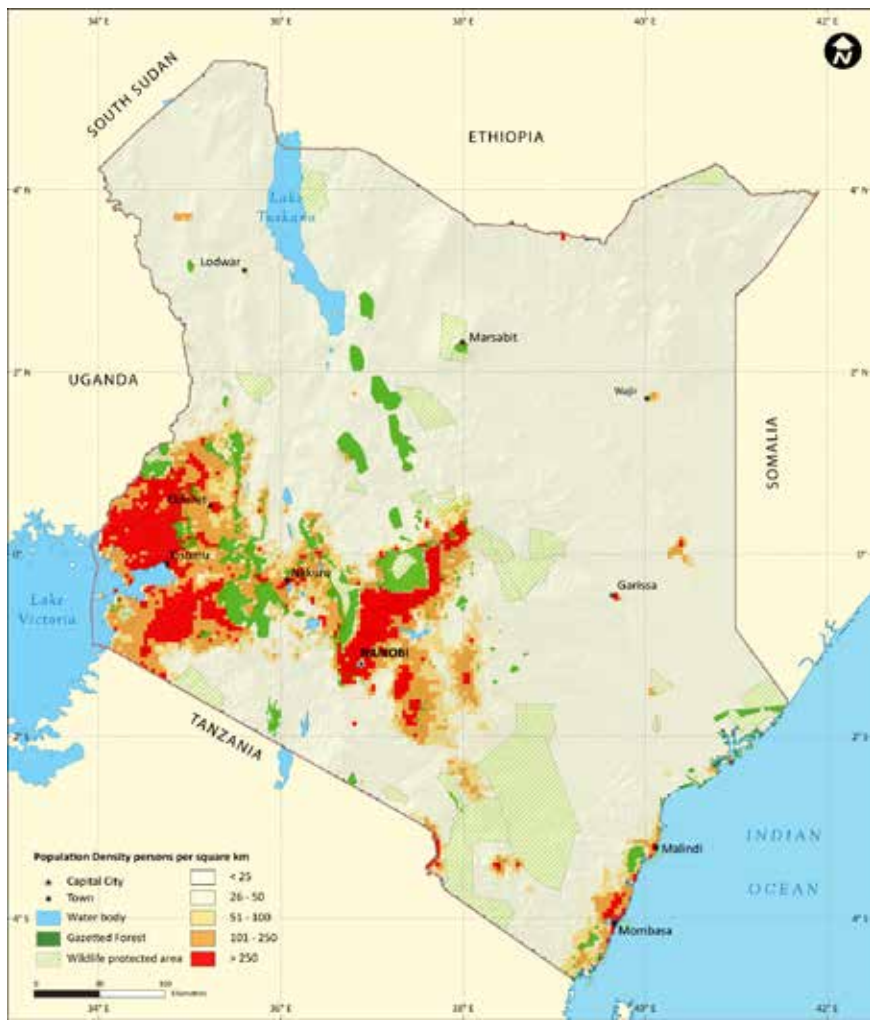


FIGURE 4.3: How rainfall effects land use patterns in Kenya
Distribution of agriculture, protected areas, grazing areas and urban areas (indicated as 'Others'), based on rainfall bands. Most of the protected areas are located in arid and semi-arid lands. Vast areas have been converted into agricultural areas in high rainfall areas. There is still potential for wildlife and livestock in the arid and semi-arid lands(less than 600mm of rainfall). *Source: ILRI*

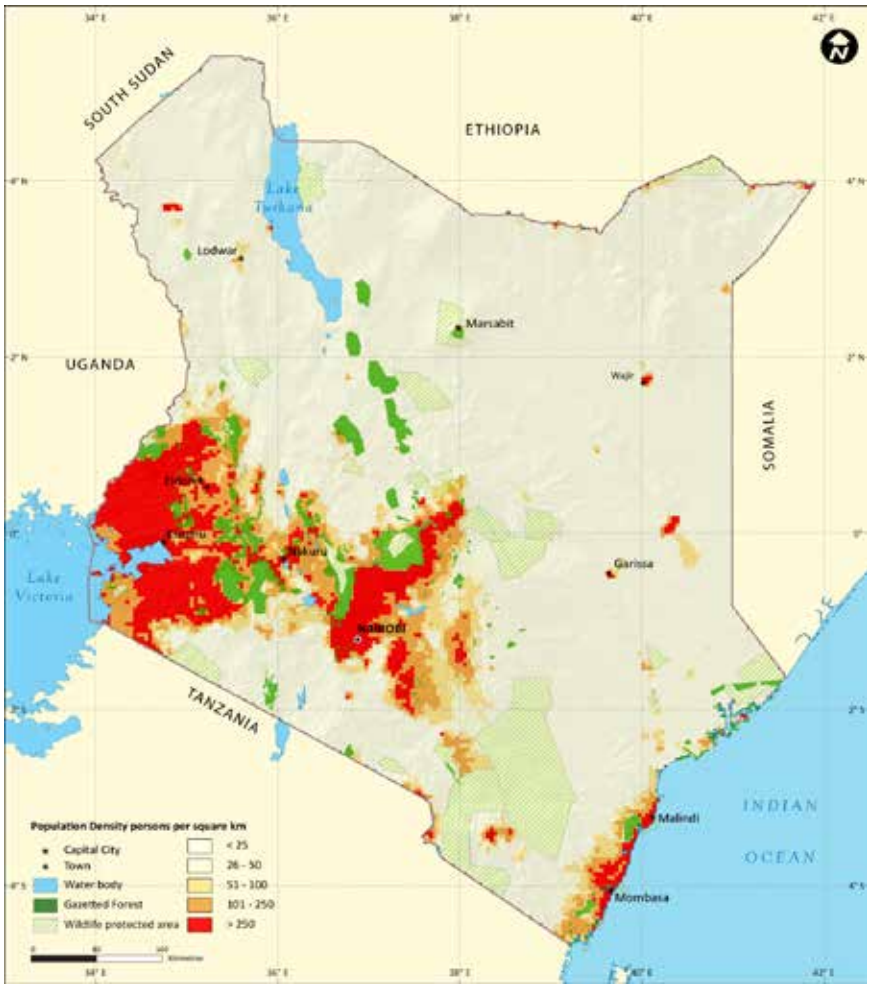
PLATE 4.3: Land-use in high rainfall areas vis land use in low rainfall areas
Areas of low rainfall are mainly used by pastoralists to graze but are important areas for wildlife and account for most of Kenya's protected areas. High rainfall areas are dominated by agriculture, urban settlement and industry. *© ILRI (R) and WRI (L).*



Population density in 1970



Population density in 1990



Population density in 2010

FIGURE. 4.4: Population density
The population density in high-potential areas of Kenya has steadily grown over the past six decades. Growth is highest in areas with good sources of water, fertile soils and moderate climate.
Source: KNBS,2011.

FIGURE 4.5: Large-and small scale farms stretch up to the edge of Kakamega Forest, the only tropical rain forest in Kenya of the Guineo-congolian type. © *Google Earth*

wind- and water erosion rates and declining soil fertility over much of Kenya, not to mention illegal forest settlement.

RESOURCE OVER-EXPLOITATION

Production patterns

Kenya has a narrow economic base. Until 1980, the economy grew largely due to agricultural expansion, boosted by booming world prices for coffee and tea exports. Following years of economic downturn, the service sector, including banking, finance, tourism, transport and Information and Communications Technology (ICT), has expanded steadily over the last 10 years. Despite the upturn, the economy has yet to see a strong growth in industry and manufacturing, which currently accounts for 11 per cent of GDP. Agricultural output is still the mainstay of the economy and population growth and poverty are still putting heavy pressure on land and natural resources. Overuse and degradation is particularly widespread across the marginal arable and pastoral areas. Weak tenure and poor access to credit makes it hard for the poor to invest in the conservation and improvement of farms, herds, land and natural resources.

Consumption patterns

The emergence of the globally competitive Kenya projected by Vision 2030 depends on stabilizing population growth, the emergence of a prosperous society and a transition to an economy based on renewable energy and the sustainable use of its natural capital. Changing lifestyle patterns based on a rapid growth in consumerism and weak conservation measures are outstripping the supply of most natural resources and causing extensive environmental degradation. Waste disposal and pollution are growing environmental hazards due to a rapidly expanding material culture, and construction and infrastructure (NBSAP, 2000). The threats will continue to grow as Kenya moves towards middle-income nation status by 2030.

Although most waste generated in Kenya is organic, and therefore biodegradable, significant amounts of municipal and industrial waste create problems for human health, species and ecosystems. Examples include disposable plastics bags and bottles, and water- and air-borne pollutants released from industrial, domestic and agricultural sources. These include exhaust gases, charcoal and fuelwood emissions, heavy metals, toxins, pesticides and fertilizers.

Changing consumption patterns also increase food and water waste (GoK, 2010). Global patterns in annual food waste and losses apply increasingly to Kenya in its transition to a market economy and through rapid urbanization. Waste levels are 40 to 50 per cent for root crops, fruit and vegetables, 30 per cent for cereals and fish, and 20 per cent for oilseeds, meat and dairy products (GoK, 2010) Water consumption is rising rapidly with population and economic growth, and with affluence. As noted in Chapter 2, Kenya is a water-

PLATE 4.4: Nairobi rivers are heavily polluted by refuse, toxic wastes, and plastic bags and bottles
Source: computerwhiz417/flickr

scarce country with a per capita availability of two-thirds the recommended UN threshold of 1 000m³/year, set to fall to 359m³ (nearly one-third) by 2020 based on present projections. The available and usable water will depend on conservation measures to reduce waste and pollution rates. Water, more than any other natural resource, will constrain Kenya's economic growth unless its supply and quality is carefully conserved and managed.

INSTITUTIONAL AND POLICY OBSTACLES

Responsibility for biodiversity is spread across many institutions, ranging from national and county governments to private landowners, local communities and NGOs. Several institutional and policy barriers impede the conservation of biodiversity. Foremost is the lack of a coherent integrated conservation policy that unifies dispersed and often conflicting legislation and policies in different sectors. Examples include the introduction of Nile Perch into L. Victoria for commercial purposes, which jeopardized one of the world's richest centres of fish evolution. Other institutional barriers and impediments include lack of technical expertise, planning and funding. Many of Kenya's wildlife and forest reserves lack the security and management to ensure protection.

Divergent value systems and cultural and religious beliefs also stall biodiversity conservation. Without the means to offset the losses from wildlife, the cost of conservation falls heavily on communities. Communities incur losses to livelihoods and risks to life and property. Local resentment for wildlife thwarts national aspirations and investment in conservation.

Climate change

Large climatic changes have naturally shifted habitats and changed livelihoods in Kenya over the past ten-thousand years. Plants, animals and people have shown considerable adaptability and resilience to these long-term, relatively gradual, changes. The rise in Greenhouse Gases (GHGs) and global warming due to human activity over the last century is, however, changing weather patterns at a quickening pace. The speed of change,

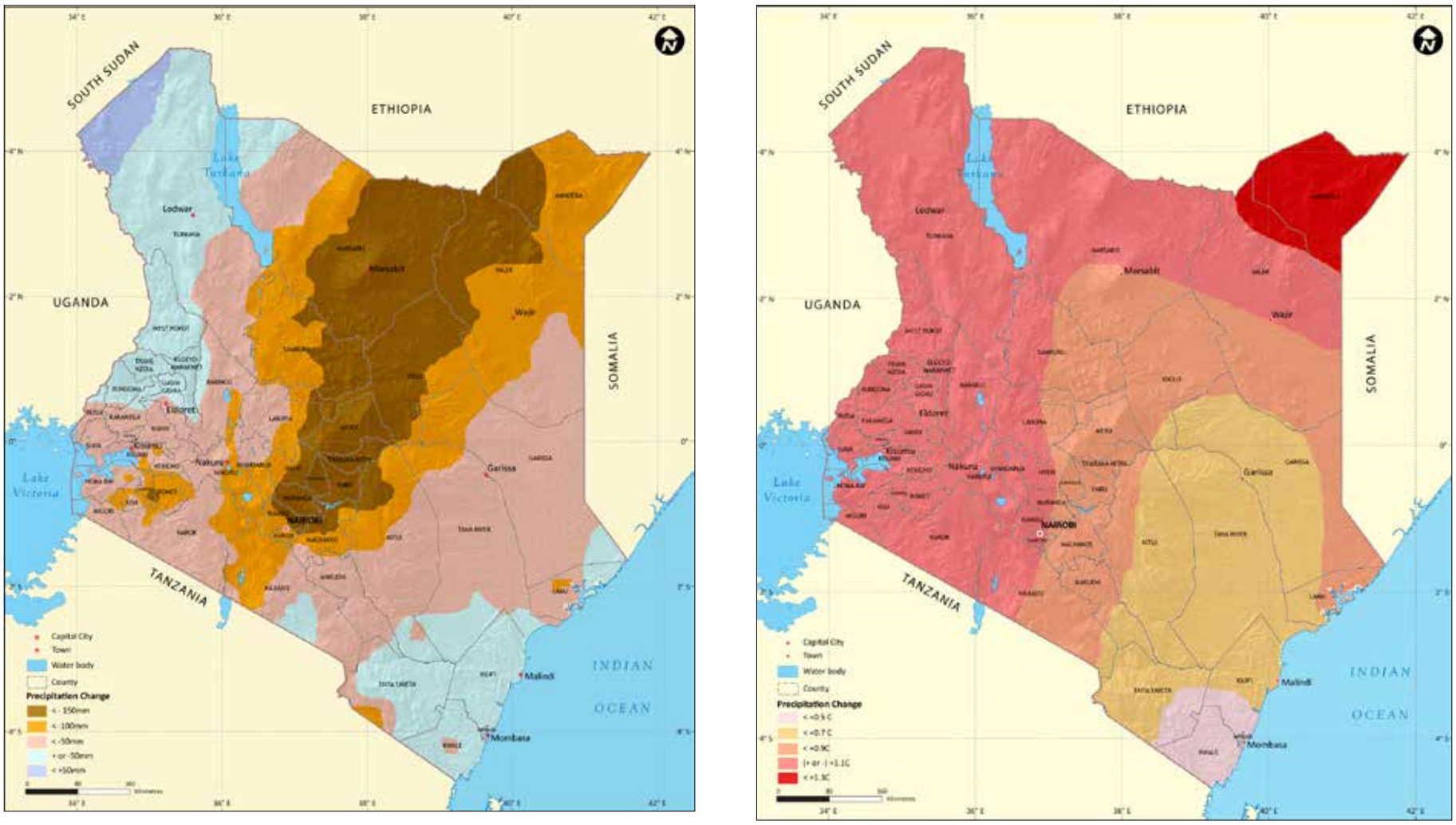
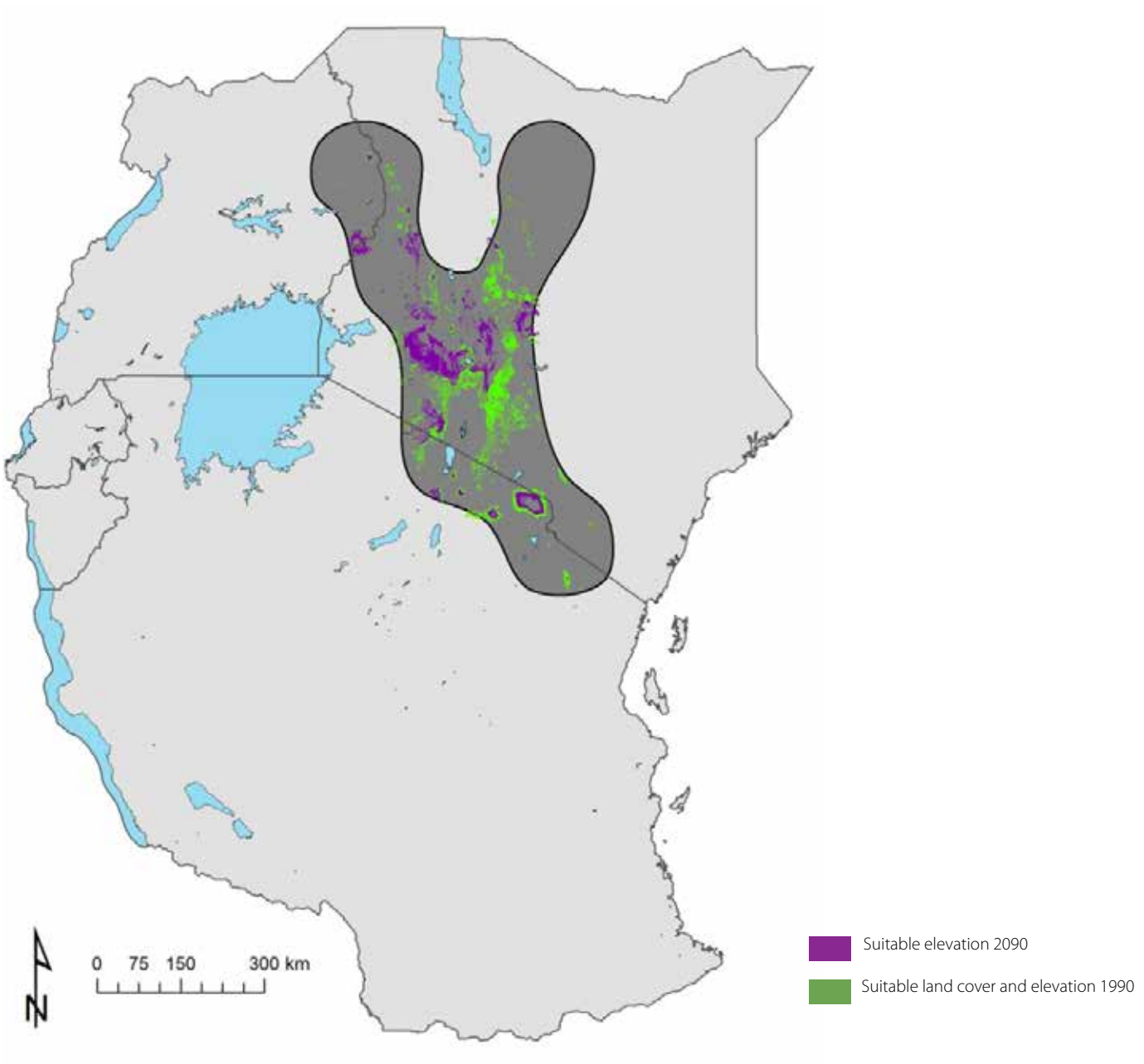


FIGURE 4.6: Projected changes in precipitation (left) and temperatures (right) in Kenya from 1975 to 2025. *Source: FEWSNET (2010)*

Climate change is expected to significantly alter African biodiversity as species struggle to adapt to changing conditions (Lovett et al., 2005). Biome sensitivity assessments in Africa show deciduous and semi-deciduous closed-canopy forests may be very sensitive to small decreases in precipitation during the growing season and that deciduous forests may be more sensitive to reduced precipitation than grasslands or savannahs (Hély et al., 2006). Climate change has also the potential to alter migratory routes (and timings) of species that use both seasonal wetlands (e.g. migratory birds) and track seasonal changes in vegetation (wildebeest, zebra, gazelles and elephants) and breeding (rates, phenology, synchrony and fecundity) and genetic structures in these population (Ogutu et al. 2014). We should also expect increase conflicts between people and large mammals such as elephants, particularly in areas where rainfall will be positive such as in Taita Taveta and Turkana (Funk et al. 2010).

PROJECTED FINE-GRAIN (1KM) RANGE CONTRACTIONS OF MONTANE BIRD SPECIES UNDER CLIMATE CHANGE



Hartlaub's Turaco *(Tauraco hartlaubi)*. is found in East African mountains and forests between 1500m and 3000m. The species belongs to a colorful family with 23 species in all.

FIGURE 4.7 : Susceptibility of montane species to climate change
The susceptibility of montane species to climate change is due to the strong association between temperature and altitude. The range of the Hartlaub's Turaco will contract with climate change from the area shown in green as a suitable habitat today to the area shown in purple by the year 2090. Preliminary projections of the impact of climate change on 102 species of montane bird species in East Africa suggest that 90 per cent of them are likely to lose at least 50 per cent of their present geographic range.
Source: Walter Jetz.

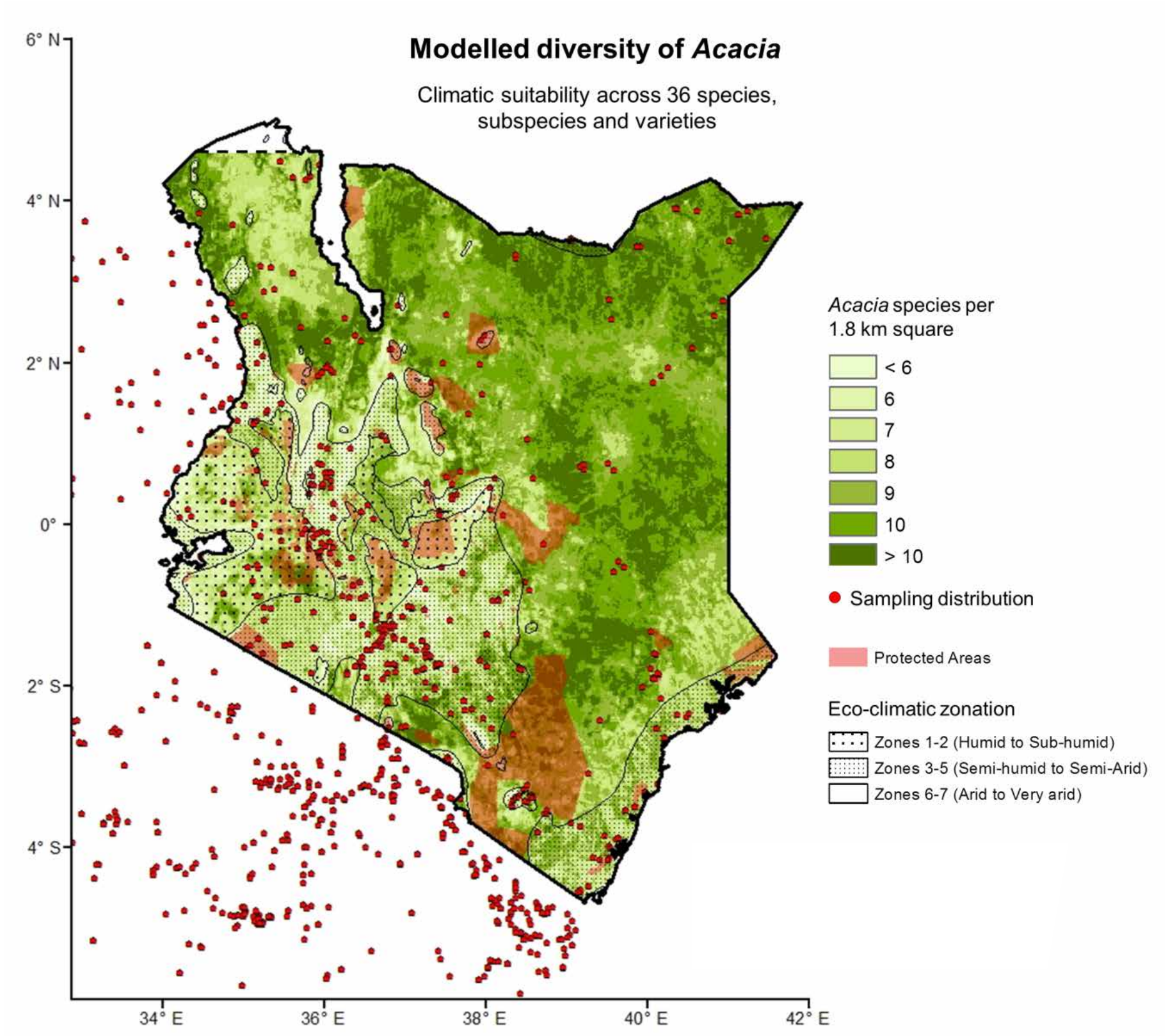


FIGURE 4.8: Modified diversity of Acacia
The 52 Acacia species in Kenya are among its most iconic species. The greatest concentration of Acacias is in northern and eastern Kenya, mainly outside protected areas. *Source: University of York*.

coupled with fragmentation of habitats and subdivision of land, threatens species and livelihoods, especially of the poor and marginalized communities. Projections point to annual temperature rising between 1° and 4 degrees C by the end of the century. Rainfall models show increasing rainfall in some parts of the country and decline in others (Figure 4.6, NEMA 2011; FEWSNET 2010).

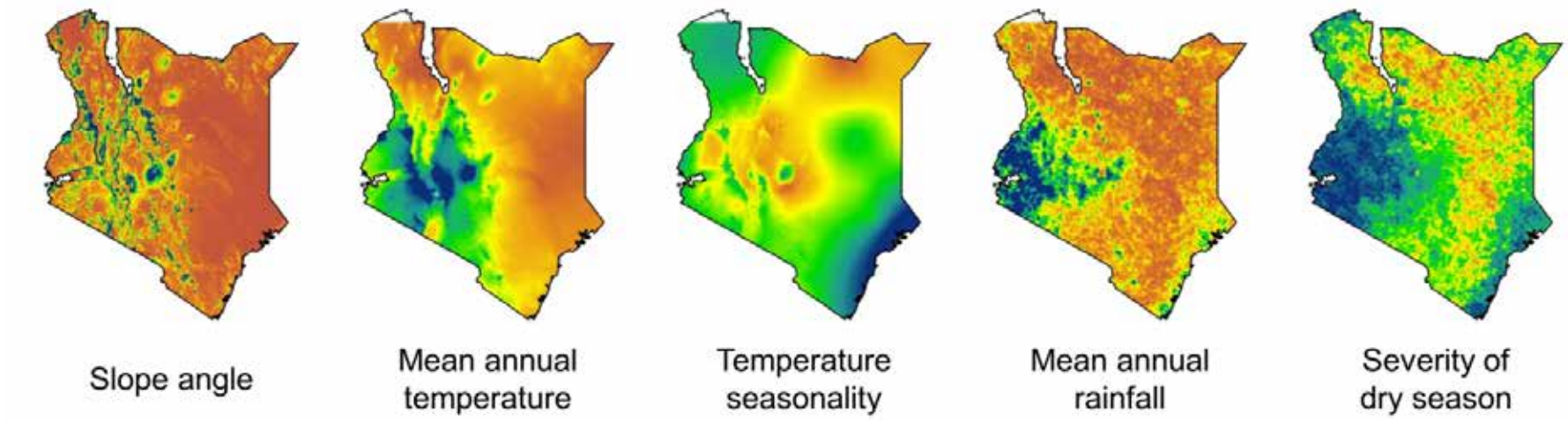


FIGURE 4.9: The ecosystem range of Acacia
The plant genus Acacia is remarkably diverse, spanning a wide range of ecosystems from deserts to forests. The 51 species of Acacia in Kenya are among the country's most iconic plants. Based on bioclimatic modelling of 36 Acacia taxa (upper panel), some of the greatest diversity of Acacias is predicted to be outside protected areas. The lower panel maps some of the environmental gradients used to predict Acacia distribution. Scale interpretation: red is flat, hot and dry; blue is steep, cool and wet. *Source: Marshall et al. 2012 in Plant Ecology and Evolution*

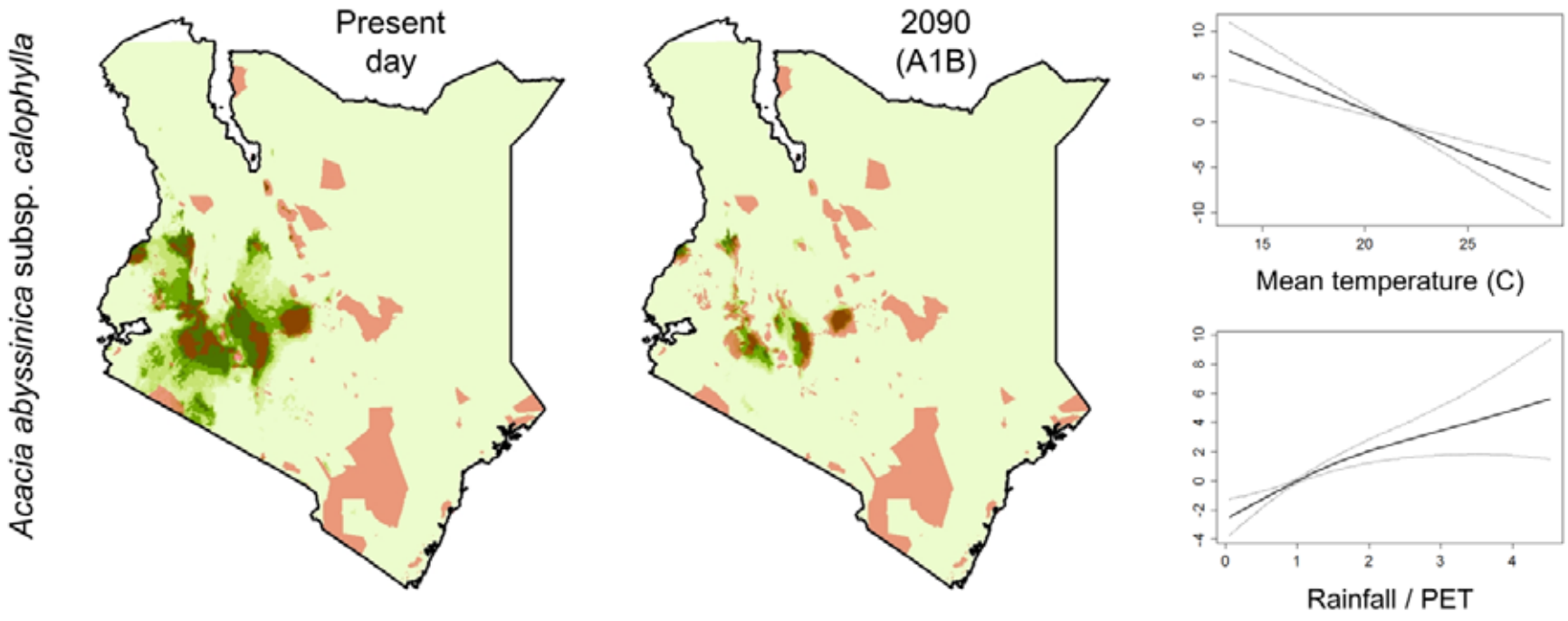


FIGURE 4.10 : Modeled distribution of Acacia
Models of Acacia distribution (Fig. 4.9) can be used to project how climatic suitability for certain species might change in the future. Projected changes under emissions scenario A1B are illustrated for *Acacia abyssinica* subsp. calophylla and *Acacia turnbulliana*. High suitability is indicated by darker shades of green. Protected areas are shown in pink. The graphs on the right describe the modelled responses of these species to potential evapotranspiration (PET) and mean annual rainfall. *Source: Marshall et al. 2012 in Plant Ecology and Evolution.*

The projected response of Acacias to climate change is a good illustration of the magnitude of the threats in the decades ahead.

Some of the main environmental factors that determine Acacia distribution are illustrated with the distribution map. Such detailed information makes it possible to project how individual species will respond to future predicted climates. Some species such as *Acacia turnbullina* are likely to increase their range in north-eastern Kenya (Figure 4.10). Others like *Acacia abysinnica*, a montane species, will see a range contraction and could face extinction. Similar analysis can be made for every species.

PRESSURES ON KENYA'S BIODIVERSITY

Habitat loss and fragmentation

Habitat loss and fragmentation, the largest threats to ecosystems and species, are driven largely by expanding human activity. Loss occurs from the spread and intensification of agriculture, settlement, infrastructure and industry. The risk of species loss and extinction rises steeply as habitats

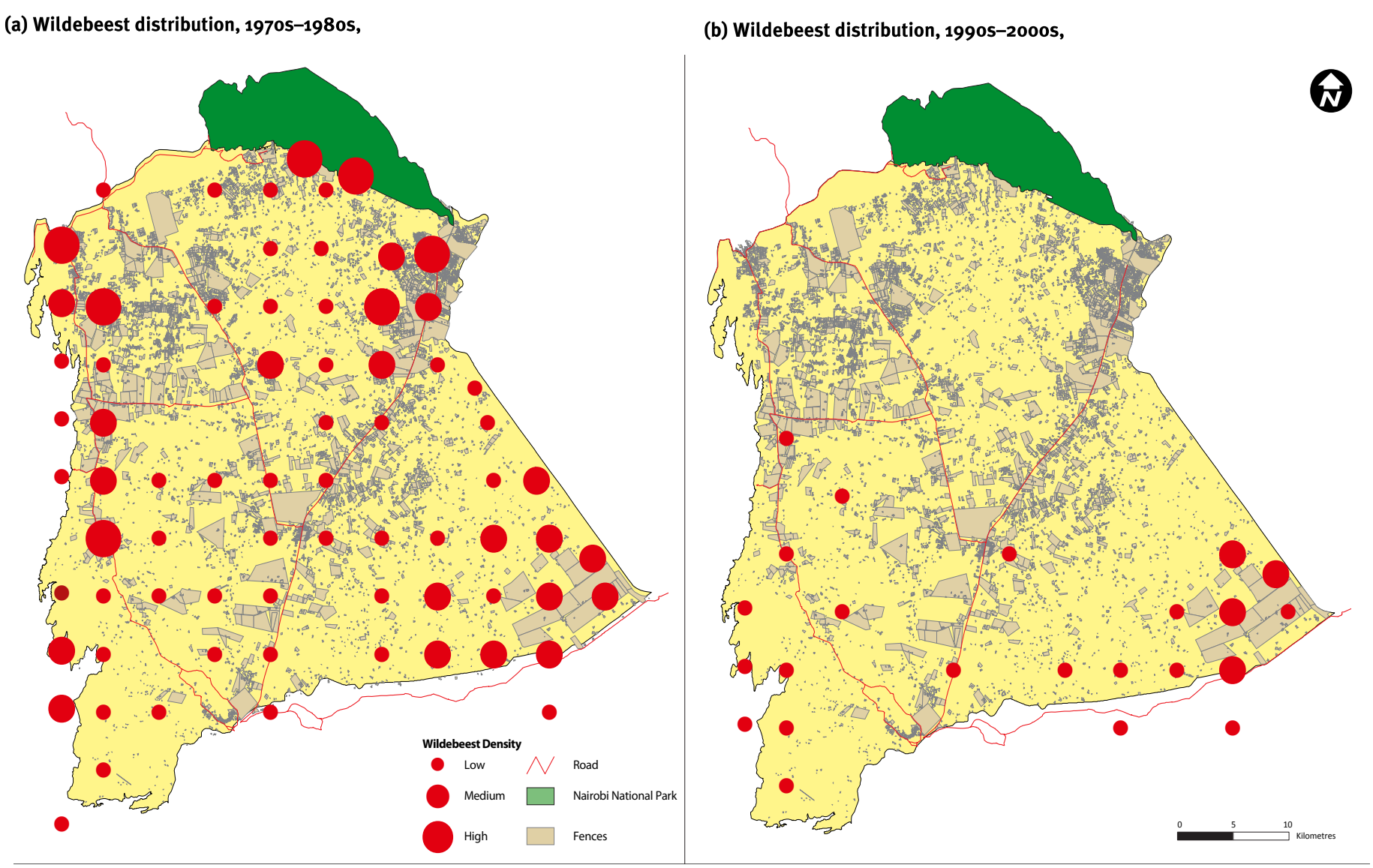


FIGURE 4.11: Wildebeest distribution
(a) Wildebeest distribution, 1970s–1980s, indicating a wide distribution across the whole ecosystem. b) Wildebeest distribution, 1990s–2000s, showing heavy declines of wildebeest south of Nairobi Park with remnant populations located in the southern plains where fencing is sparse. *Source: ILRI, DRSRS*

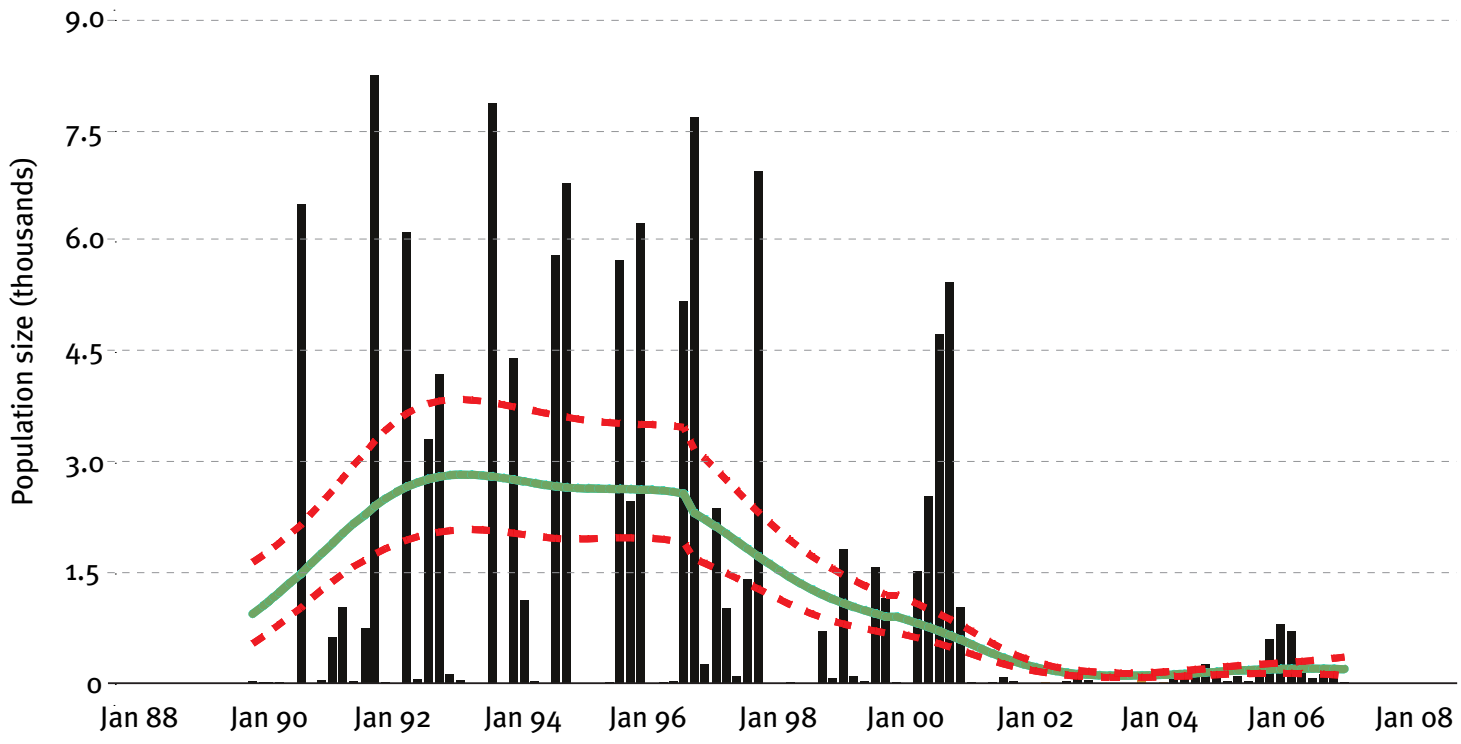


FIGURE 4.12: The effect of land fragmentation on wildlife migration
Land fragmentation is leading to a loss of wildlife and seasonal migrations. The seasonal migration of wildebeest in and out of Nairobi National Park has collapsed due to habitat loss and fragmentation around the park. the collapse of the migration occured in 2002. The build up of urban centers, homes and fencing will further reduce the movement of wildbeest and other wildlife species.
Source: KWS, Ogutu et al. 2013.

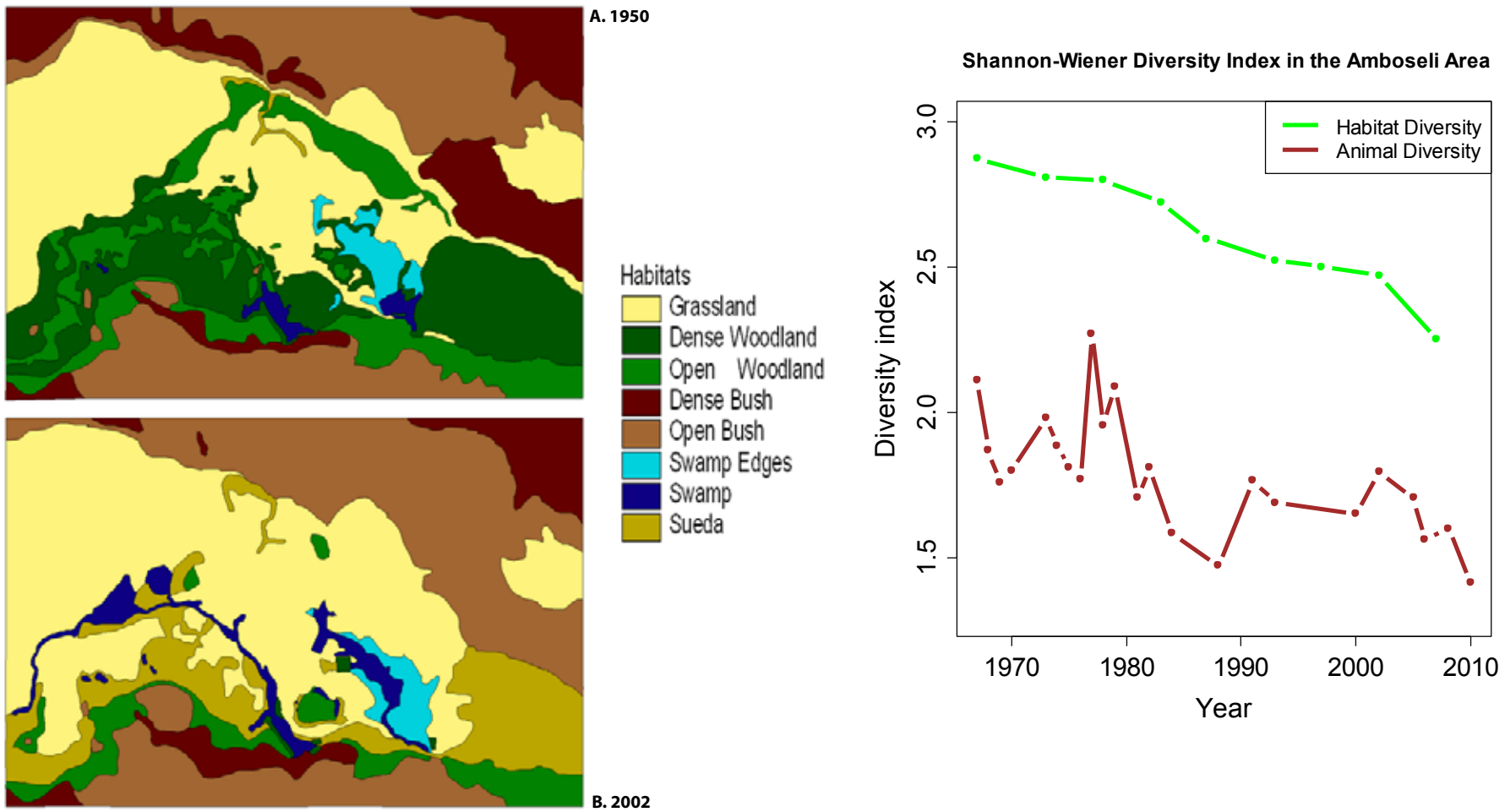


FIGURE 4.13: Loss of habitat diversity in Amboseli.
Amboseli National Park lies in the semi-arid bush and grassland savannah near the base of Mt. Kilimanjaro. (a) loss of habitat diversity between 1952–2007 (b) .The loss of habitat diversity (green) in Amboseli National Park due to disruption of elephant migration has caused a) sharp decline in animal species and in animal species diversity between 1967–2010. *Source: Western and Maitumo, 2006.*

shrink and fragment. Kenya's forests are the most vulnerable to habitat loss. The Aberdares, Mt. Kenya, Mt. Elgon and the Mau have all suffered from human influx by subsistence and large-scale farmers, heavy extraction of water, and plant and animal wealth. The loss of species due to fragmentation often causes ecological disruption leading to a loss of productivity and resilience. A good example is the Aberdares National Park where the Tree Tops Lodge lost its prime tourist attractions, including the bongo and the giant forest hog, due to forest fragmentation and habitat degradation. The loss of migratory corridors on the Athi Plains south of Nairobi National Park led to a large reduction in the diversity and abundance of animals in the park and the collapse of wildebeest migration (Fig. 4.11 and 4.12; Ogutu et al. 2013).

Degradation of land and aquatic resources

Even where habitat is relatively intact, degradation continues throughout much of Kenya. Examples include poor animal and farming husbandry practices leading to soil erosion, and loss of nutrients and productivity. Land and pasture degradation are particularly widespread in the marginal agricultural and pastoral areas where access to markets is poor and traditional husbandry practices have been abandoned. Human activity also has a large impact on terrestrial and aquatic ecosystems through fire and ecological disruption. Rivers, dams, lakes, and inshore marine waters are being polluted, while fertilizer and sediment deposits are leading to eutrophication. In all cases these are causing loss of species and decline in resilience to pressures (Fig. 4.13).

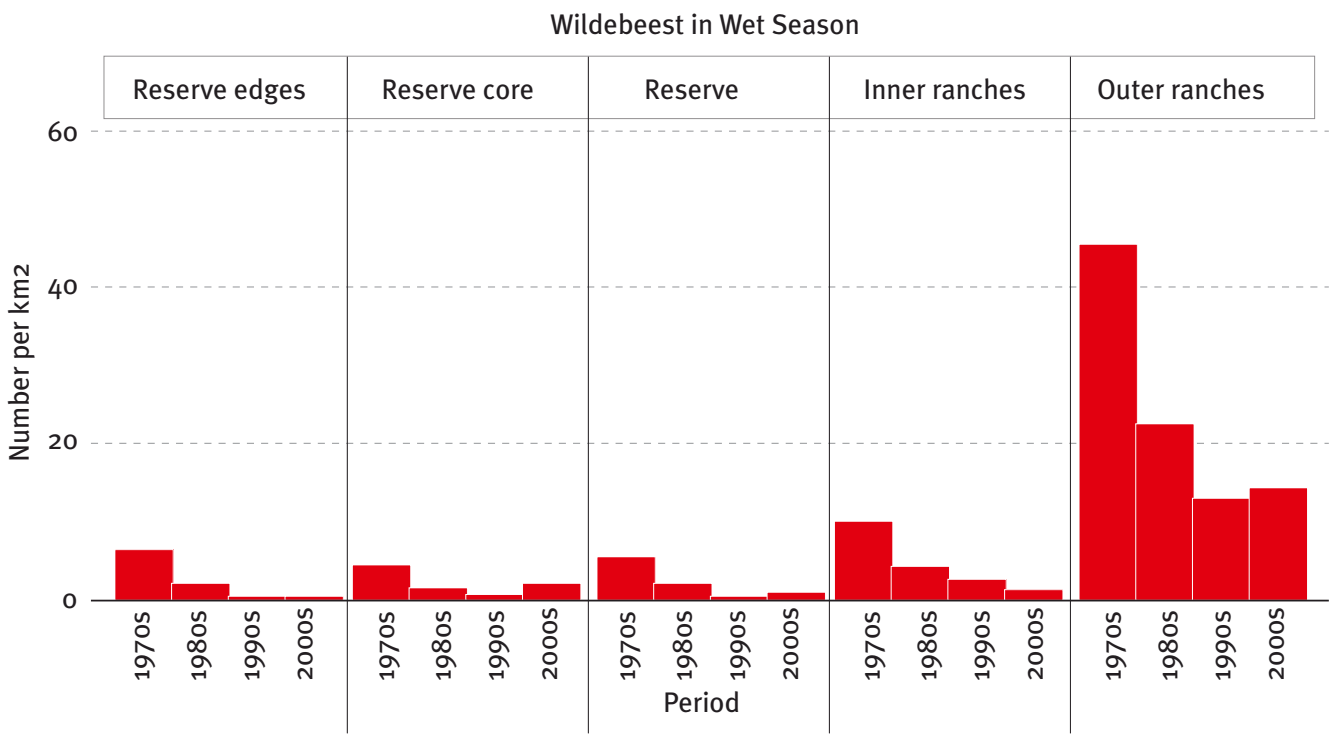


FIGURE 4.14: Trends in wildebeest populations in the Maasai Mara
Trends in wildebeest populations in the Mara, showing a decline of the resident wildebeest population. With a huge loss outside protected area (inner and outer group ranches) .*Source: Ogutu et al. 2011.*

Poorly planned tourism disturbs fragile ecosystems. The effects were most evident during the rapid unregulated growth in mass tourism from the 1960s to the 1980s, when predators were harassed and off-road driving caused serious habitat damage in the Maasai Mara and Nakuru.

Expansion of agriculture into wildlife areas has caused the loss of key habitats and impacted the population of a number of species. In the Mara ecosystem the expansion of wheat farms in the wildebeest wet season range has reduced its number from 150 000 animals in the 1970s to less than 30 000 animals in 2011 (Fig 4.14). There is also competition from increased livestock numbers.

Overharvesting

Overharvesting of species is a main cause of biodiversity loss. Overharvesting takes several forms, ranging from meat and trophy hunting to overgrazing, tree cutting and charcoaling. Overgrazing is the single biggest factor causing land degradation, loss of plant production and ecological changes in the rangelands. Tree cutting and charcoaling have a large impact on forests and woodlands.

Poaching of elephants for the international ivory trade reduced Kenya's population from 150 000 to 19 000 between 1970 and 1990. Rhino poaching pushed populations down from 20 000 to 350 over the same period. Both species were classified as endangered and have since shown some recovery. Other examples of poaching include the Hunter's Hartebeest, which dropped by 77 per cent in the 1970s and 1980s, and Grevy's Zebra, which fell from 15 000 to less than 1 500 in the last decade. Plants threatened by overharvesting and illegal trade include the Red Stinkwood (*Prunus africana*), used to treat prostatic conditions, and the African Sandalwood (*Osyris lanceolata*), a species with scented wood used to make oils and perfumes.

Charcoaling and fuelwood harvesting has stripped extensive areas around towns and settlements of woodlands and bushlands (Fig. 4.15).

PLATE 4.5: Charcoaling and fuelwood harvesting has stripped extensive areas around towns and settlements of woodlands and bushlands

A number of naturally occurring pathogens and parasites also threaten native plants and animals. The pandemic epizootic virus, rinderpest, caused a continent-wide loss of wild ungulates when introduced by cattle in the late 1800s. Canine distemper virus, transmitted by dogs, killed a third of the lions in Mara-Serengeti in the 1990s. Tuberculosis and anthrax periodically kill many native animals, ranging from elephants to primates.

Invasive and infectious disease have become more pernicious and threatening to indigenous species because of expanded human activity. One example is Rift Valley fever, a lethal mosquito-borne virus associated with prolonged rainfall and flooding.

Invasive species and lethal diseases

Invasive species have become a serious threat to native plants, animals and pastures. The water hyacinth *(Eichhornia crassipes)* has smothered large areas of inland lakes leading to a decline in fisheries production and livelihoods (Plate. 4.6). The predatory Nile Perch, introduced into L. Victoria from the Nile basin, caused the extinction of many of the abundant chichlids species of fish. The tick-berry *(Lantana camara)* has invaded Nairobi and Oldonyo Sabuk National Parks, forming dense, bushy undergrowth that inhibits natural vegetation.

PLATE 4.6: The water hyacinth has smothered the shores of L. Victoria, is reducing fish harvests, and impeding transportation and recreation.

OTHER CAUSES OF BIODIVERSITY LOSS

There are many other causes of biodiversity loss that vary widely among species. For example, cultural attitudes about nature and species differ and have a strong bearing on the status of species and biodiversity.

As illustrated in the traditional human setting (Chapter 2), many traditional cultures such as the *Mjikenda* at the coast revere and conserve *kaya* forests and other facets of biodiversity as part of their ancestral customs. The Turkana judiciously protect riverine trees using the traditional *Ekwar* system to ensure shade and seeds for their livestock in the dry season. The Maasai fence off grass reserves, or *olopololi*, for use by small stock in the dry season. They also reserve habitats such as swamps, woodlands and forests for livestock use during dry seasons and droughts. Traditional conservation practices are, however, waning under population pressure and a switch to market economies that leads to habitat clearance for farms, ranches and settlement.

Attitudes towards species and habitats vary within and among societies. Some species are considered useful or harmless, others destructive and dangerous. Preferences and tolerance determine which species increase and decrease in an area, and thus the composition and abundance of plant and animal species. Among pastoralists, traditional views of species change as livelihoods switch from livestock to farming (Fig. 4.15).

Aside from the many domestic factors in Kenya that bear on the state of biodiversity, international factors beyond its borders, and often outside its control, also pose a threat. The illegal trade in tusks and horns on the international market are two examples that have taken a heavy toll on Kenya's elephants and rhinos. Another is global warming, which will have a large impact on Kenya's biodiversity, economy and society yet lies largely outside its control. On the other hand, international tourism and conservation funding have played a large part in protecting Kenya's biodiversity.

The many human pressures, views and attitudes affecting Kenya's biodiversity defy a simple distillation of threats to species, making it a formidable task.

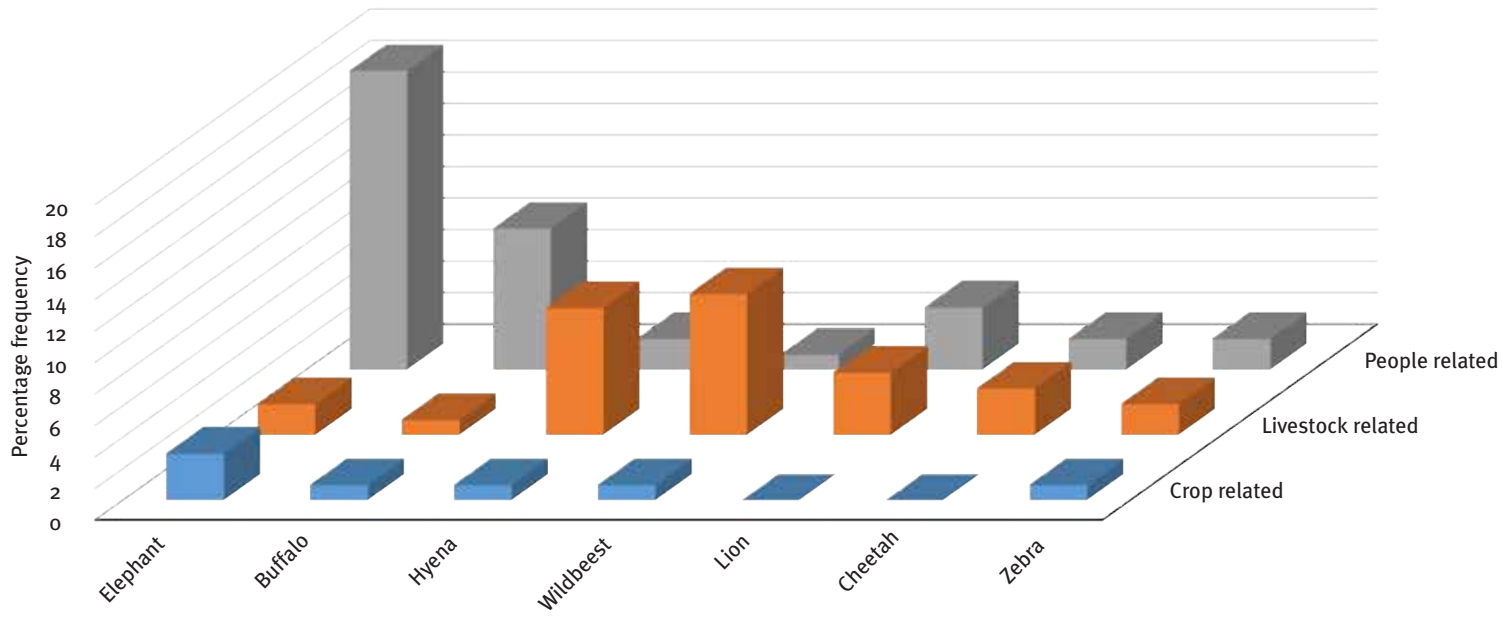


FIGURE 4.15: Species tolerance in relations livelihoods.
The tolerance of species varies with livelihoods. The Maasai attitudes towards species vary depending on whether a species is considered in relation to crops, herds or people.
Source: Amboseli Conservation Program.

Instead of providing a detailed species account, we summarize findings according to the major ecosystems described earlier and the natural resource sectors that depend on biodiversity. An ecosystem and natural resource approach simplifies a state of biodiversity account in two ways: first by highlighting biodiversity and species of greatest economic and social importance to people; and second, by grouping them according to similarity of threats and solutions. Because Kenya's major ecosystems reflect eco-climates that shape land-use potential and prevailing land-uses, as outlined in Chapter 2, an ecosystems framework lends itself to a cross-sector policy and land-planning framework. Yet another advantage is that an ecosystem and natural resource approach offers an integrated framework for evaluating biodiversity, assessing its ecological services and so fully valuing the natural capital underpinning Kenya's sustainable development.

To simplify an analysis of the threats to ecosystems, those in similar eco-climatic zones and with similar threats have been grouped together.

The rangelands: woodlands, shrublands, grasslands and deserts

The semi-arid and arid areas of Kenya make up the rangelands—water-restricted areas used by ranchers, pastoralists and agro-pastoralists. A patchwork of dry woodlands, shrublands, grasslands and deserts—the rangelands—cover 80 per cent of Kenya. They share common threats and a similar conservation status. The rangelands are the last open areas of Kenya supporting large free-ranging populations of wildlife and pastoralists. Also known as the East African savannahs, these great expanses are the main attraction of Kenya's burgeoning international tourist industry.

The many pressures in the rangelands have increased competition over land and with wildlife. The conflict has become particularly intense where farms and permanent settlement invade wildlife ranges, leading to heightened crop and livestock depredations, and human and wildlife losses (Fig 4.16). Nairobi City now engulfs Nairobi National Park, blocking the southern-bound wildlife migration through the Athi-Kapiti plains. The once-famous elephant corridor between Mt. Kenya and the Aberdares has been blocked by fences and farms, a scenario that now threatens the Amboseli and Mara ecosystems.

Wooded vegetation is being lost and degraded through fragmentation, charcoaling, settlement, land clearing and heavy grazing pressure. Migratory wildlife herds are being curtailed by land subdivision, immigration, farming and settlement. Many of the rivers and swamps, vital to late-season grazing, are been drained for irrigation and urban consumption and being settled by farmers.

The loss of traditional husbandry practices that governed the use of pastures, waters and drought refuges are contributing to a decline in conservation practices and overuse of natural resources. The main causes include overharvesting of trees for fuelwood, charcoal and timber; inappropriate crops and poor farming techniques; overgrazing; and encroachment on wildlife corridors.

Droughts have become more frequent and intense over much of the rangelands due to fragmentation of the land, depletion of water and pasture, and falling livestock holdings per family. The shrinking and fragmenting will exacerbate the impact of climate change. A rising demand on land for bioenergy production, including a proposed Jatropha plantation in the Tana Delta, is also a growing threat. The savannahs are viewed as a last frontier for agricultural expansion, leading to rapid settlement and land speculation in the moister areas, woodlands, wetlands and river courses.

BOX 4.2: MAIN THREATS TO RANGELANDS

- Subdivision and fencing.
- Urban expansion and settlement.
- Heavy grazing and conversion to rainfed and irrigated agriculture.
- Resource conflicts.
- Human–Wildlife conflict.
- Poaching for trophies and bushmeat.
- Loss of keystone species.
- Blockage of dry season wildlife and livestock refuges.
- Poor planning of water points.
- Poor management of catchment areas and upstream water over-abstraction.
- Climate change.

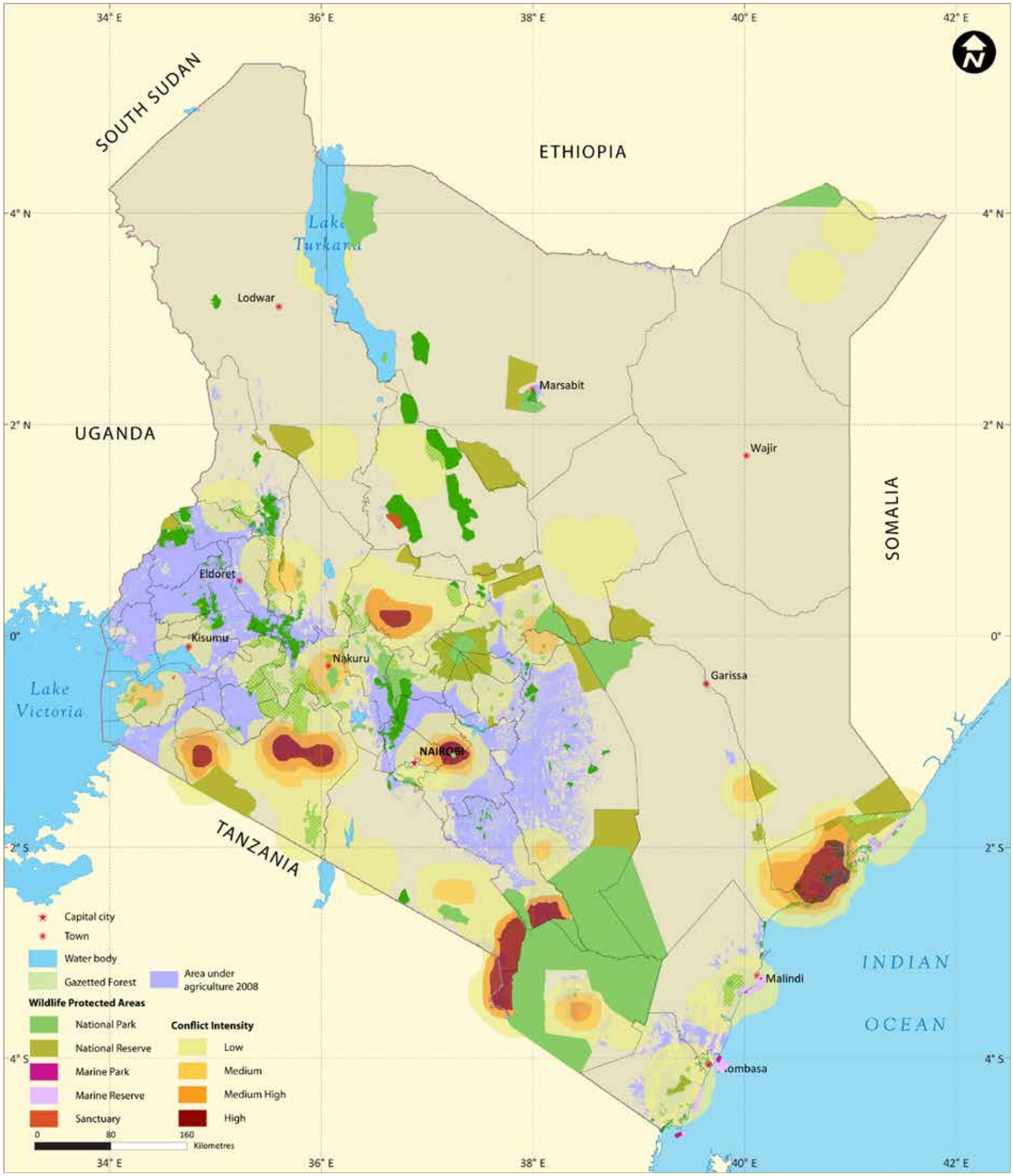


FIGURE. 4.16: Human–wildlife conflict has increased with growing human pressure on land and wild species. A conflict map shows the hotspots across Kenya in relation to national parks. The heaviest conflicts are in Laikpia, Mau, Transmara, Tsavo, Athi plains and Lamu. *Source: KWS.*

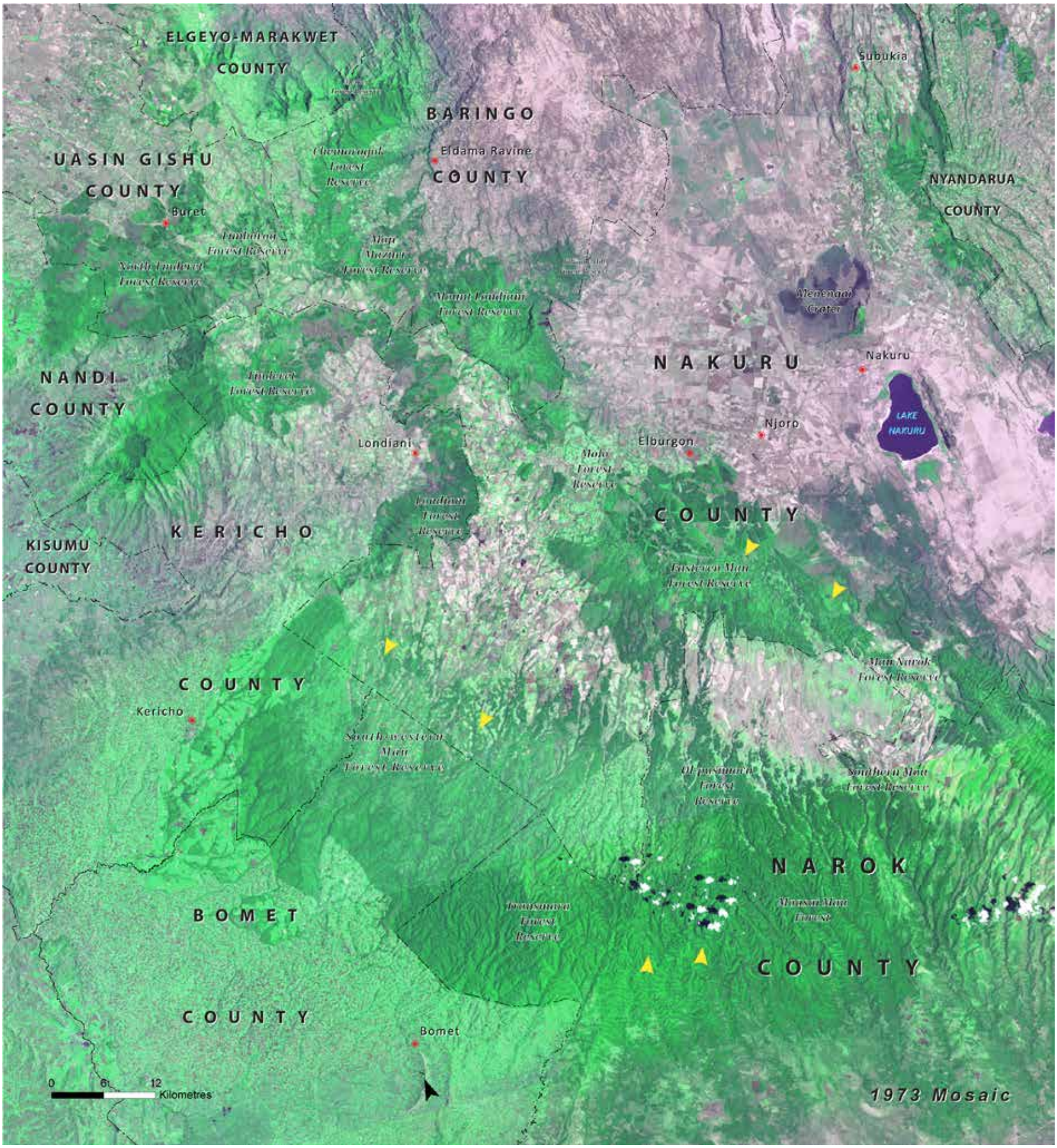
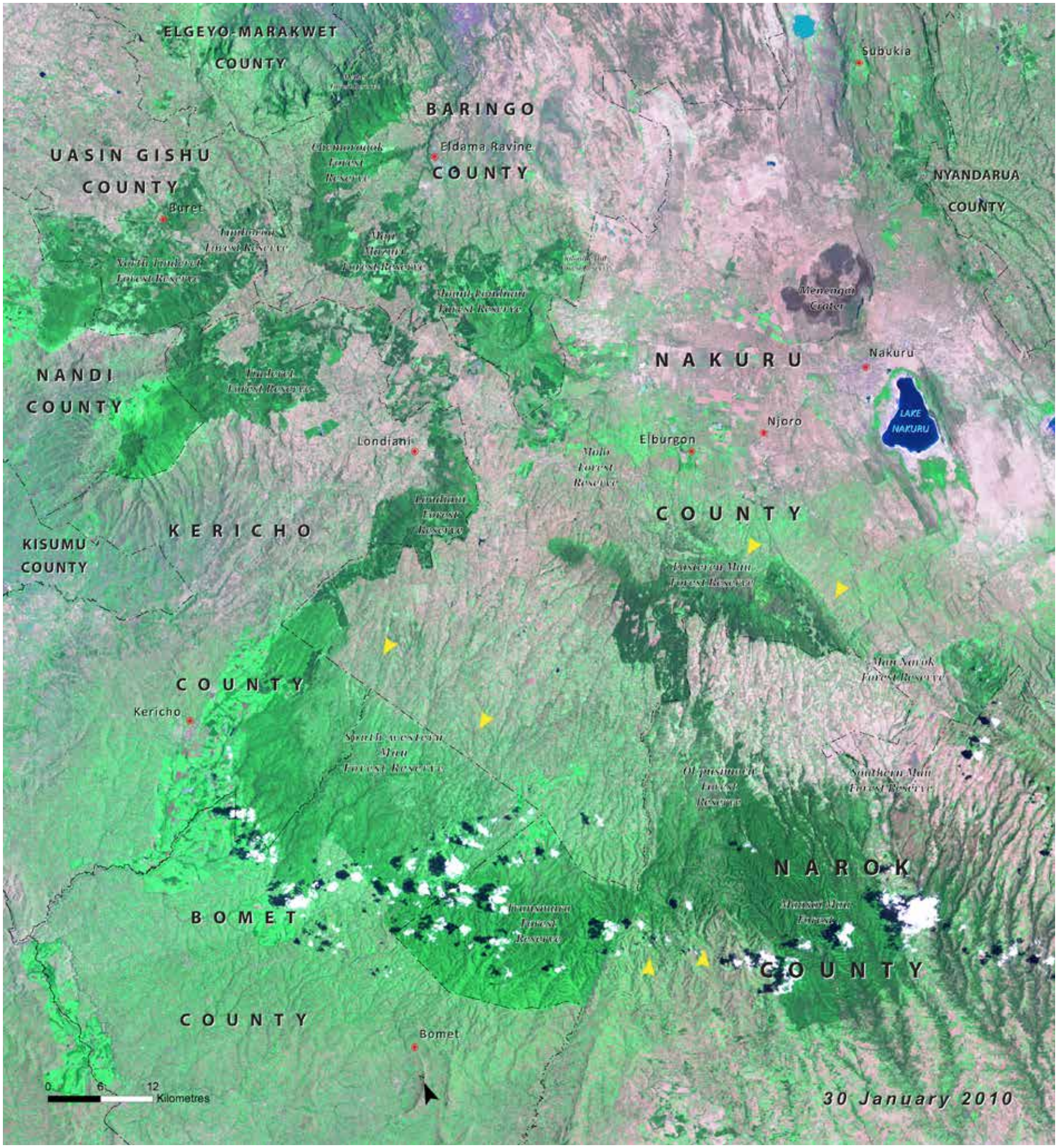


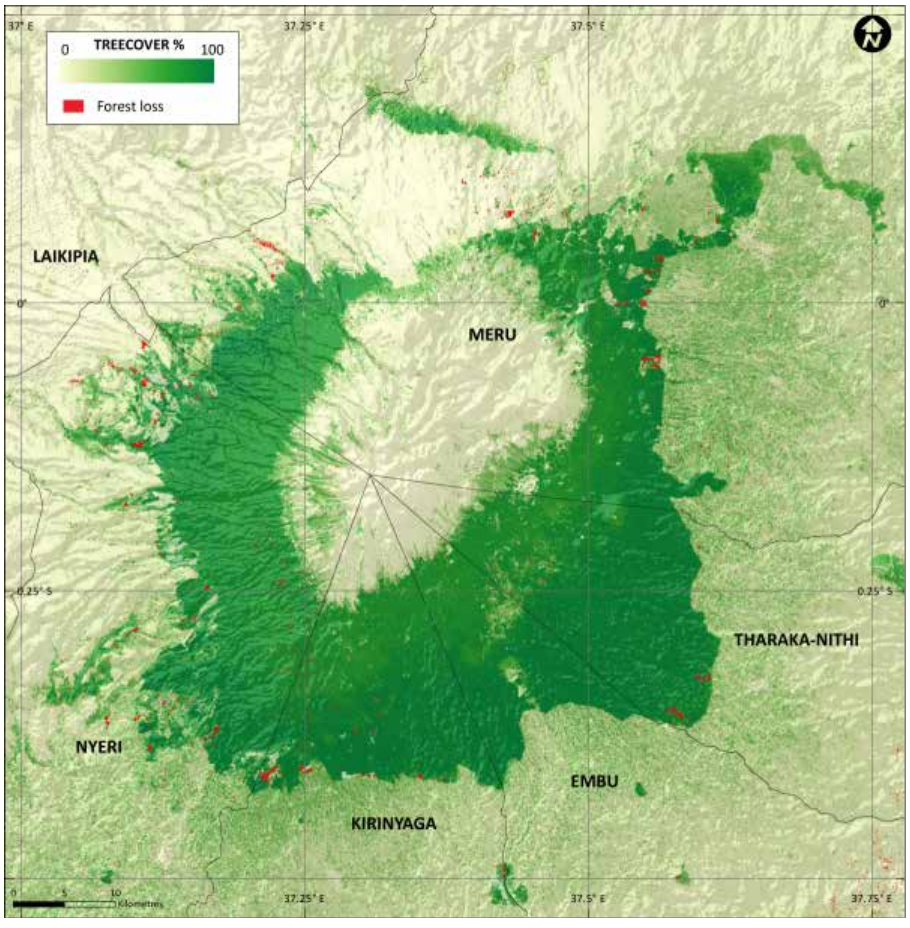
PLATE 4.17: The Mau Forest Complex, covering over 400 000 ha, is the largest of Kenya's five water towers and the single most important water catchment in the Rift Valley and western Kenya. Its waters support agriculture, hydropower, urban water supply, tourism, rural livelihoods and wildlife habitats all through western Kenya, and flow into L. Victoria and thence the White Nile. In spite of this national and international significance, however, the complex has been continuously encroached, leading to the destruction of over 100 000 ha since 2000. The satellite images from 1973 and 2010 capture 37 years of forest loss in the complex. Farm fields are depicted as light and dark patches with straight edges between the dark-green forested areas. Additional deforestation since the 2010 image is indicated by yellow arrows. Since 2010, several public-private partnerships have initiated concerted conservation and reforestation efforts, but it will take time for forest cover to be restored. The Mau Forest performs critical watershed and climate regulation functions for areas as far afield as the Maasai Mara National Reserve, L. Nakuru, the Sondu Miriu hydropower plant, and the tea-growing Kericho highlands, which together make up a massive portion of tourist, export and other earnings. Recognizing the threat that deforestation poses to these industries and a range of crucial ecosystem goods and services, the Kenyan government convened a forum in 2009 to address the health of the Mau Forest Complex.



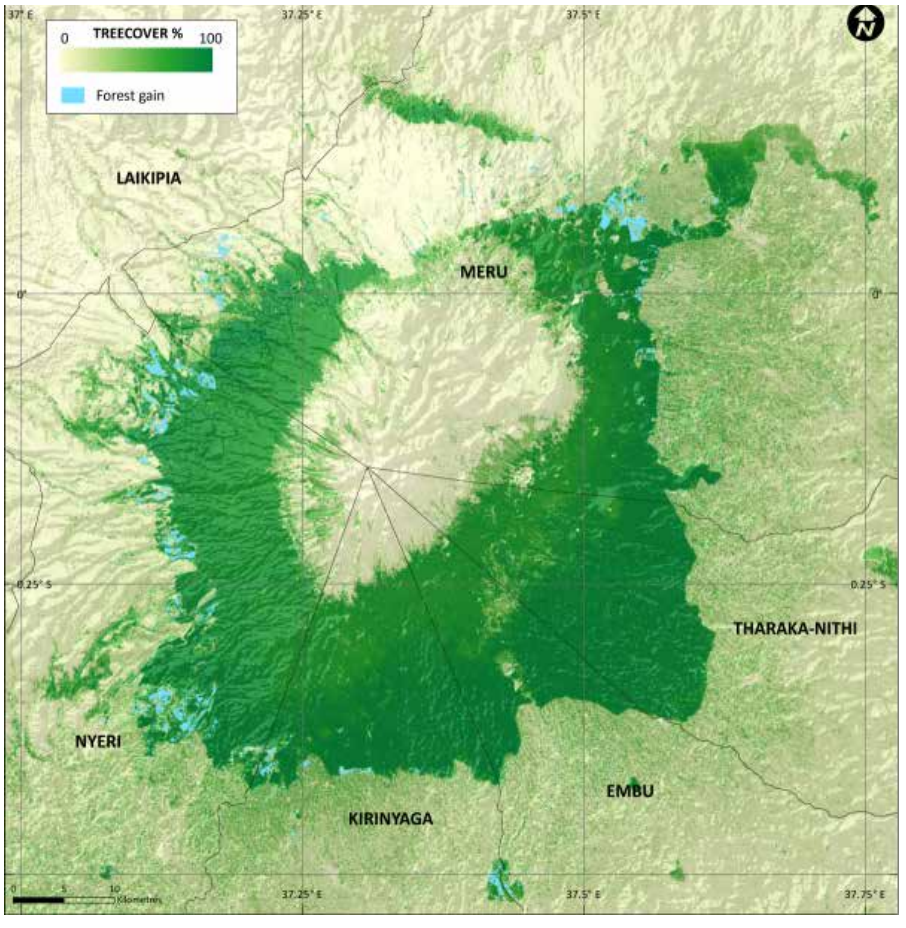
A rehabilitation plan with a budget of US$81 million was proposed, of which an estimated US$10 million had been committed by international donors in 2010. A new understanding of the Mau Forest as a "water tower" with importance well beyond its immediate area helped mobilize resources and precipitated actions that may make rehabilitation possible. The Kenyan government's goal is to rehabilitate the Mau Forest and secure its watershed functions for Kenya and its neighbours. In recent decades, the clearing of large areas of indigenous forest for tree plantations around Mt. Kenya has been compounded by illegal logging, charcoaling, and squatter farmers and settlers.

The following maps represent Tree cover in the year 2000, defined as canopy closure for all vegetation taller than 5m in height. Encoded as a percentage per output grid cell, in the range 0–100.

Mount Kenya

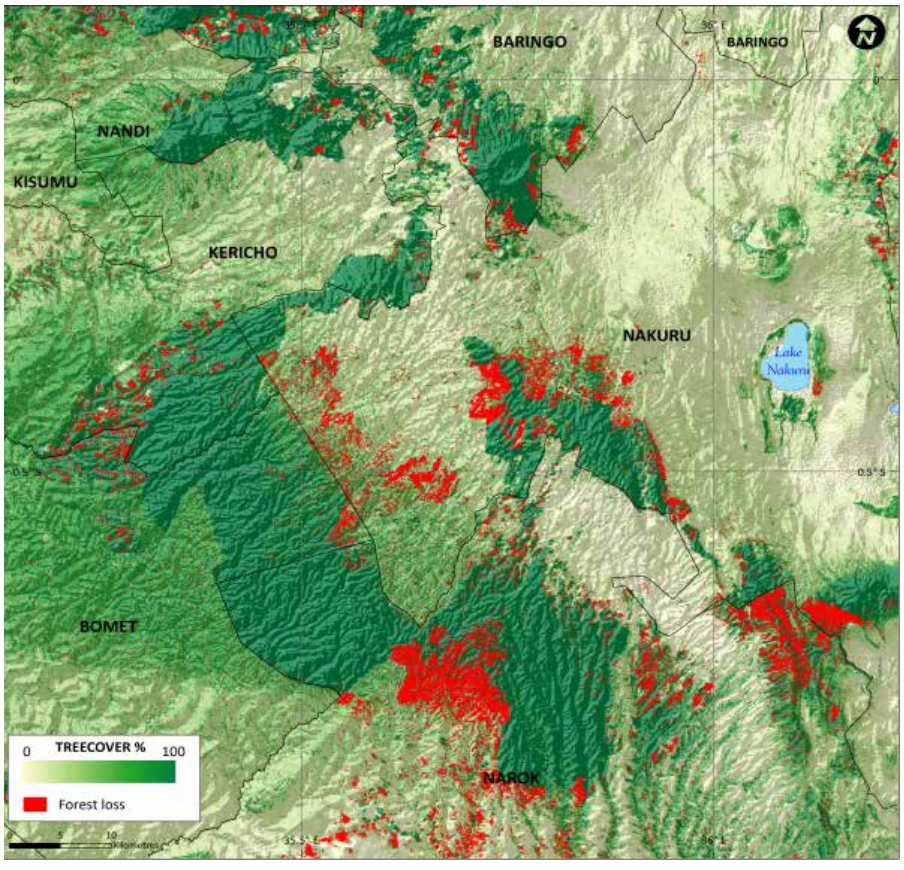


Forest loss in the Mt. Kenya area during the period 2000–2012, defined as a stand-replacement disturbance, or a change from a forest to non-forest state.

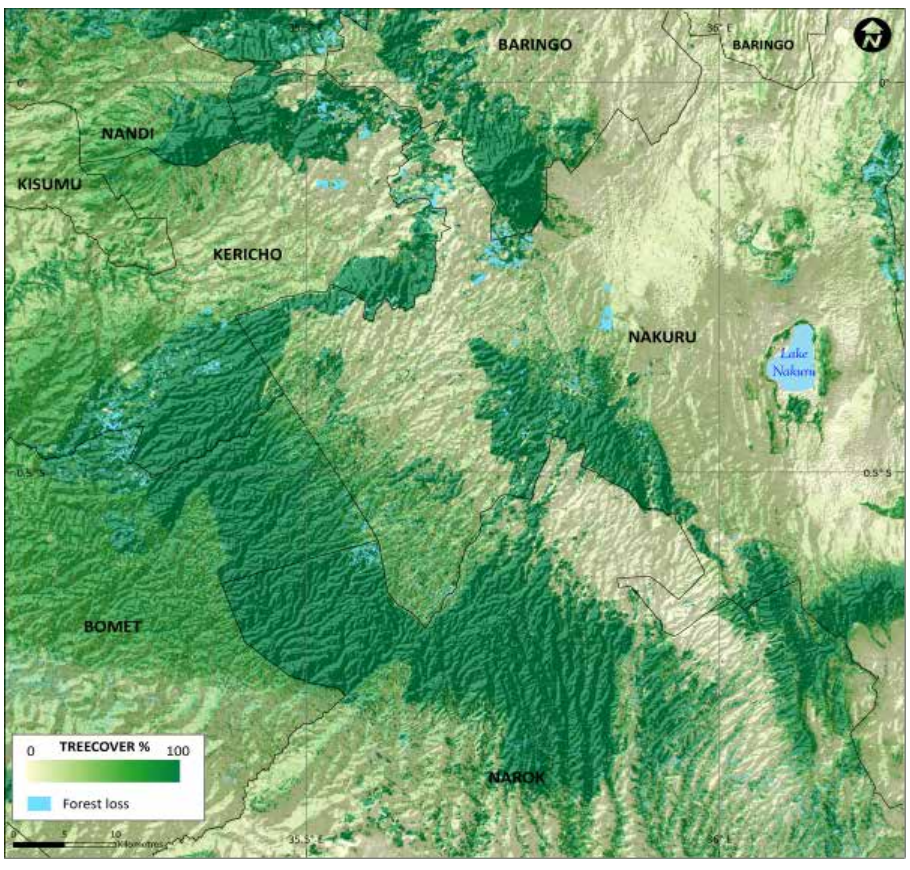


Forest gain in the Mt. Kenya during the period 2000–2012, defined as the inverse of loss, or a non-forest to forest change entirely within the study period.

Mau

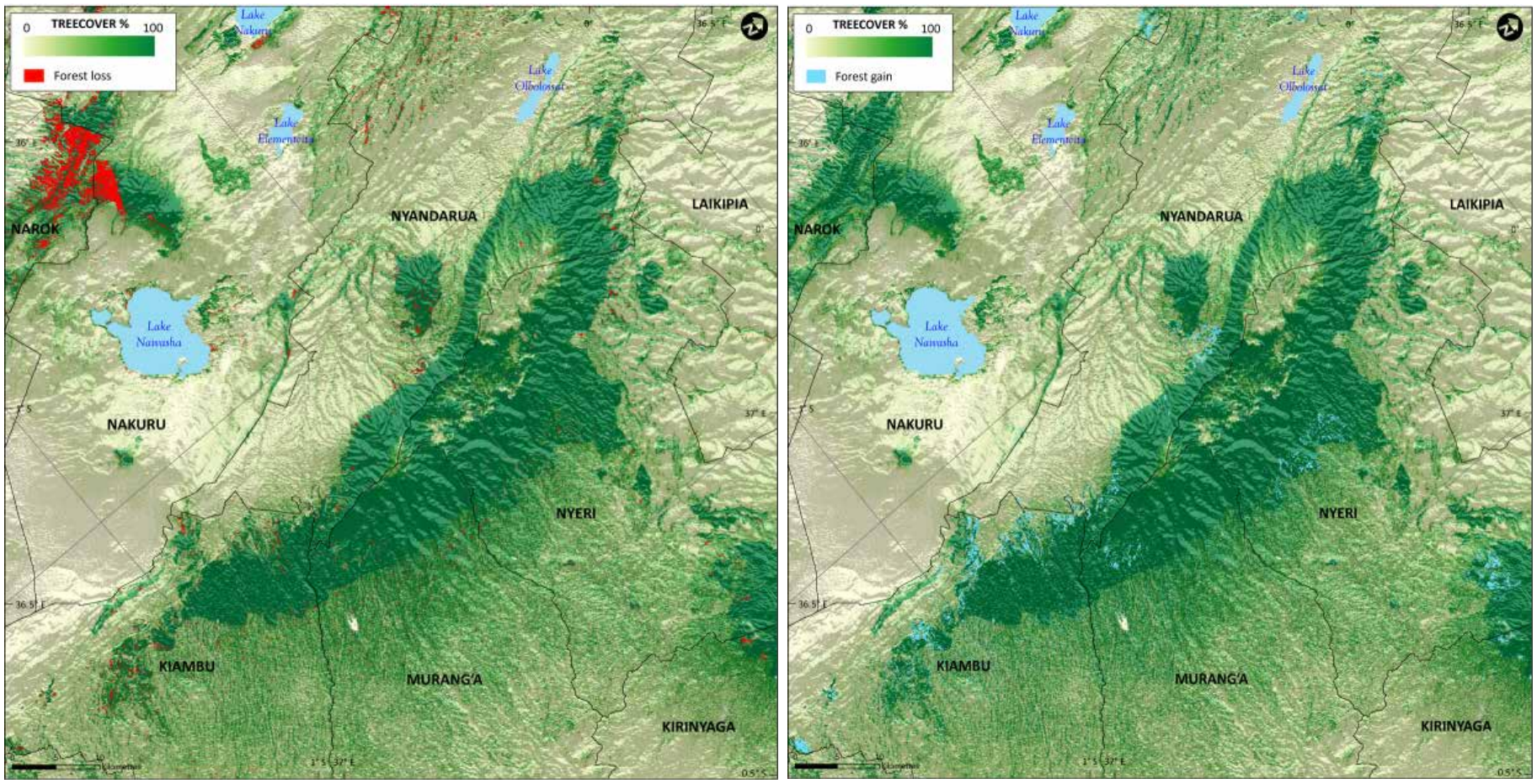


Forest loss in the Mau area during the period 2000–2012, defined as a stand-replacement disturbance, or a change from a forest to non-forest state.



Forest gain in the Mau area during the period 2000–2012, defined as the inverse of loss, or a non-forest to forest change entirely within the study period.

Aberdares



Forest loss in the Aberdares area during the period 2000–2012, defined as a stand-replacement disturbance, or a change from a forest to non-forest state

Forest gain in the Aberdares during the period 2000–2012, defined as the inverse of loss, or a non-forest to forest change entirely within the study period.

Figure 4.18: Forest changes as measured by satellite images
Forest changes as measured by satellite images. a) The red colour indicate loss of forests in the Mau Forest and the blue shows forest gains b) Shows the situation in Mt. Kenya and parts of the Aberdares. *Source: Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013.* "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from: http://Earthenginepartners.appspot.com/science-2013-global-forest.

BOX 4.3: MAIN THREATS TO FORESTS

- Smallholder and large-scale agricultural expansion.
- Spread of commercial and technology-intense farming.
- Water demand for agriculture and domestic uses.
- Extraction of exotic timber species and plantations.
- Illegal logging, charcoal production, and harvesting of forest products.
- Biofuel production in dry and coastal forests.
- Impact of fragmentation and elephant compression.

The forests: lowland, coastal, montane, mangrove and dry forests

The lowland, coastal, montane, mangrove and dry forests face much the same threats, due to their common location in the most populous areas of Kenya. Forests have been heavily encroached for farms, settlement and commercial plantations and overharvested for timber, fuelwood and charcoal. In many locations poorer populations make heavy use of forests for herding livestock and natural products. Illegal logging of cedar, camphor and other valuable timber species, along with forest fires, threaten many forests.

Forests have also suffered from policies that favour timber production over catchment forests, weak institutional developments, poor resource governance and low capital investment. The lack of replacement in plantation forests coupled with expansion to meet a growing domestic demand for timber products has also led to overdependence on indigenous forests and slow-growing trees. Politically instigated handouts for settlement schemes and gifting of state forests has also shrunk Kenya's forests. The combined effects are most clearly evident in the Mau Forest (Figure 4.17), which raised a national outcry in 2004.

Lakes, rivers and wetlands

The lakes, rivers and wetlands of Kenya share similar threats, including water extraction, agrochemical runoff, industrial and domestic pollution, eutrophication, invasive aquatic weeds and the impact of heavy settlement along their banks. With rainfall becoming more erratic in many regions, surface flows are becoming less dependable. Many perennial rivers and streams have become seasonal and ephemeral due to habitat destruction and water extraction. Many lakes such as Baringo and Turkana have fallen steeply in level and suffered siltation.

Overfishing has occurred in most lakes, rivers and wetlands, leading to declining yields for fishing communities. Heavy overfishing also causes ecological disruption and, often, a loss of indigenous plants, such as water lilies and sedges, and animals such as otters and fish eagles.

BOX 4.4: MAIN THREATS TO LAKES, RIVERS AND WETLANDS

- Water extraction for agriculture, industry and settlement.
- Reduced outflows and inflows.
- Reduced catchment recharge.
- Conversion of wetlands to farming, settlement and pasture.
- Loss of riparian vegetation.
- Pollution.
- Invasive species.
- Overfishing.

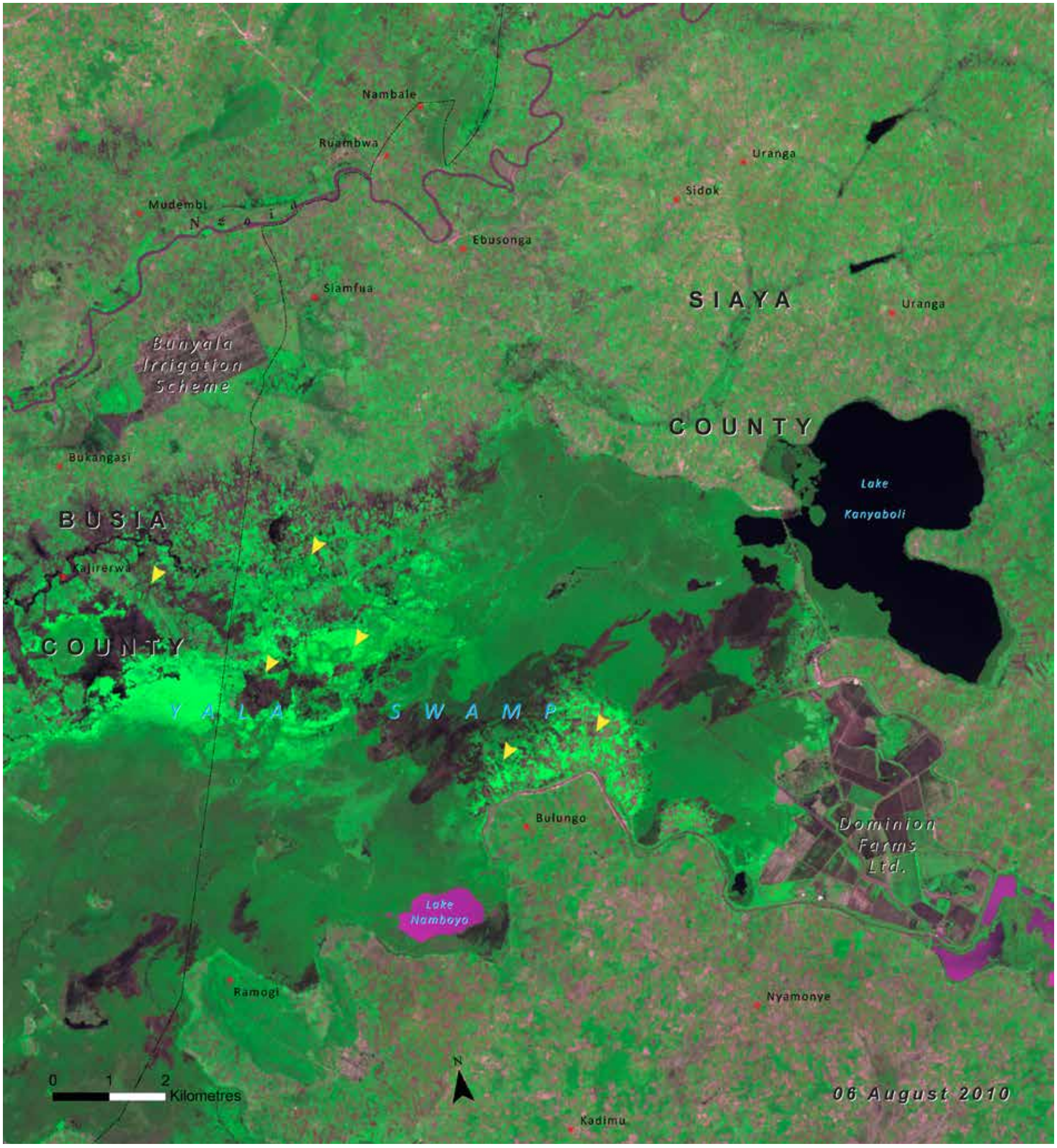


FIGURE 4.19: **The** transformation of Yala Swamp
Satellite images show the transformation of Yala Swamp caused by drainage and irrigation between 2007 and 2010. Yala Swamp, which has been drained and converted to 17 500 ha of farms and settlement since the mid-1960s, is one of Kenya's many disappearing wetlands.***Source: Kenya Atlas of Our Changing Environment, 2009.***


Nambale
Ruambwa
Uranga
Sidok
Mudembi
Nzoia
Ebusonga
Siamtua
SIAYA
Uranga
Bunyala Irrigation Scheme
COUNTY
Bukangasi
Lake Kanyaboli
BUSIA
Kajirerwa
COUNTY
YALA SWAMP
Bulungo
Dominion Farms Ltd.
Lake Namboyo
Ramogi
Nyamonye
N
0 1 2 Kilometres
12 August 2007
Kadimu

The introduction of non-indigenous plant and animal species is also a major threat to biodiversity, as one of the best-documented examples in L. Victoria shows. In the 1950s over 28 genera and 350 species of fish were found in L. Victoria along with 300 or so haplochromine cichlids. Recent assessments put the loss of species due to Nile Perch predation at over 200.

The destruction and degradation of the catchment areas of all Kenya's major lakes, rivers and swamps is the most serious common threat, causing flooding, reduced recharge, more seasonal sedimentation, and pollution. In many years, the Galana-Sabaki River now dries up before reaching the sea. The low-season flow through Tsavo National Park is often green with eutrophication from fertilizers leached from upstream farms.

Organic chemicals, fertilizers, insecticides and pesticides are a growing threat in the industrial and high-intensity farming areas, causing heavy losses to aquatic life. L. Naivasha is the best documented case of poor land-use practices, pollution and overharvesting combining to cause a major loss of biodiversity and ecological disruption.

Coastal and marine ecosystems

Coastal wetlands, beaches, mangroves, lagoons, seagrass beds, coral reefs and the open sea account for a large proportion of Kenya's biodiversity. With a coastline 600 km in length, the pelagic marine zone of the open ocean covers almost one-third of Kenya's territorial area.

BOX 4.5: MAJOR THREATS TO COASTAL AND MARINE AREAS

- Coastal development and beach erosion.
- Illegal or unmanaged resource extraction.
- Poor water and waste management and pollution.
- Overfishing and destructive fishing practices.
- Damage to the sea floor due to bottom trawling for shrimps and prawns.
- Climate change, causing ocean warming and acidification.

Coastal and marine resources provide critical, irreplaceable and often undervalued ecosystem services, particularly in protecting the coastline from storms, and in nutrient recycling. Marine biodiversity faces a number of threats ranging from a rapidly growing coastal human population, overfishing and extraction of other resources (Obura, 2001). Heavily-fished reefs not only yield smaller fish and lower yields, but also lead to a proliferation of sea urchins and algal growth that reduce coral growth and the diversity of coral gardens. Tourism has also degraded many reefs through direct damage by low-tide walkers, anchors and overharvesting of corals and shells for ornamentation and trade.

Human population pressures and coastal settlements, among the fastest growing in Kenya, are causing conflict over rights to the use of land and natural resources. The rich keystone coral species are prone to climate change and suffered severe bleaching during the 1998 El Nino.

Kenya's mangroves are being overexploited for wood products and converted to salt-panning, agriculture and other land uses. An estimated half of all mangrove forests have been lost over the past 50 years. Satellite images show rapid loss of mangroves between Ngomeni and Karawa between 2002 and 2008 (yellow arrows, Figure 4.20).

Moorland and Afro-alpine meadow ecosystem

The afro-alpine meadows and moorlands lying 3 000 m above sea-level on Mt. Kenya, the Aberdares and Mt. Elgon are, perhaps, the least modified of

BOX 4.6 : MAIN THREATS TO MOORLANDS AND AFRO-ALPINE MEADOWS

- Global warming.
- Tourism impact through erosion, fires, waste and pollution.

PLATE 4.7: Glacial retreat in Mt. Kenya from 1930s to 2002. *Source: KWS.*

Kenya's biomes due to their high altitude, remoteness from human activity and protection within national parks for many decades. These unique high-altitude ecosystems are, nevertheless, prone to human impact due to their specialized, narrow-ranged plants and animals, and sensitivity to moorland fires and global warming.

Evidence shows that the afro-alpine zone is already responding to global warming. Based on maps produced since the 1930s and subsequent photographic surveys, the largest glacier on Mt. Kenya has decreased by 90 per cent (Plate. 4.7).

The extremely cold-tolerant and high-altitude adapted plants and animals are ecologically the most unique and rare of Kenya's species. They are vulnerable to global warming as the narrow afro-alpine zone shifts upwards with glacial retreat.

Climbers and sightseers pose erosion threats to the thin soils and steep slopes of Mt. Kenya, as well as pollution risks from garbage dumped into lakes and tarns. Runaway fires, many caused by tourists, are hard to control in the remoteness of high altitudes and in the face of strong winds.

THE STATE OF NATURAL RESOURCES

The supply and sustainability of renewable natural resources depends on the state of the ecosystems and biodiversity from which they are harvested. So, for example, Kenya's wildlife attractions account for 80 per cent of US$ 1.2 billion a year generated by the tourism industry. The abundance and richness of wildlife affects visitor satisfaction, the number of visitors drawn to Kenya and the viewing fees they are willing to pay. A fall in wildlife numbers

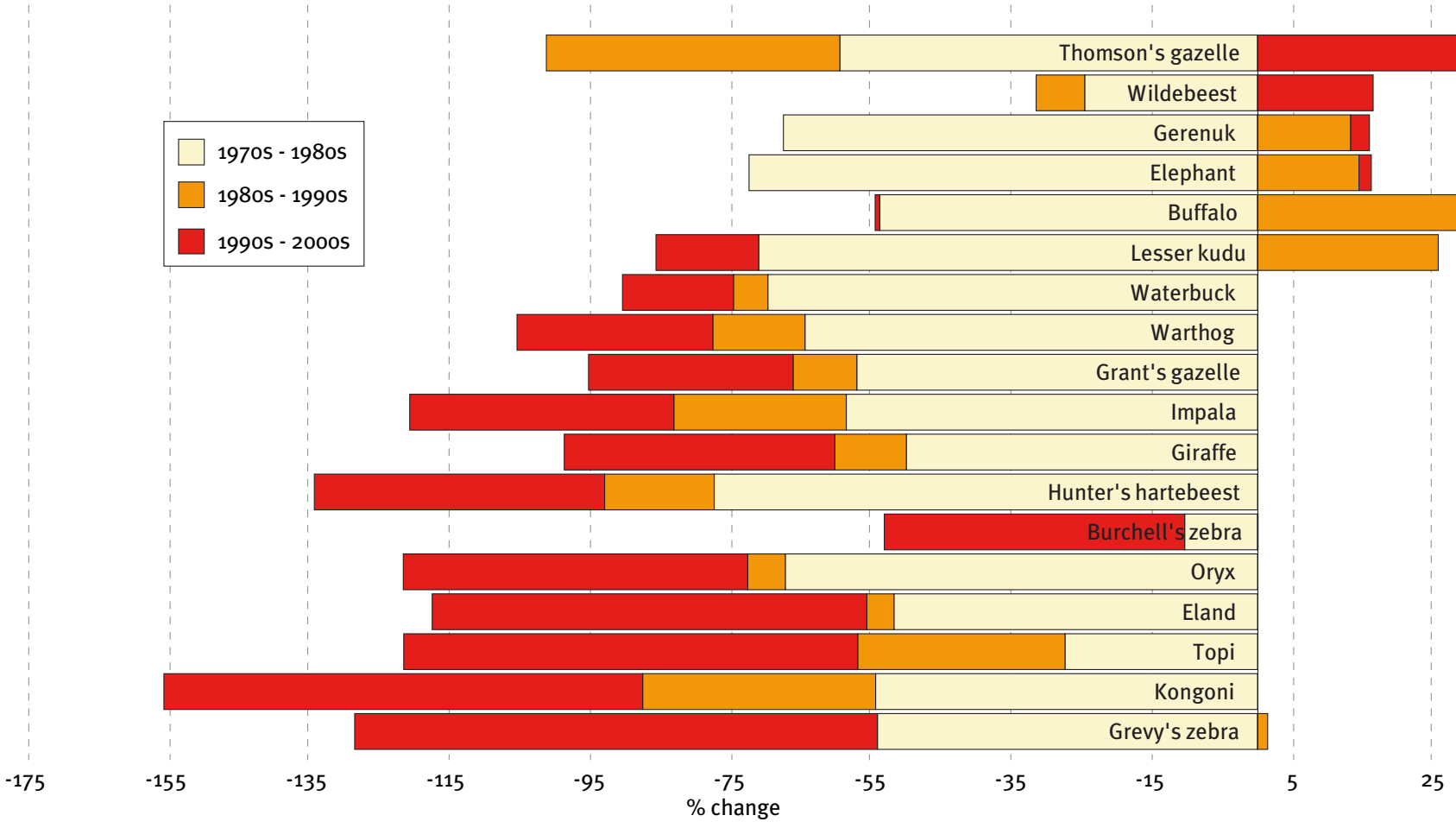
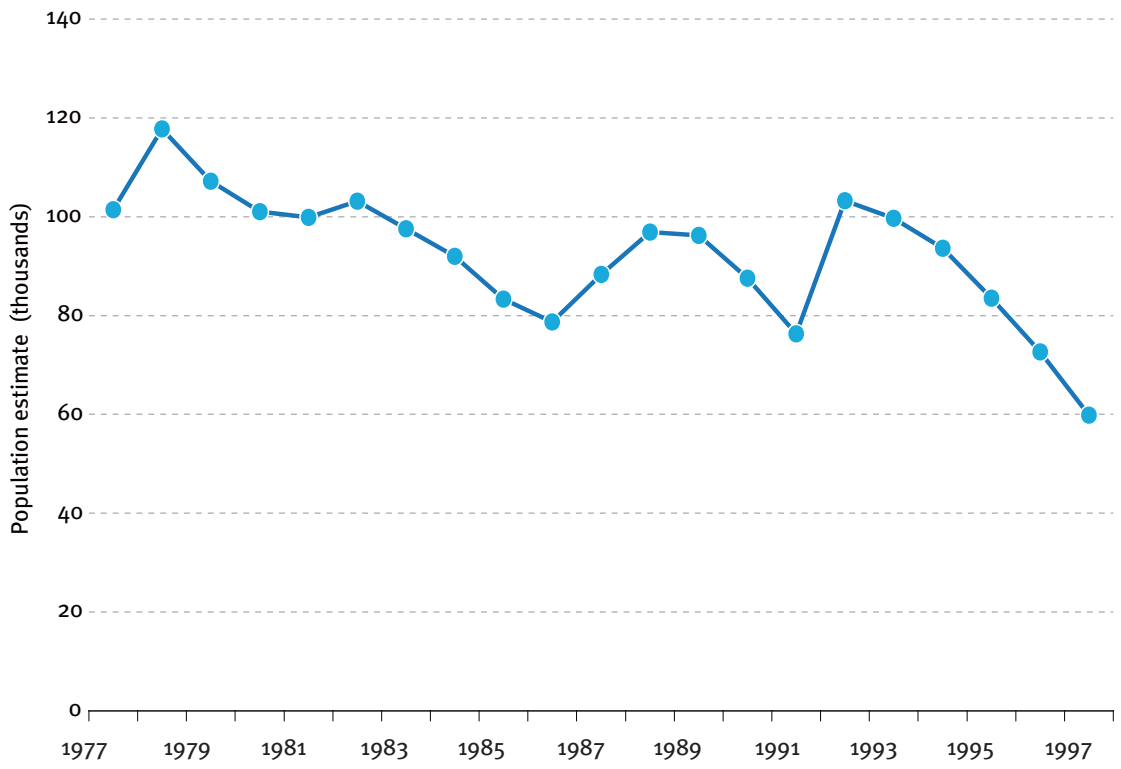


FIGURE 4.20: Wildlife trends in Kenya rangelands indicating large losses in the last 30 years.
Wildlife trends in Kenya rangelands indicating large losses in the last 30 years The period 1990s – 2000s registered heavy declines in Grevy's zebra (74%), Kongoni (68%), Topi (65%), Eland (62%), and Oryx (49%), Burchell's zebra (43%), Hunter's hartebeest (41%), Giraffe (39%) and Impala (38%) populations, There were moderate declines in Grant's gazelle (29%), Warthog (28%) Waterbuck (16%), Lesser kudu (16%) and Buffalo (1%). There were positive increases in Elephant (2%), Gerenuk (3%), W ildebeest (16%) and Thompson's gazelle (38%) populations during the period. *Source: DRSRS*



FIGEUR 4.21: Wildlife trends in parks from 1977 to 1997 match the downward trends outside parks. *Source: Western et al., 2009*

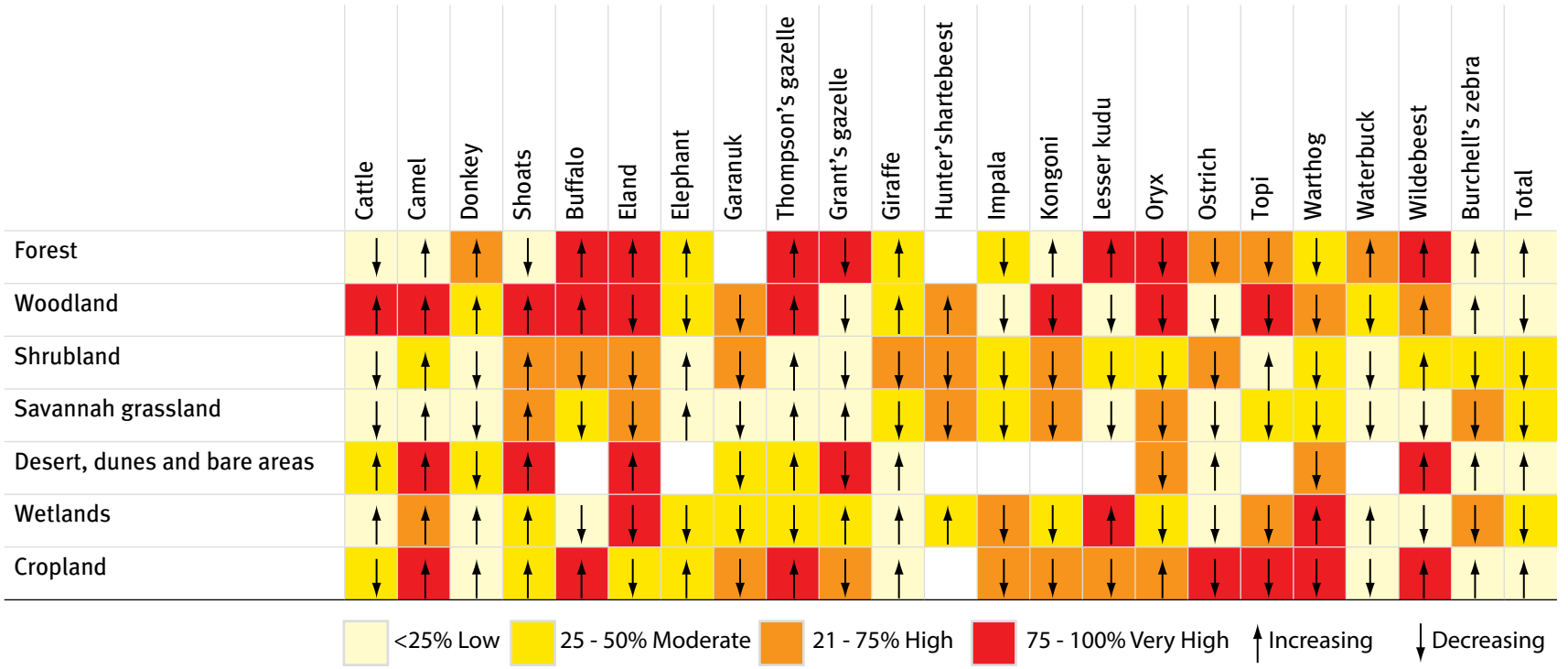


FIGURE 4.22: Wildlife and livestock trends (1990s–2000s) in relation to biomes/ecosystems.
Wildlife and livestock trends (1990s–2000s) in relation to biomes/ecosystems. The largest declines of wildlife occured in the forest, woodland and in the cropland bioms/ecosystem. This are the same area where large transformation have occurred in terms of landcover/land-use changes. *Source: DRSRS.*

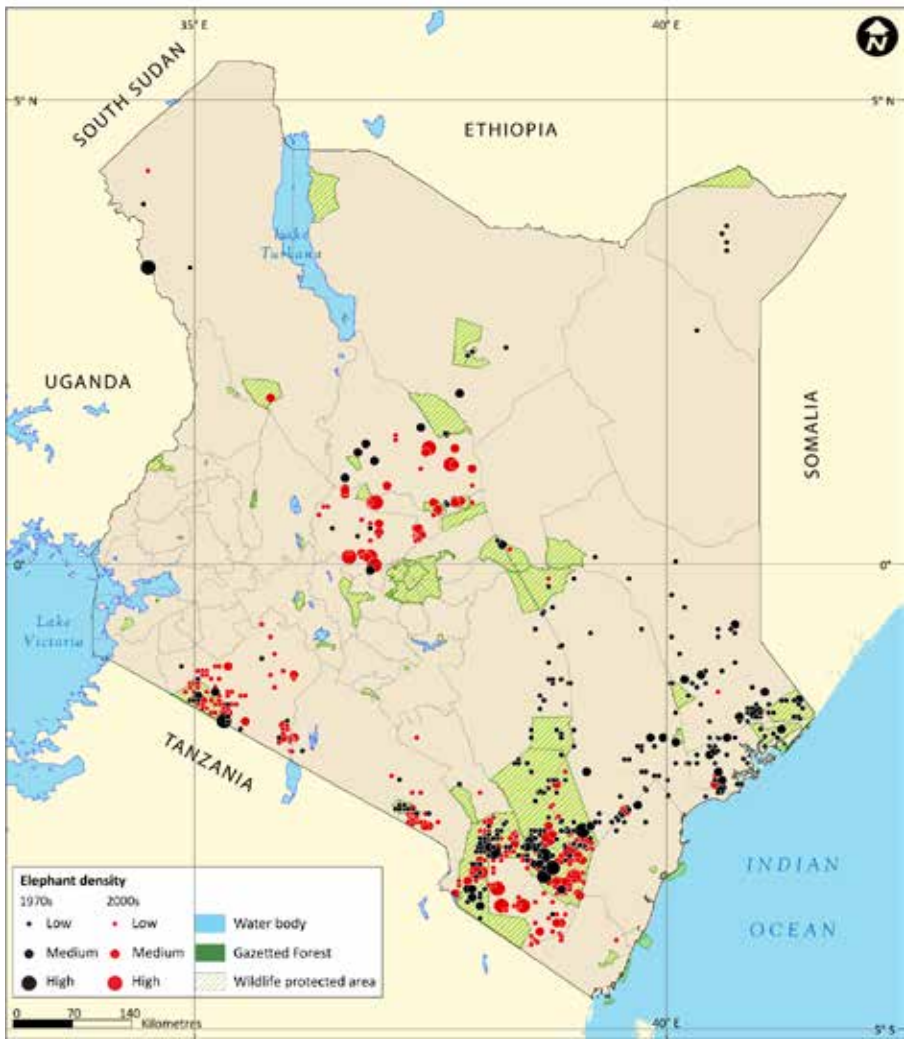


FIGURE 4.23 (a) : Trends in Elephant population
Elephant - In 1970s the elephant population countrywide numbered 160 000 animals, then declined sharply due to poaching to 19 000 in 1989. Since the international ban on ivory in 1990 and strong anti-poaching measures, elephant numbers have grown to 37 000 and this population is again threatened by the rampnat poaching.

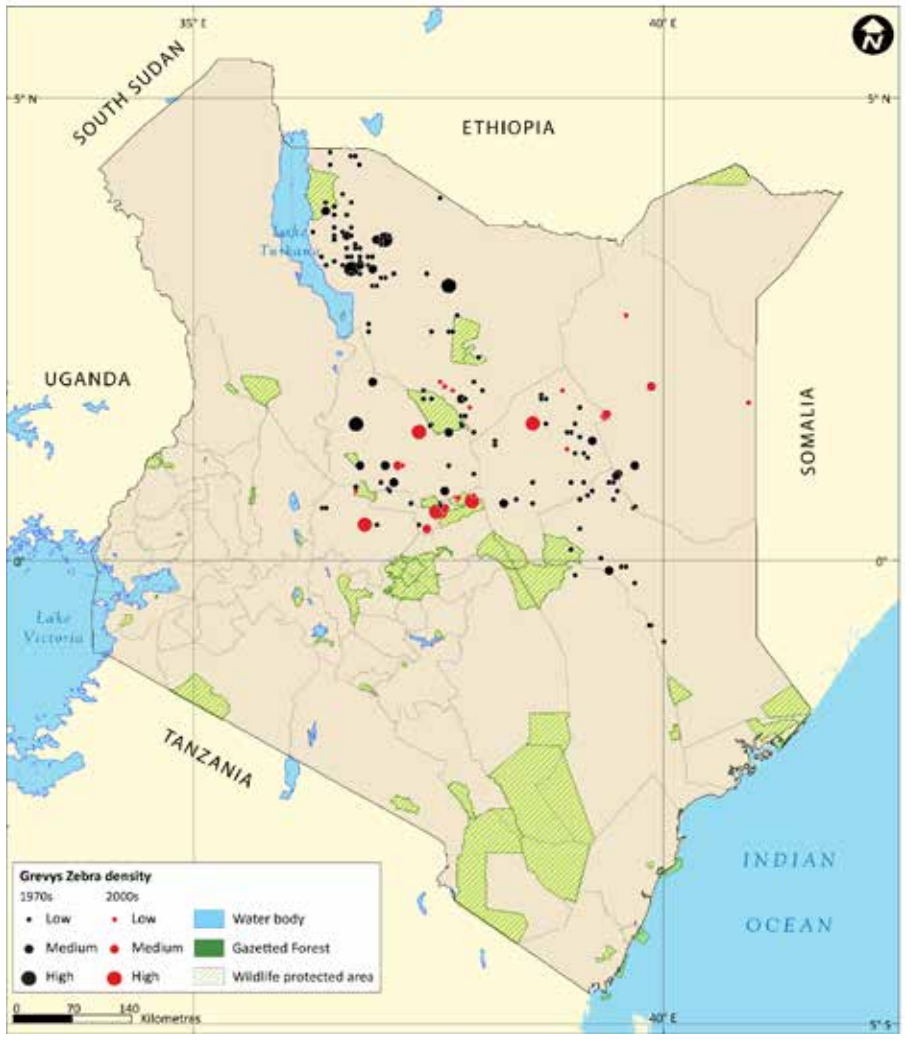


FIGURE 4.23 (b) : Trends in Grevy's zebra population
Grevy's zebra - The Grevy's zebra population numbered 15 000 in the 1970s and declined sharply to 6000 animals in the 1990s and to fewer than 1500 in the 2000s.

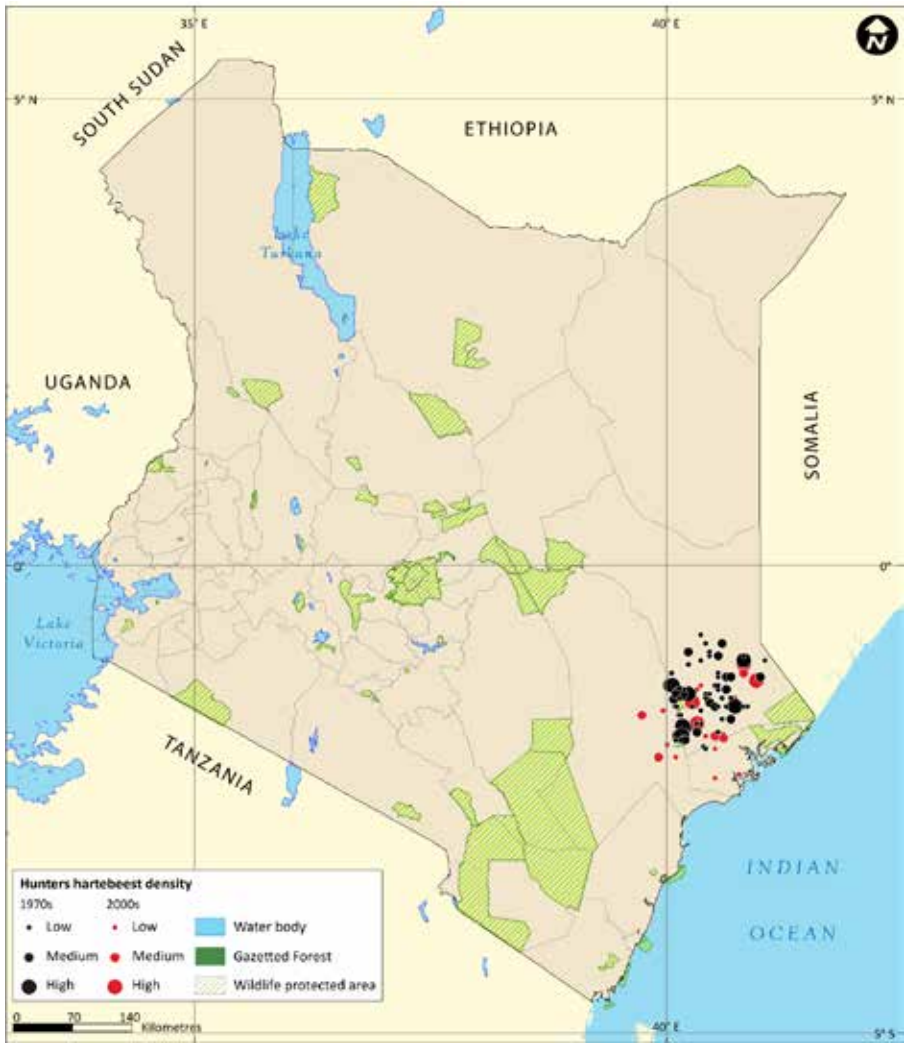


FIGURE 4.23 (c) Trends in Hunter's hartebeest population
The hirola, endemic to Kenya and Somalia, fell from 10 000 animals in the 1970s to fewer than 500 by 1990 and is among Kenya's most endangered species.

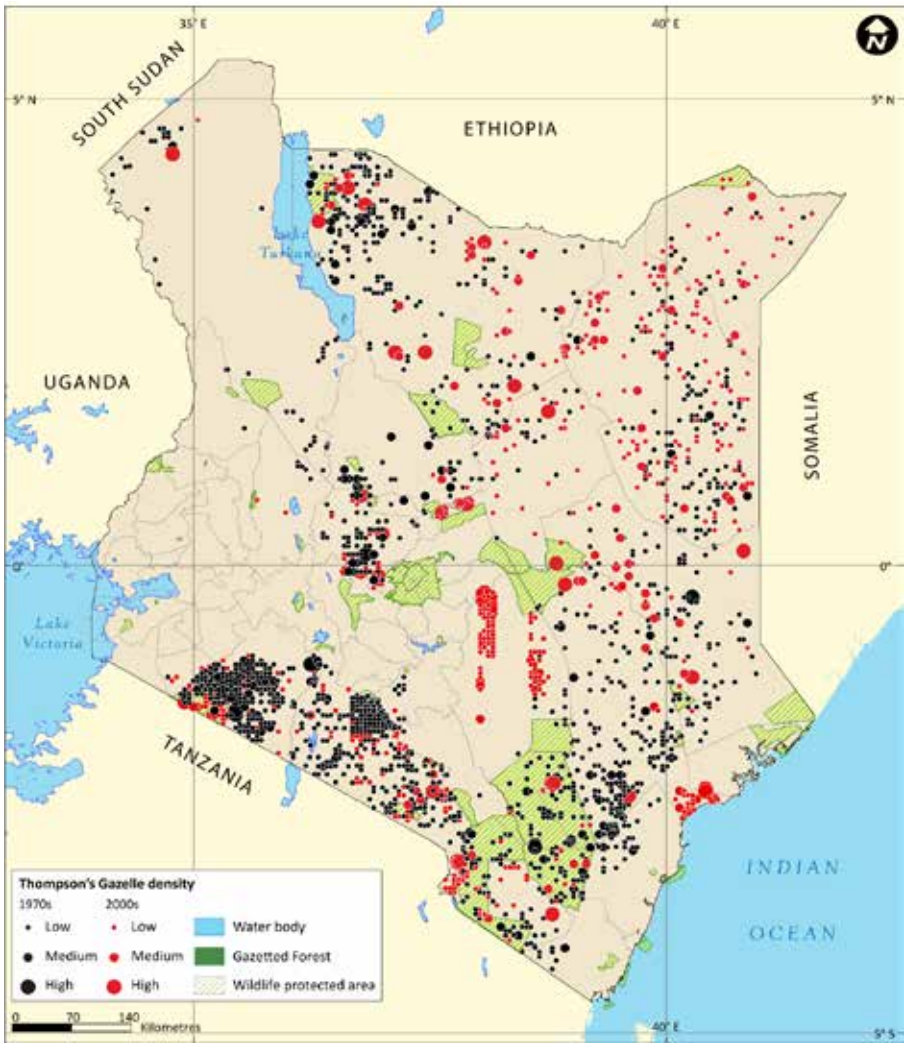


FIGURE 4.23 (d): Trends in Thompson's gazelle population
The population of Thomson's gazelle numbered more than 225 000 in the 1970s, declined to 75 000 by 1990 and has since increased to 100 000.

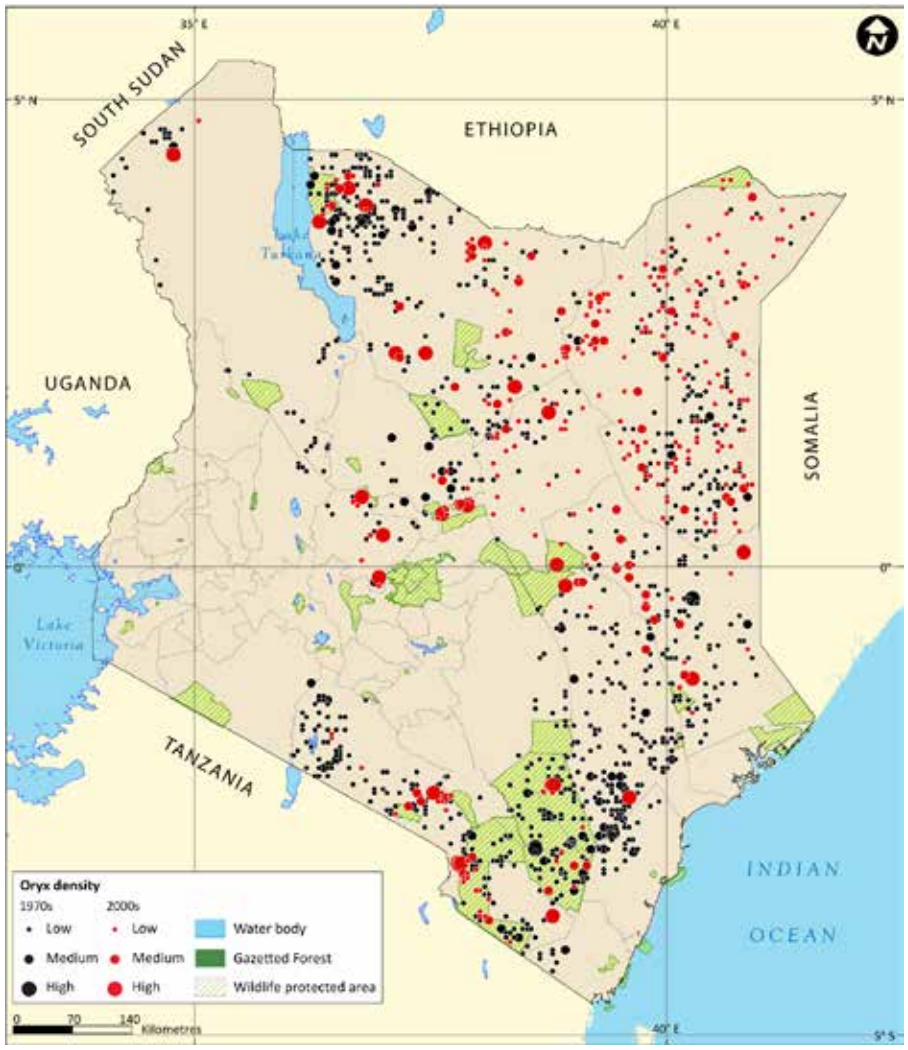


FIGURE 4.23 (e): Trends in Oryx population
The oryx in Kenya numbered more than 90 000 in 1970s and have since declined to about 15 000.

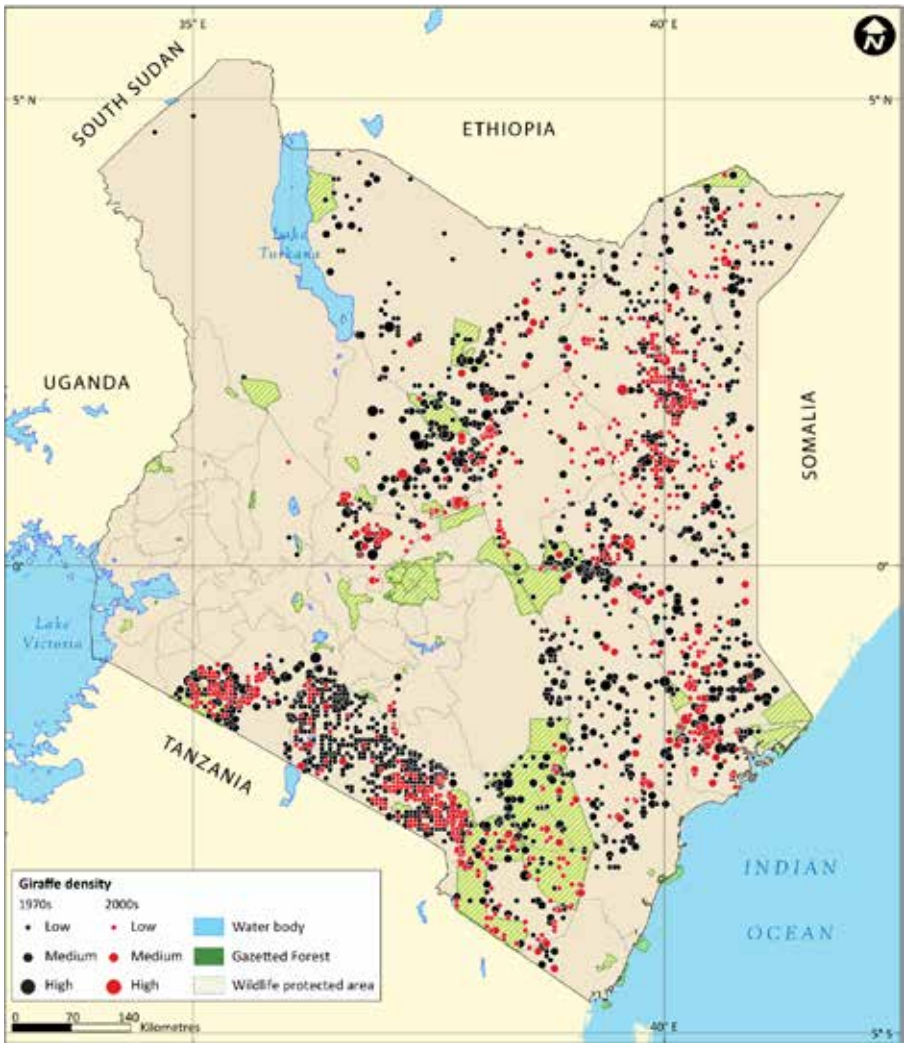


FIGURE 4.23 (f): Trends in Giraffe population
Kenya has three subspecies of giraffe, the Maasai giraffe in central and southern Kenya, the reticulated in north-eastern Kenya and the Rothschild in western Kenya. Populations have fallen from 100 000 in the 1970s to 25 000 by 2010. *Source: DRSRS*

will affect revenue potential. A fall in the numbers of prime viewing species, such as the big cats, elephants and rhinos, adversely affects the Kenyan tourism market. Media coverage of elephant poaching and lion spearing has blemished Kenya's image as an attractive and safe destination from time to time.

Wildlife

Ecological surveys of wildlife populations conducted in the Kenyan rangelands since the mid-1970s show populations have fallen steadily (Grunblatt et al. 1996; Ottichilo et al. 2000). The overall losses stood at 48 per cent between the 1970s and 1980s, halved to 23 per cent in the 1990s, and halved again to 11 per cent in 1990 (Fig. 4.21).

Within the long-established protected areas, overall large mammal populations have demonstrated a trend similar to nationwide patterns, declining by more than 40 per cent in some cases (Fig. 4.22).

Among ecosystems, the heaviest large mammal decline occurred in forests and woodlands.(Figure 4.23).

Forestry

The water catchments function of forests account for the bulk of Kenya's rural and urban water supply and some 70 per cent of power production through hydro generation. The sector contributes approximately Ksh. 20 billion annually. Forestry also accounts for 50 000 jobs directly and 300 000 indirectly. Furthermore, 2.9 million people living adjacent to forests depend in part on forest services and products such as grazing, fishing, wild foods, fuelwood, honey and herbal medicines.

Kenya's forest cover has been the subject of debate for many years. Where original closed-canopy forest covered around 12 per cent of Kenya's land surface, current estimates range from 1.7 to 3 per cent, depending on methodology. The Kenya Forest Service and Kenya National Bureau of Statistics for 2010 (KNBS, 2011) put indigenous closed canopy forest at 1 140 000 ha, public forest plantations at 111 800 ha, private plantations at 90 000 ha, and mangrove forest at 80 000 ha. Tree plantations on farms

TABLE 4.1: **CHANGES IN COVER BY FOREST TYPE BETWEEN 1990 AND 2010.**

	AREA IN HECTARES		
FOREST CANOPY COVER PER FOREST TYPE	1990	2010	% Change
Moderately Dense 40–65% CC	1 013 227	976 275	-4
Bamboo	20	8552	42 587
Mangrove	987	116	-88
Natural Forest	991 932	926 604	-7
Plantation Forest	20 288	41 003	102
Open 15–40 % CC	1 208 155	1 272 841	5
Bamboo	436	745	71
Mangrove	389	5 692	1 364
Natural Forest	1 191 054	1 247 614	5
Plantation Forest	16 277	18 790	15
Very Dense ⇢ 65 % CC	2 502 307	1 980 900	-21
Bamboo	55 548	76 396	38
Mangrove	60 442	42 720	-29
Natural Forest	2 259 184	1 728 180	-24
Plantation Forest	127 133	133 605	5
Grand Total	4 723 689	4 230 017	-10

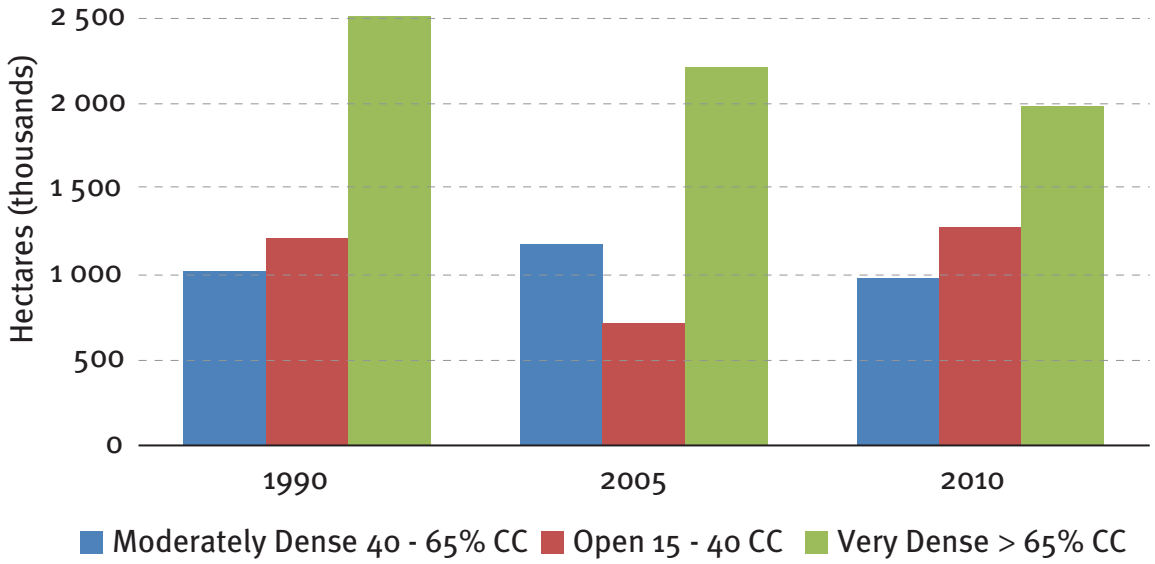


FIGURE 4.24: Trends in dense, moderately-dense and open forest.
Dense forest cover in Kenya continued to decline over the two decades 1990 to 2010, though at a slowing rate. Moderately-dense forest declined marginally and open forests increased.

are spreading and cover over 10 million ha. According to the Global Forest Resources Assessment of 2010 (FAO–FRA 2010), the overall woody biomass of Kenya's forest declined from 901 to 817 million tonnes dry weight over the two decades 1990 to 2010.

Trends are as important as total area of forest when it comes to conservation status. A comparison of forests by type and cover undertaken by the Regional Centre for Mapping and Regional Development, and Kenya Forest Service, for the period 1990 to 2010 shows a continuing loss overall, but at a slowing rate, and gains in some categories (Table 4.1). Dense forests declined by 20 per cent and dense natural forests by 23 per cent. Moderately dense forests also declined, but at a far slower rate of 3.7 per cent. Open forests, in contrast, increased by 5.1 per cent. The differing trends are shown in Fig. 4.24. The slowing trends suggest that forest conservation measures are beginning to take root. An 18 per cent increase in plantation forest indicates a steady growth in commercially grown forests in response to decreasing use of natural forests.

TABLE 4.2: **DISTRIBUTION OF KENYA'S BIOMASS ENERGY RESOURCES BY VEGETATION TYPE**

Vegetation type	Quantity
Indigenous vegetation	16 307 703 m^3
Farmlands — mainly exotic tree species such as Grevillea, Eucalyptus and remnant natural vegetation	14 380 951 m^3
Forest plantations	2 717 972 m^3
Residues from agriculture and wood based industries	3 085 800 m^3
Total	**36 492 426 m^3**

Source: Republic of Kenya (2002)/ Mugo and Gathui (2010)

Biomass energy

Biomass energy is organic matter of either plant or animal origin. The main forms include fuelwood, charcoal, ethanol, biodiesel and biogas. According to the Energy Regulatory Commission, about 70 per cent of Kenya's energy is biomass based, meeting more than 90 per cent of rural and about 80 per cent of urban household needs. Approximately one-third of biomass energy derives from charcoal, the rest from firewood. Kenya's current demand for fuelwood is 37 million m^3 against an estimated sustainable supply of about 30 million m^3 (KFS, 2011). The distribution of Kenya's biomass is outlined in Table 4.2.

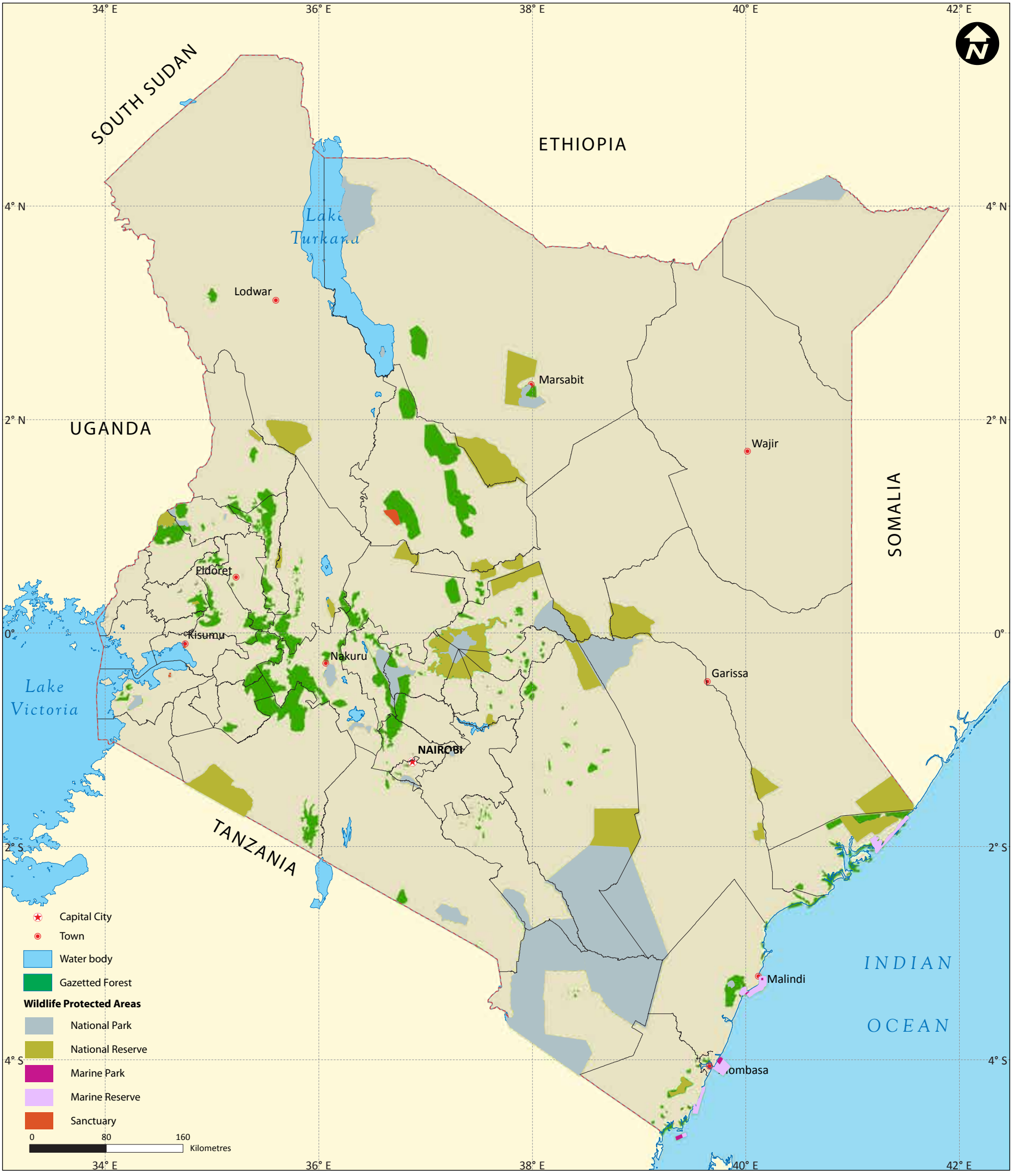


FIGURE 4.25: The distribution of National Parks, National Reserves, Marine Parks, Marine Reserves, Sanctuaries and Gazetted Forests. Nationally protected areas have formed the backbone of Kenya's conservation efforts. *Source: KWS*

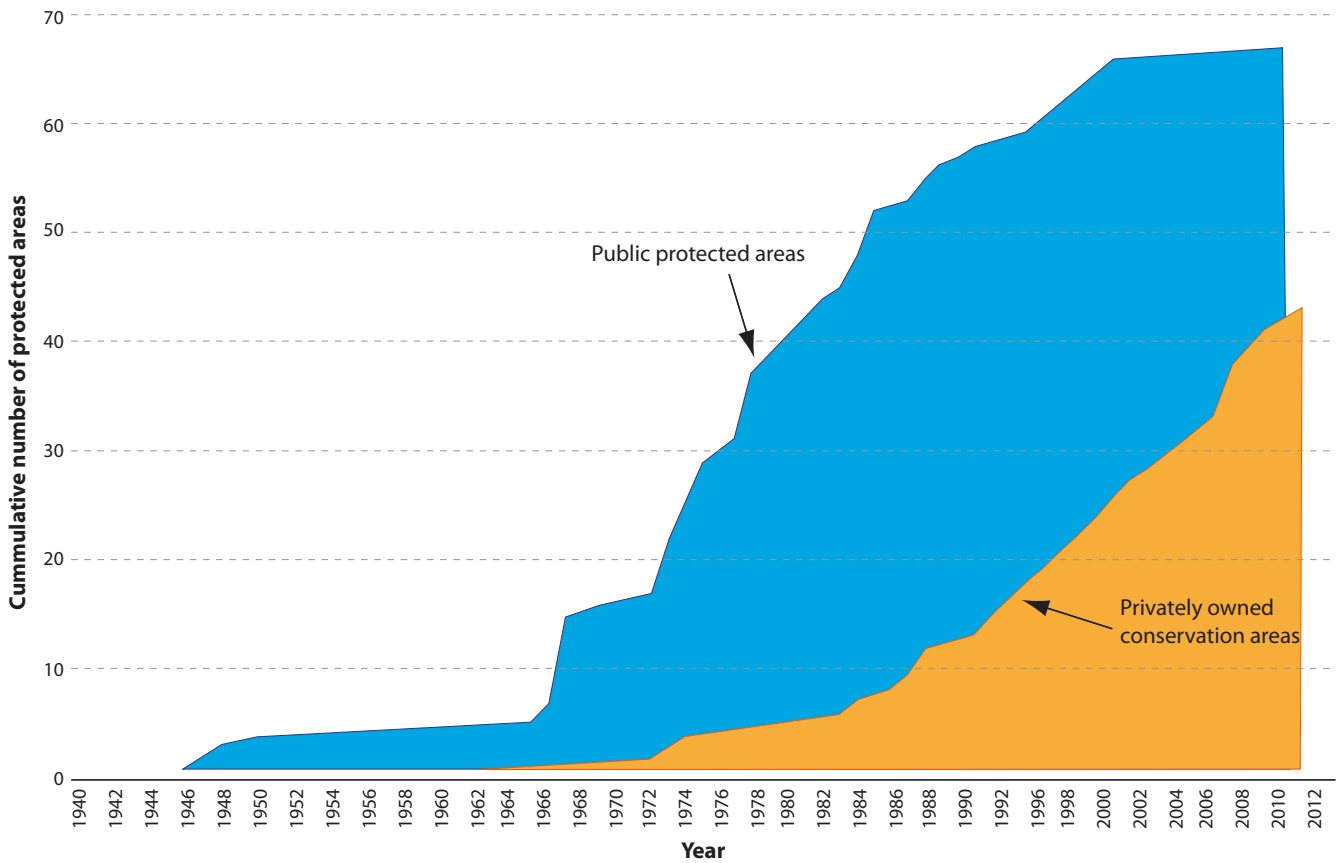


FIGURE 4.26: The growth of protected areas by year.
Burgeoning voluntary environmental initiatives since the 1970s have led to a growing proportion of Kenya's conservation activities taking place on private and community lands. *Source: KWS, ILRI, ACC, NRT, AWF*

Most charcoal is produced in traditional kilns with very low efficiency. Fuelwood and charcoal are mainly used by rural and peri-urban households, (including a substantial cottage industry) for brick making, tobacco curing, milk processing, fish smoking and baking.

THE RESPONSES

Conservation attitudes and measures have tracked the changes in the governance, aspirations and concerns of Kenyan society since the late 1800s. Traditional communities' husbandry practices, aimed at sustaining livelihoods (Chapter 2), gave way in the colonial era to the centralized governance of hunting, forests, fisheries, soils and waters through legislation, regulation, mandated husbandry practices, restricted uses and enforcement.

The command-and-control approach to land and natural resource management was at first ineffective, given the small capacity of the colonial service, the size of the country and limited infrastructure. Once the game, forestry, fisheries and agricultural departments were established and bolstered by enforcement, extension and research services, conservation became more effective. After independence, the conservation role of the government, complemented by county councils, expanded but fell far short of abating biodiversity loss and environmental degradation.

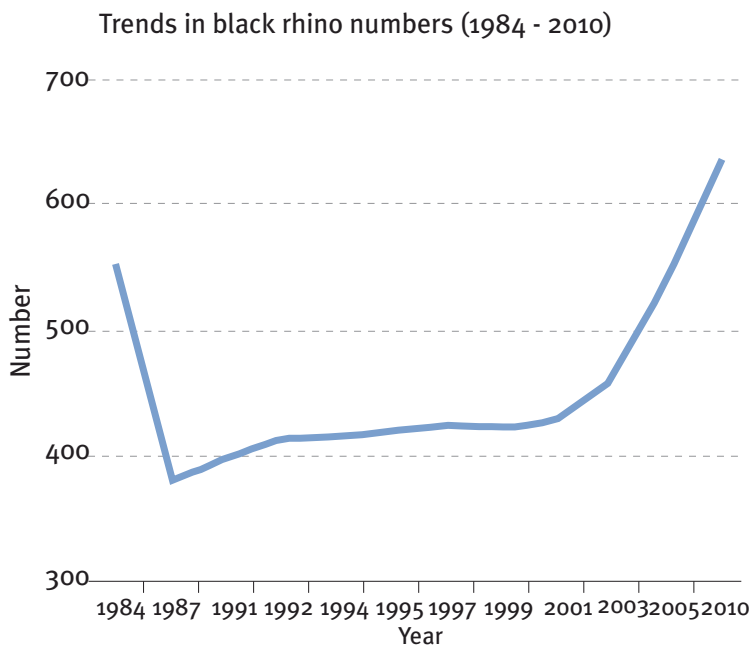


FIGURE 4.27 (a)

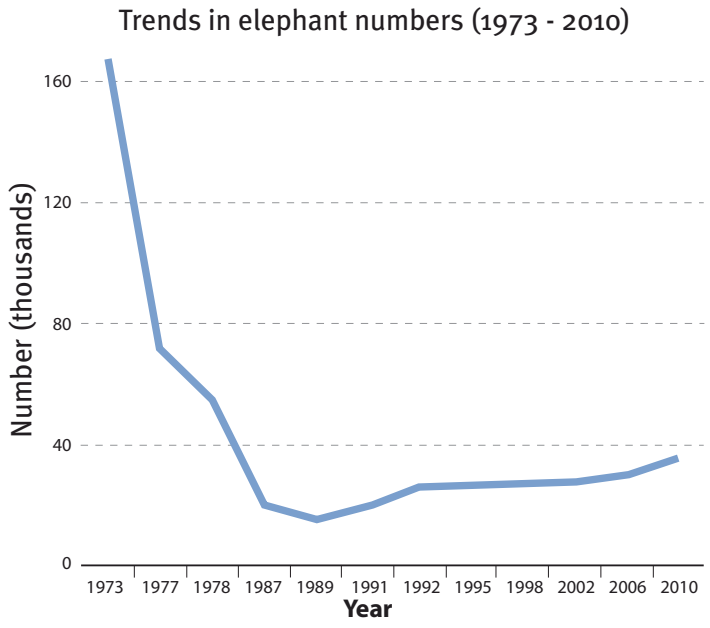


FIGURE 4.27 (b)

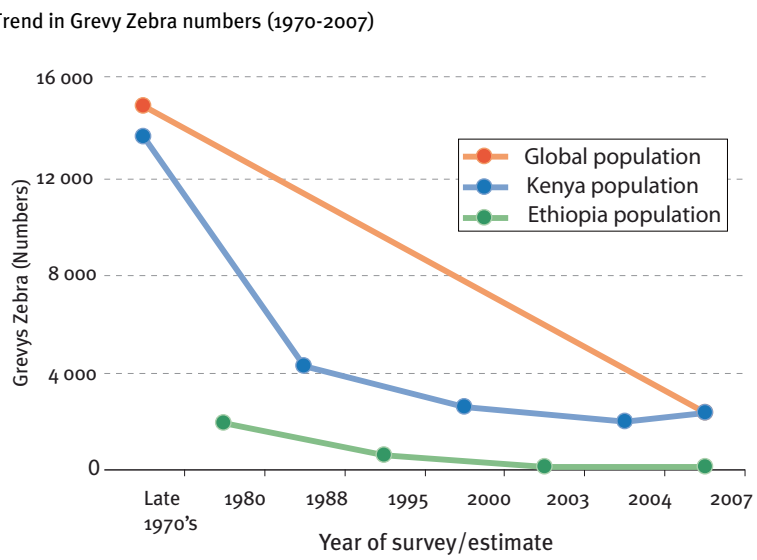


FIGURE 4.27 (c)

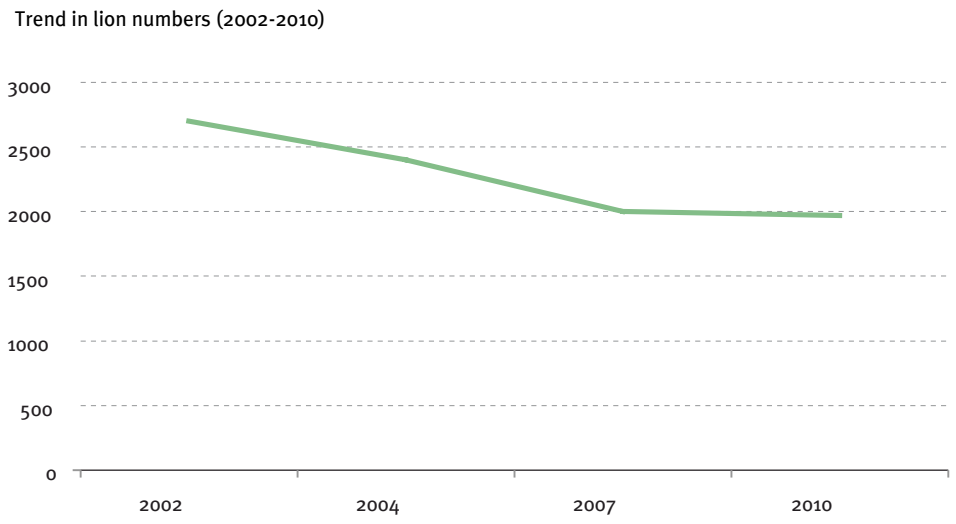


FIGURE 4.27 (d)

FIGURE 4.27: Trends in wildlife population
Trends in wildlife populations show the mixed success of kenya's conservation efforts. stringent anti-poaching operations have stemmed the collapse of populations in the 1970s and 1980s leading to a steady recovery, Grevy's Zebra and Lion populations have also declined sharply and have yet to recover.

The growing population and environmental impact in the 1960s and 1970s saw the birth of non-governmental organizations and private sector conservation. The rising tide of democracy in the 1980s and 1990s gave energy to landowner and community-based conservation organizations, and a swelling number of voluntary environmental initiatives (Figure 4.26).

These changing aspirations and concerns over the decades have also shaped the goals and methods of conservation. Most conservation efforts in the colonial and early independence years stemmed from the poor use and overuse of species, habitats and natural resources. The scope of conservation began to widen with the environmental movement of the 1960s, and with a growing body of scientific knowledge. By the 1990s conservation goals widened yet again to embrace biodiversity as something of intrinsic and cultural value and the foundation of sustainable use. By the 2000s, conservation goals expanded yet further in recognition of ecological services and natural capital as the cornerstone of human welfare and wellbeing.

CURRENT POLICIES AND LEGISLATION

The Kenya government's current policies, legislation and institutional structure largely reflect the evolution of conservation awareness and responses since the creation of the modern state. The early focus on wildlife and natural resources began to expand in the 1970s, reflecting Kenya's strong participation in international efforts to combat global environmental threats.

One of the most far-reaching and successful measures Kenya took to protect wildlife was the establishment of the Kenya Wildlife Service (KWS) through the Wildlife Conservation and Management Act (Amended) of 1989 (Kenya Wildlife Service, 1989). KWS was set up as a semi-autonomous body to protect wildlife throughout Kenya. The act was intended to solidify the Wildlife Policy of 1977. The policy points out the need to identify the best land-uses (or combination of uses) for specific areas, their long- and short-run benefits to people and the fair distribution of their benefits. The policy aims to preserve parks and reserves in a "reasonably natural state" as examples of the main habitats found in Kenya. It clearly states that wildlife shall be protected from over-utilization and that parks shall be managed within the context of a larger ecosystem to ensure their viability.

The principles of sustainability, integrated land use, ecosystem management and equity in wildlife income were inherent in the 1977 Wildlife Policy but are not fully reflected in wildlife legislation. This omission changed with Kenya's adoption of the CBD the enactment of the Environmental Management and Coordination Act (EMCA) in 2000, and the establishment of an overseeing regulatory, the National Environmental Management Authority. EMCA rests on a number of guiding principles, including the principles of sustainable development, precautionary use and equity.

The role of National Environmental Management Authority (NEMA) is to supervise and coordinate all matters relating to the environment, and to serve as the principle instrument of Government in the implementation of environmental policy. Its functions are to coordinate the activities of environmentally relevant bodies in order to promote rational use and sustainability; take stock of natural resources; audit their utilization and threats; conduct surveys; set environmental standards and guidelines; regulate and oversee Environmental Impact Assessments; enforce regulations; and educate and advise the public and relevant sectors. The act also calls for NEMA to prepare an annual report on the state of the environment for submission to parliament. Finally, NEMA was mandated to institutionalize cooperative governance and integrated environmental management through cross-sectoral policies, laws and the developmental process, guided by the National Environmental Action Plan (NEAP).

In keeping with its international commitments, Kenya is party to many conventions dealing with environmental protection, including the Convention on International Trade in Endangered Species, The Ramsar Convention on Wetlands, the Convention on Migratory Species and the Kyoto Protocol. Under the constitution these international conventions are domesticated in Kenyan law.

Following the legal passage of EMCA and the establishment of NEMA, in line with its commitment to biodiversity conservation and broader public and community engagement, and in response to growing environmental threats, Kenya has revised its policies and legislation. Subsequent policy and legislation soon followed, including the Water Act 2002, Forest Act 2005, Wetlands Conservation and Management Policy Draft 2008, National Land Policy 2009 and the Climate Change Bill of 2010. Each new item of policy and legislation recognized the broad values of biodiversity, the need to widen the scope of conservation to include land-use and the ecosystem approach, and to incorporate biodiversity in natural resource management. Vision 2030 recognized that the growth of Kenya's economy rested heavily on the productivity of its natural resources and charted the path towards sustainability.

The National Land Policy went a step further in laying out the rationale and framework for the integration of environmental protection. It recognized the need to survey all critical ecosystems, determine sustainable land-uses, establish measures to ensure environmental protection through land-use controls and to protect fragile ecosystems.

This newly emerging landscape, giving recognition to the importance of biodiversity and environmental protection, was embedded in the Constitution of Kenya 2010. The supreme law of the land gives the environment legal standing, every citizen the right to a clean and healthy environment, and a duty to sustain it and to ensure that the government does so too. The constitution devolves political authority to county governments, communities and individual landowners and managers.

Since 2010 Kenya has embarked on a raft of new policy and legislative measures to bring environmental conservation and management in line with the new constitution, as outlined in the next chapter.

Conclusions

Kenya recognized the importance of wildlife and sound natural resource management well over a century ago. In the years since, a growing body of understanding, knowhow and action has focused on the health of the environment to the point that it is now enshrined in the constitution as the right and duty of every citizen.

The values ascribed to the environment have widened from utilitarian, food, water, shelter and materials, to the many ecological, economic and cultural services we today recognize that biodiversity provides. The government has broadened and deepened its commitment to species, habitats and now biodiversity conservation through policy, legislation, protection and, increasingly, through public outreach and engagement. The growing values ascribed to the environment have seen voluntary and collaborative initiatives burgeon as the ability of the government to deal with the welter of threats has shrunk.

Notwithstanding public and private sector initiatives and some tangible reversals, this chapter shows that the state of species, habitats and the environment is still in decline—and the causes of decline are much the same as GBO3-identified drivers of worldwide biodiversity loss.

The declines point to the need to address the underlying causes rather than the symptoms of biodiversity loss. The systemic causes stem from population growth, burgeoning consumption, and expanding human impact. They can only be tackled through macroeconomic and political policies that alleviate poverty and inequality, programs that build awareness of the value of biodiversity, and the opportunity and capacity to benefit through sustainable use.

Several gaps remain in realizing these goals. They include mapping biodiversity, defining the threats and status, fully valuing ecosystem services, devolving and distributing rights and responsibilities for management as widely as possible and, at a national level, developing an integrated framework for auditing and monitoring natural capital.

CHAPTER

05

Valuation of BIODIVERSITY & ECOSYSTEM SERVICES

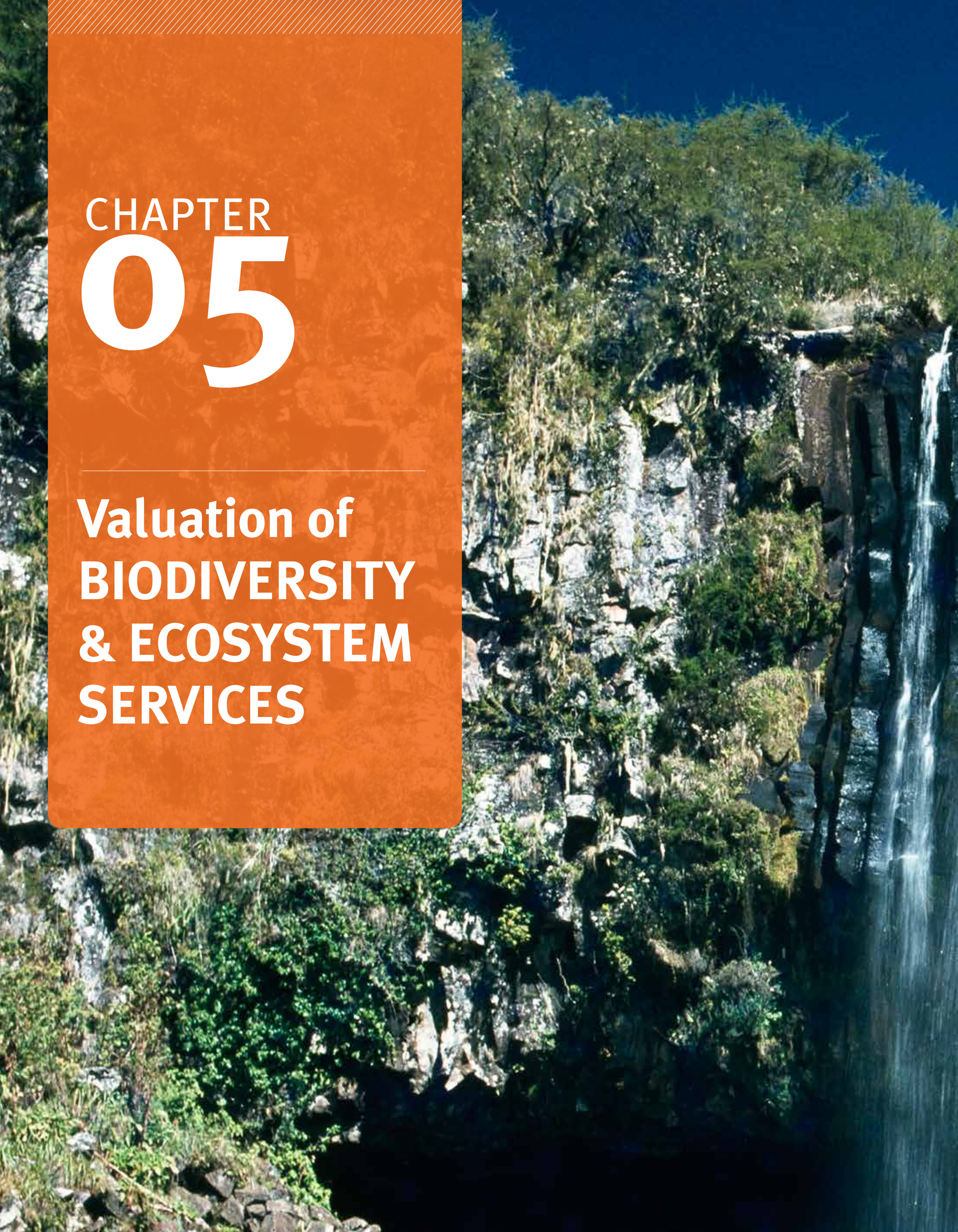


PLATE 5.1 Thompson Falls also known as Queens cave or T-Falls. © *Camerapix Ltd.*

Valuing Biodiversity and Ecosystem Services

Following the 2010 State of the Environment recommendations on embracing environmental accounting, Kenya was one of the first signatories to the Communiqué on Natural Capital Accounting at the Summit for Sustainability in Africa in May 2012. Nine other African countries also signed on. A month later at the Earth Summit in Rio, dozens more countries followed suit (WB 2012). The Communiqué on Natural Capital Accounting recognizes the limits of Gross Domestic Product (GDP) in measuring national progress and proposes adding environmental accounting to the exercise. The adoption of the Communiqué marks an international shift to widening national auditing and monitoring to reflect the multiple dimensions of a nation's wellbeing.

Kenya's adoption of natural capital accounting is essential to fulfilling the Vision 2030 goal of creating a globally competitive and prosperous nation with a high quality of life by 2030. Although the economic, social and political pillars are well articulated in Vision 2030, Kenya's natural capital and the ecosystem services accruing from its forest, freshwater, wetland, savannah and coastal ecosystems must also be elevated to a national pillar in order to ensure sustainable development. For example, agriculture is expected to contribute an additional Kenya Shillings (KES) 80–90 billion (US$ 1–1.125 billion) to the GDP by 2030 (GoK 2007). To achieve this objective, Vision 2030 proposes investing in agriculture and processing facilities, and dramatically increasing the area under agricultural production to boost yields. These strategies, however, fail to take into consideration the importance of agricultural and non-agricultural ecosystems such as the drylands, forests, wetlands and lakes in supplying water, contributing to soil fertility, providing forage and supporting pollination.

The State of the Environment Report 2010 makes it clear that Kenya must invest in its ecosystems to reverse environmental degradation (NEMA 2011 and Chapter 3 of this Atlas) to meet her agricultural and other developmental objectives.

A rapid decline in Kenya's biodiversity (Chapter 4) undercuts the Vision 2030 objective of boosting tourism revenues to more than KES 200 billion (US$ 2.5 billion) by improving infrastructure, diversifying visitor activities and preserving wildlife corridors (GoK 2007). Expansion of agricultural activity and land subdivision are already depriving wildlife access to water and forage. Balancing the agricultural and tourist sectors will be critical if Kenya is to achieve and maintain middle-income status. Similar tradeoffs between ecological, economic and social capital will need to be made in all ecosystems, including forests, savannahs and marine ones.

Social, economic and natural capitals are interdependent and only partially interchangeable (PCAST 2011). Unless the value of natural capital to the economy and society is fully recognized, managed and developed, poor decisions will undermine Kenya's capacity to expand and sustain its growth. Although the contribution of the fisheries, forestry and wildlife sectors to the national economy are partially recognized, many other ecosystem services contributing to people's livelihoods, health, security and cultural heritage are poorly appreciated.

Natural capital assessment redresses the discounting and undervaluation of ecosystem services. In Kenya and throughout the world, many efforts are underway to value and include natural capital in national accounting and local decision-making and planning.

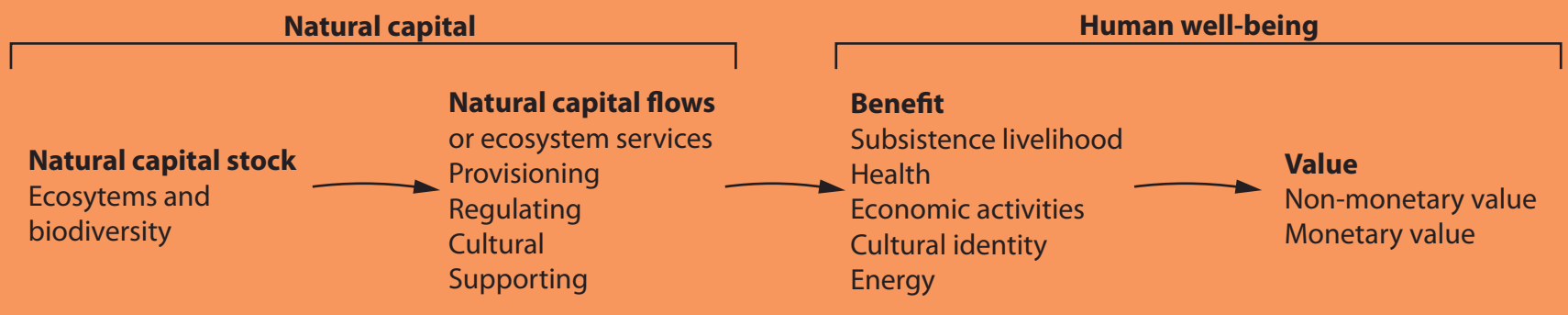
This chapter draws on case-studies, local and international, to illustrate how Kenya can secure both long-term economic growth and societal wellbeing.

BOX 5.1: NATURAL CAPITAL, BIODIVERSITY AND ECOSYSTEM SERVICES

Natural capital comprises Earth's natural assets of ecosystems and biodiversity, and the ecosystem services that flow from them and contribute to human economic, social and cultural wellbeing (adapted from UNEP 2012)

Ecosystem services can be categorized as (MA 2003):

- Provisioning: products obtained from ecosystems such as food, freshwater, natural medicines, genetic material and fuel wood.
- Regulating: benefits obtained from ecosystem processes such as storm protection, erosion control and waste water purification.
- Cultural: non-material benefits such as spiritual enrichment, physical and mental development, aesthetics and recreation.
- Supporting: services essential for sustaining all other ecosystem services such as primary production and habitats.



TYPES OF ECOSYSTEMS

Ecosystems in Kenya are varied, as are the services they supply (Figure 5.1). Chapter 3 has shown the many values flowing from Kenya's biomes, ecosystems and human uses of the land and biodiversity. Natural capital, like human and social capital, can be improved or overexploited, depending on how it is managed. Many

TABLE 5.1: **EXAMPLES OF ECOSYSTEM SERVICES**

Use of ecosystem goods and services from major sectors in Kenya		
Major sectors of Kenya's economy	Examples of ecosystem services on which the sector depends on	Examples of ecosystems that provide these ecosystem services
Agricultural	Food from crop and livestock Fibres, biodiesel, timber, fodder Water flow regulation Regulation of climate, pollination, and pest control	Forests Montane Savannah
Tourism	Wildlife tourism, beach erosion control, and spiritual value	Savannah, Montane, Coastal and Marine Forests
Energy	Woodfuel, dung, charcoal, water, water flow regulation Erosion control	Forests, Woodlands Rivers
Fisheries	Food from fisheries and aquaculture Primary production and waste water treatment	Lakes and Rivers Coastal and Marine
Forestry	Timber, non-timber forest product (Gum)	Forests and Woodlands
Pharmaceutical and Health	Medicine and Essential oils	Forests, and Coastal and Marine (fish oil)

TABLE 5.2: **EXAMPLES OF ECOSYSTEM SERVICES**

Example of ecosystem	**Examples of ecosystem services**
Afro-montane	Freshwater from the Tana river*
	Climate regulation**
	Regulation of water flow from slow melting of snow**
	Hiking and alpinism***
	Sacred site in Kikuyu culture***
Forest	Non-timber forest product* (e.g. mushrooms, medicinal plants)
	Climate regulation**
	Erosion control**
	Flood regulation**
	Recreation and tourism***
Agricultural ecosystem	Food (e.g. cereals, intensive dairy farming, rice cultivation)*
	Flowers for export*
	Pollination of crops**
	Soil carbon sequestration**
	Pest regulation for crops**
Savannah	Food from livestock*
	Recharge of aquifers (e.g. Lorian swamp)**
	Climate regulation**
	Wildlife-tourism***
	Pastoralists' cultural heritage***
Desert	Camel milk and meat*
	Tourism***
	Northern Kenyan cultural heritage***
Urban areas	Food from chickens and goats*
	Flood regulation from urban wetlands**
	Dust capture by trees**
	Recreation in green spaces***
Coastal and Marine	Food from capture fisheries and aquaculture*
	fuelwood*
	Coastal defense**
	Beach outings***
	Snorkeling***
	Swahili cultural heritage***

Legend: * Provisioning service ** Regulating service *** Cultural service

TYPES OF ECOSYSTEMS SERVICES

Afromontane:
- Freshwater*
- Climate regulation**
- Regulation of water flow from slow melting of snow**
- Hiking and alpinism***
- Sacred sites***

Woodlands:
- Agriculture*
- Livestock*
- Wood products*
- Water Catchment**
- Flood regulation**
- Recreation***

Forest:
- Forest product*
- Water Catchment**
- Climate regulation**
- Erosion control**
- Flood regulation**
- Recreation***
- Tourism***

Savannah:
- Livestock*
- Recharge of aquifers**
- Climate regulation**
- Tourism***
- Cultural heritage***

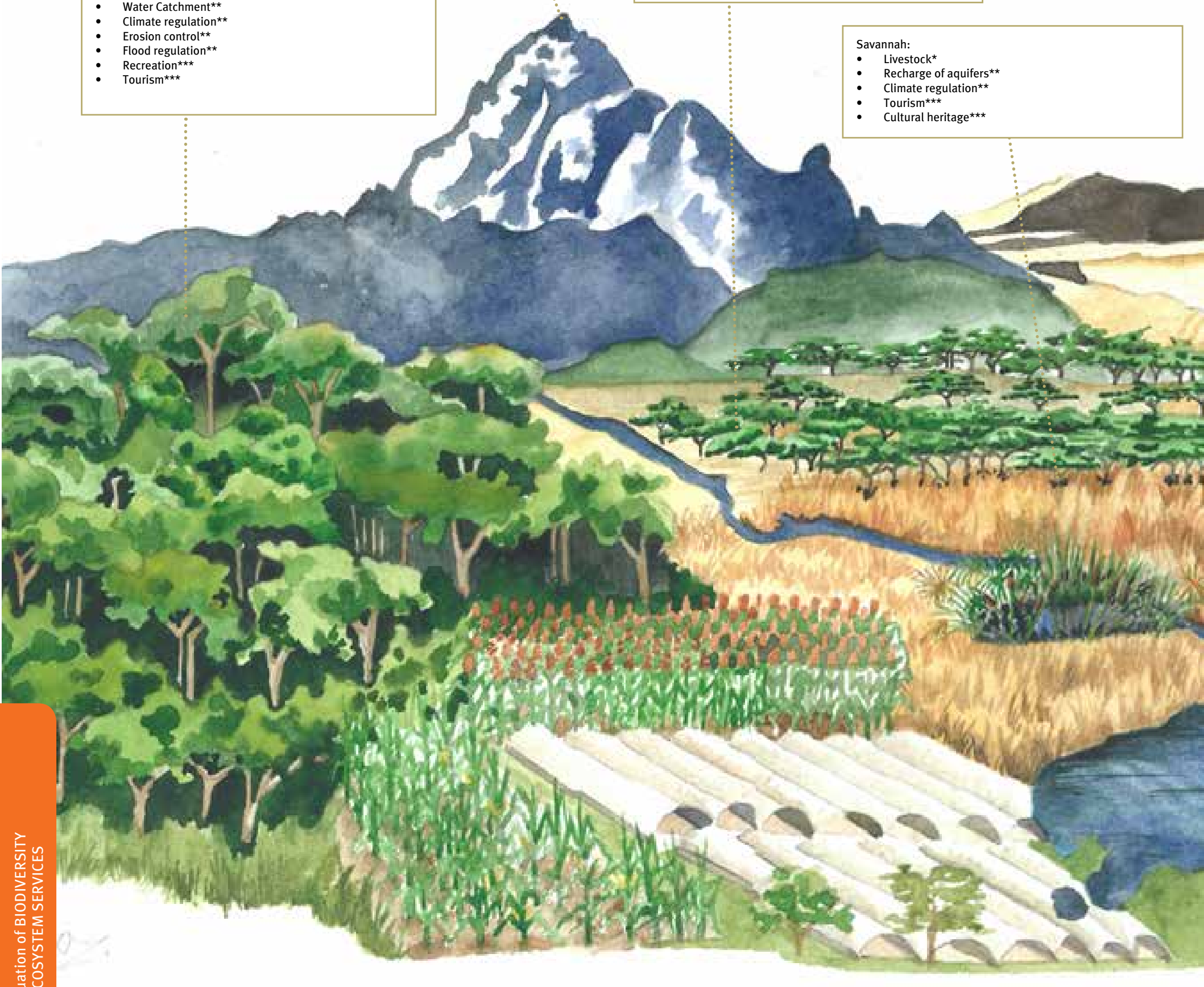


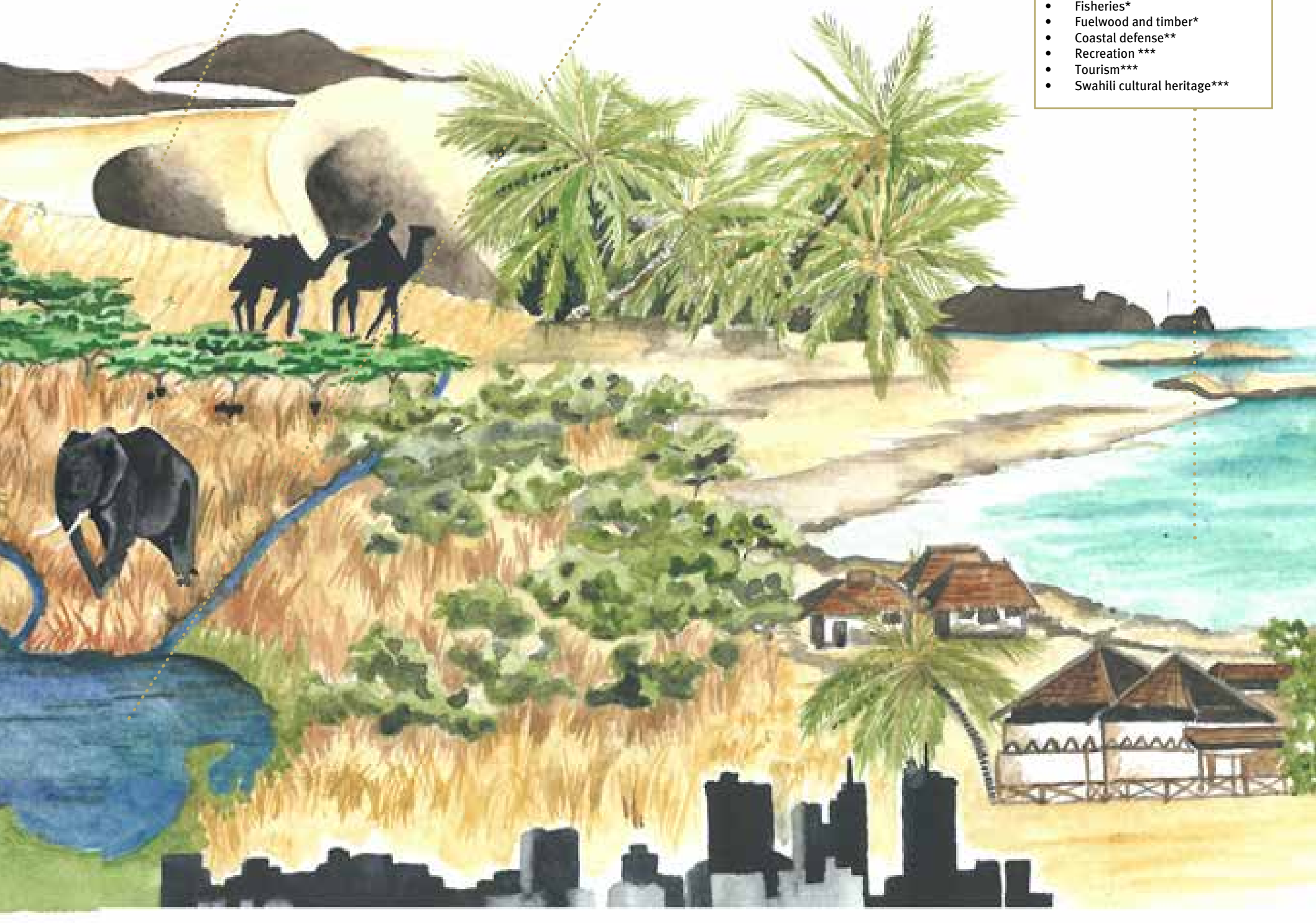
FIGURE. 5.1: The natural capital stock of Kenya
The variety of natural ecosystems in Kenya is shown in the upper half of the painting with examples of the services they provide. Tradition farming, fishing and herding communities relied on nature for all their food, shelter, medicines and cultural services. Thegrowth of Kenya's population and market economy has transformed the natural landscape to a parvhwork of farms, ranches, parks, towns and industrial estates, as shown in the bottom half of the painting. Kenya's economy still depends largely on its natural capital and cultural values of nature have expanded to include outdoor recreation, education and biodiversity. © *Theo. Source: ACC*

Legend
Provisioning service
** Regulating service
*** Cultural service

Lakes and Rivers:
- Fisheries*
- Water supplies*
- Tourism***
- Recreation***
- Pullution regulation**

Deserts:
- Camel, Sheep and Soat products*
- Tourism***
- Northern Kenyan cultural heritage***
- Artisian water*

Coastal and Marine:
- Fisheries*
- Fuelwood and timber*
- Coastal defense**
- Recreation ***
- Tourism***
- Swahili cultural heritage***

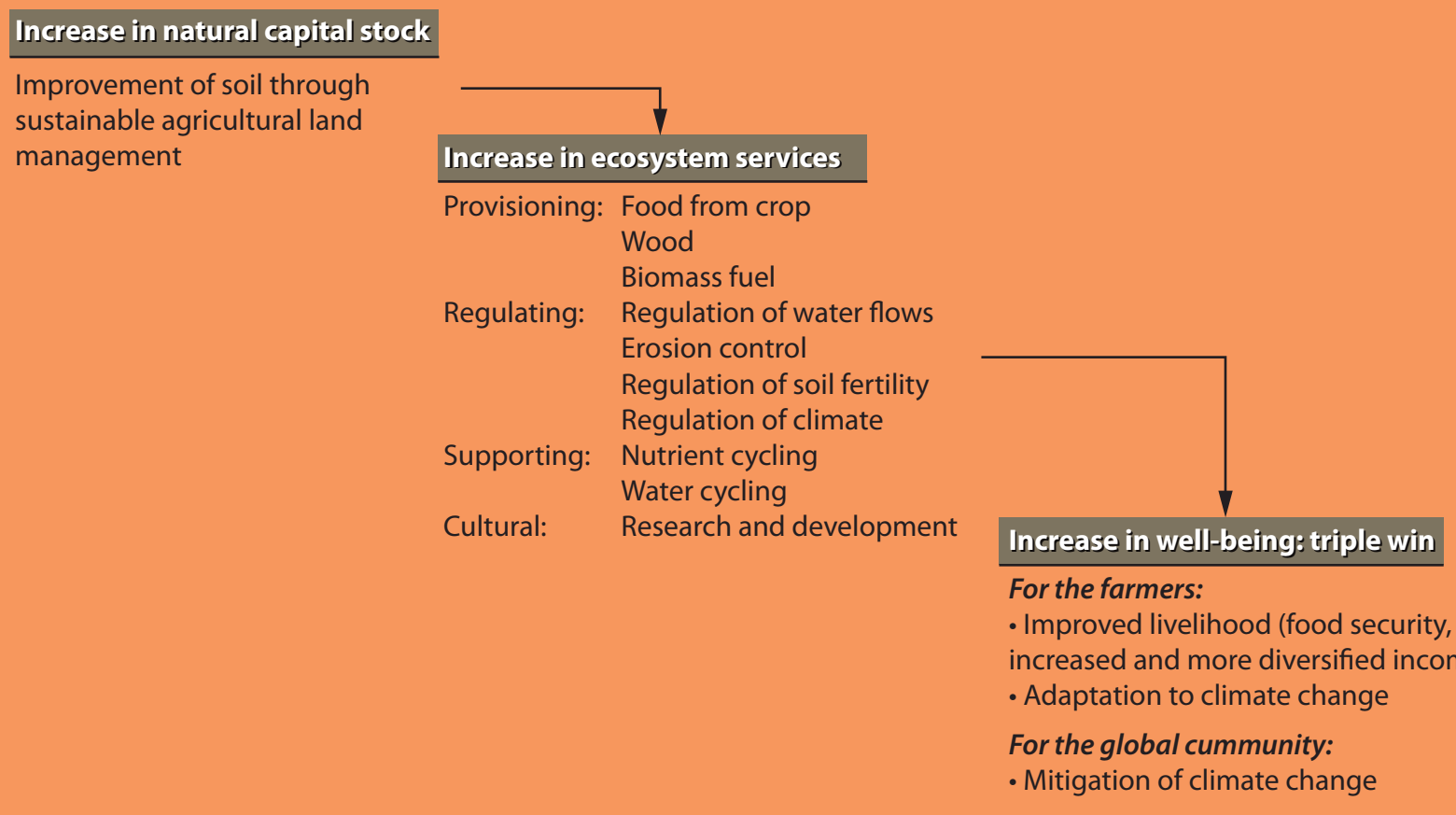


aspects of natural capital such as our wildlife, forests, wetlands and soils cannot be easily restored once lost. Good husbandry of natural capital is essential for ensuring the productive and continuing flow of ecosystem services, as the following examples show.

BOX 5.2: INVESTING IN KENYA'S SOIL CAPITAL, A TRIPLE WIN

Sixty-thousand farmers in Western Kenya are improving their livelihoods, increasing their resilience to drought, and helping combat climate change by improving soil management through the Kenya Agricultural Carbon Project, a World Bank (WB) project conducted under the technical guidance of Vi-Agroforestry.

The Kenya Agricultural Carbon Project makes smallscale agriculture play a role in climate adaptation and mitigation by using practices such as mulching, manuring and conservation tillage to boost carbon, organic matter and water storage in soils. The healthier soils improve soil fertility and water-use efficiency, boost crop production and reduce soil erosion. The increase in ecosystem services has raised the income of farmers and improved their food security and lives in general. Farmers are rewarded for improving carbon storage by the BioCarbon Fund, a public–private initiative administered by the World Bank to purchase carbon credits.



Schematic links between natural capital stock, ecosystem services and wellbeing for the Kenya Agricultural Carbon Project.

BOX 5.3: REFORESTING KENYA'S FORESTS — MORE THAN JUST WATER

Heavy destruction of forests and loss of water catchments led to efforts to rehabilitate the five water towers of Kenya—Mt. Kenya, the Aberdare Range, Mau Forests Complex, Cherangani Hills and Mt. Elgon—and expand Kenya's forest cover to 10 per cent by 2030.

The trigger for action was the declining flows and quality of water in the extensive watersheds of these forests, with consequences for smallscale farms, commercial tea estates, ranches, hydropower production, towns and national parks. The yearly contributions of the Mau Forests Complex alone to agriculture, tourism, electricity production, urban and industrial use, erosion control and carbon sequestration, among others, are estimated at KES 110 000 million (US$ 1 400 million) (UNEP 2012).

In addition, Kenya's catchment areas reduce soil erosion and sediment loads in river water; regulate local temperature and rainfall; increase groundwater recharge; and reduce floods, landslides and low season water flows (UNEP 2009). Increasing Kenya's forest cover will also benefit the global community by sequestering carbon and reducing global warming.

BOX 5.4: CULTURAL SERVICES

Cultural services are non-material benefits people derive from ecosystems. They include spiritual enrichment, physical and mental development, aesthetic pleasure and recreation. For rural Kenyans, the link between nature and culture is strong and tangible but generally undervalued.

In urban areas, where the value of cultural services has been largely ignored, public green spaces play an important role in people's wellbeing. Open spaces and biodiversity are important to people's physical and mental health as they provide space to relax, socialise, exercise and enjoy nature. Nairobi National Park brings wildlife to the edge of the city and attracts tens of thousands of visitors each year. The Nairobi Safari Walk nestled between the city and the national park hosts hundreds of thousands of visitors wishing to see wildlife close-up and enjoy a nature walk in the forest. Uhuru Park in the centre of the city is a favourite spot for family strolls, picnics and social events.

Cultural services are far harder to quantify and value than other ecosystem services but may ultimately be the most important of all for the majority of the world's population—now living in cities and craving open spaces and natural settings. Green-belts have become a major feature of urban planning because of the importance attached to the wellbeing of town and city residents.

VALUING NATURAL CAPITAL

The valuation of ecosystem services helps to gauge the value an individual places on each service, and the costs and benefits of management options. In recent years many new methods and applications have proved useful in assessing the total value of ecosystems and the services they provide countrywide over time.

One common framework for valuing ecosystem services is the Total Economic Value (TEV), which includes a range of use and non-use values (Figure 5.2).

So far, although only a handful of valuations of ecosystem services have been conducted in Kenya, they have proved their worth, as the following examples from the wildlife, energy and agricultural sectors illustrate.

One example is the cost and benefit analysis of a 400 km electrified fence around the Aberdares National Park and forest reserves (Biotope Consultancy Services 2011). The benefits included the supply of water for human and economic uses, carbon storage, tourism and biodiversity. The aggregate benefit was estimated at KES 59 400 million a year (US$ 742 million).

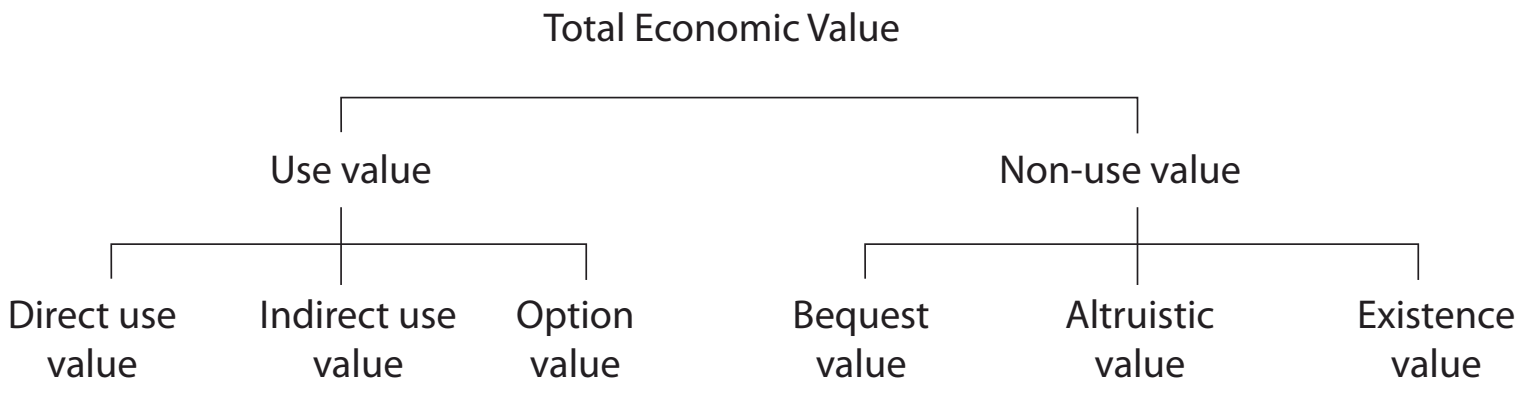


FIGURE. 5.2: The range of values assessed in the Total Economic Value framework.
In calculating the total economic value of ecosystem services, several types of values must be taken into account—including that derived from using the service (e.g. value of food and value of recreation) to that associated with knowing the service exists (e.g. value attached to endangered species).
Source: Adapted from DEFRA 2007.

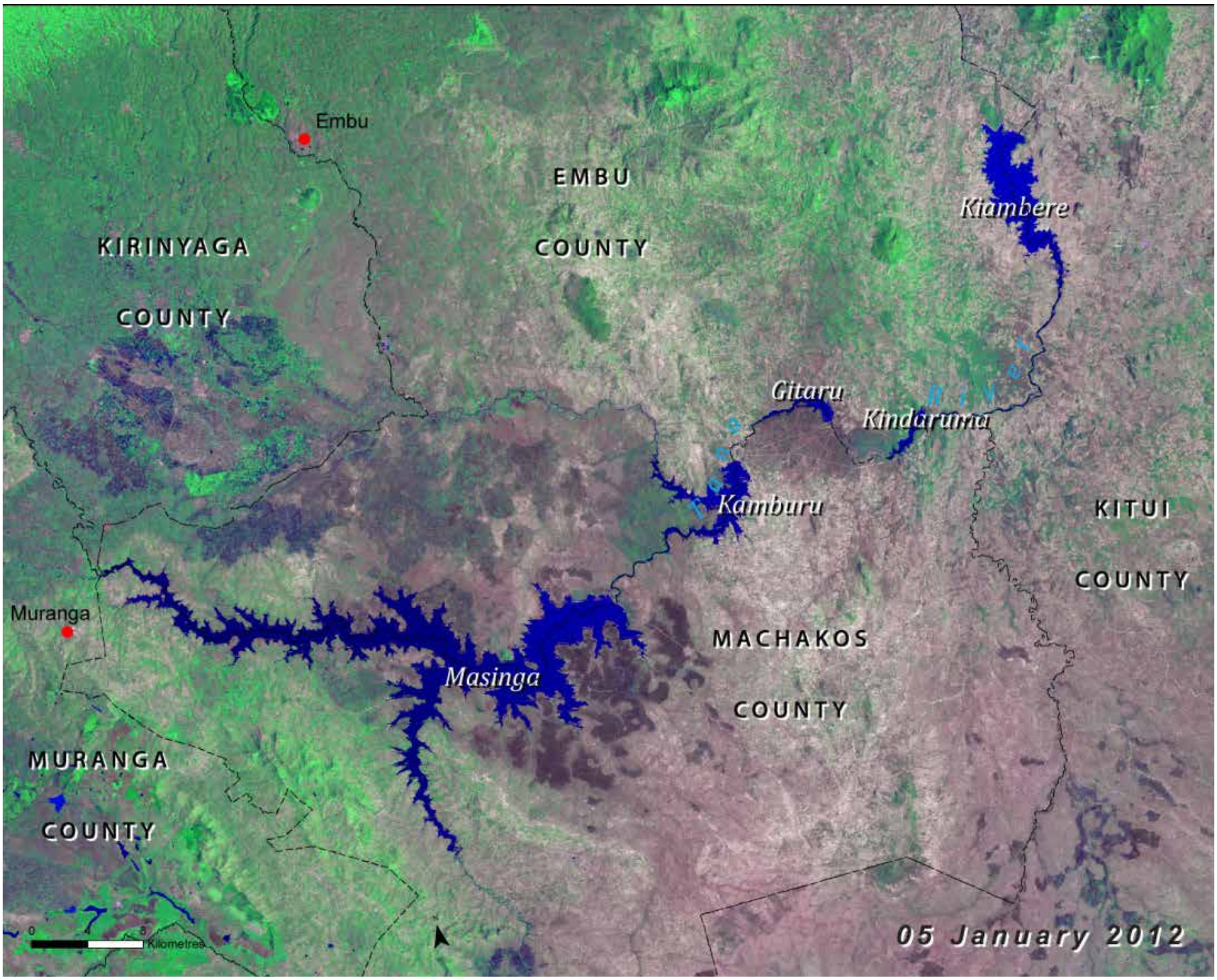


FIGURE 5.3: The dams of the Seven Forks Hydropower Scheme in the upper Tana Basin benefit from the regulation of soil erosion in upstream agricultural lands where soil and conservation practices are implemented. Source: Kenya's Atlas of our changing environment

The cost of building and maintaining the fence, along with the opportunity costs of logging, charcoal burning and livestock grazing foregone were estimated at only KES 8 800 million (US$ 110 million). All cost and benefit analyses showed the value of fencing to be higher than the unfenced option in terms of benefits accrued from ecosystem services.

Another example comes from the Upper Tana Basin, where soil and water conservation in agricultural lands upstream substantially lower siltation of hydropower dams and increase water availability downstream. These benefits were estimated at between US$ 6 and 48 million, against costs ranging between US$ 0.5 to 4.3 million—a tenfold return on investment (ISRIC undated).

Yet another example is the value of pollination services that wild bees and insects provide to smallscale farmers. In 2005, smallscale farmers in Kakamega are estimated to have made a net benefit of US$ 3.2 million from bees pollinating beans, cowpeas, green grams, bambara nuts, capsicum, tomatoes, passion fruit and sunflower. This amounted to some 40 per cent of the total market value of their crops that year (Kasina et al. 2009).

Despite the enormous benefits of pollinators, only large horticultural and coffee firms have so far started beekeeping projects that ensure maximum pollination. For the large majority of Kenyan farmers, pollination has so far been a natural service from wild pollinators. As pollinators decline from loss of natural vegetation and increased use of insecticides and pesticides, husbandry will be needed to ensure healthy populations.

Economic valuations also allow decision-makers to compare the cost of taking conservation measures against taking no action. A study of the montane forests, for example, shows how important it is to assess the benefits and costs of deforestation to the Kenyan economy (UNEP 2012). In 2010, 50 000 hectares of montane forest were deforested. The cash value from timber and fuelwood was estimated to be KES 1 400 million (US$ 17 million).

The costs of deforestation are multiple: it leads to loss in water quantity, which has direct negative consequences on productive sectors such as irrigation agriculture and electricity. It also brings about a decrease in water quality, which adversely affects fisheries and increases the costs of treating waste-water. In addition, deforestation also increases malaria incidence, which leads to a rise in healthcare costs and a loss in labour productivity. In 2010, the direct cost of deforestration of montane forests was estimated at KES 3 700 million (US$ 46 million). The interdependencies among sectors of the economy shift the cost upward to KES 5 800 million (US$ 72 million). Audited fully, each shilling from timber and fuelwood costs the economy 2.8–4.2 times as much.

Although valuing ecosystems calls for new data, much can be done with available information. “Mapping and valuing ecosystem services in the Ewaso

PLATE 5.2: The Ewaso Ng'iro watershed
The Ewaso Ng'iro watershed has a diversity of geological strata, soils, rainfall regimes and ecosystems, including forests, woodlands, bushlands and croplands in the upper watershed; and shrubland, grasslands and swamps in the lower watershed.
Source: Ericksen et al 2011

Ng'iro Watershed" (Ericksen et al 2011) used data on landcover and socio-economic information from the district-level to map the key ecosystem services of an important watershed and estimate their value.

The only permanent river, the Ewaso Ng'iro, and its tributaries, crisscross the upper watershed. The Merti aquifer and the Lorian Swamp provide water and grazing for livestock and wildlife in the dry season. The watershed is rich in wildlife including elephants, Grevy's Zebra and Jackson's Hartebeest, and in cattle, camels, sheep and goats.

The watershed can be classified in seven land-use classes: livestock production; mixed crop and livestock production; mixed livestock production and wildlife conservation; wildlife conservation; conservation forestry; production forestry; and irrigated crop production (Map 5.1).

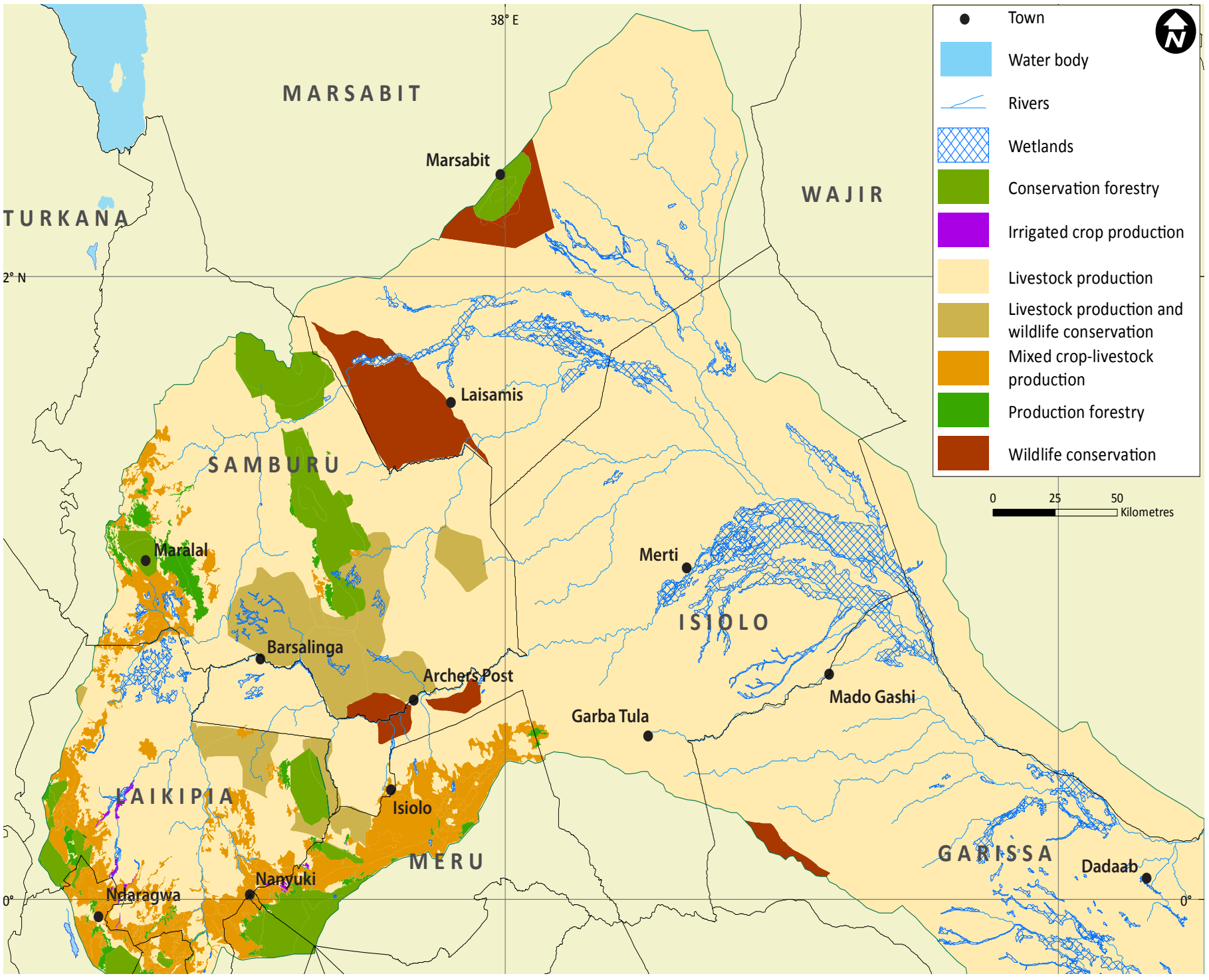


FIGURE 5.4: Land-use map in the Ewaso Ng'iro watershed.
Livestock production is by far the dominant land-use in the Ewaso Ng'iro watershed. The second most important land-use is mixed crop and livestock production, taking place in higher rainfall areas. Map makers: ILRI and Geomapa. *Sources: Administrative boundaries (KNBS 2010); catchment boundary and Digital Evaluation Model (DEM) generated from ASTER DEM 30m resolution; towns (SoK topographic maps scale 1:50,000); rivers derived from SRTM DEM 90m resolution; water bodies (FAO 2000); agro-climatic zones (KSS, Sombroek et al 1982); land-use (derived from interpretation of landcover, protected area, conservancy, and wildlife and livestock distribution and their linkages).*

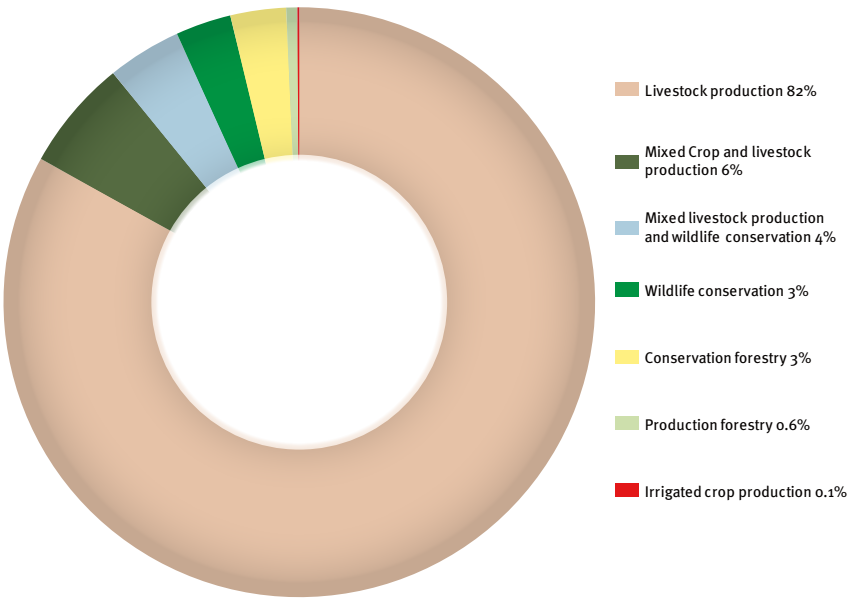


FIGURE. 5.5: Major Land-uses in the Ewaso Ng'iro watershed.
Livestock production is the dominant land-use, covering 82 per cent of the area. Mixed crop and livestock production covers 6 per cent of the area; mixed livestock production and wildlife conservation 4 per cent; wildlife conservation 3 per cent; conservation forestry 3 per cent; production forestry 0.6 per cent; and irrigated crop production 0.1 per cent. *Source: Ericksen et al. 2011*

Some uses of the land allow many compatible and complementary activities. The most common land-use, mobile livestock production, is the mainstay of the economy and culture of pastoralists. Also, it sustains wildlife on the open rangelands and diversifies tourism amenities and enterprises by adding culture, landscape and recreational options—all while sustaining the diversity of habitats and the integrity of the ecosystem. Other uses of the land are more exclusive and entail tradeoffs, as in the case of crop production and wildlife conservation, which are not found in the same part of the watershed.

The market value of crop products, livestock products and livestock assets varies across the Ewaso Ng'iro watershed (Map 5.9). Focusing only on marketed benefits undervalues the total value of ecosystem services. It also overlooks the dependence of market products on human factors such as market access. The market value of livestock products in the lower sub-catchments, for example, would benefit from better market access. As a result of these imperfections, land management decisions exclusively based on market prices are likely to favour crop production over livestock production and wildlife conservation—as market prices don't reflect the total value of ecosystem services.

BOX 5.5: EXAMPLES OF ECOSYSTEM SERVICES IN THE EWASO NG'IRO WATERSHED

Provisioning: Subsistence and cash crops along with livestock produce, wood, fibre and naturally harvested products for subsistence and income; and groundwater, rainwater and surface water for domestic consumption.

Regulating: Regulation of water means less flooding and decreased dry-season water deficits. Climate regulation happens through carbon capture in plants and potential carbon offset markets.

Cultural: Gives the pastoralists adapted to and living in semi-arid rangelands a cultural identity; promotes tourism through wildlife; landscapes offer recreation, aesthetic and spiritual benefits.

Most of these services have interlocking benefits and values, best understood as bundles of services that must be co-managed.

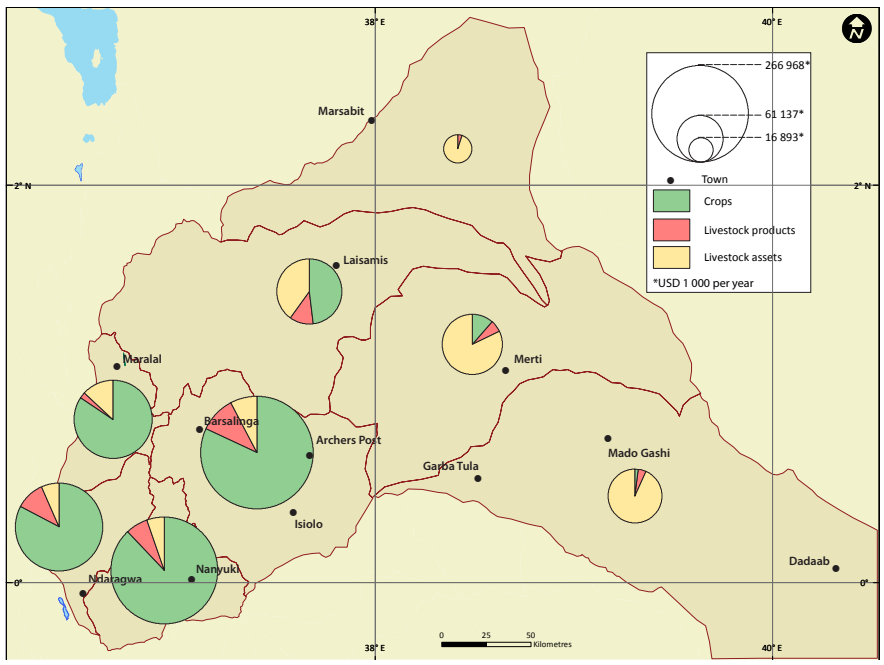


Figure 5.6: Economic valuation map of selected ecosystem services in the Ewaso Ng'iro watershed. There are large differences in total ecosystem service market value between the upper and lower sub-catchments: upper sub-catchments have bigger total market value from crop products, livestock products and livestock assets. Map makers: ILRI and Geomapa Sources: Administrative boundaries (KNBS 2010); catchment boundary and DEM generated from ASTER DEM 30m resolution; towns (SoK topographic maps scale 1:50,000); water bodies (FAO 2000); parks and reserves (IUCN, UNEP/WCMC 2006 and KWS); conservancies (NRT); livestock asset (DRSRS Aerial censuses); crop yields and area (Ministry of Agriculture); prices (Market Research and Information department at the Ministry of Agriculture, Kenya); tourism conservancies (Northern Rangelands Trust (http://nrt-kenya.org); visitors to Northern Kenya (Ministry of tourism, Kenya); livestock (KIPPRA, Muthee 2006, Rakotoarisoa et al. 2008).

The identification, mapping and valuation of the many ecosystem services in the Ewaso Ng'iro watershed illustrate the bundles of services supplied by each land unit; the beneficiaries of the ecosystem services; the links between ecosystem service bundles and land units; and the factors that affect the distribution of these ecosystem services. Using such an analysis, land planners and managers can optimize the economic and social benefits, identify who is affected, and ensure equitable and sustainable use of the natural capital and ecosystem services in the watershed. An example is the allocation of the limited water supplies of the Ewaso Ng'iro River between irrigated farming in the upper catchment and livestock production, wildlife conservation and ecotourism in the lower watershed.

CAPTURING THE VALUE OF NATURAL CAPITAL

Natural Capital Accounting

GDP is good at measuring some aspects of economic growth, but fails to help policymakers plan for sustainable development. For example, GDP does not account for the depletion and future loss of fisheries, soils, water and other scarce resources caused by overharvesting. According to Nobel Prize winner in economics, Joseph Stiglitz, basing economic decisions strictly on GDP is 'like grading a corporation based on one day's cash flow and forgetting to depreciate assets and other costs'. Natural Capital Accounting calls for more inclusive methods that take stock of all assets and services, along with their sustainability, into account.

The system of national accounts in Kenya, for example, estimates the annual contribution of forests at 1.1 per cent of GDP. The Forest Resource Account developed by the Kenya Forest Service, the Kenya Bureau of Statistics and international partners more realistically puts the contribution at 3.6 per cent. It does so by taking other products and services such as fuelwood, non-wood products, water regulation, erosion control and carbon sequestration into account (UNEP 2012).

While efforts are ongoing to produce comprehensive environmental accounts based on the System of Environmental-Economic Accounts (SEEA) (see box 5.6), a growing number of countries have already taken steps to value their natural capital and manage it sustainably.

In the case of Mexico, agricultural activities accounted for 77 per cent of inland water consumption, but contributed only 3.6 per cent to GDP. Full-cost water accounting allowed the government to increase water productivity 6 per cent by modernizing irrigation systems to increase the economic yield per cubic meter of water (WWAP and UNSD 2011).

In another example, Zanzibar established comprehensive accounting of its coastal ecosystem to value the full contributions to GDP and to identify the many beneficiaries of coastal ecosystem services. Artisanal fishing, which contributes 6.2 per cent of GDP, benefits only local communities. Adding tourism contributes a further 23.6 per cent of GDP, of which only 20 per cent accrues to local communities (Lange 2009).

BOX 5.6: NEW TOOLS FOR NATURAL CAPITAL ACCOUNTING

Developed under the leadership of the United Nations Statistics Division (UNSD), the System of Environmental-Economic Accounts (SEEA) is a method designed to augment the System of National Account (SNA), which compiles traditional measures of economic activity such as GDP. SEEA assesses 'trends in the use and availability of natural resources, the extent of emissions and discharges to the environment resulting from economic activity, and the amount of economic activity undertaken for environmental purposes' (EC et al 2012). Efforts are underway to broaden the scope of SEEA guidelines from conventional natural resource management such as fisheries to non-material ecosystem services such as pollination of crops and regulation of natural hazards.

The European Environment Agency (EEA) is developing simplified ecosystem capital accounting based on available statistics. Ecosystem accounting assesses a bundle of services supplied by an ecosystem, such as biomass and carbon content, water supplies, and regulating and cultural services that can be used sustainably (Weber 2011).

Wealth Accounting and the Valuation of Ecosystem Services (WAVES) (http://www.wavespartnership.org) is a World Bank spearheaded partnership between national governments, international institutes and other partners to establish natural capital accounting as part of the national policy and planning processes. Based on SEEA, WAVES accounts for regulating ecosystem services such as water filtration, carbon sequestration, flood protection and pollination (WAVES 2012). Developed in collaboration with the UNSD and the EEA, WAVES provides policymakers with the tools and information required for informed decisions on development priorities and investments. It is currently being developed in Botswana, Colombia, Costa Rica, Madagascar and the Philippines, where government agencies, relevant ministries and central banks have worked with a wide range of stakeholders to identify development issues that can benefit from WAVES (WAVES 2013). Botswana is looking into the optimization of water use between the tourism, mining and agricultural sectors. Madagascar is using WAVES to determine how to invest in protected natural areas for tourism development, biodiversity conservation and carbon sequestration (WAVES 2012).

Payment for Ecosystem Services

The lack of data on integration of ecosystem services prevents a full natural capital accounting for Kenya at this stage. But some steps have been taken in establishing Payment for Ecosystem Services (PES) for non-material benefits such as the regulation of water flows, waste water treatment, pollination and pest regulation. A few well-documented examples of PES show the potential it holds for sustainable development.

Payment for Watershed Services in L. Naivasha

PES in the L. Naivasha watershed shows a local initiative to improve land management, reduce poverty and promote sustainable development.
The natural capital of the L. Naivasha watershed contributes hundreds of millions of dollars to the national economy through its flower exports. It also supports smallscale farming for a large rural community and supplies water for urban communities and geothermal electricity.

The L. Naivasha watershed includes the lake, rivers and streams within the catchment area (Map 5.10). Most of the watershed is under smallscale agriculture, but substantial natural and plantation forest and shrublands remain in the uplands, and grasslands and papyrus swamps in the lowlands. The watershed also has three national parks Aberdares, Hell's Gate and Longonot and a wealth of terrestrial and aquatic animals and plants. Intensive crop farming, horticulture and floriculture are clustered around the lake shores. Naivasha's biological wealth led to its designation as a Ramsar Wetland Site.

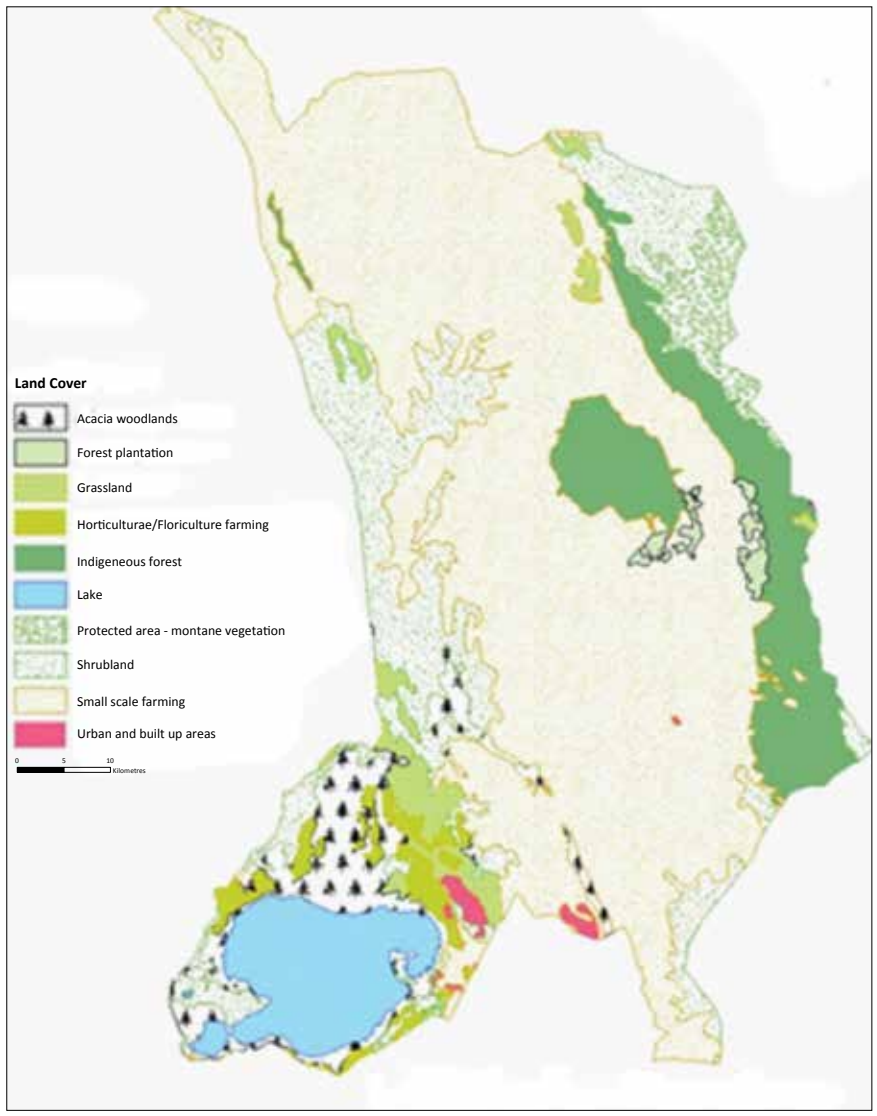


Figure 5.7: 2006 Landcover in L. Naivasha Watershed
L. Naivasha contributes many services to local communities, including crops, fish, flowers, water purification, desilting, tourism, recreation, an aesthetic landscape and a healthy environment. These services all depend directly or indirectly on the volume and quality of freshwater supplied by the watershed. *Source: LANWRUA 2006.*

TABLE 5.3: **ECOSYSTEM SERVICES OF L. NAIVASHA WATERSHED**

Watershed benefits	Service provided	Beneficiaries
Market: Goods	Water	• Flower farms and other agriculture • Domestic water users • Commercial water users
Non-market: Recreation and aesthetics	Recreational opportunities: Viewing, boating, scenic vistas	• Tourist sector including hotels of the L. Naivasha • Tourism Group and other tourism dependent businesses • Tourists
Indirect	Flood moderation Groundwater recharge Sediment trapping Soil retention Water filtration	• Flower farms and other agriculture • Domestic water users • Commercial water users • Water service provider • Tourist sector including hotels of the L. Naivasha • Tourism Group and other tourism dependent businesses • Tourists

Source: Ellis-Jones 2007

Despite the ecosystem services the Naivasha watershed provides (see Table 5.3), poor land-use practices, upstream water off-take and pollution are affecting the health of the rivers and groundwater sources feeding the lake.

To reverse these trends, World Wildlife Fund Kenya and CARE International in Kenya began a PES scheme in the Naivasha watershed in 2006. The scheme aims to regulate erosion from smallscale farms to improve water quality in the lake.

A hydrological survey identified how each sub-catchment affected downstream water quality (Map 5.10). Farmers were selected in high-sediment-yield sub-catchments to maximize the impact of changes in agricultural practices on sedimentation rates and water quality.

Payment for Wildlife Habitat in the Mara Ecosystem

The Maasai Mara Ecosystem is renowned for its abundant and rich variety of wildlife. The area is also home to a large population of Maasai and their livestock. Both wildlife and Maasai pastoralists are sustained by the rich grasslands, bushlands and woodlands of the Mara, and by rivers flowing in from the Mau Escarpment (Fig. 5.8). Smallscale farms are advancing on the Mara and drawing on upstream water supplies.

Maasai Mara National Reserve accounts for 13.4 per cent of all international visitors to Kenya (WRI et al 2007). In 2009, the reserve contributed revenues worth KES 2 250 million (US$ 28 million) to the Narok County and national government (NCC and TCC 2009). The value of ecosystem services generated by Maasai Mara wildlife and Maasai cultural tourism runs as high as US$ 57 million, or US$ 50/ha/year (Norton-Griffith et al 2008). Visitor entrance fees to the Maasai Mara National Reserve alone could generate US$ 5.5 million annually, translating to US$ 35/ha/year (Walpole and Leader-Williams 2001). The estimated value of the 1.5 million migratory wildebeests in the ecosystem, the biggest annual attraction, lies between US$ 125 and 150 per animal (Norton-Griffiths 1996).

Despite the extraordinary value of the Maasai Mara Ecosystem, wildlife numbers are falling sharply. The four main driving forces are the differential returns to land-uses and production systems; the economic conditions that influence these differential returns; the incentives to sub-divide land; policy and market distortions that undervalue wildlife benefits and ecosystem services (Norton-Griffiths and Said 2010). Land fragmentation and settlement is shrinking wildlife habitat and corridors in and outside the reserve, and jeopardizing the sustainability of Maasai Mara as Kenya's premier tourism destination.

BOX 5.7: PAYING LANDOWNERS FOR ECOSYSTEM SERVICES

Until recently, landowners received only small proportion of wildlife-related income and had little incentive to manage the land for wildlife conservation and tourism. Beginning in 2006, several PES schemes have been set up in conservancies on private land bordering the Maasai Mara National Reserve. Based on a land lease fee, tourists and tourism operators pay the Maasai landowners for wildlife viewing on their lands. In exchange, restrictions are placed on activities such as livestock grazing, cultivation, natural resource collection, settlement, fencing and land sales. The payments rise in proportion to the apparent opportunity costs incurred by landowners. For example, landowners in Olare Orok Conservancy receive US$ 43/ha/year in exchange for keeping it livestock-free during high tourism season. On the other hand, pastoral landowners in Kitengela only receive US$ 10/ha/year because the PES agreement still allows livestock grazing on covenanted land, enabling landowners to continue their traditional pastoral livelihoods.

More than 800 families benefit from the PES schemes in the Maasai Mara Ecosystem, amounting to over US$ 3.6 million annually in cash payments. The payments contribute between 20 and 40 per cent of gross income. PES payments cover basic needs such as food, clothing and education. PES schemes also benefit communities more widely through conservancy trusts assigned to improve infrastructure, schools and health facilities.

The eight PES schemes have secured 80 000 hectares for wildlife, more than half the total area of the Maasai Mara National Reserve. Although a full analysis of wildlife trends has yet to be completed, reports indicate that populations of several species, including lions and other carnivores, are on the increase in the conservancies.

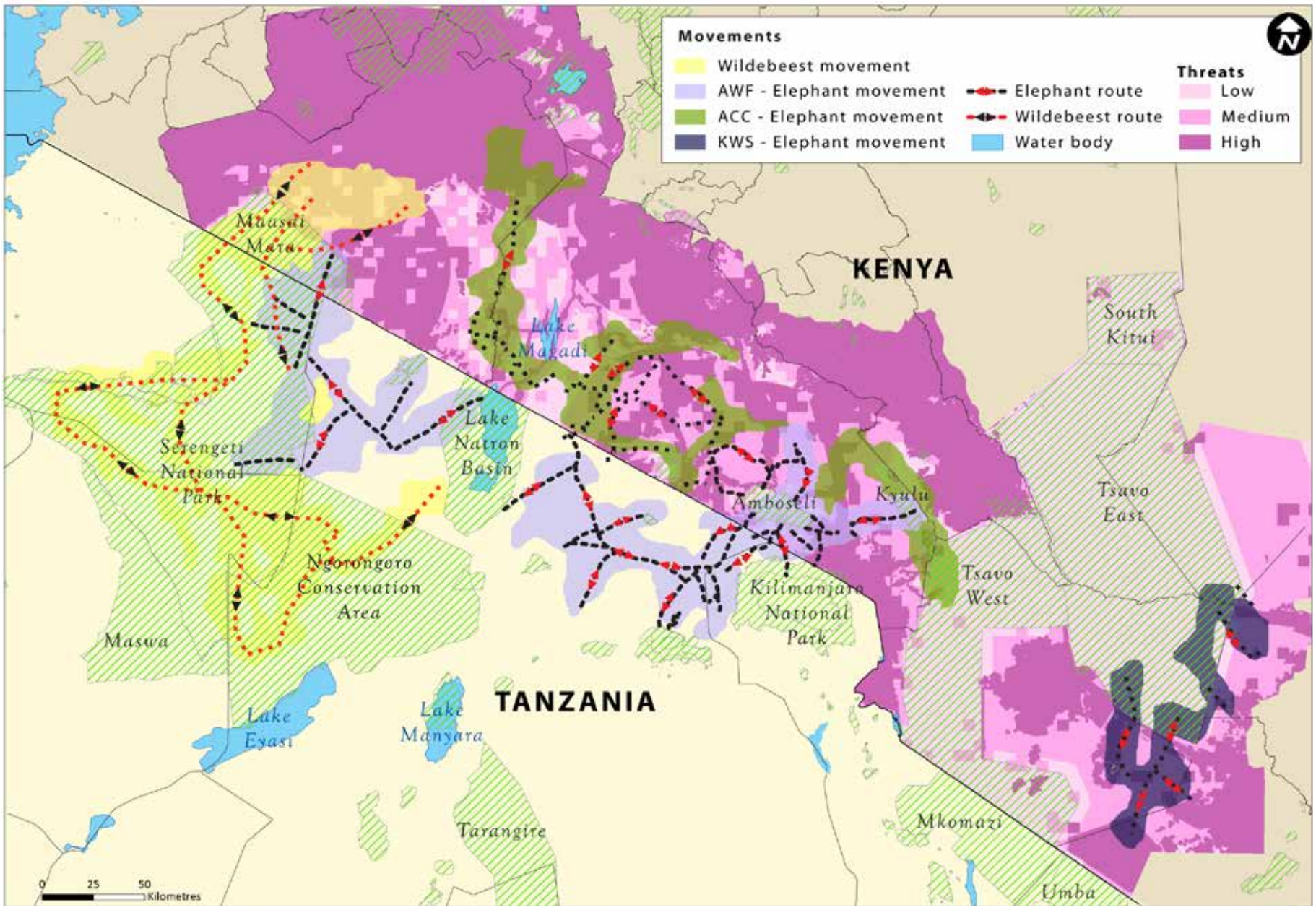


Figure 5.8: Distribution of wildlife, wildlife corridors and the relative intensity of threats they face in the southern Kenya rangelands.
The Maasai Mara-Serengeti ecosystem is known as the Eighth Natural Wonder of the World, famous for the mass annual migration of two million Wildebeest, Zebra, and Grant's Gazelle crossing the Mara River from the Serengeti Plains. The Mara's wildlife is threatened by expanding agriculture encroaching on the migratory corridors.
Sources: DRSRS.

Conclusions

Kenya has been steadily accumulating data and knowledge on the value of its biodiversity and ecosystem services. However, this information has not yet been published or incorporated in the country's decision-making processes. The following steps would ensure a better account of the country's natural capital and sustain the economic growth and wellbeing of its people.

1. The Ministry of Environment, Water and Natural Resources should work with the Ministry of Finance to establish the institutional locus and capacity to audit and monitor natural capital.
2. The natural capital auditing mechanism should work with national and international research institutes, UN bodies, the private sector and local communities to value the natural capital for the range of ecosystem services.
3. The natural capital accounting framework should be established at national, county and watershed levels.
4. Value natural capital gains and losses in projects, plans and policies stemming from environmental impact assessments and strategic environmental assessments.
5. Likewise financial incentives such as mitigation banking and PES should be provided to the private sector to encourage investment in natural capital.

CHAPTER

06

Conserving BIODIVERSITY for SUSTAINABLE DEVELOPMENT

PLATE 6.1: Aloeukambesis(Aloe vera) *Source: NMK Painting© Joy Adamson*

Introduction

The first chapter of this Atlas looks at the origins of Kenya's biological wealth and conservation movement, leading to a national and global commitment to sustaining biodiversity and natural capital as the basis of development and human wellbeing. The second chapter looks at the physical, biological and human agencies that shape Kenya's major ecosystems and provide us with the ecological services that sustain traditional livelihoods and the national economy. The third chapter looks at the diversity and distribution of Kenya's varied life-forms, its biodiversity hotspots, endemic, endangered and threatened plants and animals, the economic and ecological importance of species, and their conservation status. The fourth chapter looks at the threats to Kenya's ecosystems and natural resources, their current status and trends, the conservation measures in place and the gaps that remain in conserving biodiversity and sustaining development.

The biggest gaps lie in our failure to fully value the benefits of nature and the costs of overuse and despoliation. The fifth chapter shows how valuing the ecosystem services that biodiversity provides can be achieved through new methods of natural capital accounting. Natural capital accounting provides the link between biodiversity and sustainable development, the subject of this final chapter.

How can biodiversity and sustainable development be clearly and firmly linked as the basis of national planning? What steps can Kenya take to embrace the auditing, monitoring and sustaining of its natural capital—alongside the human and economic pillars of development?

THE GLOBAL BIODIVERSITY OUTLOOK

In 2002 the Global Biodiversity Outlook 2 (GBO 2) report of the Convention on Biological Diversity set eleven targets for reducing the loss of biodiversity.

The 2010 Global Biodiversity Outlook 3 report (GBO 3) noted that none of the targets had been met. Despite a rising public awareness of conservation and rising responses to the threats, biodiversity losses continued.

Failure to meet the GBO 2 targets was put down to focusing on proximate threats and remedial measures, such as protected areas and species survival, rather than underlying causes of loss. The underlying causes stem from a failure to value and deliver the benefits of ecosystem services. GBO 3 also noted that conservation action seldom matches the scale of threat. The 10th Conference of Parties to the CBD recommended reaching out to decision-makers to embed biodiversity conservation and ecosystem services in the development agenda: the link between biodiversity and ecosystem services must be clearly demonstrated.

As shown in the last chapter on Valuing Nature, The Economics of Ecosystem Services and Biodiversity (TEEB) methodology shows that sound policies, public engagement and a full valuation of ecosystem services, backed by market incentives, can reduce biodiversity loss and improve human health and wellbeing. TEEB emphasizes the economic benefits of avoiding rather than repairing environmental damage. For example, worldwide forest loss and degradation presently run between $2 to 4.5 trillion in terms of economic losses. Preventing the loss can be achieved at $45 billion, a 100:1 return on expenditure (TEEB, 2010).

GBO 3 calls for conserving biodiversity and sustaining development through new initiatives, which cover public communications; redressing the indirect causes of overuse; restoring habitats and ecosystems; raising the efficiency of natural resource use; sustaining ecosystem services, and encouraging local initiatives.

BOX 6.1: GLOBAL BIODIVERSITY TARGETS (GBO 2)

- Promote the conservation of ecosystems, habitats and biomes.
- Promote the conservation of species diversity.
- Promote the conservation of genetic diversity.
- Promote sustainable use and consumption.
- Reduce pressures from habitat loss, land-use change, degradation and unsustainable use of water.
- Control threats from invasive species.
- Counter the threats to biodiversity from climate change and pollution.
- Maintain ecosystems services that support livelihoods.
- Maintain cultural diversity of indigenous and local communities.
- Ensure fair and equitable sharing of genetic resources.
- Improve the capacity to implement the convention.

Shortcomings in conserving biodiversity globally also hamper the achievement of the eight Millennium Development Goals (MEA, 2005) set by the United Nations in 2000. The eight goals targeted for 2015 include the eradication of extreme poverty and hunger; universal primary education; gender equality and the empowerment of women; reducing child mortality; improving maternal health; combating AIDs, malaria and other infectious diseases; ensuring environmental sustainability; and setting up global partnerships for development. A progress report by the MDG Inter-Agency and Expert Group in 2010 (UN MDG Report 2012) concluded that, despite significant progress in achieving 21 specific targets, many of the goals will remain unachieved, especially in the poorest communities and the most marginal areas. Africa in particular lags far behind on most goals.

Much has changed since Kenya endorsed the sustainable development principles drawn up by the Brundtland Commission and adopted by the World Commission on Environment and Development in 1987. Two findings, supported by strong scientific evidence, are pertinent:

First, growing human populations and increasing activity threaten not only species and habitats, but also the also Earth's oceans, atmosphere, climate, biogeochemical cycles and biodiversity as a whole. Global environmental changes could be abrupt and irreversible, threatening human life and wellbeing no less than biodiversity. Two well-documented examples that have led to global agreements to counter the threats include the thinning ozone layer protecting the Earth from damaging radiation, and global warming due to the release of greenhouse gases (GHGs) from the combustion of fossil fuels. Concerns over global warming led to the Kyoto Protocol on Mitigating Climate Change.

Second, evidence that planetary properties are essential for a thriving global society has become incontrovertible. Ozone thinning, global warming, acidification of the oceans, toxic wastes, disruption of biogeochemical cycles and loss of biodiversity have global consequences that affect all species and all peoples no matter where they are.

A failure to meet the GBO 2 goals on the one hand and the MDG targets on the other, means that the two prongs of sustainable development—improvement to human welfare and wellbeing, and sustaining Earth's life support systems—are not being met and are poorly connected in policy and practice (Griggs et al., 2013).

The UN Rio+20 summit of 2012 identified the key obstacles to achieving the MDG goals and committed governments to setting Sustainable Development Goals (SDGs) for incorporation into the MDGs after their 2015 deadline. Expanding or extending MDG goals is not sufficient, according to recent policy analysis (Griggs et al, 2013). We must link social and economic targets firmly to the Earth's ability to sustain ecological services and support life. The linkage calls for expanding the definition of sustainable development. Sustainable development must not only be able to meet the needs of the present without compromising the ability of future generations to meet their needs. It must also safeguard Earth's life support systems on which the welfare of all generations and all life depends. Development targets must, in short, be set within planetary boundaries that assure planetary support systems are maintained (UN, 2012).

Maintaining planetary and life-support systems is not possible without first changing the way we value nature's services and making natural capital a main pillar of development alongside human and economic capital. Sustaining life-support systems and ecosystem services calls for national policies that value natural capital and cost unsustainable actions. Sustainability economics calls for greater efficiency in resource and energy use, and ultimately depends on adopting a green economy.

Sustainable development and human wellbeing can be achieved by quantifying, auditing and monitoring natural capital and setting up the public and private sector institutions needed to ensure sound environmental governance and compliance. If each nation takes steps to use and conserve its environment without imposing costs to others and to future generations, the health and future of our planet can be assured.

BIODIVERSITY AND GOVERNANCE

Kenya ranks among the richest nations in lifezones, ecosystems and cultures by virtue of its geographical location, varied landscapes, climates and history. Kenya is also unique in preserving its abundance and richness of large vertebrates. Traditional knowledge, practices and cultural institutions, coupled with historical contingencies, explain how Kenya has sustained its ecosystems and biodiversity.

Traditional knowledge was vested in environmental governance practices that linked the survival and the welfare of the community to the sustainability of crops, herds and natural resources (Western et al, 1993). The governance procedures of traditional herding and fishing societies in Kenya have been described in Chapter 2 under The Traditional Human Setting. Nobel Laureate, Elinor Ostrum (Ostrum, 1990), has shown that successful traditional environmental governance systems apply to common property resources globally as well as locally. The rules include agreements on the goals of cooperation, rules of access and off-take, monitoring, policing, enforcement of rules, and penalties for infractions. The feedback between land and natural resources practices and the welfare of the individual was usually visible enough to ensure conservation awareness, personal responsibility and good practices, enforced by the community at large. Kenya's world famous wildlife herds of Mara, Amboseli and Samburu and the *kaya* forests of the *Mjikenda* peoples of the coast testify to the effectiveness of traditional pastoral practices.

The rise of national sovereignty over natural resources, market economies, consumerism, urbanization and a breakdown of traditional natural resource practices have obscured the links between ecosystem services and human wellbeing. Market economies driven by short-term profits are often too remote for consumers to know of, much less care about, the effects of their purchases on air and water pollution and land degradation.

The links between land and human health and wellbeing are once again becoming apparent as Kenya's population and economic growth degrades the environment and affects human health and livelihoods. Prosperity cannot be achieved or maintained nationally in future any more than it could locally in the past—without sustaining the natural capital underpinning Kenya's growth and development.

The link between environment health and sustainable development is fully recognized by the government and lies at the heart of Vision 2030 and the Constitution of Kenya, 2010. Yet despite policies, legislation and institutions being in place for several decades to conserve forests, our fisheries, wildlife, water and soils, biodiversity and natural resources continue to decline. Our remedies have focused on proximate factors like protected areas and regulations, rather than tackling the demographic, economic, social and governmental causes of loss.

Creating the opportunity and capacity to benefit from biodiversity is key to stemming the losses. Fully valuing nature's services and delivering benefits locally and nationally is a start but far more is needed. Communities dependent on land and natural resources need access to markets, credit, extension services and social services. These are the catalysts for communities increasing the efficiency of resource use, and productivity and value of their produce in order to thrive and avoid eroding natural capital.

The ability of the nation state to stem biodiversity loss is limited and declining. The sheer scale of the losses and limited budgets, as well as the challenge to central governments of democracy, rights and pluralism, calls for distributed and devolved solutions and governance.

Kenya took the firsts steps to devolved governance of natural resources in the 1970s when pastoralists around national parks were paid to protect migratory wildlife herds. This early form of payment for ecological services saw wildlife numbers flourish and local communities develop their own ecotourism enterprises. The momentum gathered through voluntary practices in ecotourism and community-based conservation took root and expanded to include forestry, water and pasture conservation.

These devolved governance practices have grown voluntarily and flourished, driven by partnerships between communities, business and conservation bodies and new conservation tools such as easements and conservancies. The role of government has been modest but all important in enabling, seeding and encouraging such initiatives (CBNRM, 2013).

The challenge facing Kenya is the speed at which the voluntary and devolved initiatives must take place to stem biodiversity and natural capital loss. The Constitution of Kenya, 2013 mandates devolution of government, land planning and management to a county level. The counties must establish environmental committees and institute integrated land-use planning, yet the funds and capacity to do so are limited. The Constitution grants communal and private landowners a large measure of responsibility to use and manage natural resources, and mandates that every county shall decentralize its functions and services to the extent that it is efficient and practicable to do so (Article 176 (2)).

Fortunately three decades of devolved experiments in the governance of wildlife, forestry and pasture has fueled the growth of landowner associations working in collaboration with county and national governments, the private sector and non-government organizations. Yet for all the progress, the voluntary initiatives are lacking the standards, services, coordination and integration they need to flourish and manage biodiversity effectively (CBNRM, 2013). Creating a successful voluntary environmental movement calls for county and government support to link sustainable natural resource development and livelihoods.

Another challenge is to reconnect the welfare and wellbeing of Kenyans no longer making a living on the land to the health and diversity of environments. With over a third of the population living in towns and cities and set to exceed a half within two decades (chapter 1), environmental degradation will be far less visible than in rural communities. Demonstrating the value of ecological services to health and welfare subsistence needs takes on new significance in urban populations. The cost of environmental abuses is rising rapidly in urban areas in the form of respiratory and waterborne diseases caused by pollution. Open space for recreation and relaxation is lacking. As urban populations rise, the demand for a clean, healthy and enjoyable environment will grow, as noted in Chapter 5.

Biodiversity provided most of the food, clothing, shelter, energy and sustenance of life for Kenya's traditional hunters and gatherers, farmers,

PLATE 6.2: Variety of farm produce derived from Kenya's rich natural capital.

herders, fishermen and traders. Ecosystem services have not lost their value in modern Kenya. They have simply become less visible. Three quarters of Kenya's population still depends on natural capital, whether piped water or biomass energy.

Rapid population growth, urbanization, commerce and industry heavily-reliant on fossil fuels mask the dependence of modern economies on ecosystem services. Economic models and forecasts project a continual stream of benefits without fully accounting for the depletion of Kenya's natural capital. Development plans and aid projects pay far too little attention to the rising costs of environmental degradation, depletion and pollution, and underinvest in abatement and restoration (TEEB, 2010).

Ignoring the value of our environment, and overusing and underinvesting in conservation, has depleted our forests, fisheries, rangelands, water towers and other ecological services. As illustrated in Chapters 4 and 5, overuse and underinvestment in conservation has caused widespread soil erosion and loss of habitat, pasture and wildlife. Air and water pollution is rising sharply, causing health hazards from pesticides, toxins and urban smog. The loss of open space in which to play, relax and enjoy the outdoors is depriving rapidly-growing urban populations of the recreational, spiritual and aesthetic benefits of nature.

RECONNECTING PEOPLE AND ENVIRONMENT

Kenya has taken many steps to conserve its natural resources. As outlined in Chapter 4, the steps include policies, legislation and regulations governing soils, water, forests, habitats, wildlife, toxic wastes and emissions. However, it was not until the Environmental Management and Coordination Act (EMCA) of 1999 that Kenya set up a national framework for coordinating environmental management and conserving biodiversity (EMCA, 1999)

EMCA recognizes the right of every person to a clean and healthy environment. Among its foundation principles, EMCA includes intergenerational equity, the precautionary and polluter pay principle, international cooperation over shared resources, and the recognition of traditional rights and practices related to natural resources. EMCA established a National Environmental Management Authority (NEMA) to ensure compliance with environmental legislation and undertake Environmental Impact Assessments. It also mandated five-yearly National Environmental Action Plans (NEAP) to be approved by the National Assembly.

Vision 2030, drawn up in 2008, laid out a strategy and timetable for Kenya to become a newly industrializing middle-income country providing a high-quality life to all its citizens. Vision 2030 rests on economic, social and political pillars. The social pillar includes a clean, secure and sustainable environment and aims to move Kenya to a post-oil economy dependent on renewable energy (Vision 2030, 2008).

The right of every person to a clean and healthy environment and an obligation to conserve it is embedded in the Kenya's Constitution, 2010 (Kenya Constitution, 2010), along with the goal of expanding Kenya's forest cover to 10%, decentralizing government to county level and deploying natural resources management to the lowest effective and efficient level.

In line with the constitution, Kenya has embarked on a raft of new environmental policies and legislation, as outlined in Chapter 4. Kenya has also recognized the severity of environmental threats and the benefits of investing in environmental mitigation, as opposed to recovery. The threat of global warming and climate change to Kenya's national economy and biodiversity is one example.

In 2010 the government prepared the National Climate Change Response Strategy (NCCRS, 2010). In 2012 there followed a Report on Strengthening Institutional Capacity for Integrated Climate Change Adaptation and Comprehensive National Development Planning in Kenya. Based on the global projection of a 3 per cent annual loss of GDP until 2030 arising from climate change, the report recognized Kenya's environmental vulnerability. Three quarters of its population still depends on land and ecological services for food, energy, shelter and the mitigation of floods, soil loss and other environmental hazards. Taking early action to sustain environmental services by investing 2 per cent of GDP annually in climate change adaptation will reduce the disruption, boost growth by some 13 to 19 per cent and pay back the investment within 3 to 10 years.

Voluntary Environmental Management will take on a greater role in Kenya in line with devolved government and the growing scale and complexity of environmental threats. Kenya has been a pioneer in community-based

conservation. EMCA and wildlife, forestry, fisheries and water management legislation are being redrafted to devolve more rights and responsibilities for environmental management and governance to local communities. In 2011 NEMA drew up *Integrated National Land Use Guidelines* and the Ministry of Water, Environment and Natural Resources policy guidelines for collaborative natural resource management (CBNRM, 2013). A new National Environmental Policy has been drafted.

The government is committed to identifying conservation priorities, addressing environmental threats and bolstering national and county-level administration. It will also bolster private sector and voluntary conservation initiatives. Kenya will meld environmental conservation into national development plans and the promotion of human wellbeing. As it does so, priorities will shift from the costly retroactive restoration to thrifty preventative conservation built into national aspirations, planning, investment and development.

At the Summit for Sustainability held in Botswana in 2012, the Kenya government joined other African states in issuing the Gaborone Declaration on natural capital. The declaration outlines a number of overarching objectives and concrete actions "to ensure that the contributions of natural capital to sustainable economic growth, maintenance and improvement of social capital and human wellbeing are quantified and integrated into development and business practice". (Gaborone Declaration, 2012)

Such a national commitment calls for a holistic conservation vision and the setting of clear targets and strategies for biodiversity conservation as the foundation of ecosystem services and natural capital. A vision and strategy for conserving biodiversity is set out in the Kenya National Biodiversity Strategy and Action Plan 2000.The findings of this Atlas, documented in the preceding chapters, highlight a number of specific targets.

ADOPTING NATURAL CAPITAL ASSESSMENT

With the Kenya National Biodiversity Strategy and Action Plan in place and regularly updated, clear biodiversity targets set and a viable conservation area drawn up, Kenya will be well positioned to take the final steps towards a natural capital system of accounting.

Finally, incorporating natural capital auditing into the national planning framework alongside human and economic capital calls for the institutional capacity to do so. At a time when government is reducing the number of government bodies and devolving functions, new institutions, it is important to avoid layers of bureaucracy and heavy costs. Current capacity for monitoring and assessing the environment can be expanded.

BOX 6.2: THE GABORONE DECLARATION ON NATURAL CAPITAL

- Integrate the value of natural capital into national accounting and corporate planning and reporting processes, policies and programmes.
- Build social capital and reduce poverty by transitioning agriculture, extractive industries, fisheries and other natural capital uses to practices that promote sustainable employment, food security, sustainable energy and the protection of natural capital through protected areas and other mechanisms.
- Restore ecosystems as well as actions that mitigate stresses to natural capital.
- Build the knowledge, data, capacity and policy networks to promote leadership and new models in the field of sustainable development and to increase the momentum for positive change.
- Ensure effective communication and public education of the objectives and actions for natural capital.

BOX 6.3: TARGETS FOR CONSERVING KENYA'S BIODIVERSITY

- Protect ecosystem, species and genetic diversity.
- Protect unique ecosystems.
- Protect endemic and threatened species.
- Sustain Kenya's globally unique wildlife populations.
- Ensure connectivity between biomes to accommodate wildlife movements and adaption to climate change.
- Link livelihoods and wellbeing to ecosystem health and diversity.
- Establish a Minimal Viable Conservation Area framework for defining conservation priorities based on importance and threats.

The Kenya Natural Capital Atlas is a first step towards setting up a national biodiversity database. In the next step MEWNR will adopt interactive biodiversity informatics platforms and software systems for easy access to natural capital data by planners, decision-makers throughout the devolved system of government and the public at large.

Kenya's vision, strategy and plans for auditing natural capital anticipates and contributes to the adoption of the Sustainable Development Goals called for in the expanded concept of sustainable development and revised MDGs in 2015.

BOX 6.4: TOWARDS A NATUAL CAPITAL ASSESSMENT AND ACCOUNTING

- Define a national vision for conserving Kenya's biodiversity, ecosystem services and natural capital.
- Map and quantify biodiversity and ecosystem services.
- Identify the threats to biodiversity and gaps in conservation policy and coverage.
- Assess the impacts of land-use and climate change on livelihoods dependent on biodiversity and natural capital.
- Develop the use of Payments for Ecosystem Services for sustaining strategically important biodiversity and services.
- Establish a national digital database that can be continually upgraded and easily accessed at every level of government and all sectors of society.

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Kenya's Natural Capital: A Biodiversity Atlas.

The Ministry of Environment Natural Resources and Regional Development Authorities convened an international conference in 2010 to celebrate the United Nations International Year of Biodiversity. Titled, Biodiversity, Land Use and Climate Change, the conference showed the Kenya–Tanzania borderlands to be the richest site for vertebrate diversity in Africa and among the most important worldwide. The conference called for a fuller assessment of Kenya's biodiversity as the basis for sustainable development and conservation planning.

Kenya's Natural Capital: A Biodiversity Atlas is a national endeavor commissioned by the Ministry of Environment, Water and Natural Resources to document the natural wealth of Kenya. The atlas maps Kenya's biodiversity, explains the richness of its ecosystems, looks at the status and threats of Kenya's biodiversity and assesses the ecosystem services provided by nature's capital. The atlas concludes by outlining the vision and strategy needed for Kenya to incorporate natural capital as a foundation of a sustainable development, along with the economic and political pillars on which Vision 2030 is founded.

The atlas offers Kenyans in all walks an illustrated guide to the wealth and importance of its rich biological heritage and lays the foundation for the conservation and sustainable use of the nation's natural capital.

ISBN 996621178-0
9 789966 211781