KENYA WETLANDS ATLAS

UNEP

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TABLE OF CONTENTS

CHAPTER 4: HUMAN WELLBEING, ECOLOGICAL AND NATIONAL DEVELOPMENT ROLES OF KENYA'S WETLANDS

CHAPTER 5: WETLAND PRESSURES, IMPACTS, CONSTRAINTS AND OPPORTUNITIES

CHAPTER 6: CLIMATE CHANGE AND VARIABILITY, AND KENYA'S WETLANDS

CHAPTER 7: TOWARDS SUSTAINABLE MANAGEMENT OF KENYA'S WETLANDS

FOREWORD

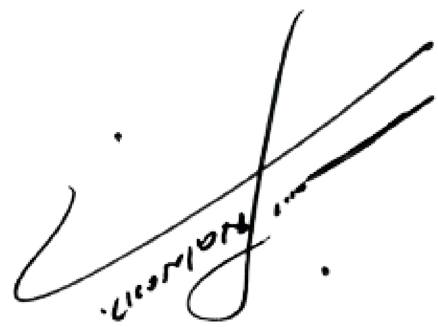
Wetlands are among the most important ecosystems in Kenya. The integrity of the country's water resources and agricultural productivity is sustained by our wetlands. They are nutrient rich and productive most of the year. During the dry seasons, wetlands are the only places where the local communities are able to access quality pasture and their edges support production of vegetables and other quick maturing crops for household consumption. They also control floods and clear water of pollutants through filtration. Wetlands are therefore a key resource for the achievement of Vision 2030.

Despite the important role that wetlands play in sustaining livelihoods in Kenya, they have been subjected to severe pressure and rapid degradation. The results have been detrimental and even catastrophic in many areas of the country. For example, flash floods in western Kenya have become more common, severe and destructive as there are no wetlands to hold back any massive overland flow, leading to loss of property, destruction of infrastructure and damage to crops. This phenomenon is compounded by climate change and the increasing frequency of extreme weather events. In some parts of the country, this has now become an annual event and the resulting shock to the country's national economy has been a major destabilizing factor to sustained economic growth. It is therefore apparent that the attainment of the Vision 2030 goals hinges on how well we manage our wetlands.

The government is mindful of the opportunities lost through wetland degradation and has embarked on a long term strategy to promote their protection. This strategy will, however, only be effective if all Kenyans embrace it through valuing the services rendered by wetlands. This demands that every Kenyan has access to reliable and up to date information on the dynamics playing out in wetland ecosystems and their value to the economic development of the country. This information should be especially clear and easily understood by all Kenyans who depend on wetlands for their livelihoods. The Ministry of Environment and Mineral Resources is therefore very pleased to release the Kenya Wetlands Atlas. It provides decision-makers, interested readers, and others who care about the integrity of Kenya's wetland with invaluable visual information about the state of the country's wetlands resources using satellite images, maps, graphics, ground photographs, and scientifically evidence based story lines to provide a succinct account of what is happening to the various wetlands in the country.

The Ministry is grateful to UNEP for its support in preparing this Atlas and continues to treasure the close collaboration it has with this global institution which Kenya is honoured to host. We are also indebted to DANIDA for the generous support the agency has continued to extend to the environment sector in Kenya.

I would like to congratulate all the national and international experts, national institutions and development partners whose contribution has made this landmark publication possible. It is my sincere hope that this publication will inspire every Kenyan into action. I wish you an enjoyable reading.



Hon, AMB, Chirau Ali Mwakwere, EGH, FCIT, MP.
Minister of Environment and Mineral Resources

PREFACE

Wetlands occupy approximately 3-4 per cent of Kenya's land area. Despite this seemingly small geographic extent, wetlands provide some of the most critical ecosystem services to a large number of communities in the rural areas and are indispensable to the very survival, health and welfare of human beings and biodiversity. They are therefore crucial to the attainment of the MDGs and the Vision 2030 goals. Despite the critical functions wetlands provide they are constantly under threat and many continue to be degraded and even lost at an alarming pace.

The Kenya Wetlands Atlas provides visual evidence of the extent and severity of the changes taking place in Kenya's wetlands spanning thirty years, mostly occasioned by intense detrimental human activities. The Atlas is the first major publication depicting the dynamics in Kenya's wetlands using satellite imagery. The site-specific, side-by-side display of "before and after" satellite images show different kinds of changes in wetland ecosystems all over the country such as: agricultural encroachment; urban growth into wetland areas; altered hydrology (dams, shrinking lakes, river diversions, and drained wetlands); modified and degraded coastal areas; and the impacts of climate change. The satellite images and the story lines are supported by graphs, maps, and photographs to provide complete and compelling scientific evidence. It is important to note that the different sites highlighted by the change pairs in the Atlas only serve as examples to illustrate that degradation and loss of Kenya's wetland ecosystems is a widespread problem that needs to be urgently addressed.

The visual story told by these images should spur action among all decision makers in the country and trigger concerted remedial action at all governance levels. The Atlas, among others;

- provides scientific evidence of environmental change in Kenya's wetlands and raises decision-makers' awareness about its causes and effects;
- depicts the links between wetland ecosystems and people by showing where and how human populations have interacted with the wetlands and how the population may be affected by the highlighted and anticipated changes;
- provides resource materials for educational purposes.

The Kenya Wetlands Atlas is a very valuable resource for all who have an interest in the sustainable management and conservation of Kenya's wetlands. It is the result of collaboration among many partners of the Government of Kenya. I would like to express the gratitude of the Government of Kenya to our partners in this process, especially the United Nations Environment Programme (UNEP) and the United States Government whose support through its technical agencies not only made the availability and analysis of satellite data possible but also made capacity building of our national experts possible. I am confident that this Atlas will raise the stature of the country's wetlands and provide evidence-based information to support the process of formulating the National Wetlands Policy.

Ali D. Mohamed, CBS
Permanent Secretary
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ACRONYMS

AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds (African-Eurasian Waterbird Agreement)
ASALs	Arid and Semi Arid Lands
AWF	African Wildlife Foundation
AWS	Africa Water and Sanitation
CAACs	Catchment Area Advisory Committees
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
CSOs	Civil Society Organizations
DANIDA	Danish International Development Agency
DECs	District Environmental Committees
DRSRS	Department of Resource Surveys and Remote Sensing
EAC	East African Community
EMCA	Environmental Management and Coordination Act
ESFC	Environmentalistes San Frontier Consultants
ESP	Economic Stimulus Package
EWEs	Extreme Weather Events
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse gases
GIS	Geographic Information Systems
GoK	Government of Kenya
IBAs	Important Bird Areas
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
JF	January and February
JJA	June, July and August
JJAS	June, July, August and September
KEFRI	Kenya Forestry Research Institute
KenGen	Kenya Electricity Generating Company Limited
KEWI	Kenya Water Institute
KFS	Kenya Forest Service
KFWG	Kenya Forest Working Group
KMD	Kenya Meteorological Department
KMFRI	Kenya Marine and Fisheries Research Institute
KSh	Kenya Shilling
KWS	Kenya Wildlife Service
LVBC	Lake Victoria Basin Commission
LVEMP II	Lake Victoria Environmental Management Project Phase II
LVFO	Lake Victoria Fisheries Organization
MAM	March, April and May
MDGs	Millennium Development Goals
MEAs	Multilateral Environmental Agreements
MEMR	Ministry of Environment and Mineral Resources
MPAs	Marine Protected Areas
NBCs	Nile Basin Countries
NBI	Nile Basin Initiative
NEMA	National Environment Management Authority
NEPAD	New Partnership for Africa's Development
NEWP	New England Wetland Plants
NIB	National Irrigation Board
NMK	National Museums of Kenya
NOAA	National Oceanic and Atmospheric Administration
NRCS	USDA Natural Resources Conservation Service
NTEAP	Nile Transboundary Environmental Action Project
NWCPC	National Water Conservation and Pipeline Corporation
OND	October, November and December
REDD+	Reducing Emissions from Deforestation and Forest Degradation, Forest Conservation, Sustainable Management of Forests and Carbon Stock Enhancement
SEI	Stockholm Environment Institute
SST	Sea-Surface Temperature
TDIP	Tana Delta Irrigation Project
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP DEWA	UNEP Division of Early Warning and Assessment
UNEP/WCMC	UNEP World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
URT	United Republic of Tanzania
US$	United States Dollar
USA	United States of America
USAID	United States Agency for International Development
USDA	US Department of Agriculture
USGS	United States Geological Survey
VIP	Ventilated Improved Pit latrine
WAB	Water Appeal Board
WASREB	Water Services Regulatory Board
WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	Water Resource Institute
WRMA	Water Resource Management Authority
WRUAs	Water Resources Users Associations
WSBs	Water Services Boards
WSPs	Water Service Providers
WSTF	Water Services Trust Fund
WWF	World Wildlife Fund
WWF-ESARPO	WWF Eastern and Southern Program Office

LIST OF FIGURES, TABLES AND BOXES

FIGURES

TABLES

BOXES

An aerial view of a section of Lake Nakuru, one of Kenya's Ramsar Sites.

Aurainja/Flickr

CHAPTER 1

AN OVERVIEW OF KENYA'S WETLANDS AND REGULATORY FRAMEWORK

Introduction

Although there is admittedly no universally accepted definition of wetlands (Finlayson and others 2011; Flournoy 1997; Copeland 2010), they are perceived as those ecosystems that integrate the characteristics of terrestrial and aquatic environments notably, water, soil and vegetation (Lathrop 2011). The degree to which these properties are combined exhibits spatial, temporal and wetland type variability. The latter accounts for the broad definitional base contained in Article 1 of the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, popularly referred to as the Ramsar Convention whose overarching aim is to 'stem the progressive encroachment on and loss of wetlands.'

The Convention describes wetlands as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.' Instructively though, this definition does not encompass permanent, deep water bodies and courses although it includes the shallow portions near the shorelines and riverbanks. Kenya acceded to the Ramsar Convention and it came into force in the country on October 5, 1990. Kenya Wildlife Service (KWS) is designated as the convention's implementing authority and national focal point (Ramsar Convention Secretariat 2012a).

The Environmental Management and Coordination Act (EMCA), which is Kenya's framework environmental law defines wetlands simply as 'areas permanently or seasonally flooded by water where plants and animals have become adapted.' However, a more far reaching definition, which is largely based on the Ramsar Convention, is offered by the Environmental Management and Coordination (Wetlands, Riverbanks, Lakeshores and Sea Shores Management) Regulations 2009. These regulations define wetlands as 'areas permanently or seasonally flooded by water where plants and animals have become adapted; and include swamps, areas of marsh, peat land, mountain bogs, banks of rivers, vegetation, areas of impeded drainage or brackish, salt or alkaline; including areas of marine water the depth of which at low tide does not exceed six metres. It also incorporates riparian and coastal zones adjacent to the wetlands'. Both the definitions of the Ramsar Convention and EMCA Wetland Regulations are fairly extensive and include shallow lakes and rivers, floodplains as well as coastal belts and marine areas in their ambit.

Wetlands occupy approximately 6 per cent of the Earth's surface area (Ramsar Convention Secretariat 2006). Although the exact extent of Kenya's wetlands is unknown owing to the lack of a wetlands inventory, they are estimated to occupy around 3-4 per cent of Kenya's land mass although this can temporarily soar to 6 per cent during the rainy seasons (Kenya Wetlands Forum 2012).

Despite their modest geographic extent, wetlands provide a number of critical ecosystem services that are indispensable to human beings and biodiversity's very survival, health and welfare. These provisioning, supporting, regulating, and cultural services (Millennium Ecosystem Assessment 2005), along with the wetlands' ecological and national development roles are discussed in detail in Chapter 4. Paradoxically though, the wetlands' provisioning services have led them to be overexploited and many of these ecosystems are receding

KEY MESSAGE

Owing to its diverse geography, Kenya is endowed with a variety of wetland types that range from riverine; lacustrine; palustrine; estuarine; marine; to human-made. Even though the Ramsar Convention has been in force in Kenya since 1990, an environment-friendly Constitution was promulgated in 2010 and the Environmental Management and Coordination Act and its by-laws contain a number of innovative wetland provisions, the absence of a national wetlands policy and a sector-specific wetlands law continue to impede the sustainable management of these vital but fragile ecosystems.

and are seriously degraded as is discussed in Chapter 5. This state of affairs has been compounded by climate change although as is explained in Chapter 6, this presents a range of exciting opportunities at all levels of governance from national and to community levels.

Floating *macrophytes* (water lilies) in Ondiri Swamp.

Characteristics of Wetlands

Because wetlands are in a continuous state of temporal and spatial flux, they are especially dynamic ecosystems. Nevertheless, it is generally understood that to qualify as wetlands, relevant ecosystems must meet some habitat and biological community criteria although the proportions of each of these is not constant within and across wetland types (Mitsch and Gosselink 1993).

Hydrology

Given that a wetland is wet land, land and water are important aspects of wetlands regardless of whether the water is fresh, brackish or saline. In this respect and given that wetlands either occupy a vital intermediate point between land and water or occur as isolated oases (Tiner 2012), they are often defined as habitats where the water table is at or near the ground surface and which host vegetation that is suited to these seasonally or permanently waterlogged conditions (Hejny and others 1998). Factors related to hydrology that influence the functioning of wetlands include the geomorphological setting, hydrodynamics, microclimate and soil types (Brouwer and others 2003) although there are mutual interactions among and between these factors.

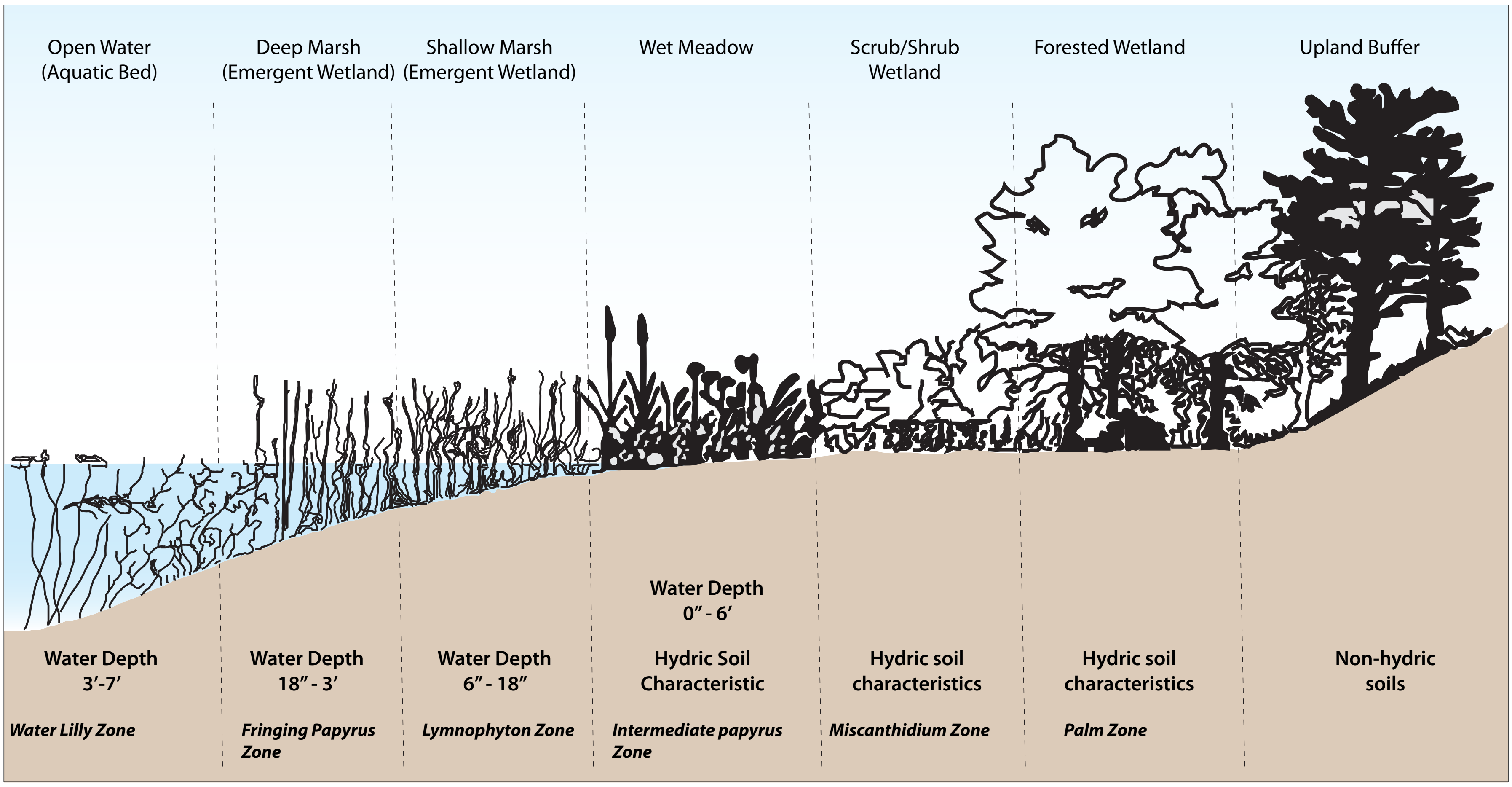
Mangrove forests in Manda Bay, Lamu.

Biological Community

Vegetation

Another criterion of wetlands is the presence of indicator organisms, the most perceptible of which is vegetation. Vegetation is in addition, a gauge of environmental integrity and an important determinant of an ecosystem's biotic composition (Hejny and others 1998). Wetland vegetation is typified by hydrophytes which are plants that have adapted morphologically (by for instance, possessing aerial root tips), physiologically (through for example, anaerobic respiration that enables these plants to withstand the absence of atmospheric oxygen), and reproductively (by, for instance, producing viviparous seeds which germinate within the fruit) to specifically tolerate partial or complete inundations for short or prolonged periods of time (Tiner

Figure 1.1: Diagrammatic representation of the various wetland vegetation types across a gradient of decreasing wetness.



Source: NEWP 2012

A fish catch in the Shimoni area, South Coast, Kenya.

2012). Examples of hydrophytes that are common in Kenya include mangroves (particularly *Rhizophora mucronata* and *Ceriops tagal*), *Arundo donax* (giant reed), *Phragmites* (reed), *Typha* (cattail, bulrush, kachalla and reedmace) and *Cyperus papyrus* (papyrus). Figure 1.1 contains a diagrammatic representation of the various wetland vegetation types.

Animals

Both freshwater and marine wetlands are species-rich and contain an array of invertebrates, birds, amphibians, reptiles and mammals (Dvorak and others 1998). Many wetlands exhibit high levels of endemism because the water component acts as a physical barrier to the dispersion of some taxonomic groups. An example is the 300 cichlid species that are endemic to wetlands in the Lake Victoria basin (Millennium Ecosystem Assessment 2005). Besides feeding on the ecosystem's vegetation, many of the animals within a wetland prey on each other, consequently forming an elaborate food chain that comprises plants at the base, herbivores in the middle and carnivores at the apex (Ulgiati and Brown 2009). The water-vegetation-animal feedback loop helps to ensure habitat continuity.

Soils

Owing to the hydrology of wetlands, soils that predominate in these ecosystems are characterized as hydric. The US Department of Agriculture Natural Resources Conservation Service (NRCS) provides a working definition of a hydric soil, terming it as 'a soil that is formed under conditions of saturation, flooding, or ponded long enough during the growing season to develop anaerobic conditions in the upper part' (NRCS 2012). The Yala Swamp situated in the Lake Victoria basin and its lakes namely: Sare, Kanyaboli and Namboyo which exhibit this type of soil are a lifeline for the neighbouring communities (Osumo and others 2006). So are the Kano plains which host the West Kano Rice Irrigation Scheme (Augustine 2009).

Nevertheless soil is not a necessary condition of wetlands as these ecosystems may occur in areas where there are no soils, provided hydrophytes are present such as rocky shores that are covered with seaweed. Moreover, areas with neither soils nor hydrophytes may be classified as wetlands if they are seasonally flooded, with tidal flats and gravel beaches being cases in point (Tiner 1997).

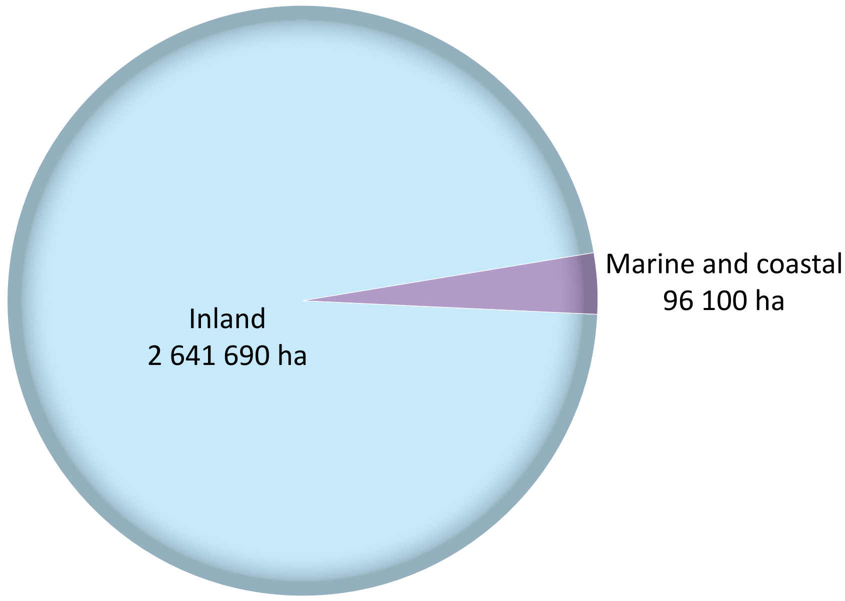
A community water pan on the Kano plains used to meet domestic and livestock needs dries up.

Categories of Kenya's Wetlands

The Ramsar classification of wetland types contains three broad categories: inland; marine and coastal; and human-made. These are then sub-divided into 42 types. Owing to Kenya's diverse climate and topography, the country is home to six wetland types: riverine; lacustrine; palustrine; estuarine; marine; and constructed wetlands. As is demonstrated in Figure 1.2, the area covered by inland wetlands far outstrips that covered by their marine and coastal counterparts.

Asymmetrical rainfall (depicted in Figure 1.3) and geomorphological features are the principal determinants of the distribution of the country's wetlands. The detailed classification of Kenya's wetlands and their general components is contained in Table 1.1, while the location of the country's natural wetlands is depicted in Figure 1.4.

Figure 1.2 Estimates of the area covered by Kenya's inland freshwater and marine wetlands.

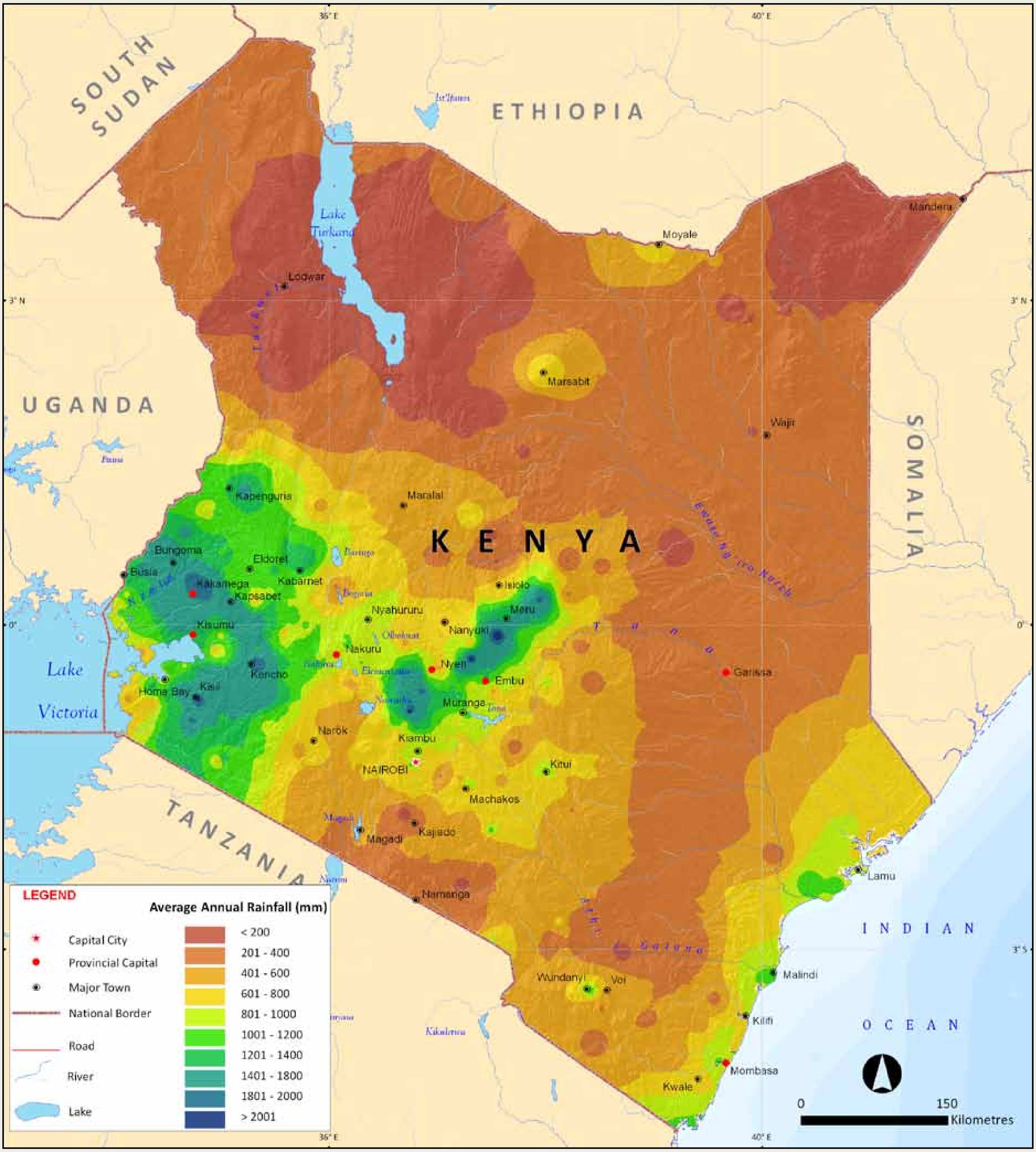


Source: Finlayson and others 1999

Table 1.1: Detailed classification of Kenya's wetlands and their components.

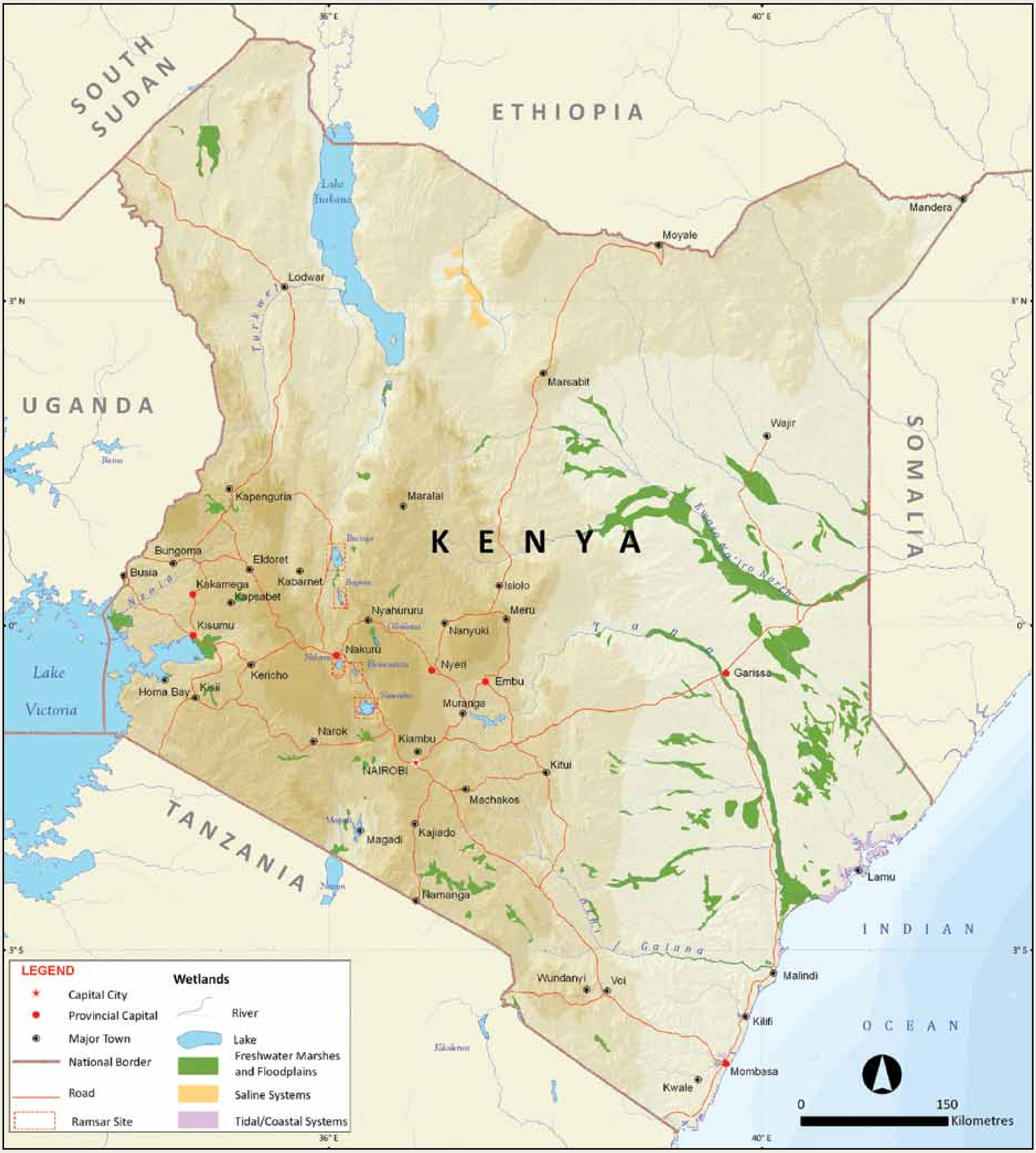
Formation	System	Sub-system	Hydrology	Description
Natural	Coastal and Marine	Marine	Subtidal	Shallow marine waters
				Marine aquatic beds
				Coral reefs
			Intertidal	Rocky marine shores
				Sand/shingle beaches
		Estuarine	Subtidal	Estuarine waters
			Intertidal	Intertidal mudflats
				Salt marshes
				Mangrove/tidal forests
		Lacustrine/palustrine	Permanent/seasonal	Brackish/saline lagoons
				Coastal fresh lagoons
	Inland	Riverine	Perennial	Permanent rivers/streams
				Inland deltas
				Intermittent rivers/ streams
			Intermittent	Floodplain wetlands
		Lacustrine	Permanent	Permanent freshwater lakes
			Seasonal	Seasonal freshwater lakes
			Permanent/seasonal	Permanent/seasonal saline lakes and marshes
		Palustrine	Permanent	Permanent freshwater ponds and marshes
				Open peat bogs, fens
				Shrub dominated swamps
				Freshwater swamp forests
				Peat swamp forests
			Seasonal	Freshwater springs, oases
				Seasonal freshwater marshes
		Geothermal		Geothermal wetlands
Human-made		Aquaculture		Fish, shrimp ponds
		Agriculture		Farm ponds, small tanks
				Irrigated land, rice fields
				Seasonally flooded arable land
		Salt exploitation		Salt pans, salines
		Urban and industrial		Reservoirs, barrages
				Gravel pits
				Sewage treatment plants

Figure 1.3: Average annual rainfall.



Source: Kenya Meteorological Department n.d.

Figure 1.4: Location of natural wetlands.



Source: NEMA 2011

Riverine

Riverine wetlands occur along rivers and streams. They are especially common along the country's main watercourses enumerated in Table 1.2. The most important of these are the Athi, Ewaso Ng'iro, Nyando, Yala and Tana Rivers although the latter is covered in more detail under the estuarine category of wetlands.

Table 1.2: Attributes of Kenya's main twelve river systems.

River	Catchment area (sq. km.)	River length (km)	Drainage body
Nzoia	12 696	315	L. Victoria
Yala	3 262	261	L. Victoria
Mara	9 574	198	L. Victoria
Turkwel	20 283	390	L. Turkana
Kerio	14 172	403	L. Turkana
Ewaso Ng'iro South	8 534	213	L. Natron
Ewaso Ng'iro North	91 428	740	Lorian Swamp
Athi	36 905	631	Indian Ocean
Tana	95 430	1 050	Indian Ocean
Nyando	3 450	153	L. Victoria
Sondu	3 489	153	L. Victoria
Kuja	6 868	180	L. Victoria

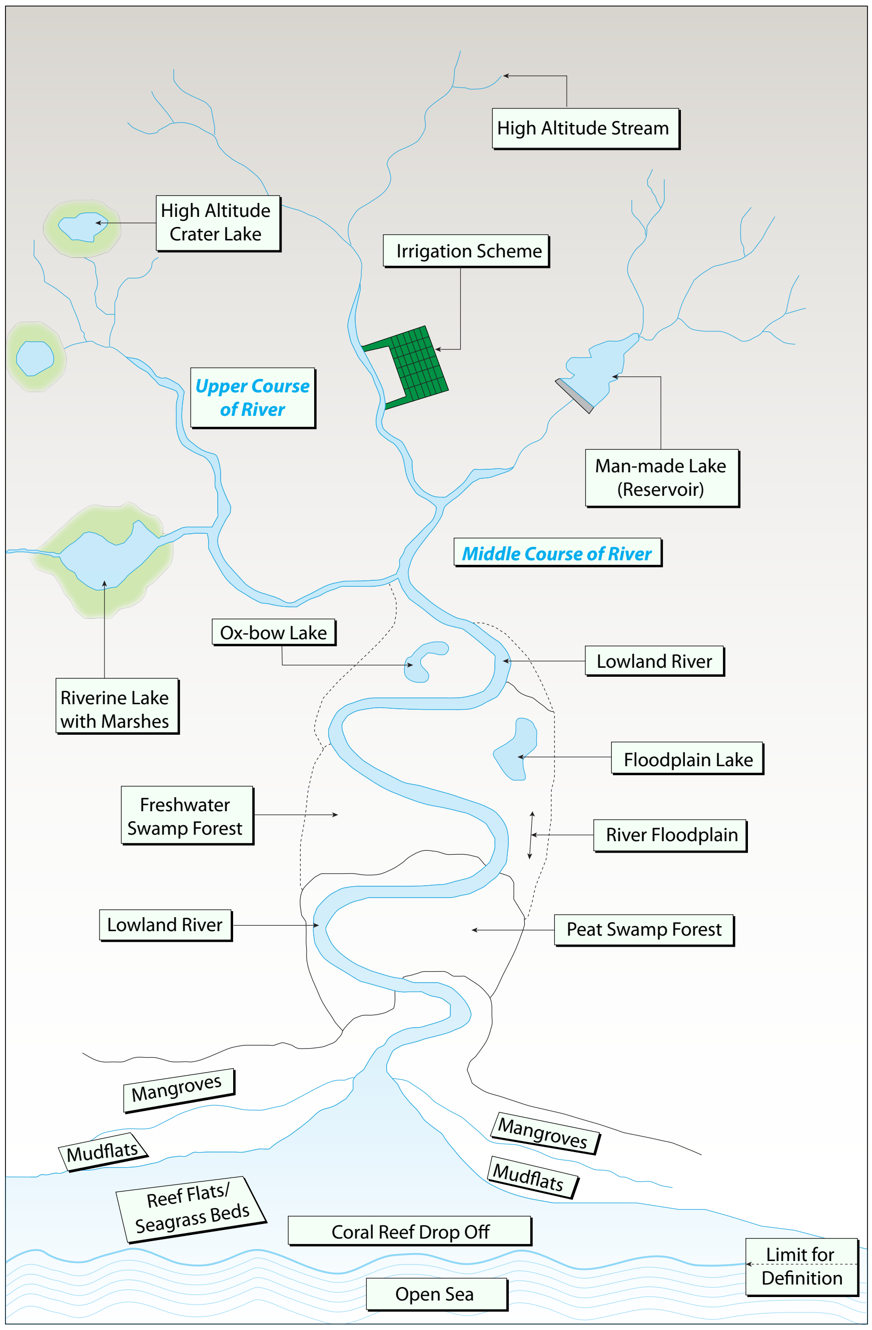
Source: Various scholarly publications

As rivers often traverse hundreds and sometimes thousands of kilometres, a number of wetlands occur within their basins. However, the types of wetlands that occur in a river catchment vary as you move downstream. For example, natural wetlands that occur upstream conventionally include high altitude streams and high altitude crater lakes. Artificial wetlands that are likely to occur near the upper course of a river, on the other hand, include irrigation schemes and man-made lakes. Riverine lakes with marshes as well as ox-bow lakes typically occur along the middle course of the river. Mangroves and mudflats are characteristically found along a river delta, just before the watercourse gushes into the ocean. Reef flats, seagrass beds and coral reefs mark the lowest downstream limit of wetlands, before the riverine waters merge with those of the open sea. The schematic illustration of the different types of wetlands along a hypothetical watercourse is contained in Figure 1.5.

Lacustrine

Lacustrine wetlands occur in and around lakes and are predominantly influenced by these water bodies, whether these are fresh or saline. As

Figure 1.5: Schematic illustration of different types of wetlands along the course of a river.



Source: Davies and Claridge 1993

lakes are situated in topographic depressions, water is the dominant feature and they typically lack trees, shrubs and persistent emergents (Tiner 1984; Armbruster 1990; McKernan and Braden 2001). Although lacustrine wetlands are common in the Lake Victoria basin and Rift Valley region, they also occur in craters, for instance Lakes Simbi and Sonachi (Ballot and others 2004) as well as mountains for example,

Lake Alice, Mount Kenya.

Table 1.3: Characteristics of the major Kenyan Lakes.

Name of lake	River(s) draining into lake	Surface area (sq. km.)	Maximum depth (m)	Water quality
Lakes with special categories (Ramsar sites or World Heritage Sites)				
Lake Nakuru (Ramsar/World Heritage Site)	Njoro, Makalia, Lamark, enderit, Ngosir	49	4.5	45% saline (pH 10.5)
Lake Elementaita (Ramsar/ World Heritage Site)		18	1.9	40% saline (pH 9.4)
Lake Baringo (Ramsar)	Pekerra, Molo, Ndoo, Toigibe	130	8	fresh
Lake Bogoria (Ramsar/World Heritage Site)	Wesseges	42.5	8.5	35% saline (9.8-10.3)
Lake Naivasha (Ramsar)	Malewa, Gilgil, Karati	156	7	fresh
Transboundary lakes				
Lake Victoria	Nyando, Yala, Nzoia, Sondu, Kibos, Kuja Mara,	68 800	84	fresh
Lake Turkana	Turkwel (Kenya), Kerio (Kenya), Omo (Ethiopia)	6 105	120	brackish
Lake Jipe	Umi	28	2	fresh
Lake Chala	(Underground seapage)	6	90	fresh
Lake Magadi	Ewaso Kedong	105	0.5	saline (pH 10.5)
Other lakes				
Lake Kamnarock	Kerio	1	shallow	fresh
Lake Ol Bolossat	Ewaso Ng'iro North	43	shallow	fresh
Lake Amboseli	Namanga		shallow	fresh
Yala swamp (Lake Kanyaboli)	Yala	15	3	fresh

Source: Adapted from the Ramsar Convention Secretariat 2011

Mount Kenya's Lake Alice, Tyndall Tarn, Hut Tarn and Hanging Tarn. The characteristics of the major lakes in Kenya are tabulated in Table 1.3.

All of the five sites in the country that have been designated as Wetlands of International Importance (Ramsar Sites) are lakes (Nakuru, Naivasha, Bogoria, Baringo and Elementaita) that are part of the Great Rift Valley system. All these lakes are important bird habitats and are particularly renowned for their large flamingo populations. As such, they are frequently visited by ornithologists, making them an important component of the tourist circuit. While Baringo and Naivasha are freshwater lakes, Nakuru, Bogoria and Elementaita are alkaline. These relatively shallow lakes collectively cover an area of 101 849 ha (1 018 sq. km.) as is specified in Table 1.4.

Table 1.4: Kenya's Wetlands of International Importance (Ramsar Sites).

Site	Date of Designation	Province	Area	Coordi-nates
Lake Baringo	10/01/02	Rift Valley	31 469 ha	00°32'N 036°05'E
Lake Bogoria	27/08/01	Rift Valley	10 700 ha	00°15'N 036°05'E
Lake Elementaita	05/09/05	Rift Valley	10 880 ha	00°46'S 036°23'E
Lake Naivasha	10/04/95	Rift Valley	30 000 ha	00°46'S 036°22'E
Lake Nakuru	05/06/90	Rift Valley	18 800 ha	00°24'S 036°05'E

Source: Ramsar Convention Secretariat 2012b


Steve Garvie/Flickr

Large flocks of the Lesser Flamingo frequently patronize Lake Bogoria.

Papyrus reeds growing along the Athi River.

Palustrine

Palustrine wetlands comprise marshes, swamps, bogs and floodplains. As these lack flowing water and are typically non-tidal, a defining characteristic is that they are dominated by persistent emergent wetland plants such as *Cyeprus papyrus*. Many small palustrine wetlands in the country serve as insular habitat islands in the centre of heavily populated areas. Others serve as agricultural land such as the King'wal Swamp in Nandi District and the Nyando floodplains. Even in instances where palustrine wetlands are preserved, they are at risk of degradation from agricultural chemical run off, invasive alien species and climate change.

Estuarine

Estuarine wetlands occur where fresh and salty water mix and include deltas, tidal marshes, and mangrove swamps. Kenya's estuary wetland inventory includes those in the Tana River Delta (Figure 1.6), at Mombasa, Shimo La Tewa, Kilifi, Turtle Bay as well as the islands of Lamu, Pate and Manda (Nyamweru 1992).

As the wetlands in these estuaries are shielded from high Indian Ocean waves and they receive fertile sediment from the permanent Tana and Sabaki Rivers and the seasonal rivers at Shimoni-Vanga, Funzi and Gazi Bays, and Port-Reitz, Tudor, Mtwapa, Kilifi and Mida Creeks, they are important habitats of the country's nine mangrove species although the dominant ones are *Rhizophora mucronata* and *Ceriops tagal* (Mocha 2011). The Tana Delta is also home to an array of fresh and brackish lakes, grasslands, wetlands, riverine forests, woodlands, dunes, beaches and streams and is considered to be one of Kenya's most important wetland areas.

However, because of the fertile sediment deposited downstream, the integrity of Kenya's estuarine wetlands is under immense pressure from a number of anthropogenic activities. These range from intensive agriculture such as that carried out in the Tana Integrated Sugar Project to salt works that are located dangerously close to fast degrading swathes of mangrove forest.

Figure 1.6: Tana Delta Wetland.

Marine

Marine wetlands are those that are exposed to the waves and currents of the open ocean and as such display a high level of salinity that typically exceeds 3 per cent (USGS n.d.). Kenya's marine wetlands portfolio consists of lagoons, shingle beaches, mangroves, rocky shorelines, salt marshes, mudflats, sea beds and coral reefs (Nyamweru 1992; Kenya Wetlands Forum 2011) with each of these exhibiting unique hydrological and topographical attributes. For example, while the country's sea grass beds predominantly occur in shallow reef slopes and sandy beaches are associated with coastal areas that are dominated by terrigenous sediment but without fringing reefs (Mocha 2011), coral reefs occur farther seaward, around the Marine Protected Areas (MPAs) such as the Mombasa Marine National Park and the Watumu Marine National Reserve.

Table 1.5: Kenya's largest dams.

Name of dam	River	Major basin	Sub-basin	Dam height (m)	Reservoir capacity (million m^3)	Reservoir area (thousand m^2)	Major purpose
Sasumua	Sasumua	Athi drainage basin	Galana	45	13.25	1 500	Water supply
Kindaruma	Tana	Tana drainage basin	Tana	24	16.0	250	Hydroelectricity
Gitaru	Tana	Tana drainage basin	Tana	30	20.0	310	Hydroelectricity
Thika	Thika	Tana drainage basin	Tana	63	70.0	2 900	Water supply
Kamburu	Tana	Tana drainage basin	Tana	56	150.0	15 000	Hydroelectricity
Kiambere	Tana	Tana drainage basin	Tana	112	585.0	25 000	Hydroelectricity
Masinga	Tana	Tana drainage basin	Tana	70	1 560.0	120 000	Hydroelectricity/ flood control
Turkwel	Turkwel	Rift Valley drainage basin	Lake Turkana	155	1 645.0	66 100	Hydroelectricity

Source: Adapted from FAO 2006

Human-made

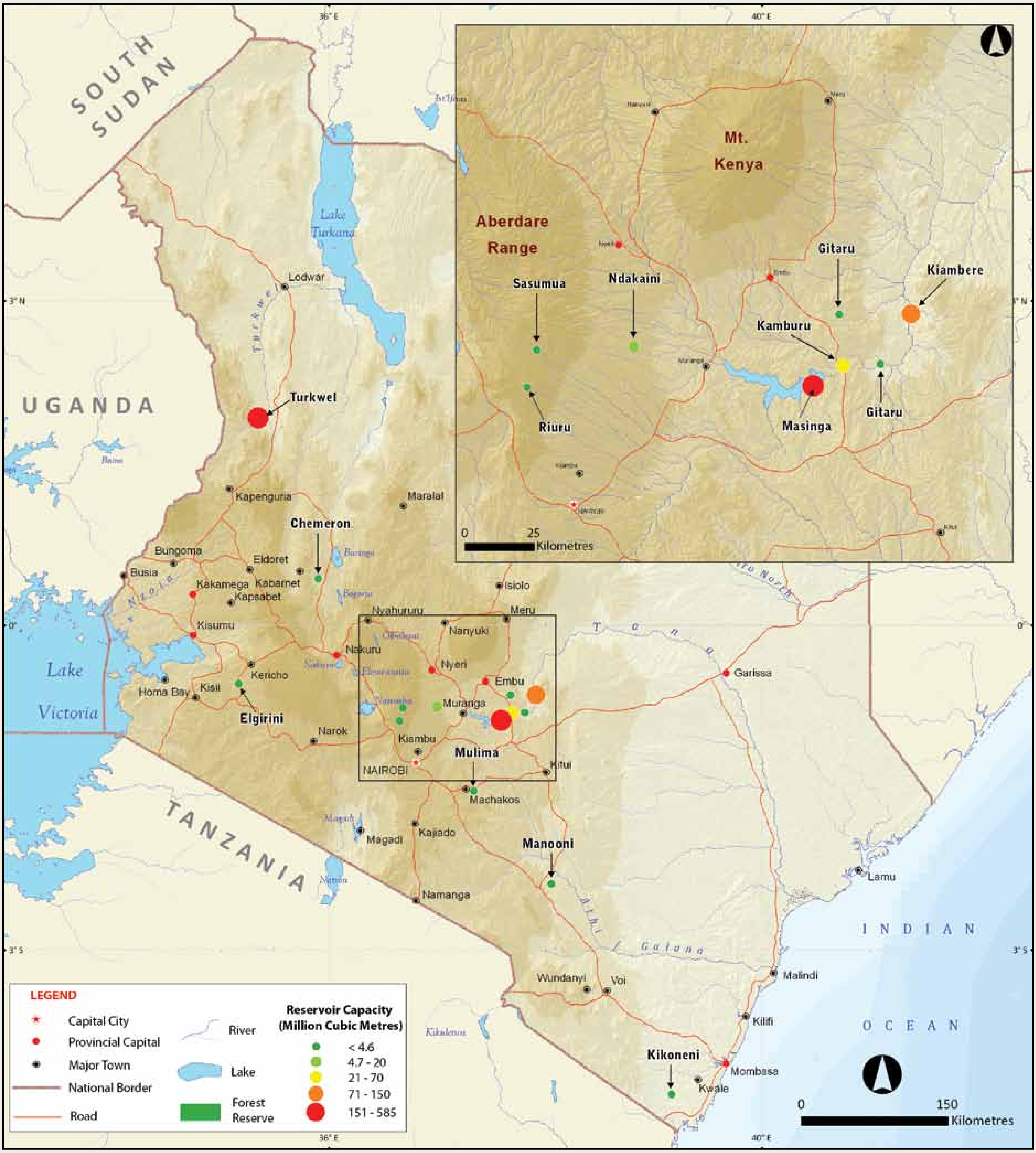
Kenya's human-made wetlands comprise a number of disparate artificial structures. These include water impoundment for irrigation (such as the Mwea, Ahero and Bunyala irrigation schemes) or hydroelectric power generation with the attendant major dams detailed in Table 1.5 and Figure 1.7. Other artificial wetlands consist of salt pans, sewage farms as well as fish and shrimp ponds. The stature of fish and shrimp ponds together with the associated economic and environmental consequences are poised to rise given the KSh. 1.12 billion (US$ 13.2 million) government Economic Stimulus Package (ESP) boost to aquaculture in the 2009/2010 financial year. The allocation funded the construction of 28 000 new fish ponds in 140 constituencies countrywide in order to strengthen food security and livelihood sources (GoK 2010).

Sewage farms present peculiar environmental challenges because they are not intuitively regarded as wetlands. This is exacerbated by the fact that, besides the sewage treatment plants run by the country's local governments, sanitation management in Kenya is characterized by disparate sewage treatment or disposal units (typically septic tanks, soakage pits and pit latrines) as only a negligible percentage of households is connected to the sewer lines.

A waste water and sewage treatment pond.

Eugene Apindi Ochieng

Figure 1.7: The location of Kenya's main dams.



Source: Adapted from FAO 2006

Thanks to CITES and rigorous enforcement by the Kenya Wildlife Service, the country's elephant population rose from the 1970s to 2011. However, more recently, poaching has been on the rise in order to feed a flourishing contraband ivory trade after Botswana, Namibia, South Africa, and Zimbabwe were permitted to sell off their stockpiles.

Regulatory Framework

International Policy and Legal Framework

As already indicated, Kenya became party to the Ramsar Convention in 1990. The convention imposes a number of obligations on the member states which can be grouped under three broad themes. First, Kenya is obligated to ensure the wise use of wetlands by including wetland conservation considerations in national planning processes, to establish natural reserves on wetlands and to prioritize capacity building in wetlands research, management and wardening. Second, Kenya undertook to designate qualifying wetlands for listing as Wetlands of International Importance (Ramsar Sites). Third, the country committed itself to international cooperation; to consult partner states especially with respect to transboundary wetlands, water systems and the dependent floral and faunal species.

Although the Ramsar Convention is the principal international instrument on wetland management, there are a number of other relevant conventions that Kenya is party to. These include the Convention on Biological Diversity (CBD) which Kenya ratified on 11 June 1992 and which entered into force on 26 July 1994; the

Pelicans on the shores of Lake Naivasha.

United Nations Framework Convention on Climate Change which was ratified by Kenya on 30 August 1994 as well as its Kyoto Protocol which Kenya acceded to on 25 February 2005 and which came into force on 26 May 2005; and the Convention Concerning the Protection of the World Cultural and Natural Heritage which Kenya acceded to on 5 June 1991. Other relevant instruments are the United Nations Convention to Combat Desertification (UNCCD) which Kenya ratified on 24 June 1997.

Others are the Convention on the Conservation of Migratory Species of Wild Animals also known as the CMS or Bonn Convention which entered into force in Kenya on 1 May 1999; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) which Kenya ratified on 13 December 1978 and which came into force in the country on 13 March 1979 as well as the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (also known as AEWA or African-Eurasian Waterbird Agreement) which entered into force in Kenya on 1 June 2001. A primer on these international instruments which complement the Ramsar Convention is contained in Box 1.1.

Domestic Policy and Legal Framework

Policy Famework

Kenya does not have a national policy on wetlands although a draft policy exists. Finalizing a national policy is important as it would raise the stature of these indispensable ecosystems, draw attention to their rapid degradation and provide an urgently-needed coherent and coordinated framework for their conservation and sustainable management.

Legal Framework

<u>Constitution</u>

Although the Constitution, which is Kenya's paramount law, does not expressly refer to wetlands, it enshrines a number of novel environmental provisions that can potentially improve wetland management. The preamble which is founded on the principle of respect for the environment affirms the determination and commitment of Kenyans to pursue a sustainable development path. Further, Article 42 entitles every person to a clean and healthy

Box 1.1: International legal instruments which complement the Ramsar Convention.

Convention on Biological Diversity (CBD)

One of the principal objectives of the CBD is the conservation of biological diversity. In this respect, it prioritizes the protection of ecosystems (such as wetlands) which are species-rich and are an important haven for endemic and threatened species.

Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention)

CMS is the only global convention that focuses on the conservation of terrestrial, aquatic and avian migratory species, their habitats and migration routes. Wetlands are an important habitat category because the migratory waterbirds use them as layover sites for feeding, resting and sheltering from harsh weather.

Agreement on the Conservation of African-Eurasian Migratory Waterbirds (also known as AEWA or African-Eurasian Waterbird Agreement)

Developed under the aegis of CMS, AEWA provides for coordinated and concerted action by the Range States in order to stem the decline of migratory waterbird species and their habitats in the geographic area of the African-Eurasian waterbird migration systems. Wetlands are singled out as requiring special attention because migratory waterbirds are highly dependent on them. However, these essential ecosystems are both receding and becoming degraded because of unsustainable human activities.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES seeks to regulate international trade in endangered species of wild animals and plants to ensure that this does not threaten their survival. It accords varying degrees of protection to more than 30 000 species of animals and plants. Rules governing trade of Appendix I species (which are threatened with extinction), are the most stringent. Many of the endangered and threatened species inhabit wetlands.

Convention Concerning the Protection of the World Cultural and Natural Heritage

The convention seeks to protect the world's cultural or natural heritage of outstanding value for the benefit of humankind as a whole. Lakes Bogoria, Nakuru and Elementaita, which are an integral part of the Kenya Lake System in the Great Rift Valley, were designated as World Heritage Sites. This is because these lakes are home to astoundingly diverse bird species, 13 of which are threatened. They are also the most important foraging site for the lesser flamingo, and a vital nesting and breeding ground for great white pelicans. The lakes are also inhabited by several mammalian species including the black and white rhino, and Rothschild's giraffe which are endangered. As such, they are recognized for their intrinsic worth and as valuable for the study of ecological processes.

United Nations Convention to Combat Desertification (UNCCD)

The UNCCD aims to slow the expansion of the world's deserts (and by extension the recession of wetlands) by entrenching the concept of sustainable land management and concomitantly maintaining and restoring land and soil productivity. It also addresses the specific challenges of the arid, semi-arid and dry sub-humid areas, (collectively referred to as drylands) which are some of the Earth's most fragile ecosystems and where a sizeable proportion of the world's vulnerable populations live.

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC seeks to coalesce international efforts to stabilize greenhouse gas (GHG) concentrations in the atmosphere at a point that would prevent grave anthropogenic interference with the climate system. It was envisaged that such a level would be achieved within a time frame that would enable ecosystems such as wetlands to adapt naturally to climate change. The convention also aims to promote conservation and enhancement of ecosystems which are reservoirs of GHGs (such as wetlands).

Kyoto Protocol to the United Nations Framework Convention on Climate Change

The Kyoto Protocol sets binding targets for 37 industrialized countries and the European community to reduce GHG emissions. The developed countries are required to reduce these emissions by five per cent in the 2008-2012 period relative to 1990 which is used as the base year. The Protocol offers the Annex I parties three market-based mechanisms for achieving these targets: emissions trading; clean development mechanism (CDM) and joint implementation. Increasingly, other programmes such as REDD+ (which are rooted in Articles 2 and 3 of the Protocol), and wetland conservation and restoration are seeking to reduce GHG emissions.

Source: Compiled from the conventions enumerated above.

Lake Paradise in Marsabit, Northern Kenya.

environment while Article 70 provides for redress in case of right infringement.

According to Article 64, sustainable management of land resources as well as sound conservation and protection of ecologically sensitive areas are some of the principles that undergird land management. Article 66 empowers the State to regulate land use while Article 68 mandates Parliament to revise, consolidate and rationalize existing land and land use laws. Article 69 obligates the State and persons to ensure sustainable use of the environment and natural resources and to establish environmental impact assessment, environmental audit and environmental monitoring processes. Article 72 obligates Parliament to enact legislation to give full effect to the Constitution's land and environment stipulations while the Fifth Schedule enumerates the laws that need to be enacted.

Environmental Management and Coordination Act (EMCA)

As the framework environmental law, EMCA contains a number of general provisions that augur well for the sustainable use of the country's wetland resources. But it also contains several wetland-specific provisions. Section 42 contains a range of stipulations on wetlands. First, it proscribes certain activities, such as construction, excavation and drilling in wetlands unless the prior written approval of the Director General of NEMA has been obtained. Second, it empowers the Minister responsible for the environment to declare a wetland as a protected area. Third, it authorizes the Minister to issue specific orders, regulations or standards for the management of wetlands including those at the risk of environmental degradation. The regulations were issued in 2009 and are discussed in the following section.

Environmental Management and Coordination (Wetlands, Riverbanks, Lakeshores and Seashores Management) Regulations 2009 (EMCA Wetland Regulations)

The objectives of the EMCA Wetland Regulations are to, among others, provide for the conservation and sustainable use of wetlands and their resources, ensure their protection as habitats for floral and faunal species, prevent and control their pollution and siltation and to provide a framework for public participation in their management. Regulation 5 also reiterates the need to have Environmental Impact Assessments and Environmental Audits as provided for by EMCA and discussed in the preceding section. Regulation 6 states that the Standards and Enforcement Review Committee established under EMCA shall advise NEMA on the wise use, management and conservation of wetlands.

The Minister responsible for the environment can, under Regulation 8, declare a wetland to be a protected area on account of its biological diversity, ecological importance, landscape, natural heritage, or aesthetic value. This declaration automatically triggers the prohibition of all activities in wetlands other than those touching on research, ecotourism, restoration or enhancement of the wetland or the activities identified in the management plan.

Regulation 9 sets out an elaborate procedure that must be followed before a wetland is declared a protected area while Regulation 10 obligates NEMA to develop and maintain a national wetland inventory. Regulation 11 lists the permitted uses of wetlands and includes harvesting of papyrus, medicinal plants, trees and reeds on a subsistence scale; collection of water for domestic use and; fishing. By Regulation 14, owners, occupiers and users of land which is adjacent or contiguous to wetlands have a duty to prevent its degradation or destruction.

The regulations are evidently comprehensive and their enforcement would help to address many of the issues that bedevil wetland management in the country. A major systemic shortcoming however, is that as regulations are merely subsidiary legislation, they rank below the Constitution and statutory laws in the hierarchy of legal authority.

Other policies and laws that are relevant to wetland management

Other Kenyan laws that are relevant to wetland management are contained in Box 1.2.

Box 1.2: Other policies and laws that are relevant to wetland management.

- National Land Policy, 2009
- Agriculture Act (Cap 318)
- Fisheries Act (Cap 378)
- Forests Act, 2005
- Kenya Maritime Authority Act, 2006
- Physical Planning Act (Cap 286)
- Water Act, 2002
- Wildlife (Conservation and Management) Act (Cap 376)
- The National Land Commission Act, 2012
- The Land Registration Act, 2012
- The Land Act, 2012.

A degraded wetland

Conclusion

The chapter has set the context for the rest of the Atlas. It has defined wetlands, outlined their characteristics and briefly discussed the types of wetlands that can be found in Kenya. It has also explored the applicable international and national policy and legal framework. Although some progressive developments such as the promulgation of the new Constitution and the issuance of the EMCA Wetland Regulations have been registered in this arena, some vacuums, such as the absence of a national wetland policy and a substantive wetland law, could well have negative implications for the management of the country's wetlands and wetland resources.

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A Saddle-billed Stork with fish in beak.

Axel Foley/Flickr

CHAPTER 2
INTERNAL WETLANDS

Introduction

From a geographic perspective, internal wetlands are those that occur within Kenya. They therefore differ from transboundary wetlands (which are discussed in Chapter 3) which by their very nature straddle two or more international boundaries. Given the inherent relationship between water and wetlands, these ecosystems are grouped by basin as designated by the Water Resources Management Authority (WRMA). WRMA is the lead agency in water resources management and is responsible for catchment and sub-catchment planning, management, protection and conservation of water resources. In accordance with this mandate, it has subdivided the country's hydrological areas into six major basins: Lake Victoria North; Lake Victoria South; Rift Valley; Ewaso Ng'iro; Tana and Athi (Figure 2.1). The following sections describe these hydrological basins, the major wetlands associated with them as well as the pressures exerted on them and the

KEY MESSAGE

Kenya is blessed with an array of internal wetlands dispersed around its six water basins. Some of these wetlands possess such aesthetic beauty and play such important ecological roles that they have been designated as Wetlands of International Importance (Ramsar Sites) or World Heritage Sites. However, despite having complete jurisdiction over these vital ecosystems, many of these are continually degrading due to the over-abstraction of water, wetland vegetation and eutrophication caused by domestic, agricultural chemical and industrial runoff. These are themselves primarily symptoms of lack of a holistic and participatorily developed national wetland policy as well as a substantive wetland-specific law.

Sindo, Lake Victoria.

M. Wagner/Flickr

Figure 2.1: The six WRMA designated basins.

Source: Modified from WRI and others 2007

A storm over Lake Victoria.

amalthya/Flickr

resulting impacts. Obviously, because basins which are situated near international borders often straddle two or more countries, some of the attendant wetlands are bound to be transboundary and these are discussed in Chapter 3. This Chapter therefore focuses on the internal wetlands, irrespective of the geographic scope of the associated basins.

Lake Victoria North Basin Wetlands

The Lake Victoria North basin (whose main attributes are in Table 2.1), which is diagrammatically depicted in Figure 2.2, is located to the north of Lake Victoria, the world's second largest freshwater lake. The main rivers associated with it are the Nzoia and Sio-Siteko. The headwaters of the Nzoia River drain Mount Elgon, the Cherangani Hills and northern sections of the Mau Forest Complex, East Africa's largest closed canopy forest. The Nzoia River basin is the largest sub-basin in the Lake Victoria North basin (Nyadawa and Mwangi 2010). The Yala River emanates from the northern portion of the Mau Forest Complex and the Kakamega Forest, Kenya's only rainforest. The major wetlands in the Lake Victoria North basin are the Yala Swamp, Lake Kanyaboli and the Sio-Siteko River Wetland. The latter is a transboundary wetland and is therefore discussed in Chapter 3.

Figure 2.2: Lake Victoria North Basin.

Source: Modified from WRI and others 2007

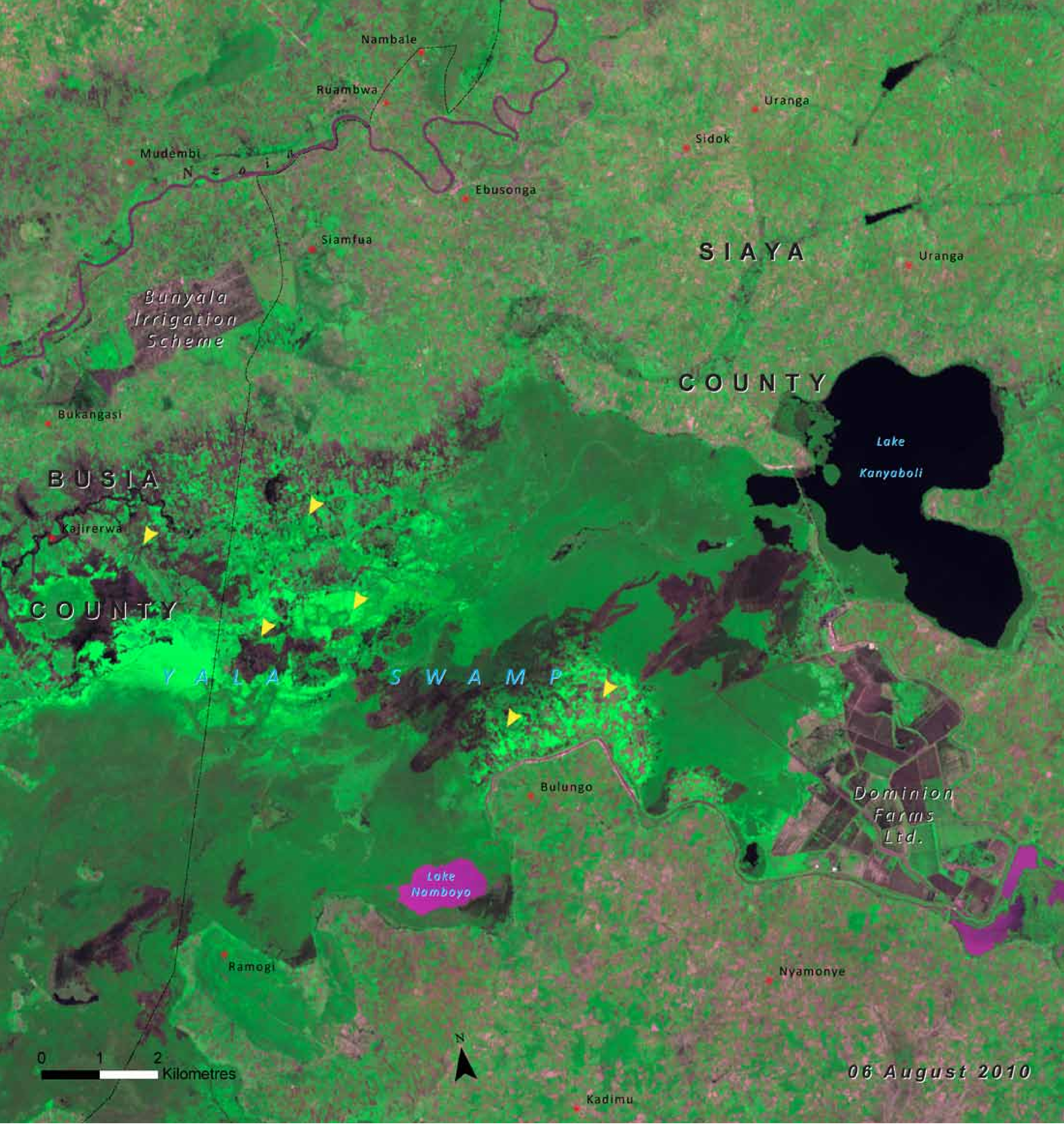
Table 2.1: Characteristics of the Lake Victoria North basin.

Basin and Basin area (sq. km.)	Major wetlands	Major land /wetlands uses	Pressures	Impacts
Lake Victoria North 32 384 sq. km.	• Lake Victoria • River Yala • Yala Swamp • Lake Kanyaboli • River Nzoia • Sio-Siteko	• Fishing • Large scale farming • Mining • Harvesting papyrus reeds • Brick making • Forestry • Conservation- Kakamega forest • Tourism and recreation • Irrigation • Power production • Artisanal products	• Inappropriate land use and overutilization • Conversion of wetlands to agricultural land • Unsustainable exploitation of resources • Land subdivision and fragmentation	• Pollution • Loss of land cover • Invasive species • Reduced water quantity and quality • Loss of biodiversity • Flooding • Reduced fisheries

Yala Swamp

Yala Swamp, Kenya's largest freshwater wetland, is located on the deltaic sediments of the Nzoia and Yala Rivers at the point at which they empty in Lake Victoria. The expansive wetland contains three freshwater lakes: Kanyaboli, Sare, and Namboyo (Kenya Wetlands Forum 2006). Its vegetation is dominated by papyrus (*Cyperus papyrus*), phragmites and typha. The wetland is one of the few refuges of the threatened Sitatunga antelope (*Tragelaphus spekeii*) in Kenya. The associated lakes contain some critically endangered haplochromine fish species, some of which have been rendered extinct in the main basin of Lake Victoria. The Yala Swamp is also profuse with birdlife.

Yala Swamp also has tremendous socio-economic value to surrounding communities for whom it is a source of arable land, fish protein, vegetables, medicinal herbs



and construction materials. However, because only the Lake Kanyaboli portion of the wetland is legally protected (because it was gazetted as a national reserve), it is prone to overexploitation.

The images above illustrate the conversion of the wetland's vegetation to agricultural use. In the 2007 image, only the large scale Dominion Farm project is visible while in the 2010 image, an additional portion of the swamp's vegetation (represented by yellow arrows) has been cleared by small-scale farmers. While conversion of the wetland may yield short-term gain, it invariably leads to long-term economic, social, and environmental ills such as higher food costs, loss of soil fertility and lower yields (Kenya Wetlands Forum 2006).

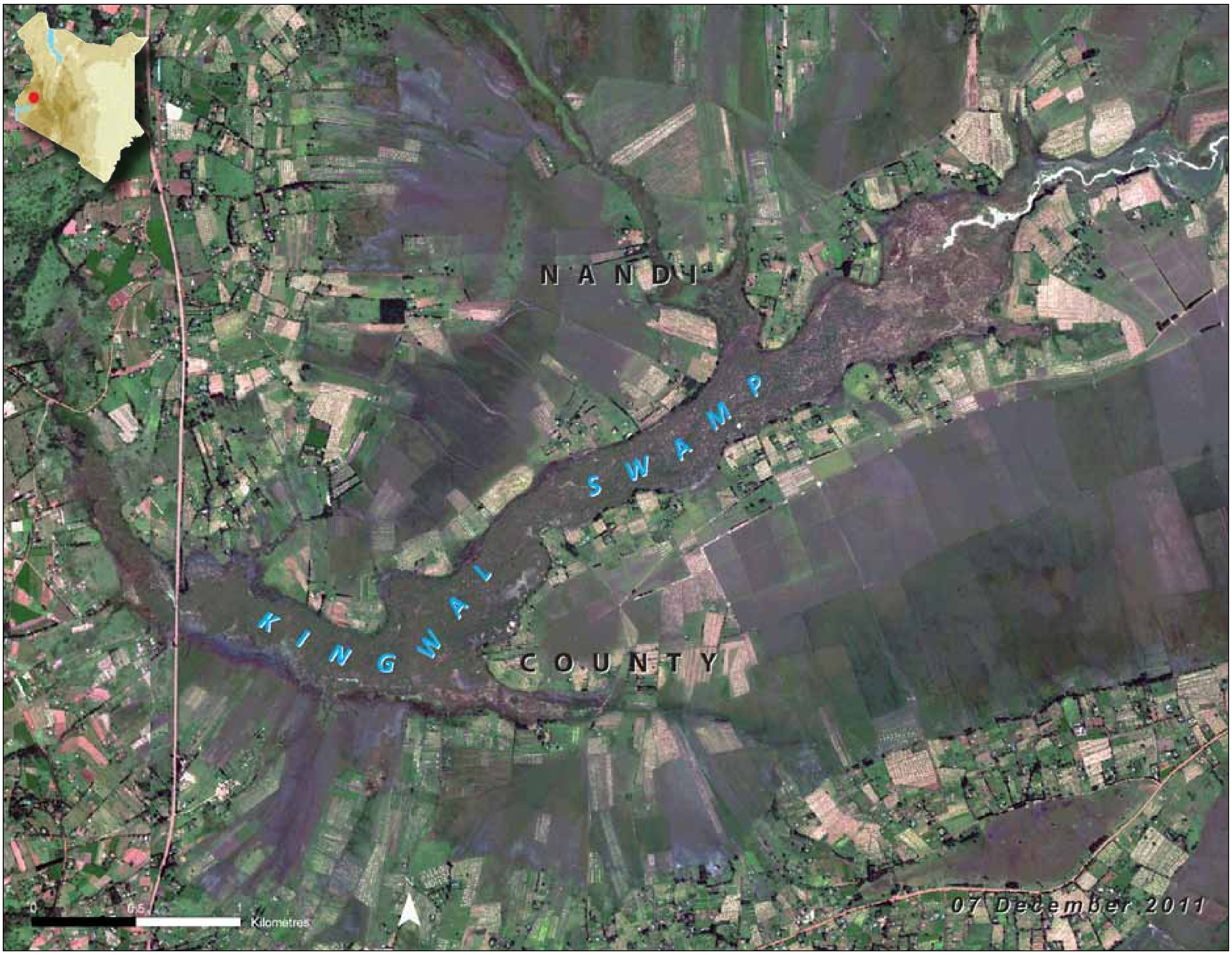
The rare Sitatunga antelope.

Kingwal Swamp

The Kingwal Swamp is a hitherto extensive high altitude wetland located north of the Nandi hills. It is renowned as a breeding site for the Sitatunga antelope (*Tragelaphus spekii*) that is both rare and endangered (Sitienei and others 2012). It is also a habitat for a considerable crane bird population and the water berry (*Syzygium guineense*) which can grow 15-30 m tall and is valued by local communities (Ambasa 2005) for its medicinal properties, edible purple-black fruit, leaves that are used for fodder, its red-brown wood that makes excellent firewood and charcoal as well as its bark that can be used for tanning and dyeing and for glazing ceramics (Orwa and others 2009). The swamp is also used for communal grazing during the dry spells and for carrying out the culturally important initiation rites of the Nandi community (Ambasa 2005).

The Kingwal Swamp is mainly fed by the Kesses River as well as its Legetet and Kibore tributaries. Vegetation is dominated by large stretches of papyrus (*Cyperus papyrus*) although phragmites (*Phragmites karka*), bulrushes (*Typha domingensis*), reeds (*Echinochloa pyramidalis*), a number of *Cyperus sp*. and sedge (*Pycreus lanceus*) are also present. The swamp also has extensive patches of low

A high resolution satellite image showing the Kingwal Swamp. Much of the swamp has been drained in order to make it amenable for settlement and cultivation.



A dried pond in the Nyando/Kado Swamp.

vegetation which primarily consist of *Polygonum setosulum, Hydrocotyle ranunculoides, Oenanthe palustris, Hygrophila spiciformis, Ranunculus multifidus* and *Pennisetum sp*.

Part of the wetland has been excavated in order to provide clay for a thriving brickmaking industry while much of the swamp has been drained in order to make it amenable for settlement and cultivation. Planting of rows of eucalyptus trees has further shrunk the wetland (Ambasa 2005). Intensive agriculture also exposes the wetland to fertilizer leaching with the resulting eutrophication creating conducive conditions for the spread of invasive alien species such as Elephant grass (*Pennisetum sp.*) which has already colonized the Saiwa Swamp, displacing the native Typha vegetation (Mohamed 2002). A positive development, nevertheless, is that while the swamp has not been designated as a protected area, concerted community conservation efforts have resulted in the decline of incidences of poaching the already endangered Sitatunga antelope.

Lake Victoria South Basin Wetlands

The Lake Victoria South basin covers the area around Lake Victoria that sits between the Yala River, past the Migori River and up to the border with Tanzania as is displayed in Figure 2.3. The basin's central attributes are contained in Table 2.2. The main wetlands of the basin are associated with the Migori, Nyando and Sondu Miriu Rivers. All these rivers originate in the Mau Forest Complex but eventually drain into Lake Victoria.

Figure 2.3: Lake Victoria South Basin.

Source: Modified from WRI and others 2007

Table 2.2: Characteristics of Lake Victoria South basin.

Basin and Basin area (sq. km.)	Major wetlands	Major land /wetlands uses	Pressures	Impacts
Lake Victoria South 18 613 sq. km.	• Lake Victoria • River Nyando • Migori River • Lake Simbi • River Sondu-Miriu	• Fishing • Large scale farming • Mining • Harvesting papyrus reeds • Brick making • Pastoralism • Forestry • Conservation- Ruma, Ndere island • Energy • Water supply • Recreation • Artisanal products	• Inappropriate land use and overutilization • Conversion of wetlands to agricultural land • Unsustainable exploitation of resources • Land subdivision and fragmentation	• Pollution • Loss of land cover • Invasive species • Reduced water quantity and quality • Loss of biodiversity • Flooding • Reduced fisheries

High sediment load near Nyando mouth.

Worldagroforestry.org

Nyando (Kusa) Swamp

The Nyando (Kusa) Swamp forms at the mouth of the Nyando River where it enters the Winam Gulf of Lake Victoria. It is generally covered with dense papyrus (*Cyperus papyrus*) beds. The water grass (*Vossia cuspidate*) typically occurs at the deep water fringes of the papyrus, and reeds (*Phragmites spp.*) fringe the landward edges of the swamp (BirdLife 2012). The wetland is a valuable habitat for rare bird species such as the Papyrus gonolek (*Laniarius mufumbiri*) while several other bird species are endemic to the papyrus (BirdLife 2012). Like other papyrus swamps on Lake Victoria, Kusa provides an important

Nyando Swamp forms at the point where River Nyando meets Lake Victoria. This wetland, threatened by reclamation for rice farms in the North, is an important buffer between the Lake and terrestrial human activities that lead to water pollution.

Papyrus growing along the shore.

Melanie Lukesh/Flickr

refuge for larval fish, thus supporting Kenya's fisheries sector (Owino and Ryan 2007). Papyrus swamps such as Kusa provide some filtration to sediments and other pollutants entering Lake Victoria (Kyambadde and others 2004). The papyrus reeds also support a local mat making industry (BirdLife 2012), providing livelihoods to thousands of the wetland's inhabitants.

Significant portions of the Kusa Swamp have already been converted to agriculture and settlement. Indeed, the population growth rate in the swamp in the 1990s exceeded 3.5 per cent per year, well above the national average. Further, the unsustainable harvesting of papyrus to feed a lucrative local handicraft industry led to the loss of 34- 50 per cent of the wetland's papyrus between 1969 and 2000 alone (Owino and Ryan 2007) which in turn negatively impacted the ecological functions of the wetland (BirdLife 2012). Another challenge is that the Nyando River has an unsustainably high rate of irrigation development. The attendant sediment, together with the upstream residential runoff and industrial and sewage discharges, affect the quality of Lake Victoria's water (Ong and Orego 2002).

Rift Valley Basin Wetlands

The Rift Valley (illustrated in Figure 2.4) is a 60 km-wide internal drainage basin. The main wetlands in the region, whose characteristics are outlined in Table 2.3, are Lake Magadi, Lake Nakuru, Lake Naivasha, Lake Baringo, Lake Turkana and Turkwel River. Apart from the freshwater Lake Naivasha and Lake Baringo (Britton and Harper 2006; Hickley and others 2004), all the basin's lakes are alkaline. Major rivers in this basin include the Mara, Ewaso Ng'iro and Kerio which all originate in the Mau Forest Complex, as well as the Turkwel River which drains Mount Elgon (Gichuki and others 2001).

Figure 2.4: Rift Valley basin.

Source: Modified from WRI and others 2007

Table 2.3: Characteristics of the Rift Valley basin

Basin and Basin area (sq. km.)	Major wetlands	Major land /wetlands uses	Pressures	Impacts
Rift Valley 138 459 sq. km.	• Lake Nakuru • Lake Naivasha • Lake Baringo • Lake Turkana • Lake Magadi • Turkwel River	• Conservation • Mining • Fishing • Forestry • Pastoralism • Energy- geo and hydro power • Ranching • Tourism and recreation • Irrigation	• Urbanization • Inappropriate land use • Conversion of land for agriculture • Unsustainable exploitation of resources • Increased demand for resources • Land subdivision and fragmentation	• Pollution • Soil erosion/siltation • Loss of land/forest cover • Overgrazing • Reduced quantity and quality of water

Some wetland vegetation remains on the eastern edge of the lake but it is under immense pressure from alternative land uses.

Lake Naivasha

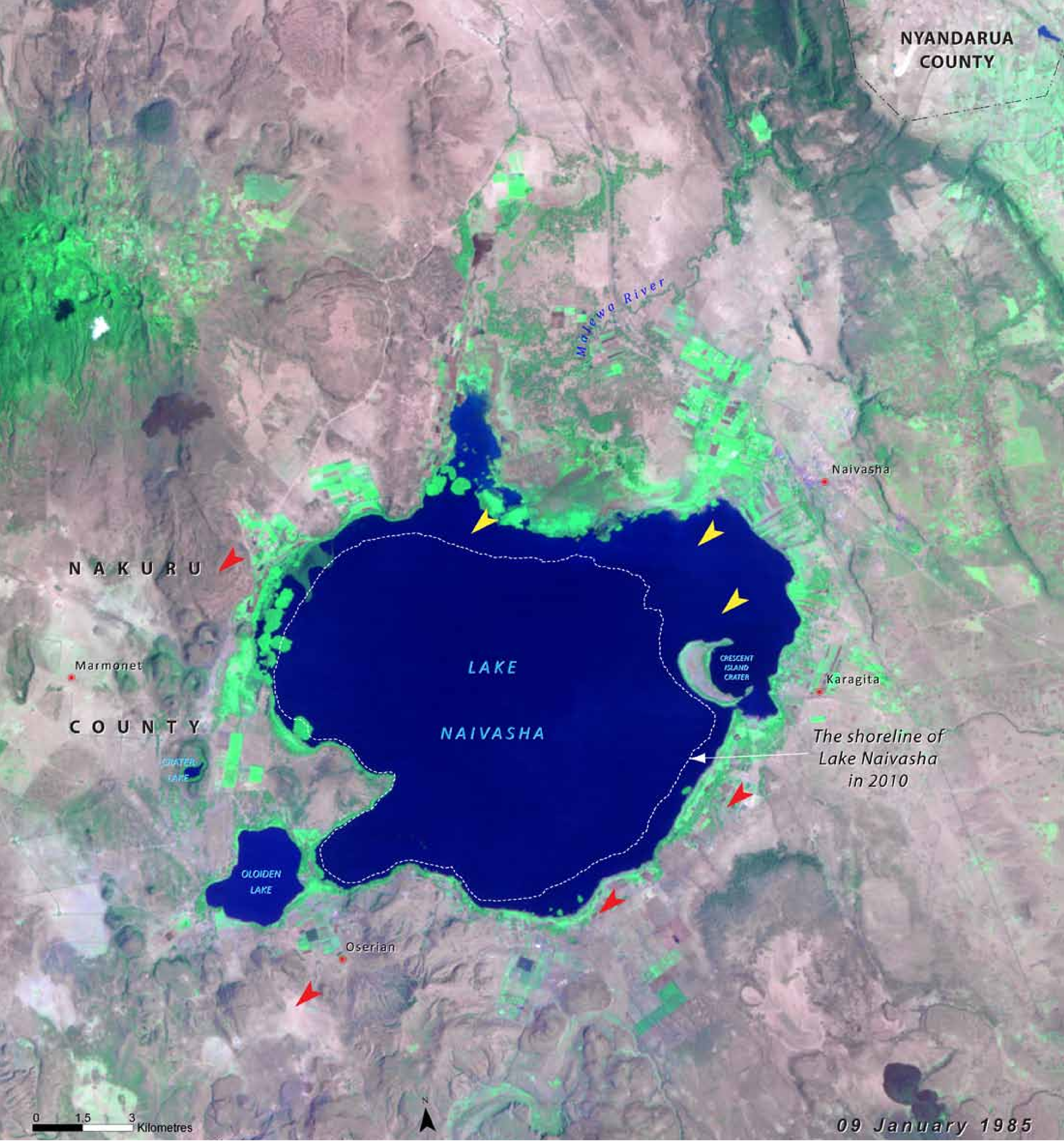
As already discussed above, Lake Naivasha is one of only two freshwater lakes in the Kenyan Rift Valley. Due to its ecological significance, uniqueness and rich biodiversity, the lake was designated as a Ramsar Site in 1995 making it the second Wetland of International Importance (Ramsar Site) in Kenya after Lake Nakuru. The perennial Malewa and Gilgil Rivers which originate from the Nyandarua ranges (Gherardi and others 2011) account for nearly 90 per cent of the lake's inflows (Otiang'a-Owiti and Oswe 2007) while the seasonal Karati River accounts for most of the remainder (Ayenew and Becht 2008). The Malewa River has catchment area of 1 730 sq. km. while the Gilgil basin spans an area of 429 sq. km. (Ayenew and others 2007). The area surrounding the lake supports a wide variety of fauna including large mammals such as the hippopotamus, zebra, giraffe, waterbuck, buffalo, hyena, and jackal, as well as over 350 species of birds, reptiles and amphibians.

Lake Naivasha.

A series of commercial greenhouses surround Lake Naivasha although there is a marked concentration of these along the southern shoreline.

Native Daphnia fish species in the lake have been replaced by introduced species including large mouth bass (*Micropterus salmoides*) which is native to USA, Common carp (*Cyprinus carpio*) which was dispersed from the Central Highlands by the 1997 El Nino rains and Gervais (*Tilapia zilli*) which was originally confined to Lake Victoria. In addition, the *Gambusia sp., Poecilia sp.,* and *Lebistes reticulate* were introduced into the lake in order to biologically control mosquitoes (Mergeay and others 2004).

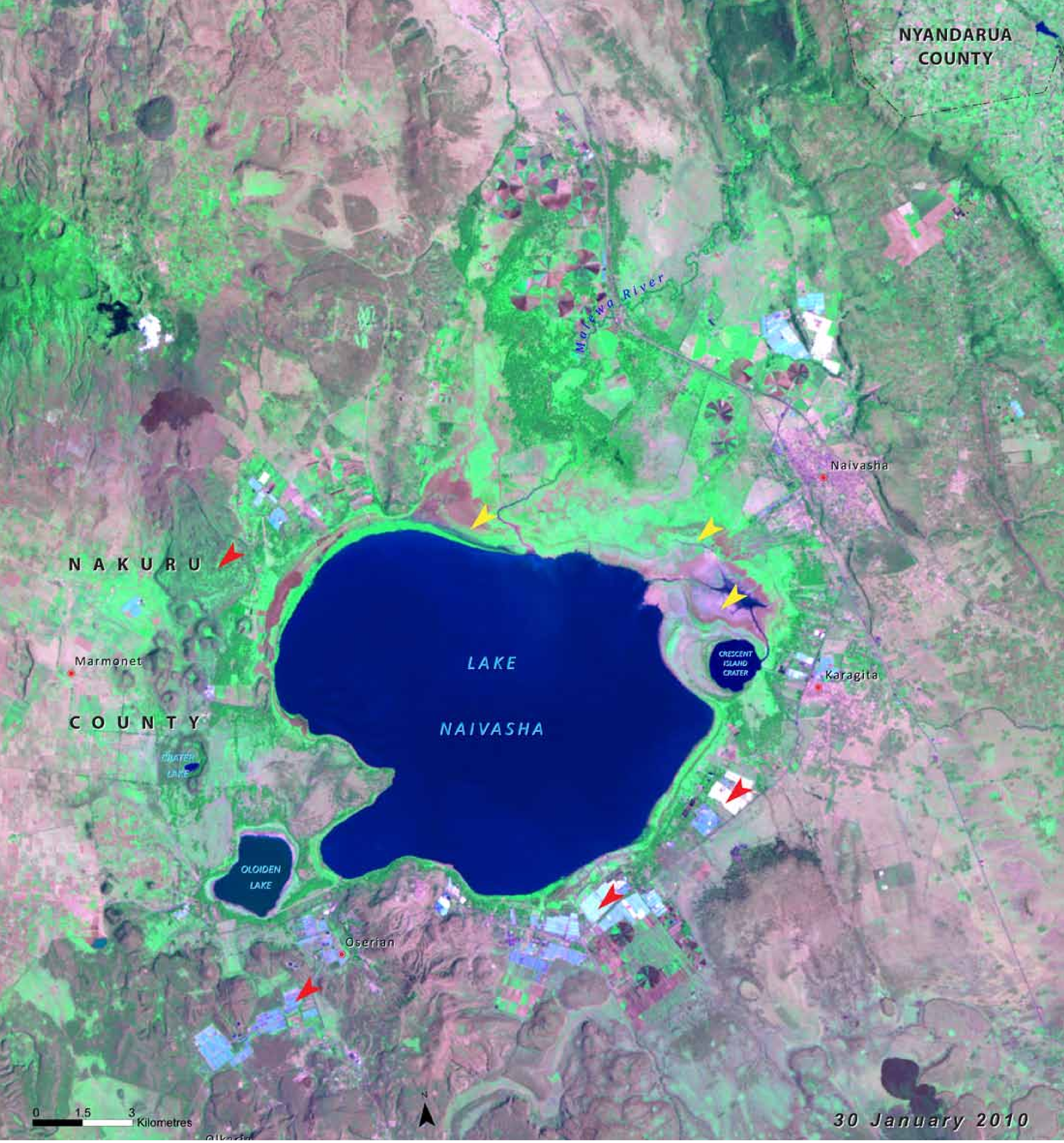
The lake supplies drinking water to Nakuru, irrigation water to a flourishing Naivasha-based horticultural sector and water to the Olkaria Geothermal Power Station (Becht and Harper 2002). Owing to the attendant economic opportunities, the human population in Naivasha Town and its environs has grown dramatically, resulting in over-abstraction of water from the lake's hydrological system (Harper and Mavuti 2004) and exerting enormous environmental pressure on the lake and the associated wetlands. Indeed, owing to anthropogenic activities, a perennially low lake level and destruction by large herbivores, much of the papyrus (*Cyperus papyrus*) that once lined the lake's shoreline and which was instrumental in maintaining the lake's water quality is severely degraded (Morrison and Harper 2009).



Lake Naivasha

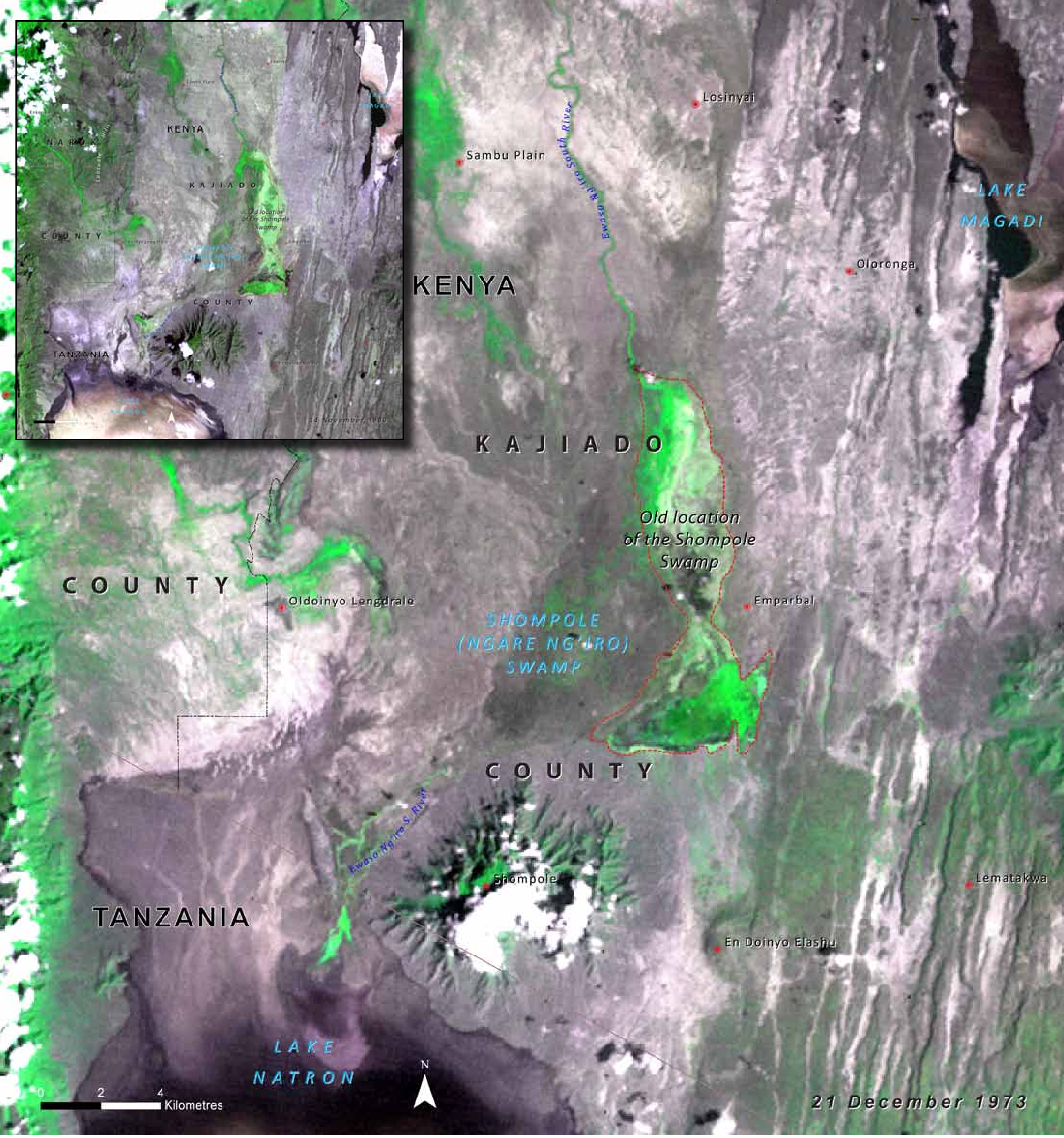
Lake Naivasha was designated as a Wetland of International Importance (Ramsar Site) in 1995. Despite this, the pressure exerted on the Lake has increased as anthropogenic activities have intensified throughout the catchment. This is attributable to the fact that the human population in Naivasha Town and near the lake shores has increased 50-fold over the past three decades, to more than 120 000.

Some of the threats to Lake Naivasha include heavy sedimentation, clearing of natural vegetation for agriculture especially horticulture, and over-harvesting of the fringing papyrus along the main inflow rivers, the Malewa and Gilgil as these traditionally shield the water body from excess sediment inflow. Several of these physical changes (denoted by red arrows) can be seen in the differences between the 1985 and 2010 satellite images.



Many greenhouse flower farms have been built since the early 1980s and the markedly bright white and the light blue, square greenhouse roofs are clearly decipherable.

However, Lake Naivasha has a history of fluctuating depths and surface area due to its shallow depth (maximum depth of nine metres) and rainfall variability within its catchment. When the rains fail or are lower than average, the lake's surface area reduces dramatically. For example, in the 2010 satellite image, taken during a drought year, the lake receded so much that even the crescent island crater was completely separated from the rest of the lake by land (yellow arrows). This is a stark contrast to the situation in 1985 (Stoof-Leichsenring and others 2011).



Shompole (Ngare Ng'iro) Swamp

Shompole (Ngare Ng'iro) Swamp is located within the Ewaso Ng'iro South River floodplain in the Ngare Ng'iro plain. The river flows through this swamp before eventually draining into Lake Natron. The weather in Shompole is characterized by high ambient temperatures and low, bimodal rainfall. Mean annual rainfall varies from 300 to 800 mm.

Although this is an arid/semi arid area, the Shompole Swamp, along with the Ewaso Ng'iro South River, provides sufficient water for domestic use and for livestock watering. Its significance is highlighted by the fact that during the dry spell, the wetland is virtually the only grazing land available for livestock herders. The Shompole Swamp is also home to an array of faunal and floral species.

However, according to satellite imagery and other studies, the wetland is gradually shifting its position. Using 1973 as the base year, it is evident that the swamp starts shifting position in 1980, through 1984 (which was characterized by extreme drought hence the diminished size of the swamp), and eventually settles in a new position in the 2011 image.

Obviously, the changes of wetland location are attended by changes in habitat ranges, with consequent disturbances on the dependent biodiversity species. The shifts also impact the farming activities of the local communities as in order to 'follow the swamp,' farmers often have to frequently change the location of their fields. This has adverse financial implications as it necessitates periodic reinvestments in land preparation and in the digging irrigation and drainage canals.

The Ewaso Ng'iro North River.

Don Heffernan/Flickr

Ewaso Ng'iro North Basin

The Ewaso Ng'iro North basin represented in Figure 2.5 has an estimated area of 213 731 sq. km. making it the largest of the WRMA designated basins. The attributes of the basin's wetlands are contained in Table 2.4. The Ewaso Ng'iro North River, a mid-sized, permanent river, is the most important wetland in this basin. It drains Mount Kenya and the Aberdare Range in the central Kenya highlands (Off and others 2008) and flows eastward into Somalia, running alongside the Lorian Swamp.

Lorian Swamp

Lorian Swamp lies on a vast floodplain in an arid zone of North Eastern Kenya. Although the area receives average annual rainfall of 150-600 mm, this is highly variable, making flooding and drought recurrent in the area (Mati and others 2005). Ranging from 24º C to 30º C, the mean annual temperature is quite high with the result that evaporation can be ten times the annual rainfall in some locations (Mati and others 2005).

The swamp is fed by the Ewaso Ng'iro North River and to a lesser degree by seasonal streams or wadis from the southwest and northeast. The river drains a considerable area in the eastern slopes of the Aberdares while other tributaries (the Naro Moru, Burguret, the Liki, Nanyuki, and the Sirimon) drain some of the slopes of Mount Kenya (Leibundgut 1983). Stream gauge data shows the river's flow to be highly seasonal with dry season flows accounting for a negligible

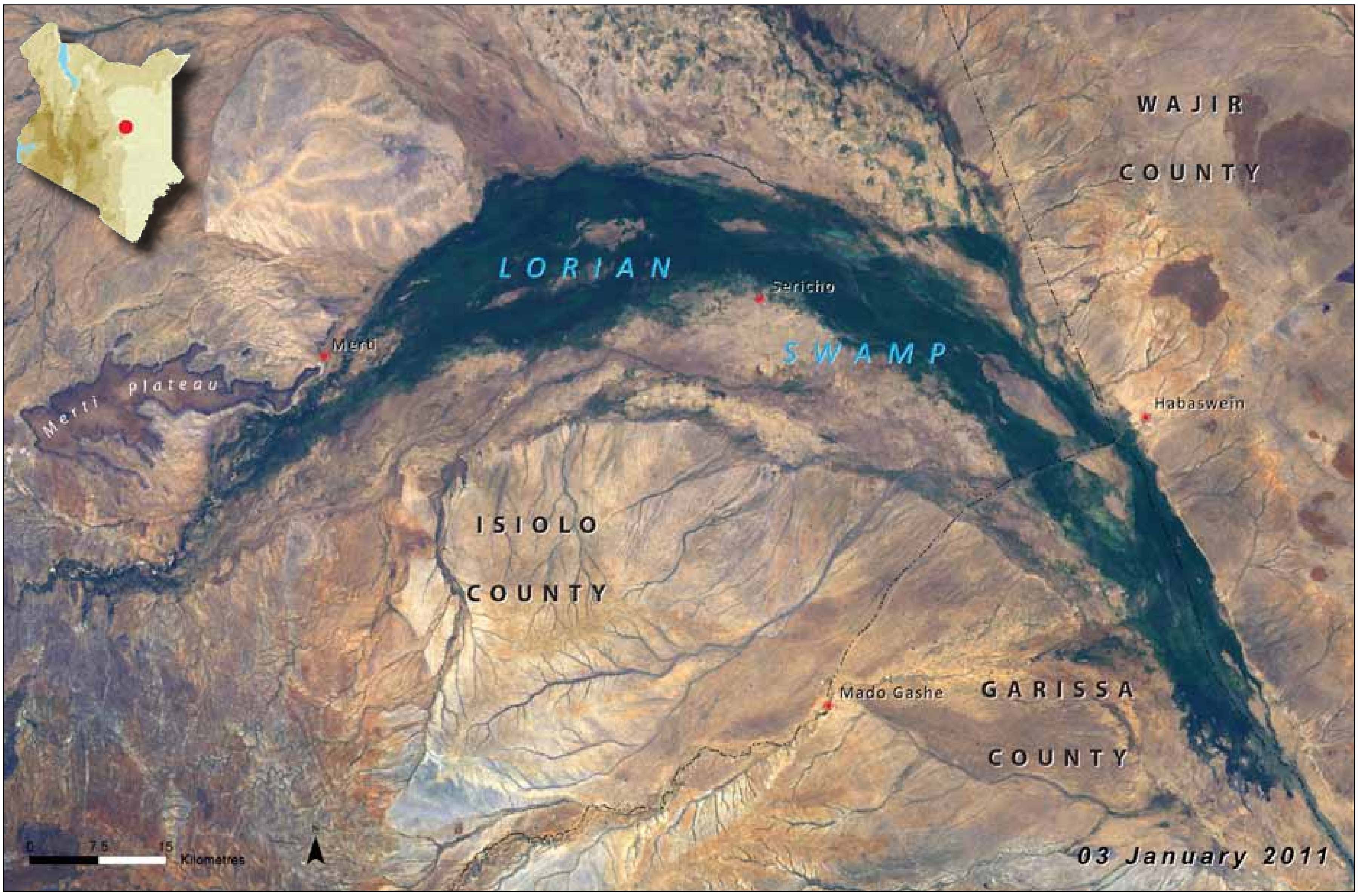
Figure 2.5: Ewaso Ng'iro North basin.

Source: Modified from WRI and others 2007

Table 2.4: Characteristics of the Ewaso Ng'iro North basin.

Basin & Basin area (sq. km.)	Major wetlands	Major land /wetlands uses	Pressures	Impacts
Ewaso Ng'iro North 213 731 sq. km.	• Lorian Swamp • Ewaso Ngiro rivers • Lake Ol Bolossat • Shompole swamp • Amala river • Habasweni swamp	• Large scale commercial farms • Pastoralism • Ranching • Wildlife conservancies • Oil and gas exploration • Forestry • Grazing • Water supply • Fish farming • Tourism	• Inappropriate land use • Overutilization of water • Conversion of land to agriculture • Overstocking of livestock • Settlements • Loss of catchment forests • Increased demand for resources • Reduced water levels • Land subdivision and fragmentation	• Pollution • Soil erosion/ siltation • Overgrazing • Reduced water volume

A satellite image showing a section of the Lorian Swamp.



portion of the annual flow (Mati and others 2005). The highly variable rainfall also makes the inundation of the area largely unpredictable as well (Hughes and Hughes 1992). In addition, high rates of abstraction for upstream irrigation considerably reduce the amount of water flowing within the river and reaching Lorian Swamp during the dry season (Gichuki and others 1998).

Acacia (*Acacia elatior*) woodlands line the course of the Ewaso Ng'iro River through much of the floodplain (Hughes and Hughes 1992). Sedge and grass species populate the swamped floodplains, providing grazing for the large faunal species such as the buffalo (*Syncerus caffer*). The African elephant (*Loxodonta africana*), Vervet monkey (*Cercopithecus aethiops*) and Nile crocodile (*Crocodylus niloticus*) are also found in the wetland (Hughes and Hughes 1992). Livestock is not grazed far into the wetland but makes extensive use of the shallow waters, particularly during the dry season. The wetland is infested with malaria carrying mosquitoes as well as snails that carry the Schistosomiasis (bilharzia) causing parasite (Hughes and Hughes 1992). Nonetheless, the wetland is not well studied due to an inhospitable and inaccessible terrain as well as widespread insecurity that is frequently manifested through ferocious inter-ethnic clashes (Boye 2011).

Elephants crossing the Ewaso Ng'iro North River

Patrick Meier/Flickr

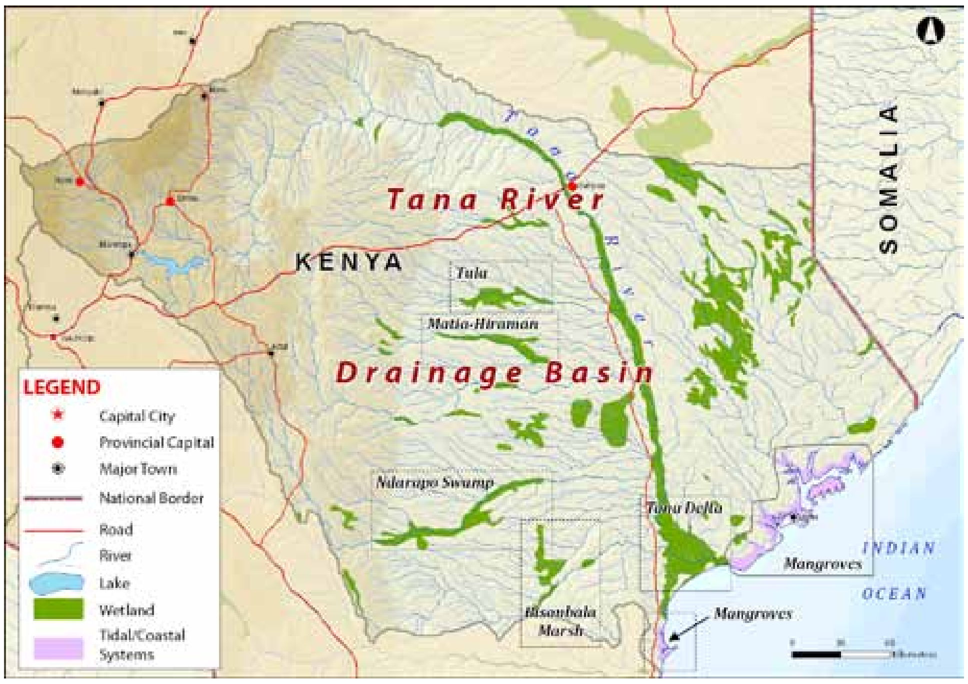
The Tana River Basin

The Tana River is Kenya's longest watercourse while the Tana River basin, which is illustrated in Figure 2.6, is one of the country's largest and richest wetlands. The basin's attributes are contained in Table 2.5. The Tana River catchment stretches from Mount Kenya and the Aberdare Mountain Range to the Indian Ocean where it empties before the coral reef drop off illustrated in Chapter 1. The Tana River also supplies water to the Seven Forks hydroelectric power plants where a large proportion of the country's hydropower is generated (UNEP 2009).

The Tana Delta

Near the end of its nearly 1 000 km trek from the foothills of Mount Kenya to the Indian Ocean, the Tana River passes through a large floodplain of wetlands, riverine forests, woodlands, bushlands, fresh and brackish lakes, estuaries, mangroves and grasslands (Hamerlynck and others 2010). The entire floodplain is commonly called the Tana Delta. It falls within the Eastern

Figure 2.6: Tana River Basin.



Source: Modified from WRI and others 2007

Table 2.5: Characteristics of the Tana River Basin.

Basin and Basin area (sq. km.)	Major wetlands	Major land /wetlands uses	Pressures	Impacts
Tana 120 925 sq. km	• Tana River • Tana River Delta • Seven Forks hydropower dams	• Large scale farming • Conservation • Irrigation • Pastoralism • Mining-sand • Fishing • Quarrying • Forestry • Hydropower generation • Recreation • Water supply	• Inappropriate land use • Overutilization of water • Conversion of land to agriculture • Overstocking of livestock • Conversion of land to settlements • Loss of catchment forests • Increased demand for resources • Reduced water levels • Land subdivision and fragmentation	• Pollution • Soil erosion/siltation • Overgrazing • Reduced water volume • Loss of critical habitats and species • Reduced hydrological capacity

Christy Gillmore/Peace Fellow

A banana farm near Garissa that uses the Tana River as a water source.

An aerial view of a section of the Tana River delta.

Arc Mountains and Coastal Forests biodiversity hotspot. The Delta's biodiversity is known to include many endemic or range restricted plants, primates, amphibians and reptiles, but has yet to be thoroughly studied (Moinde-Fockler and others 2007). Nevertheless, the delta plays host to a high concentration of crocodiles and hippopotamuses (Terer and others 2004; Otengo 2011).

The downstream Tana River basin also provides a habitat for 320 plant taxa. Fifty-eight of these are tree species, two of which are critically endangered, while the conservation status of 21 per cent of the plants is of concern. The area hosts seven plants on the IUCN Red list. These are *Cynometra lukei* which is classified as endangered and *Oxystigma msoo*, *Angylocalyx braunii*, *Dalbergia vaciniifolia*, *Chytranthus obliquinervis, Diospyros greenwayi* and *Pavetta linearifolia* which are categorized as vulnerable (Luke and others 2005). Globally threatened birds recorded in the delta include: the Lappet-faced Vulture (*Torgos tracheliotos*), Southern Banded Snake Eagle (*Circaetus fasciolatus*), Malindi Pipit (*Anthus melindae*) and the Basra Reed Warbler (*Acrocephalus griseldis*). The estuaries, mangroves and shorelines provide a habitat for a wide range of fish species. Three shark species listed under the CITES Appendix 1 have been recorded in the Tana Delta area.

A Malindi Pipit.

The value of farming, fisheries, livestock, tourism and other incomes derived from land and wildlife is more than Ksh. 3.5 billion (US$ 41.1 million). Approximately 115 000 people practise agriculture on the Tana's banks and floodplains (Emerton 2005) although research has also found that the plains also hold Kenya's most irrigable potential (Temper 2009). The delta's mangroves provide protection to the coast estimated at US$ 4.6 million annually in terms of avoided infrastructural and residential housing damage and the concomitant maintenance and re-establishment costs saved (AWS 2010). Artisanal fishing mostly on a subsistence basis is common along the Tana River while the delta's forests provide numerous non-timber products to local people including construction materials, traditional medicines and food (Hamerlynck and others 2010).

Annual rainfall along the delta rapidly declines from just over 1 000 mm at the coast to roughly half of that just 50 km inland at Garsen (Hamerlynck and others 2010). As such, the Tana River's waters are indispensable to the continued integrity of floodplain ecosystems and indeed to the entire delta system. However, the construction of dams has altered the pattern of flooding especially in the delta's higher reaches (Maingi and Marsh 2002). This is expected to have a negative impact on the delta's ecosystem because flooding deposits fertile sediment, maintains riverine forests and recharges the groundwater, for example (Hamerlynck and others 2010).

The Tana Delta Irrigation Project (TDIP) converted a roughly 40 sq. km. block of land to the east of Garsen to commercial rice production in 1988 and operated for a decade. The TDIP was resuscitated in 2011 after being out of operation since the 1998 El

The Tana Delta Irrigation Project (TDIP) converted a roughly 40 sq. km. block of land, shown in this satellite image, to commercial rice production.

A satellite image showing the Kurawa Salt Works in the Tana Delta area.

Niño flooding. Plans to expand large commercial irrigation on the delta by roughly 300 sq. km. for sugar, biofuels (notably *Jatropha curcas*) and a number of food crops are in advanced stages (Temper 2009; McVeigh 2011). The quest to transform Kenya into a rapidly industrialized country has taken its toll on vital components of the Tana Delta ecosystem. For example, large swathes of mangrove forest have been cleared to make way for aquaculture as well as salt pans and works. This has been compounded by the death of mangroves owing to the hypersalinity generated by crystallizing salt ponds. This worrying tide is particularly evident along the 20 km stretch between Kurawa and Ngomeni (Abuodha and Kairo 2001). For example, Kurawa Salt Works which sits on a seven kilometre coastline has encroached on an expanse of mangrove forest.

The Athi River.

Judith Nyunja

The Athi River Basin

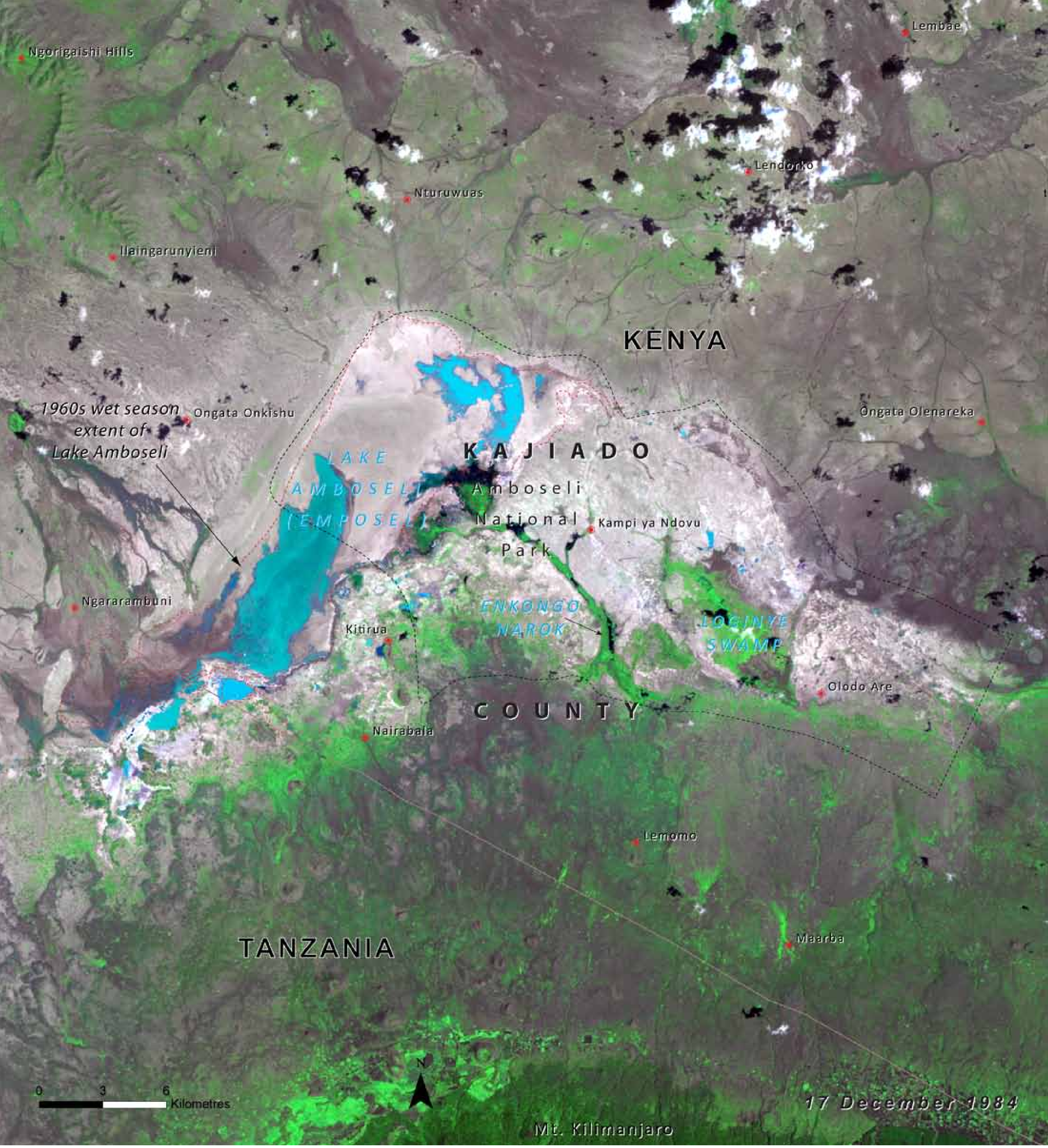
Apart from the Athi River itself, the wetlands in the Athi basin (Figure 2.7 and Table 2.6) are also associated with the Nairobi River which originates from the Ondiri Swamp, the Mbagathi River which originates from the Ngong Hills, the Kiboko River whose main catchment is Endoinyo Narok and the Tsavo River, which drains the northern slopes of Mount Kilimanjaro. These rivers supply water to the Athi River which, like the Tana River, empties into the Indian Ocean (Gichuki and others 2001). The Amboseli sub-basin (an internal drainage basin), situated north of Mount Kilimanjaro, is a significant component of this basin with Lake Amboseli being the main wetland in this sub-basin. Although it is seasonal, it receives a regular water supply from Namanga River (Williams 1972), which comes from the Meto Hills. The basin also receives both surface runoff and underground water supply from Mount Kilimanjaro's melting snow (Koch and others 1991). The seepage of underground water in the basin maintains a series of freshwater marshes, swamps and springs on the lake's eastern shores. In addition, there are seasonal wetlands, such as the Kimana pans, which fill with water during the long wet season (Gichuki and others 2001).

Figure 2.7: Athi River drainage basin.

Source: Modified from WRI and others 2007

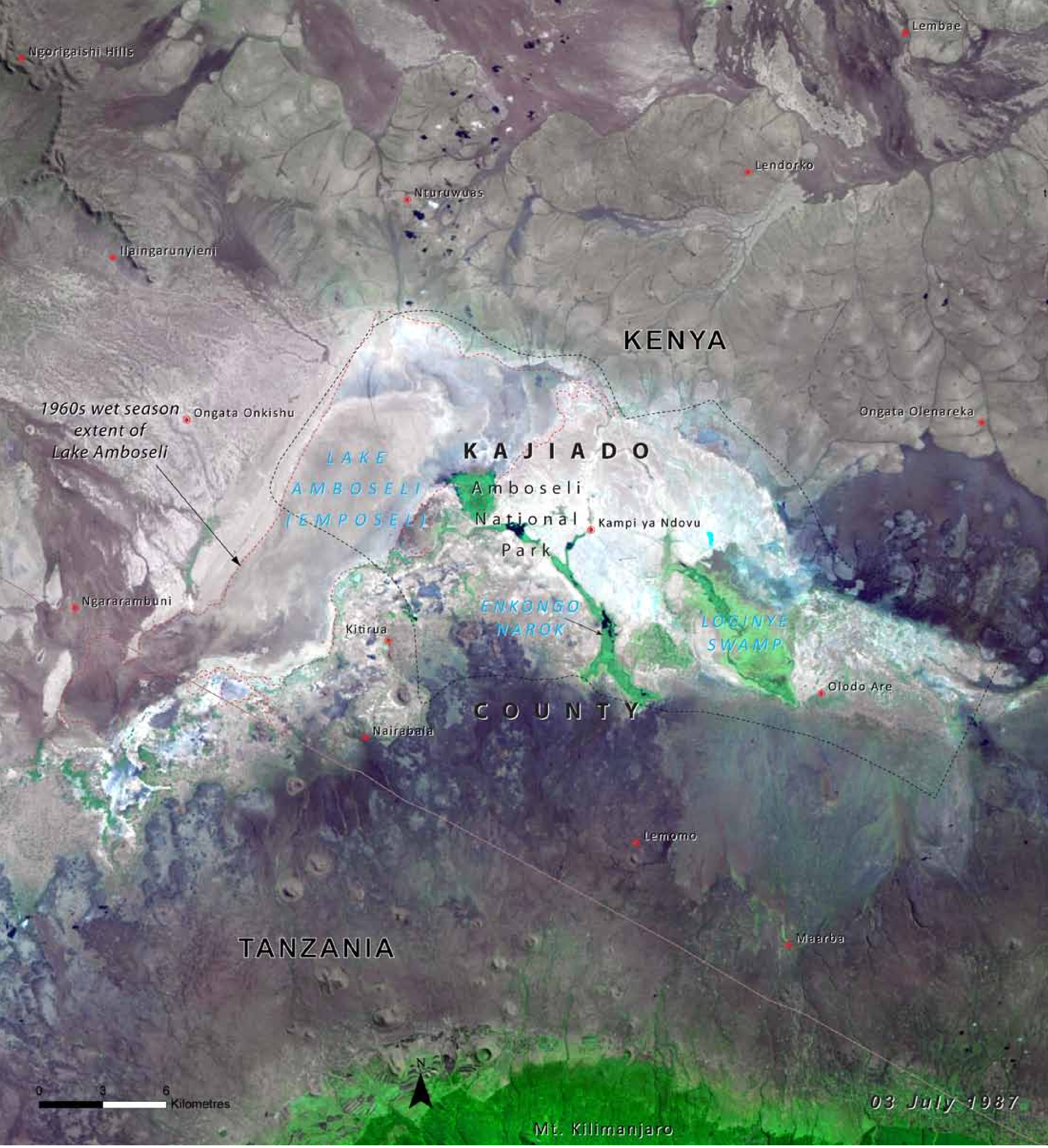
Table 2.6: Characteristics of the Athi River basin.

Basin and Basin area (sq. km.)	Major wetlands	Major land /wetlands uses	Pressures	Impacts
Athi 67 337 sq. km.	• Athi River • Ramisi River • Nairobi River • Lake Amboseli	• Wildlife conservation area- (Nairobi National Park, Amboseli, Tsavo East and Tsavo West, Shimba Hills) • Industrial use • Farming- subsistence and commercial • Pastoralism • Livestock ranching • Mining- sand, limestone • Fishing • Forestry • Energy- wind and thermal water supply • Nature conservation and recreation • Irrigation • Sand harvesting • Salt harvesting • Dry season grazing • Cultural and spiritual use • Watering points for livestock • Waste water treatment • Fishing	• Over-exploitation of surface and groundwater resources. • Wetlands resources degradation • Unregulated diversions of river channels • Catchment degradation due to overgrazing and sand harvesting. • Land use changes for settlement and agriculture • Climate change and variability	• Acute water scarcity due to high water demand • Limited ground water recharge • Changing river regime • Pollution of water resources from industrial effluents, and agricultural and domestic waste

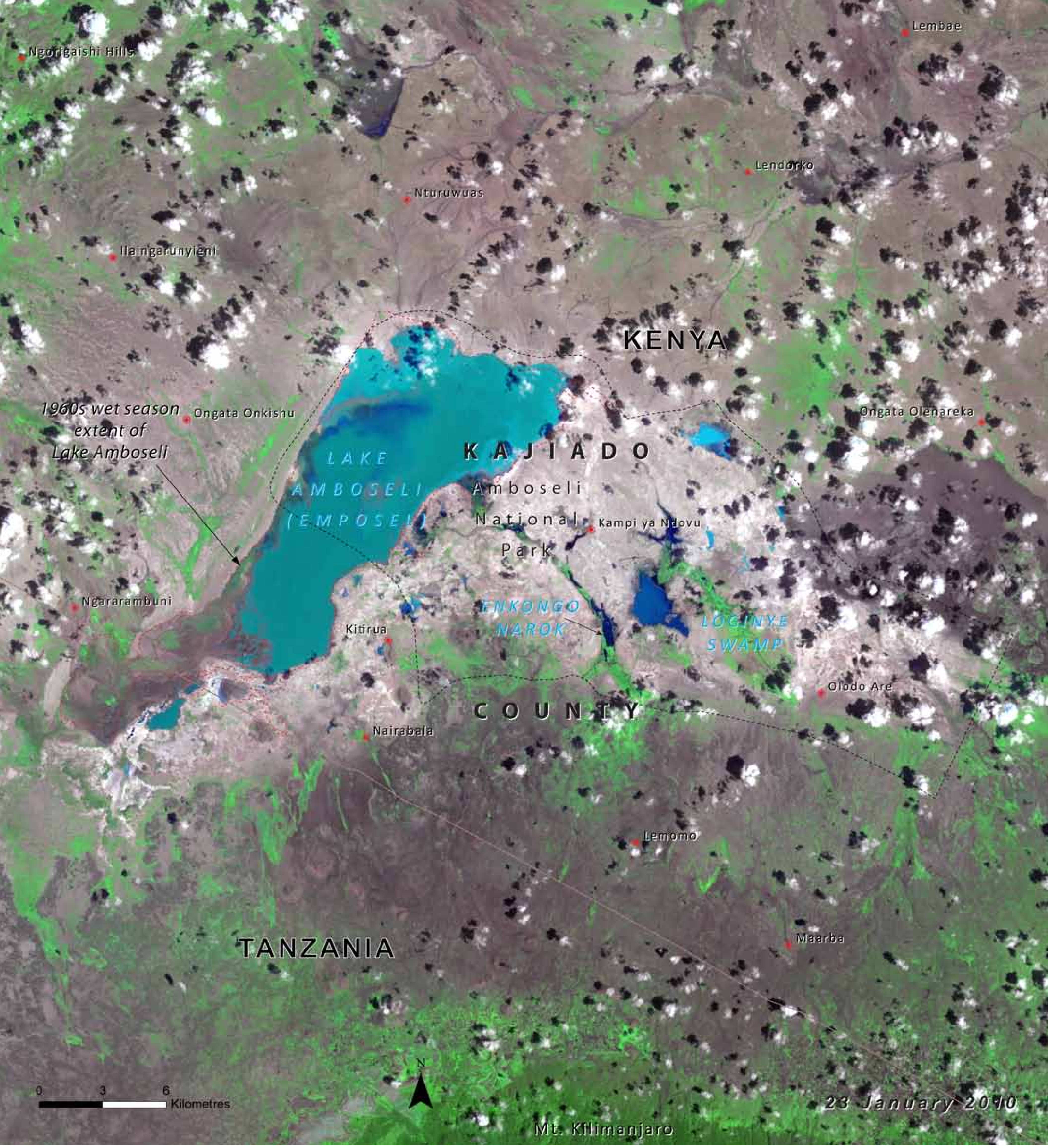


Lake Amboseli

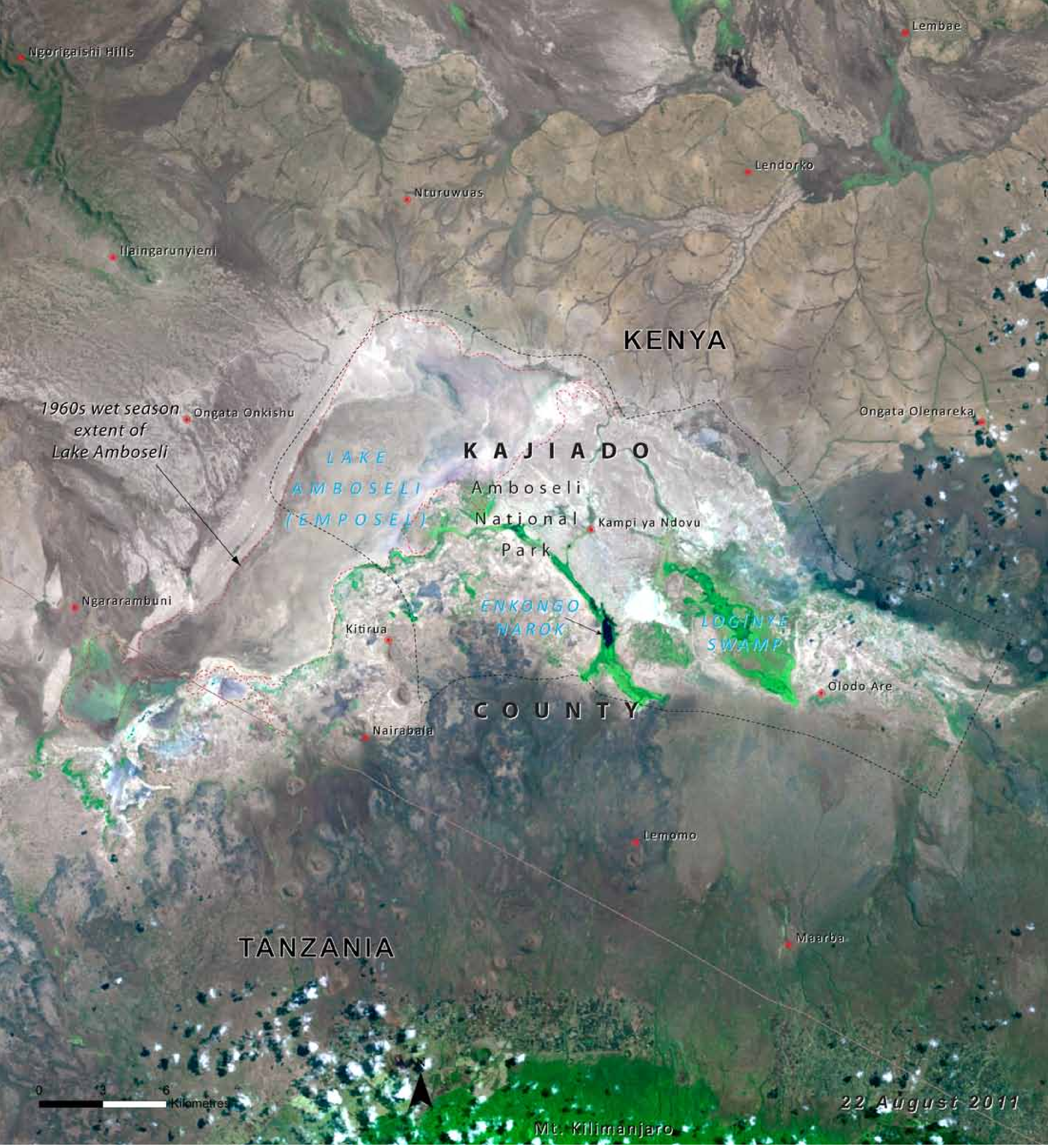
Amboseli National Park lies in the semi-arid bush and grassland savanna near the base of Mount Kilimanjaro. Its wetlands rely on hydro-geological connections with the mountain and receive much of their water through groundwater flows originating from the slopes of the Kilimanjaro (Sarkar 2006). While Lake Amboseli and its associated Enkongo Narok and Loginye swamps are an important source of water to the park's biodiversity, the wetland system is nevertheless seasonal, filling only when there is adequate water during wet seasons.



The park and the adjacent areas form an important habitat for a variety of large mammals notably the African elephant (*Loxodonta africana*), African lion (*Panthera leo*), cheetah (*Acinonyx jubatus*), jackal (*Canis adustus*), bat eared fox (*Otocyon megalotis*), aardvark (*Orycteropus afer*), yellow baboon (*Papio cynocephalus*), spotted hyena (*Crocuta crocuta*) and white tailed mongoose (*Ichneumia albicauda*) (Koch and others 1991), wildebeest (*Connochaetes taurinus*), Grevy's zebra (*Equus grevyi*) and buffalo (*Syncerus caffer*) (KWS 2010). A large population of free ranging elephants and proximity to Mount Kilimanjaro make the park a popular tourist destination (Sarkar 2006).



However, adoption of crop cultivation by the hitherto nomadic pastoralist Maasai (Kioko and Okello 2010) and their sedentarization, land fragmentation (Western and others 2009) as well as contraction of and closing off wildlife dispersal areas and migration corridors have had an adverse effect on Amboseli's mammalian population. These factors have been compounded by severe recurrent drought which resulted in the dramatic decline of the national park's wildebeest, zebra and buffalo populations (KWS 2010).

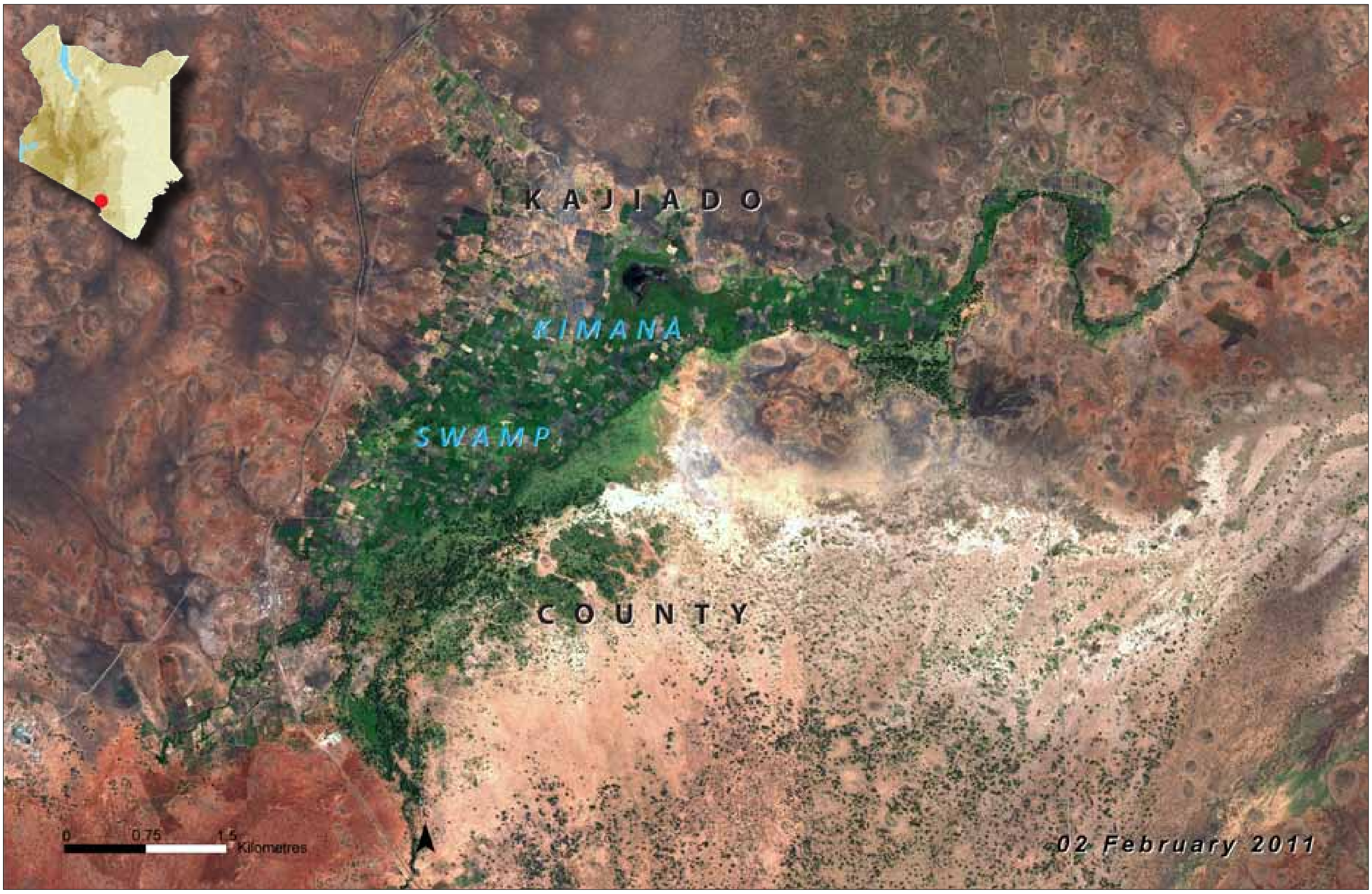


During the wet season when Lake Amboseli is full and vegetation is abundant (as is the case in the 1984 and 2010 satellite images), this competition for resources is not noticeable. However, during dry seasons, Lake Amboseli completely dries up (as is the case in the 1987 and 2011 satellite images) leaving Enkongo Narok and Loginye swamps as the only sources of water and forage. These dry periods present major challenges to the surrounding pastoralists who have to go deeper into the park to access water and in the process risk precipitating the human-wildlife conflict.

A buffalo in Amboseli National Park.

Wetland and upland ecosystems in the Amboseli National Park have undergone considerable change in the past 50 years (Western 2007; Sarkar 2006; Kioko and Okello 2010; Altmann and others 2002). The most notable change with regard to the vegetation is that the dense woodlands that covered roughly 30 per cent of the area in the 1950s had given way to scrub and grassland by 2000 (Western 2007, Sarkar 2006, Kioko and Okello 2010, Altmann and others 2002). During the same timeframe, average temperatures rose significantly and at a rate far greater than that of global warming (Altmann and others 2002; Western and Maitumo 2004; and Western 2007).

Kimana Swamp to the east of Amboseli National Park is one of the few remaining wetlands surrounding the park. An important resource for the Maasai, their livestock and for wildlife, Kimana is being converted to agriculture at an alarming rate.



Nairobi River

As the headwaters for the Nairobi River, Ondiri Swamp is critical to the capital's water supply.

Conclusion

The chapter has enumerated and profiled some of Kenya's most important internal wetlands by water basin. It has also discussed the specific natural and anthropogenic challenges that the wetlands that are discussed in-depth have to contend with. As the pressure exerted by many of these challenges is projected to heighten in the coming years as the country's population rises and as natural variables such as climate change intensify, a comprehensive wetland policy would better enable the country to cope with these unprecedented changes.

Christy Gillmore/Peace Fellow

The Nairobi River runs through Korogocho and the Dandora dump, where many people live.

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Sunrise over Lake Turkana.

aocrane/Flickr

CHAPTER 3
TRANSBOUNDARY WETLANDS

Introduction

This chapter provides in-depth geographic, hydrological and taxonomic descriptions of Kenya's major transboundary wetlands as well as the threats they face. Transboundary wetlands are those that are shared by two or more countries. Management of transboundary wetlands, as distinguished from wholly internal ones, is fraught with a peculiar set of challenges. This is largely predicated on the reality that ecosystems are not constrained by geographic jurisdictional limits (Hannah and others 2002; Maltby and Dugan 1994). Kenya shares borders with five countries: Ethiopia, South Sudan, Uganda, Tanzania and Somalia. Consequently, many ecosystems, including wetlands are inevitably transboundary.

Some of Kenya's important transboundary wetlands are the shallow shorelines of Lake Victoria and Lakes Turkana, Jipe and Chala as well as the Mara, Malakisi, Sio and Ewaso Ng'iro South Rivers. As these wetlands straddle two or more international borders, they are regulated by disparate national policies, laws and practices. However, the lack of harmonized regulatory and institutional frameworks has the potential to foment regional conflict but also critically from an environmental perspective, to imperil the ecosystem services rendered by these wetlands that enhance human welfare and biodiversity conservation (especially that of migratory species). Improving bilateral and regional cooperation is therefore key to ensuring the wise use of these wetlands and associated resources.

KEY MESSAGE

Kenya shares a number of important wetland ecosystems with neighbouring countries. These include Lake Victoria, Lake Turkana, Lake Jipe, Lake Chala as well as the Mara River. As a consequence, a single wetland may be subjected to a plethora of complex and often inconsistent principles, regulations, policies and laws originating from various governments, public institutions and other stakeholders thereby heightening the potential for conflict. Cooperative regional governance based on the principle of integrated ecosystem management is therefore indispensable to ensuring the conservation and wise use of these vital but fragile transboundary ecosystems, shared water systems and the attendant migratory species.

Lake Victoria

Lake Victoria is Africa's largest, and the world's second largest freshwater lake. It has a surface area of 68 800 sq. km. and a catchment of about 284 000 sq. km. (Ntiba and others 2001). It is shared by Kenya (6 per cent), Uganda (45 per cent) and Tanzania (49 per cent) (Namisi 2001; Kivaisi 2001; Awange and On'gan'ga 2006), and is arguably the dominant geographical feature in East Africa. The lake

Figure 3.1: Lake Victoria basin.

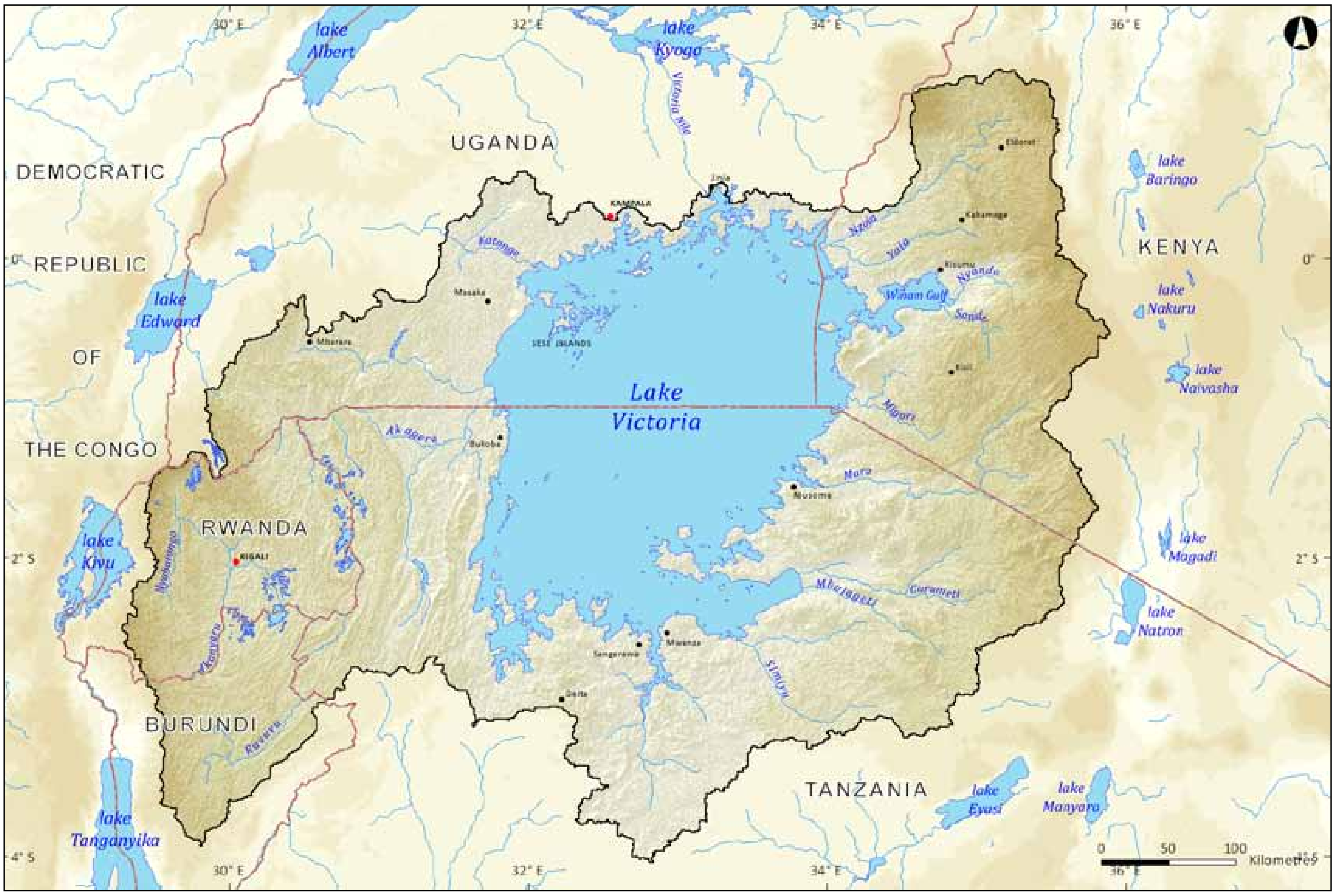
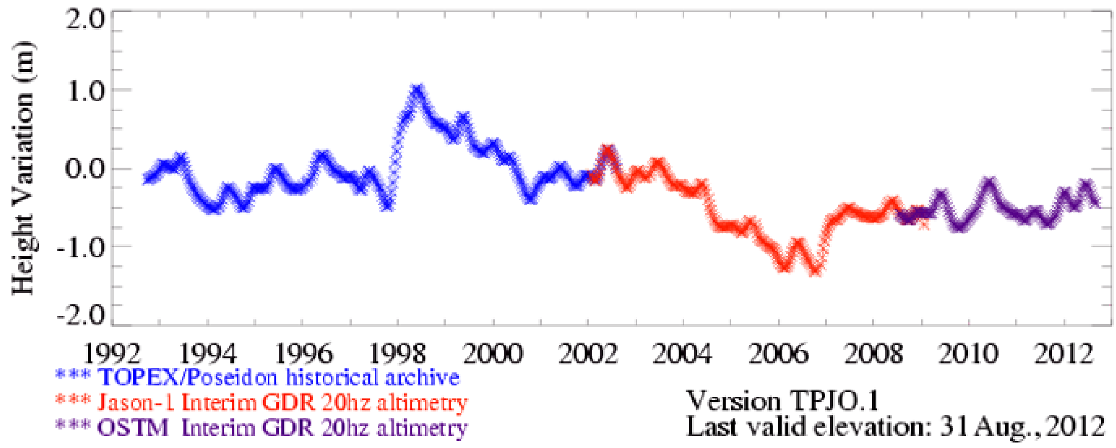


Figure 3.2: Fluctuations in Lake Victoria's water levels.



Note: Height Variations from TOPEX POSEIDON Jason-1 and Jason-2 OSTM Altimetry

Source: USDA 2012

basin's significance is underlined by the fact that, although it covers only about 8 per cent of Kenya's surface area, it accounts for over 54 per cent of the country's freshwater resources (Mocha 2011).

As is evident in Figure 3.1, the main rivers in Kenya that feed the lake are Sio, Nzoia, Yala, Nyando, Sondu-Miriu and Awach. Given that the lake has an average depth of 40 m with a maximum depth of 80 m (Ntiba and others 2001) which exceeds the largely accepted wetland threshold depth, most of the lake is not considered a wetland although the shallow portions, such as Winam Gulf, are.

Lake Victoria is itself surrounded by an extensive network of wetlands that perform crucial ecological functions and support an array of aquatic biodiversity. Indeed, a total of 422 wetlands spanning an area of 4 322 sq. km. have been mapped around the water body. Sixty-one of these occur in Kenya, 142 in Tanzania and 219 in Uganda (LVBC 2011).

The major lakeshore wetlands in Kenya include the Sio, Yala, Nzoia, Sondu/Miriu, Nyando, Kabonyo, Kuja, and Kenga/Kibos and Nyam. The wetlands are primarily swamp systems characterized by rooted herbaceous and grasslike plants largely consisting of papyrus (*Cyperus papyrus*), reeds (*Phragmites sp.*) and hippo grass (*Vossia cuspidata*). These swamp systems are complemented by shrubland systems dominated by perennially green shrubby vegetation (LVBC 2011).

Threats

Owing to the interlinkages between water systems and the associated wetlands, the threats enumerated below affect the wetlands that are adjacent to the lake. Lake Victoria has to continually confront a series of environmental challenges such as fluctuating water levels, worsening water quality, land cover and land use changes and invasive alien species (UNEP 2009). Each of these is discussed in detail below.

Table 3.1: Historical water levels in Lake Victoria.

Year	Month	Level in m.a.m.s.l	Height above 1923 level (m)
1923	March	1 133.19	0.00
2006	January (10th)	1 133.46	0.27
2005	October	1 133.66	0.47
1961 (before the flood)	January	1 133.70	0.51
2004	September	1 133.99	0.80
1994	February	1 134.18	0.99
1994	October	1 134.21	1.02
1986	September	1 134.26	1.07

Note: m.a.m.s.l: metres above mean sea level

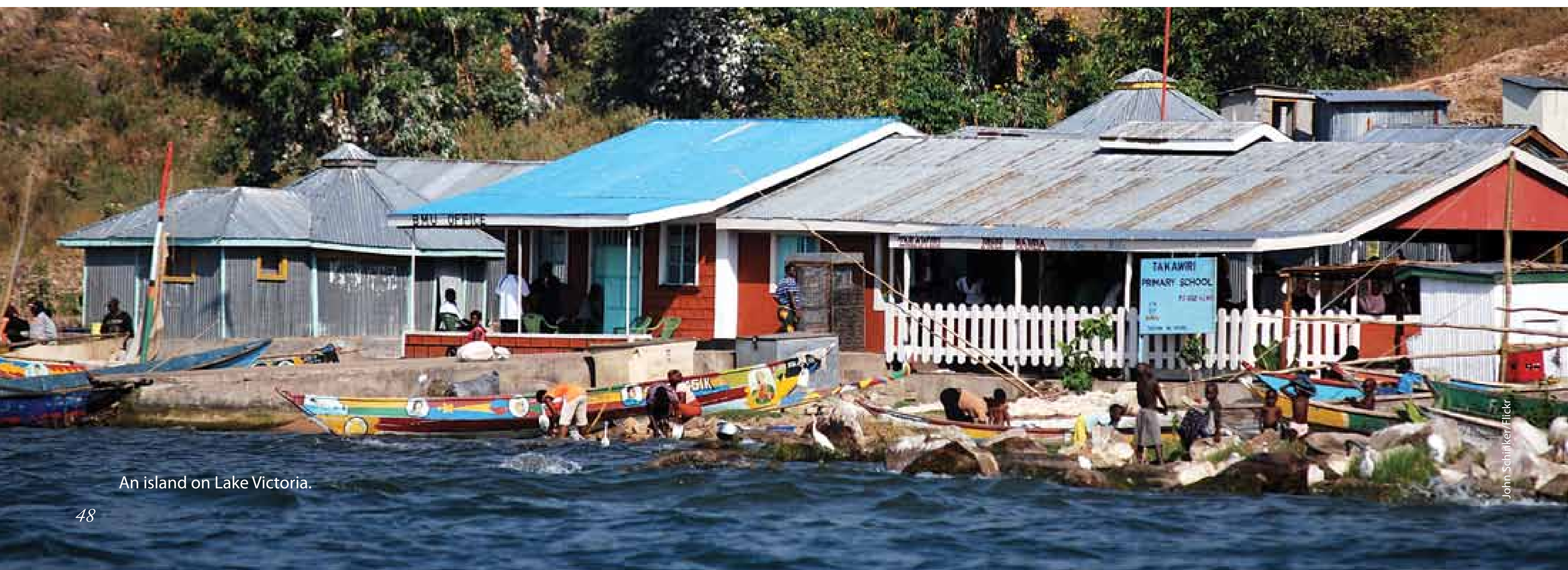
Source: GoK 1998

Fluctuating Water Levels

Lake Victoria's water levels have fluctuated widely over more than a century of record keeping. Although 1961 and 1962 witnessed a spike of nearly two metres, the lake's water level has largely registered a downward trend (UNEP 2009) as illustrated by Table 3.1 and Figure 3.2. This inclination is projected to continue well into the 2030s as the impacts of climate change intensify (Tate and others 2004). This is a worrying prognosis because the portions of wetlands that recede during the dry spells are especially vulnerable to reclamation for agriculture (Schuyt 2005).

Population Growth

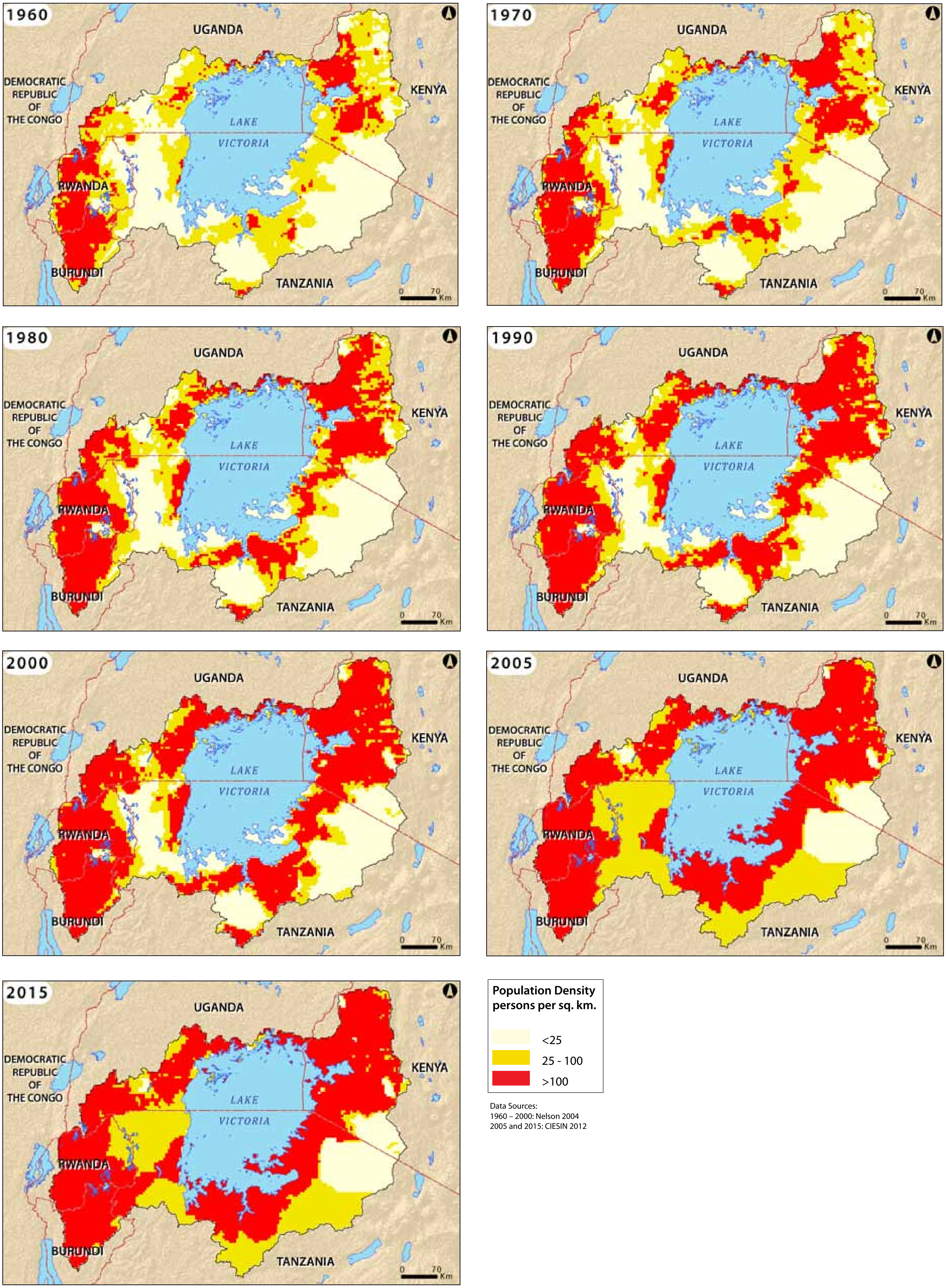
With a 3.8 per cent average annual population growth rate (Njiru and others 2008) and a population density of up to 1 200 persons per sq. km. in parts of Kenya (World Agroforestry Centre 2012), the Lake Victoria basin has one of the world's densest rural populations. This high and rising population density (Figure 3.3) is largely attributable to the abundant fishing opportunities and the favourable agricultural conditions (Mailu 2001).



An island on Lake Victoria.

John Schinker/Flickr

Figure 3.3: Actual and projected growth in population density around Lake Victoria.



Data Sources:
1960 – 2000: Nelson 2004
2005 and 2015: CIESIN 2012

Fishing on Lake Victoria.

Ryan Harvey/Flickr

However, the population growth is also fuelling rapid urbanization, conversion of land to agriculture, industry and settlement (Odada and others 2004; Kairu 2001). These are in turn depleting wetland resources at a rate that outstrips that of their natural replenishment as the reduction in fringing lakeside vegetation and in fish populations and diversity attests (Kairu 2001; Masifwa and others 2001). These problems threaten the lake and wetland ecology, and potential recreational opportunities but also the lifestyles and livelihoods of local communities (LVBC 2011).

Invasive Alien Plant Species

Rapid population growth and urbanization, non-point pollution from agriculture as well as increased siltation and sedimentation in the catchment area have led to a considerable nutrient load in Lake Victoria (Kateregga and Sterner 2007). The resulting eutrophication has led to the proliferation of the water hyacinth (*Eichhornia crassipes*). The most affected area in the Kenyan portion of the lake is the Winam Gulf (Mailu and others 1998; UNEP 2009) which marks the water body's easternmost limit. The proliferation of the water hyacinth has a range of negative ramifications that are discussed in detail in Chapter 5.

Sedimentation and Siltation

A rapid rise in the human population in the Lake Victoria basin has led to increased solid waste and sewage generation. Owing to the shortage of proper waste and sewage disposal and management systems, most of these end up in the lake. In addition, poor land management practices, including deforestation in the lake's upper catchment consisting of the Mau Forest Complex, Tinderet and Nandi Hills, have resulted in excessive sediment flowing into the lake (Ogutu 2011).

Further, owing to increased agriculture, agrochemicals are transported through streams into the lake (Odada and others 2004). These pollutants cause blue-green algal blooms (Aloo 2003) that deplete the dissolved oxygen in the water, suffocating fish populations (Verschuren and others 2002).

Transboundary Initiatives

The Lake Victoria basin is an important asset of the five East African countries—Kenya, Uganda, Tanzania, Rwanda and Burundi. Taking cognizance of this, a number of regional initiatives have been formed to ensure its sustainable management. These umbrella programmes are the Lake Victoria Basin Commission (LVBC), the Lake Victoria Fisheries Organization (LVFO) and the Nile Basin Initiative (NBI).

LVBC is a tripartite (Kenya, Uganda and Tanzania) programme formulated to ensure the 'overall management and rational utilization of the shared resources of the Lake' (LVBC 2012). LVBC's flagship project is the transboundary Lake Victoria Environmental Management Project Phase II (also known as LVEMP II), an East African Community (EAC) project that is currently being implemented in five Lake Victoria Basin countries namely: Kenya, Burundi, Rwanda, Tanzania and Uganda. LVEMP II's two-pronged objective is to enhance cooperation in the management of the transboundary natural resources of the Lake Victoria Basin and to attenuate environmental stress in selected pollution hotspots (LVBC n. d.).

As the name suggests, LVFO was formed to coordinate the management of Lake Victoria's fisheries resources. It is mandated to adopt conservation and management measures in order to ensure ecologically sound utilization of the lake's living resources and that the resulting socio-economic benefits trickle down to the citizens of the three partner States (LVFO 2012). As a creation of an EAC convention, it is regarded as an institution of the EAC.

The Nile Basin Initiative (NBI) is an intergovernmental organization formed by the Nile Basin Countries (NBCs) to ensure the equitable and sustainable utilization of the diverse resources of the Nile Basin in order to achieve water security and avert conflict. The initiative's member states are Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda while Eritrea is an observer (NBI 2012).

The Sio-Siteko Wetland System

The Sio-Siteko wetland system (Figure 3.4) spans the Kenya-Uganda border. It traverses Busia and Samia Districts in both Kenya and Uganda and is part of the wider Sio-Malaba-Malakisi catchment (World Bank 2009). The wetland consists of a number of interconnected secondary and tertiary wetland subsystems that drain into Lake Victoria. The Sio River originates from the foothills of the Kenyan segment of Mount Elgon (Barasa and others 2011) and has a total length and catchment area of about 85 km and 1 338 sq. km. respectively (GoK 2009).

The Sio-Siteko wetland complex provides a number of valuable ecosystem goods and services, including storing and purifying water that flows into Lake Victoria (Ouma 2010). It is also a source of food (especially fish and fingerlings) and construction materials such as sand, clay and poles. It also supports agricultural crops such as arrowroot, sugar cane, potato, maize and millet. In addition, it stores and supplies water for domestic and livestock use. The wetland complex also filters and purifies polluted water from urban areas.

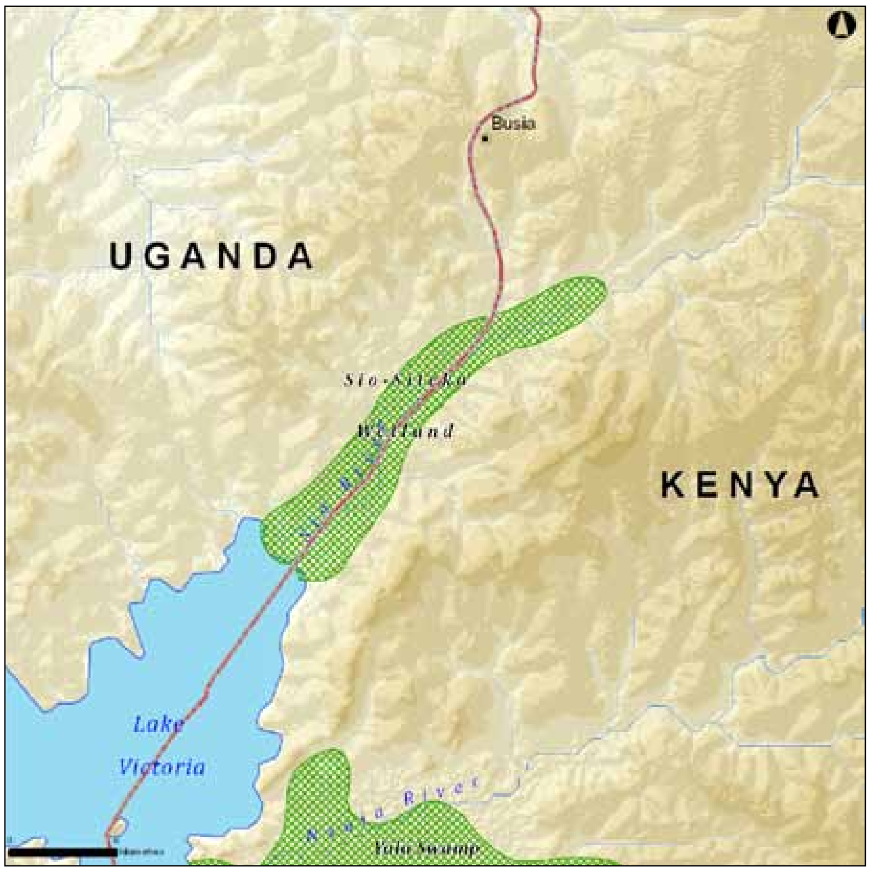
The Sio River catchment and its associated wetlands are a rich fauna and flora repository and provide a habitat for 206 plant, 29 fish, 25 mammal, eight reptile and several invertebrate species (Ouma 2010). The wetland is also an Important Bird Area (IBA) as more than 300 bird species including the globally threatened Papyrus Gonolek (*Laniarius mufumbiri*) and Pallid Harrier (*Circus macrourus*) have been recorded there (Bird Life International 2008). Some of the mammals that commonly occur in the area include the Vervet monkey, Otter, Sitatunga, hippo and water mongoose with the implication that the wetlands have a considerable ecotourism potential. This in turn can improve local community livelihoods which are currently primarily based on fishing and horticulture (Ouma 2010).

Threats

Changes in Hydrological Conditions

Canal construction, over-abstraction of water and sand harvesting in the Sio-Siteko wetlands have led to hydrological changes and fluctuations in their water levels. This affects the hydrological characteristics of the wetlands, leading to increasingly impervious

Figure 3.4: The Sio-Siteko wetland.



Source: UNEP/DEWA - Africa

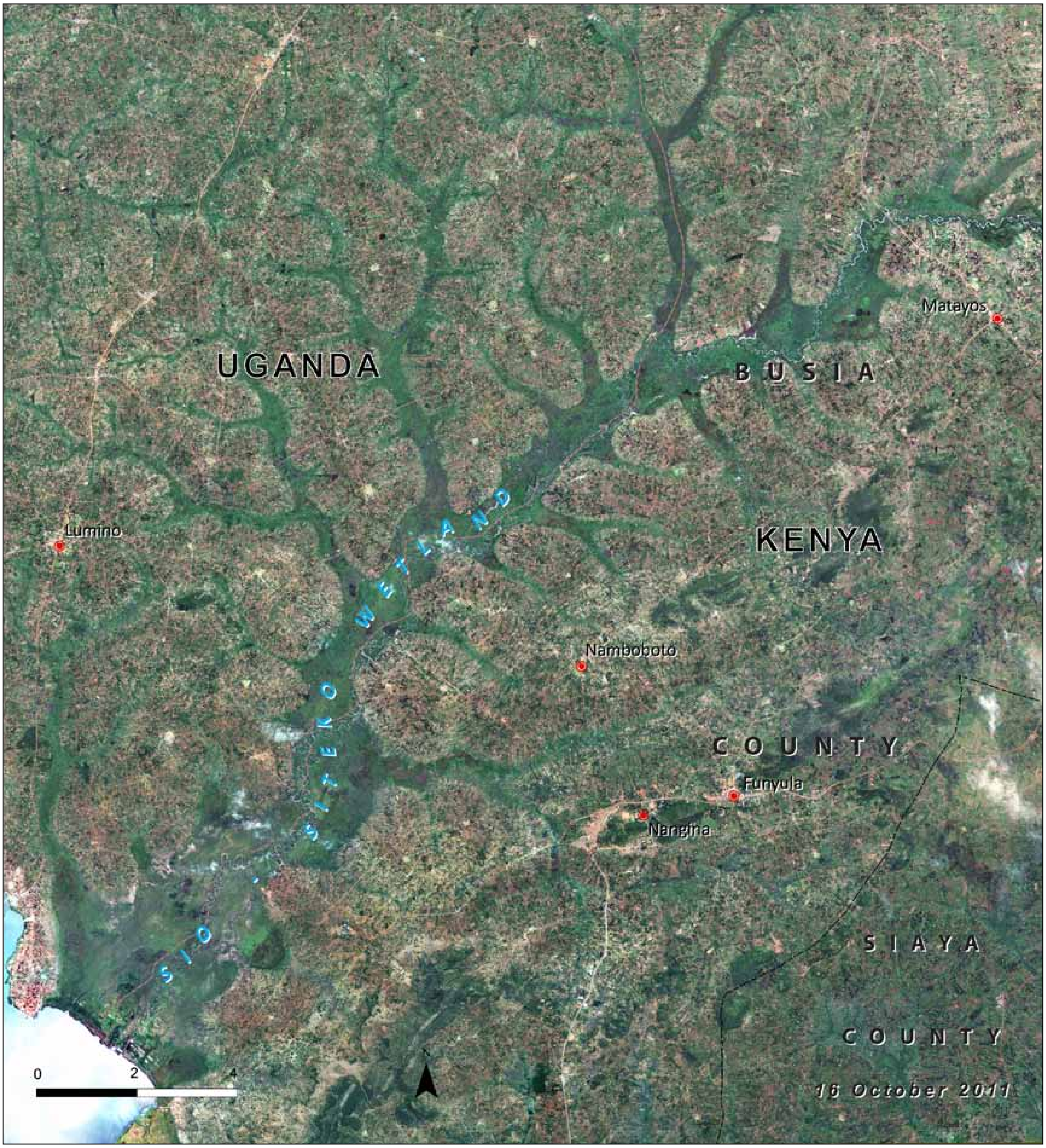
surfaces in the catchment and to significant inundation that spans widths of up to three kilometres near its outfall to Lake Victoria, disrupting water supply and adversely affecting crops that are intolerant to water logged conditions (GoK 2009).

Poor agricultural husbandry and other unsustainable human activities have adversely impacted the Sio-Siteko wetland system's water quality. For example, elevated turbidity, high total dissolved solids and depleted organic matter have been recorded in the River Sio delta (Wanjogu and Njoroge 2005). These conditions inevitably compromise the wetland's capacity to act as a buffer and to sieve effluents from both point (specific) and non-point (diffuse) sources of pollution (Nieminen and others 2005).

A vervet monkey.

Sergey Yeliseev/Flickr

The Sio-Siteko wetland drains an area along the Kenya-Uganda border filtering inflow to Lake Victoria.



Land Use Changes

Increasing human pressure is leading to the intensification of land use and to overgrazing, overfishing, sand harvesting, brickmaking and the drainage of the Sio-Siteko wetlands, mostly for agriculture. The synergistic effect of the above has been to appreciably reduce water levels and other resources such as sand and clay, organic matter and grasslands with the latter reducing the amount of nitrogen available in the top and sub-soils (Barasa 2011).

Conflicts over Resource Use

Conflict over the Sio-Siteko wetland system's resources is rife between different resource-use interests such as crop farmers and herdsmen, water users and herdsmen, plant harvesters and fishermen, grass harvesters and clay miners, and herbalists and crop farmers. And, given that this is a transboundary wetland complex, these conflicts often spill over to Kenya and to Uganda as well.

Transboundary Initiatives

In an attempt to address the challenges faced by the Sio-Siteko wetlands in an integrated manner, diverse stakeholders from Uganda and Kenya participated in formulating the Sio-Siteko Transboundary Wetland Community Based Management Plan (NBI 2009). The plan was prepared under the aegis of the now closed Nile Transboundary Environmental Action Project (NTEAP) which fell under the Nile Basin Initiative's (NBI) Shared Vision Programme. The programme's stated objective was 'to provide a strategic environmental framework for the management of the transboundary waters and environmental challenges in the Nile River Basin' (NBI n. d.). Instructively, wetland conservation was one of the project's components. The Sio-Siteko management plan fosters community based management of the wetland's resources (NBI 2009).

Figure 3.5: Mara River Basin.

Sources: UNEP/DEWA - Africa

The Mara River Basin

The Mara River Basin (Figure 3.5) is shared between Kenya (65 per cent) and Tanzania (35 per cent) (LVBC and WWF-ESARPO 2010a) as is depicted in Figure 3.6. It also forms part of the larger Nile Basin that is shared by ten African countries. The source of the river is the Napuiyapui swamp in the Mau Forest Complex in Kenya (Mati and others 2008). This river meanders through the internationally renowned Maasai Mara-Serengeti ecosystem before its outfall in Lake Victoria at Musoma in Tanzania.

The waters of the Amala and the Nyangores Rivers which are the perennial tributaries of the Mara are complemented by the Talek, Engare Ngito and Sand Rivers (LVBC and WWF-ESARPO 2010b). There are only a few permanent wetlands in the Maasai Mara, since most are seasonal, occurring where water is trapped at the surface by the reserve's black cotton soil, or where underground streams emerge. The significance of the Mara River is underscored by the fact that it is regarded as the lifeblood of the vast Maasai Mara-Serengeti ecosystem that covers a catchment area of 25 000 sq. km.

The Mara ecosystem is also home to a high concentration of non-migratory predators such as the African lion, leopard, cheetah and spotted hyena and herbivores notably the elephant, rhino, Maasai giraffe, gazelles, a variety of primates (Hale and Windram 2006) and profuse birdlife (Urama and others 2008). The Maasai Mara's global eminence is nevertheless attributable to a spectacular annual natural phenomenon where upwards of a million wildebeest, along with scores of zebras, make the short but perilous journey across the hippopotamus- and crocodile-infested Mara River from the dry Serengeti into the lush Maasai Mara plains. These ungulates retrace their footsteps a few months later when the weather conditions are reversed. Both these protected areas are major tourist destinations and important foreign exchange earners for both Kenya and Tanzania. However, the Mara River basin's varied climate and topography explain the breadth of land uses that besides tourism, include cultivation, livestock keeping, forestry, fishing, dairy farming and even gold mining (Urama and others 2008). Strikingly though, all of these are directly or indirectly dependent on the Mara river basin wetlands.

Threats

Population Pressure

The human population of the Mara basin was estimated at 838 701 in 2010 (LVBC and WWF-ESARPO 2010a). At an annual growth rate of three per cent (Hoffman 2007), the basin's population is projected to stand at around 891 790 in 2012. An exponentially rising population is bound to exert more pressure on wetlands and their resources. This growing demand is likely to outpace the wetland's capacity to provide the ecosystem services discussed in detail in Chapter 4.

The resulting acute degradation of the basin's wetlands would have far reaching effects on the human, livestock and wildlife populations, the economies of Kenya and Tanzania and the complex ecosystem dynamics (LVBC and WWF-ESARPO 2010a). Already, land use changes are manifesting themselves in erosion of important habitats such as forests, grasslands, shrubland and savannah at an irreversible rate as is evident from Table 3.2. If this trend continues, positive changes such as those associated with wetlands are unlikely to last owing to the inherent interconnectedness of ecosystems (Perrings and Opschoor 1994). Equally ominously, human-induced

Table 3.2: Extent of land use and land-cover changes in the Mara River Basin, 1973-2000.

Land cover type	1973 (sq. km.)	1986 (sq. km.)	2000 (sq. km.)	Change	
				(sq. km.)	%
Forest	1 008	893	689	-319	-32
Tea/ open forest	621	1 073	1 948	+1 327	+214
Agricultural land	826	1 617	2 504	+1 678	+203
Shrubland	5 361	5 105	3 546	-1 815	-34
Grassland	2 465	1 621	1 345	-1 120	-45
Savannah	3 163	2 867	2 354	-809	-26
Wetlands	286	604	1 94	+1 109	+387
Water bodies	104	54	55	-49	-47

Source: Mutie and others 2006

Herds of migrating wildebeest cross the Mara River in Kenya.

Tveito/Flickr

Aerial view of a section of the Mara River.

Colin Jackson/Flickr

habitat loss and degradation threaten the abundance of wildlife species, biodiversity, water resources and of watershed systems. Climate change will only exacerbate this already dire situation.

Resource Utilization and Conflicts

Water scarcity is often a major driver of conflict in Kenya (Evans 2011; Berger 2003). In the case of the Mara basin, this frequently pits wildlife tourism versus livestock keeping, for example (Urama and others 2008), resulting in several human-wildlife conflicts. These conflicts also spill over into tussles over revenue sharing been the county councils, park managers and the local Maasai residents.

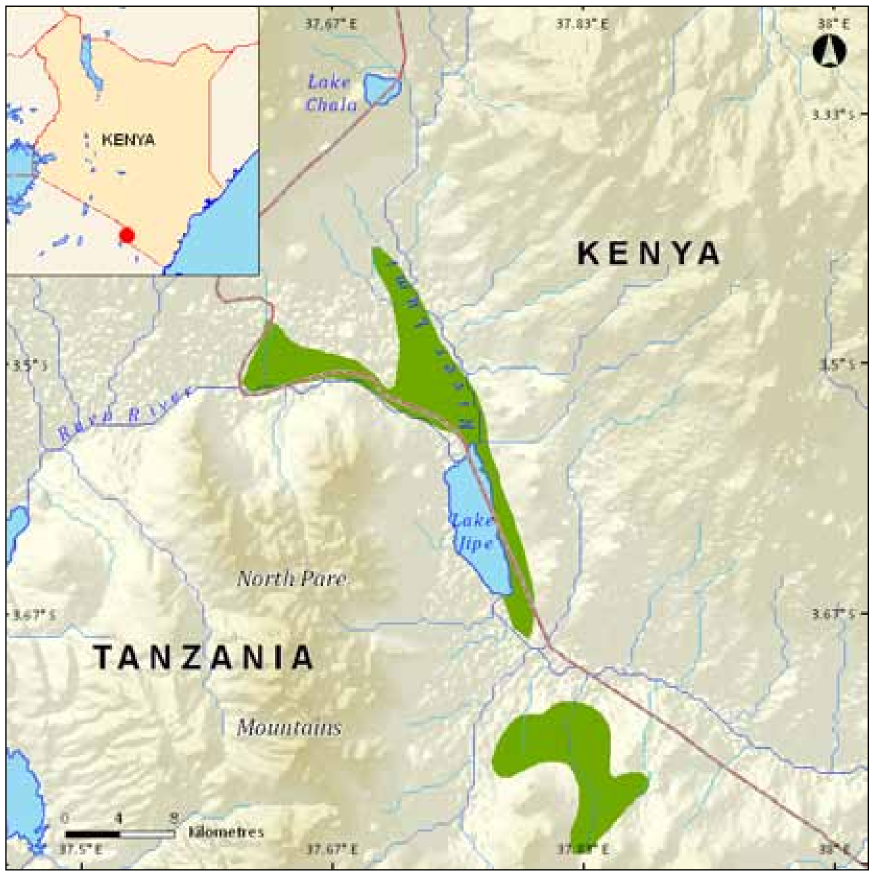
More recently, the conflict over the Mara basin took on a transboundary dimension when Kenya successfully lobbied for the relocation of the Loliondo-Serengeti-Mugumu Highway that was initially scheduled to bisect the Serengeti. It was argued that from an ecological perspective, the highway construction would halt the Great migration, lead to a plummeting of wildebeest numbers and substantially reduce these herbivores' nutrient recycling (as less excreta would be produced) with unprecedented effects on the delicate Mara Basin ecosystem (Haas 2011; Dobson and others 2010). And owing to the fallibility of human judgment, the project could have well had adverse, extensive and unforeseeable impacts on the Mara Basin's wetlands.

Lake Jipe

Lake Jipe lies 37.7º E and 3.58º S and sprawls over both Kenyan and Tanzanian territory. More specifically, it extends from Tsavo West National Park in Taveta District in Kenya to Manga District in Tanzania both of which are found to the southeast of Mount Kilimanjaro (Figure 3.6). The lake's main reservoir measures around 10 km long by 3 km wide, making this an area of 30 sq. km. while the dimensions of the fringing wetlands vary widely. The lake is a very shallow, with an average depth of less than three metres (Mtalo 2005). It is fed mainly by the Lumi River, which emanates from Mount Kilimanjaro as well as the Muvulani and Kirurumo Rivers which drain the Pare Mountains (Mahonge 2010).

Lake Jipe and its wetlands are considered to be socially, economically and ecologically significant. This is because this transboundary resource is a habitat for a diversity of fauna and flora including the endemic *Oreochromis jipe* Tilapia fish species. Other species that occur in the lake are the crocodile, hippopotamus, water monitor and the otter. Fauna that proliferate around the lake include the elephant, giraffe, and zebra.

Figure 3.6: Lake Jipe and floodplain.



Source: UNEP/DEWA - Africa

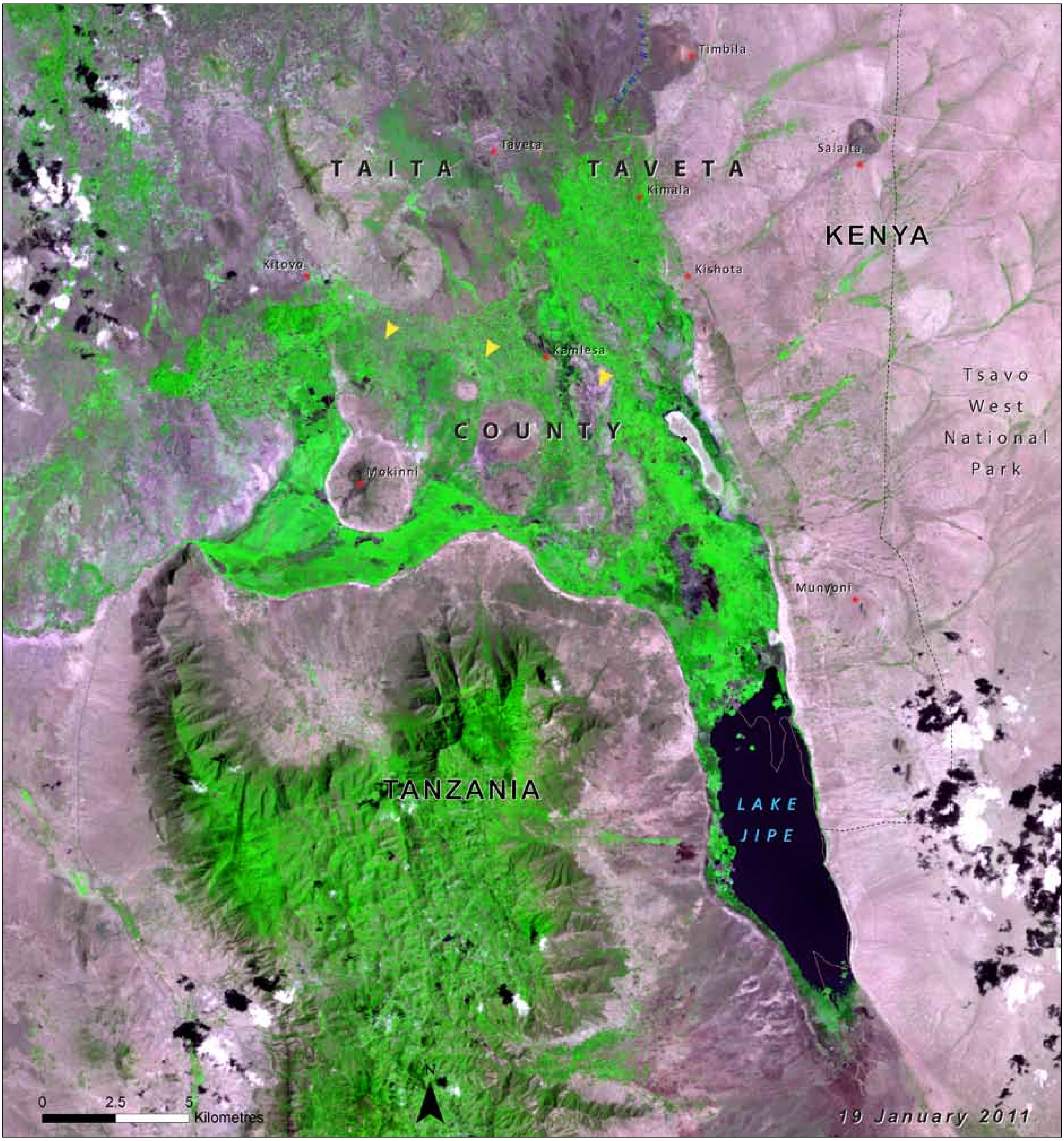
It hosts a wealth of waterbirds such as the purple Gallinule and the lesser Jacana which are rare in the rest of the East African region. The lake is also a habitat for the Madagascar squaco heron, Black heron, African darter and African skimmer (URT 2004) and as an important staging site for migratory birds (KWS n. d.). In addition, it is a permanent water reservoir for the wildlife of Tsavo West National Park in Kenya and the Mkomazi Game Reserve in Tanzania. It is also a source of livelihood for more than 120 000 inhabitants who earn a living as fisherfolk and as water transporters (NEMA 2009).

Threats

Shrinking Surface Area and Water Depth

The course of the Lumi River, which is one of the lake's two feeder rivers, has been diverted at various points largely to support irrigation agriculture on riparian land on the Kenyan side. This results in heavy siltation and a decline in the water level. Indeed, while Lake Jipe originally covered a surface area of 100 sq. km., this has shrunk to a mere 30 per cent of its original size (Ndetei 2006). In fact, the rising lake levels are attributable to a rising silt load rather than increasing water

The course of the Lumi River, which is one of Lake Jipe's feeder rivers, has been diverted at various points largely to support irrigation agriculture on riparian land on the Kenyan side (yellow arrows). This results in heavy siltation and a decline in the water level.



depth. The water shortage is compounded by the low levels of rainfall (500-600 mm per annum) although precipitation follows a bimodal cycle (ESFC 2005).

Overgrazing and Siltation

Owing to water scarcity in the upper reaches of the catchment, herders migrate from Kajiado to areas adjacent to the lake during dry spells. This does not just aggravate the already existing overstocking and overgrazing, the back and forth livestock movement denudes the riparian areas' vegetation cover, exposing these areas to wind, sheet and gully erosion (ESFC 2005). The increased soil erosion in turn leads to siltation and eutrophication, which stimulates the proliferation of invasive alien species such as *Prosopis juliflora* on land and bulrush (*Typha domingensis*) in the water, fomenting intra-national and cross border natural resource (primarily pasture and water) conflicts (Ndetei 2006; Mahonge 2010).

An aerial view of a section of Lake Chala.

Christian Lambrechts

Declining Fisheries

Once the pride of the local community, the fishing industry now is a pale shadow of its glorious past. The combined effect of the diversion of the Lumi River, siltation and colonization of the lake by *Typha* has reduced the fisheries catch (ESFC 2005). The vanishing fish income has led to a higher incidence of poverty on the lake's shores and a switch of livelihoods to new, unfamiliar trades or migration to the comparatively more pristine Nyumba ya Mungu reservoir in Tanzania (Ndetei 2006).

Human-Wildlife Conflict

The rising human population around Lake Jipe is exerting mounting pressure on land and land-based resources. Thus the last decade has witnessed increased reclamation of swamps that were formerly inhabited by crocodiles and hippopotamuses, precipitating human-wildlife conflict (ESPC 2005). The magnitude of this conflict is aggravated by the fact that the lake is bordered by Tsavo West National Park which hosts a high concentration of wildlife. Elephants, for example, raid and destroy crops while humans retaliate by killing the culpable elephants (Smith and Kasiki 2000). Wild pigs, gazelles and monkeys cause considerable crop damage while livestock predation by carnivores such as lions, hyenas and cheetahs is also common in the areas adjacent to the park (Patterson and others 2004; Makindi 2010).

Water Pollution and Solid Waste Management

Non-point pollution of Lake Jipe results from agrochemical runoff. This is a serious problem because of the considerable use of agrochemicals in irrigated and horticulture farms in the lake's catchment notably Moshi, Arusha and the Kilimanjaro region (URT 2004). These in turn increase the nutrient load in the lake consequently compromising its ability to carry out its traditional ecosystem functions. The risk of oil sludge pollution from the numerous petrol stations and garages that operate in the commercial centres around the lake is also high.

Further, the danger of seepage of waste from septic tanks, soakage pits and storm drains is especially real in Taveta, Kitobo, Kimorigo and other rapidly urbanizing areas in Kenya. The hazard is compounded by the fact that although the water table is high in these areas (Huggins 2002), they have no centralized sewerage systems although some of these, such as Taveta, rank well above the national average in sanitation matters owing to the use of septic tanks, ventilated improved pit (VIP) latrine and covered pit latrine (USAID 2012).

Lake Chala

Lake Chala is a small (5 sq. km.) but relatively deep (with an average depth of 97 m), freshwater crater lake that traverses the Kenya-Tanzania border (Milne 2007) although only a small portion of the lake lies on Kenyan territory. As the lake has no known surface inlets, it is recharged by underground springs that drain Mount Kilimanjaro's melting snow (EFSC 2005).

Lake Chala is ecologically significant for five principal reasons. First, it is picturesque, making it a source of unbridled aesthetic beauty. Second, it is a habitat for an endemic species of Tilapia (*Oreochromis hunteri*) that are considered to be critically endangered yet their population is rapidly declining (Hărșan and Petrescu-Mag 2008). Third, it is home to a little-known endemic plant species referred to *Aloe penduliflora*. Fourth, it is a rich avifauna repository. Fifth, it has one of the highest population densities of crocodiles in the country. These together make it an important tourist attraction. Other major economic activities around the lake include fishing, farming and livestock production.

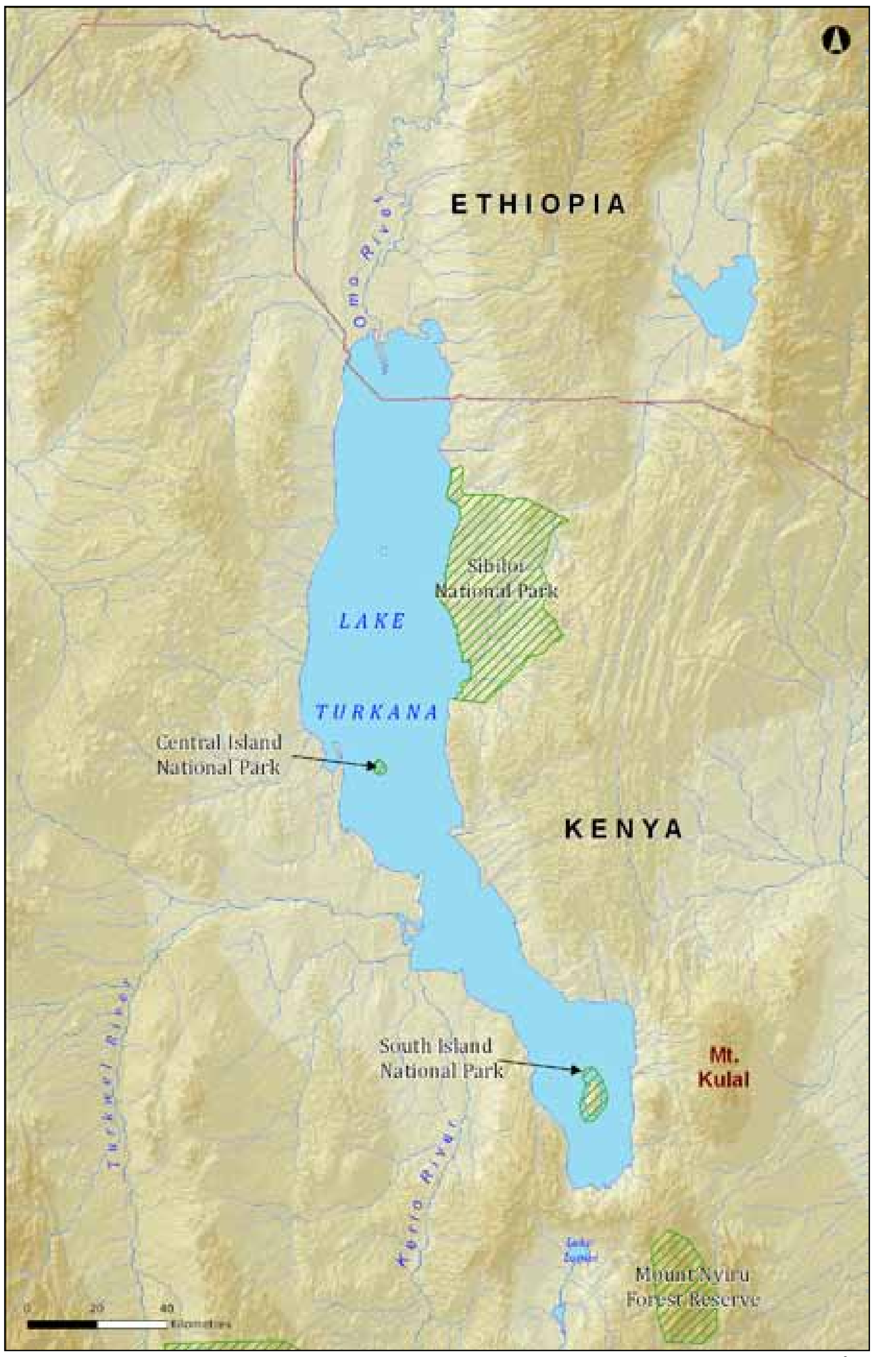
Lake Turkana

Lake Turkana is located in northwestern Kenya (Figure 3.7) in the country's portion of the Great Rift Valley. Although it measures about 250 km by 30 km and has an average depth of 35 m, its basin spans nearly 210 000 sq. km. stretching well into neighbouring Ethiopia (UNEP 2009). It holds the twin distinctions of being the world's largest permanent desert lake but also its largest alkaline water body.

As Lake Turkana is located in the hot and arid northern Kenya, the average temperature can reach 40°C. In the circumstances, rainfall is, as would be expected, erratic and quite low and averages less than 250 mm per annum (Karanja 2006). The water level of the lake is regulated by the equilibrium between the inflows from rivers and groundwater, and evaporation from the lake's surface.

The lake receives more than 90 per cent of its water influx from the Omo River, the lake's only permanent inlet that originates in the

Figure 3.7: Location of Lake Turkana.



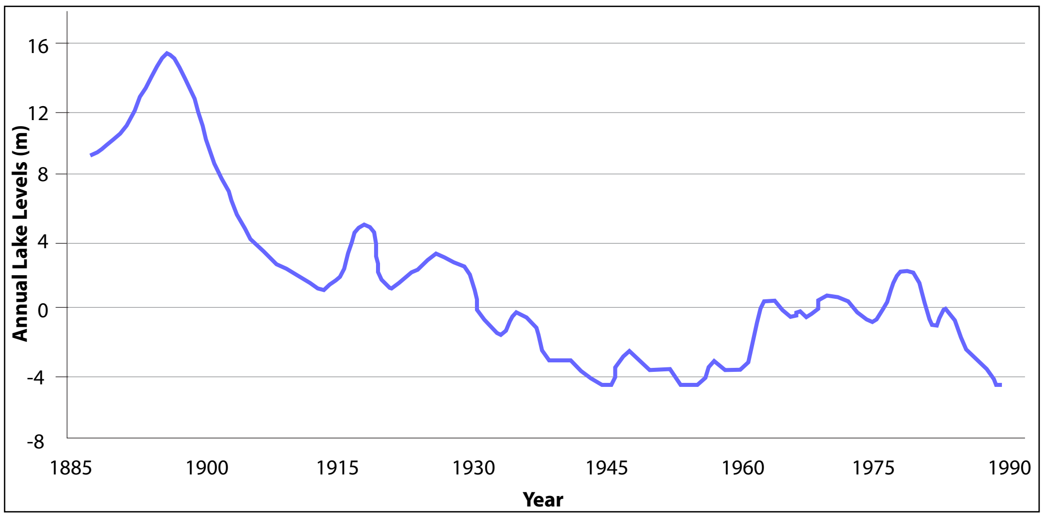
Source: UNEP/DEWA - Africa

Dry vegetation along the shores of Lake Turkana.

Ethiopian highlands (Nicholson 1998). Lake Turkana has no outlet and water is lost from the lake primarily through evaporation (Johnson and others 1987). The evaporation rate has been estimated at more than 2 300 mm per year (Ricketts and Hohnson 1996). Although seasonal variations in water levels can be as high as 3-4 m, the level plummeted 10 m between 1975 and 1992, increasing the lake's salinity (UNEP-WCMC 2008). Although the water is still drinkable, it is anticipated that if this trend continues, it will eventually disrupt the lake's optimal chemical balance. Figures 3.8 and 3.9 illustrate the historical changes in the lake's water levels while the relevant satellite images focus on changes in the lake's Ferguson's Gulf.

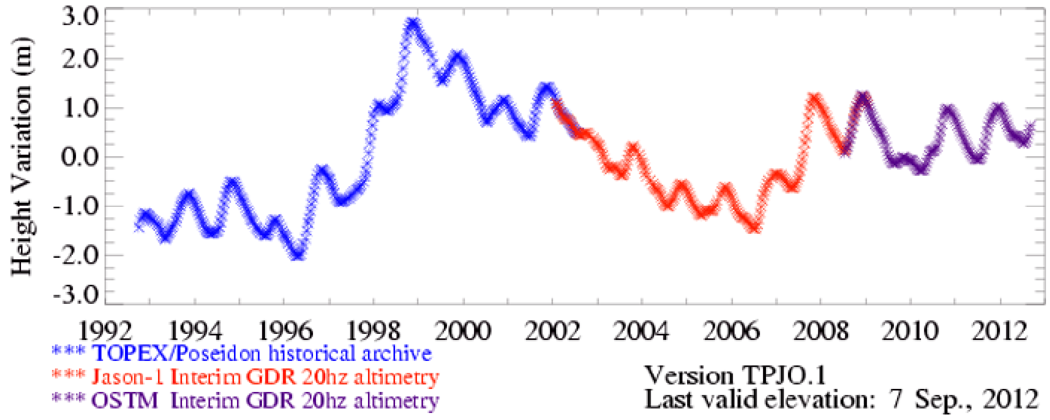
As the lake's vicinity is characterized by desert conditions, its shores are either sandy or rocky with barely any aquatic vegetation (UNESCO 2008). Fauna that can be found in the surrounding parks include the Beisa oryx and Grevy's zebra whose habitat in the country is limited to Northern Kenya; as well as the African lion, cheetah, crocodile, Burchell's zebra, Grant's gazelle, hartebeest, topi and lesser kudu. Over 350 terrestrial and water bird species have been sighted around the lake, nearly one third of which are regionally threatened. As Lake Turkana is located in the flight path of an important migratory route, it serves as an essential stopover for migrating avifauna, such as wagtails,

Figure 3.8: Historical fluctuations in the level of Lake Turkana, 1888 -1989.



Source: ILEC 2012

Figure 3.9: Fluctuations in the level of Lake Turkana, 1992-2012.

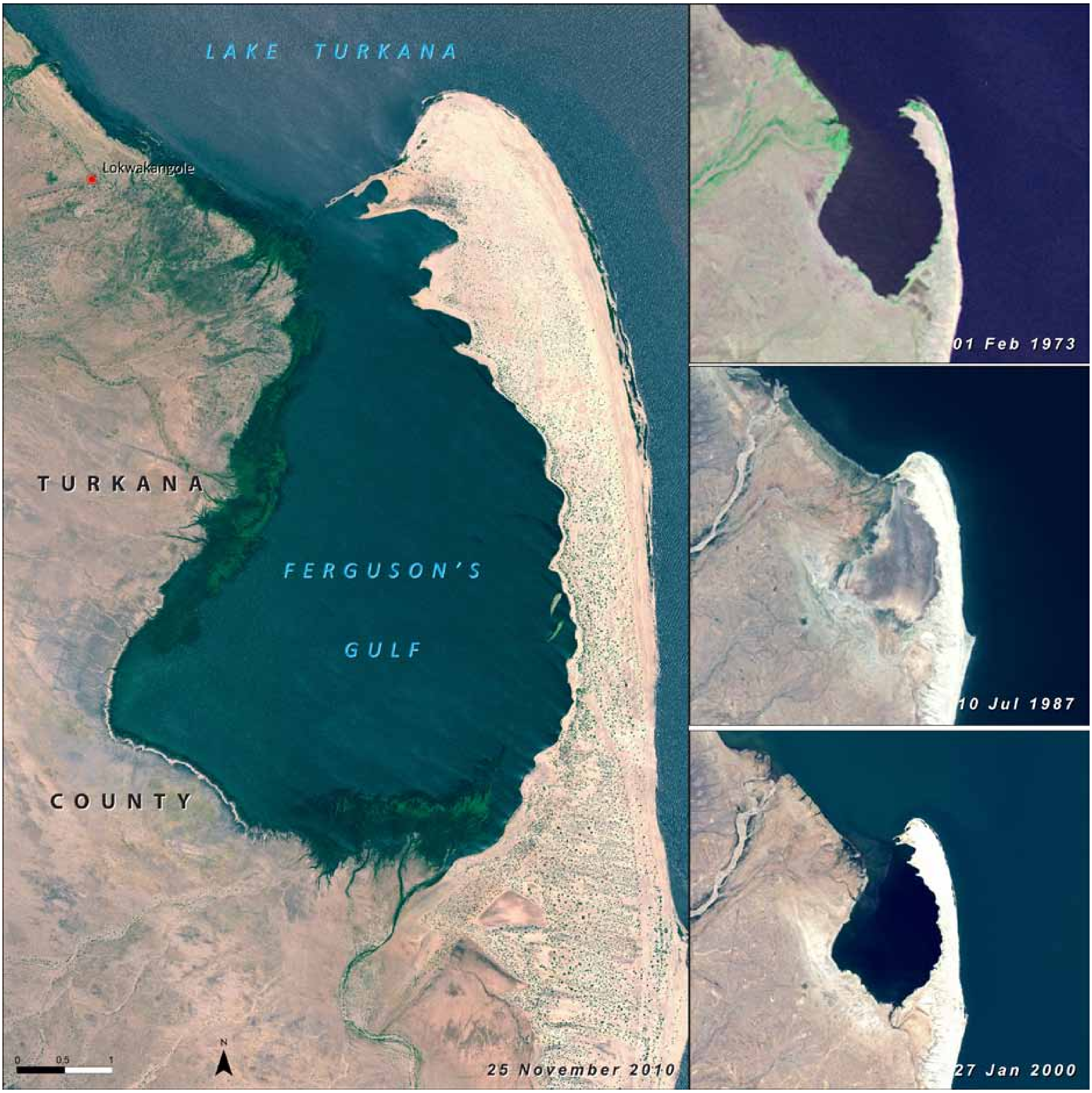


Source: USDA 2012b

The Yellow-breasted Apalis is a widespread warbler in sub-Saharan Africa.

Ian N. White/Flickr

The water level in Ferguson's Gulf in Lake Turkana fluctuates with the annual and inter-annual variations in Lake Turkana's levels. The small images on the right show the Gulf at different levels over the past several decades, drying up entirely in 1987. This is reported to have happened in 1946 and 1955-56 as well (Kolding 1993), which corresponds to the low points in the graph of 20th century water levels for Lake Turkana. The large November 2010 image shows emergent wetland vegetation, particularly along the south and west shorelines.



warblers and little stints (UNESCO 2008), which are attracted by its considerable plankton (UNEP-WCMC 2008).

Besides the ubiquitous acacia (*Acacia tortilis*), tree species that dominate the landscape are the Gingerbread palm tree (*Hyphaene thebaica*), whose oval fruit is edible and the Doum palm (*Hyphaene coriacea*).

However, Lake Turkana's unique biodiversity is particularly underlined by the fact that, unlike its Rift Valley counterparts whose aquatic fauna is dominated by cichlids, the lake's fish fauna shows a striking bias for Nilotic riverine species (Lowe-McConnell 1993). This more than compensates for the relatively low level of diversity among the fish species; of the 50 fish species that are known to inhabit the lake, 11 are categorized as endemic to it. The lake therefore provides neighbouring communities with important sources of protein and income. Some recession agriculture is also practised although its year-on-year viability is almost entirely dependent on the Omo River's inflows.

Threats

Threats to the Lake Turkana region and the wetlands around the lake include severe droughts, climate change impacts, siltation and receding water levels (UNESCO 2008). Major political and management concerns in the basin include insecurity because of conflicts within the

A lone acacia tree on the shores of Lake Turkana.

Luciano Rizzello/Flickr

neighbouring countries, including disputes over chronic water scarcity and drought-related food insecurity. Grounding the principles of the United Nations Convention to Combat Desertification (UNCCD) would help to gradually attenuate the natural resource scarcity instigated conflicts.

Conflict Due to Food Insecurity

Significant increases in both human and livestock populations in recent years are putting immense pressure on the Lake Turkana region. The diminished resource base on which the local communities are dependent precipitates inter-community conflicts over pasture and water rights (Young and Sing'oei 2011). For example, although Turkana and Pokot have been traditional rivals for centuries, there is a marked increase in the frequency of inter-ethnic disputes following the increasingly shorter intervals between droughts (Okumu 2010).

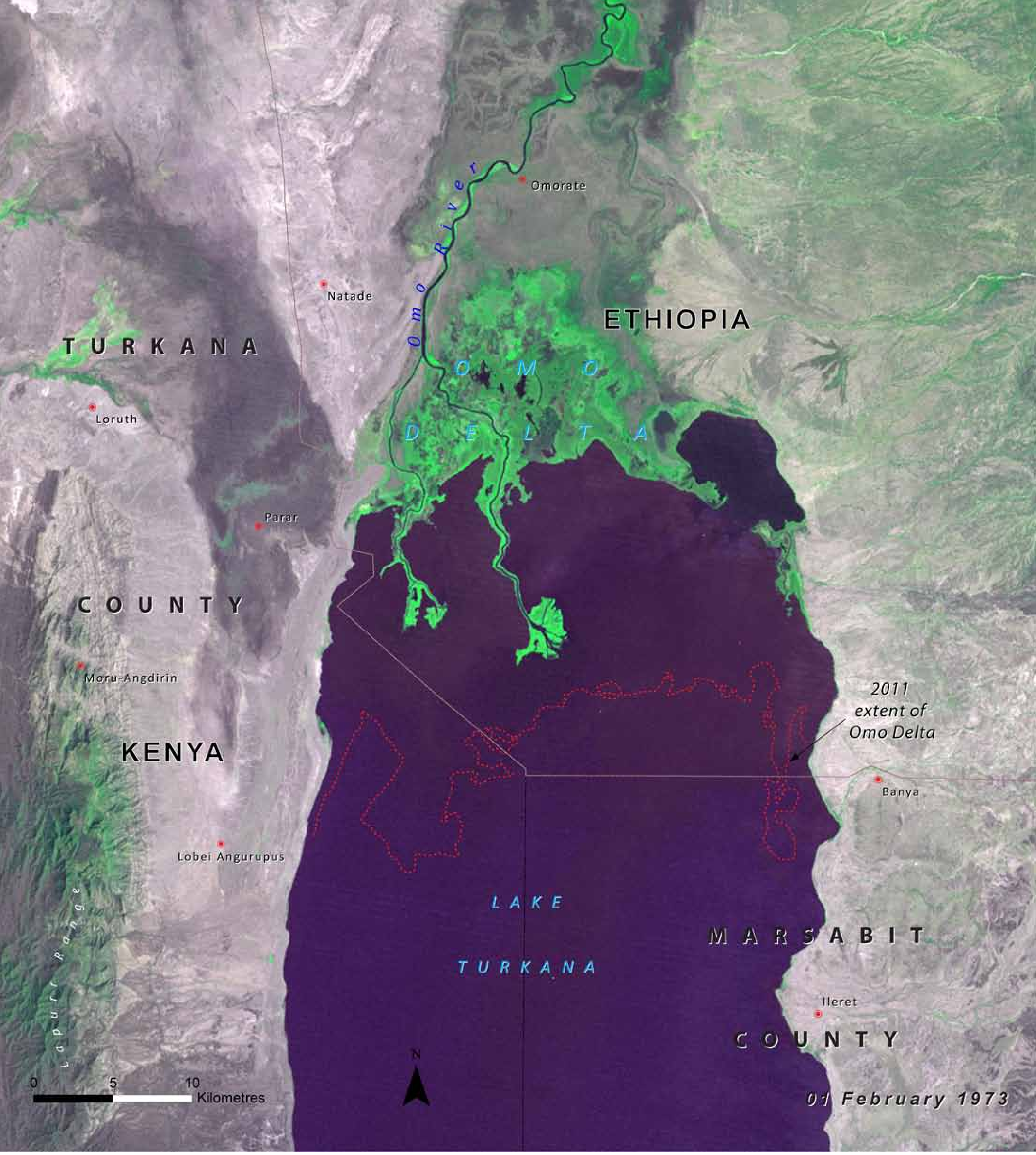
Moreover, since the 1970s, the regular occurrence of drought spells resulted in large numbers of livestock deaths, eroding pastoral livelihoods and necessitating regular flow of relief food and other related humanitarian aid. One of the consequences has been increased tension between local people (Evans 2011) and others migrating to the region in search of food relief and local resentment towards mostly Somali refugees who occupy the Dadaab refugee camp (Abdi 2005). Another potential source of conflict is the lack of agreement between Kenya and Ethiopia on the joint management of the Lake Turkana Basin.

Impacts of Changes in the Omo River

The Omo River is the very lifeblood of Lake Turkana because not only does the influx of floodwaters ensure that the lake is continually recharged, these waters stimulate fish spawning and determine the lake's ecology (Avery 2010). In effect then, the Omo makes it possible for the inhabitants of northern Kenya to wring fairly decent subsistence out of the scorched landscape of northern Kenya (International Rivers 2011). A correlation therefore exists between the Omo River's flood regime and breeding among 70 per cent of the lake's most important aquatic and terrestrial species (Avery 2010).

Despite its critical role, the Omo's own continued integrity is in doubt following the clearing of vegetation, including forests in the river basin over the past two decades (Velpuri and Senay 2012). The amount of the river's waters that outfall in Lake Turkana are highly variable as a result. When runoff does increase, soil erosion accelerates and sediment accumulates downstream, leading to changes in the geographic extent of the Omo Delta.

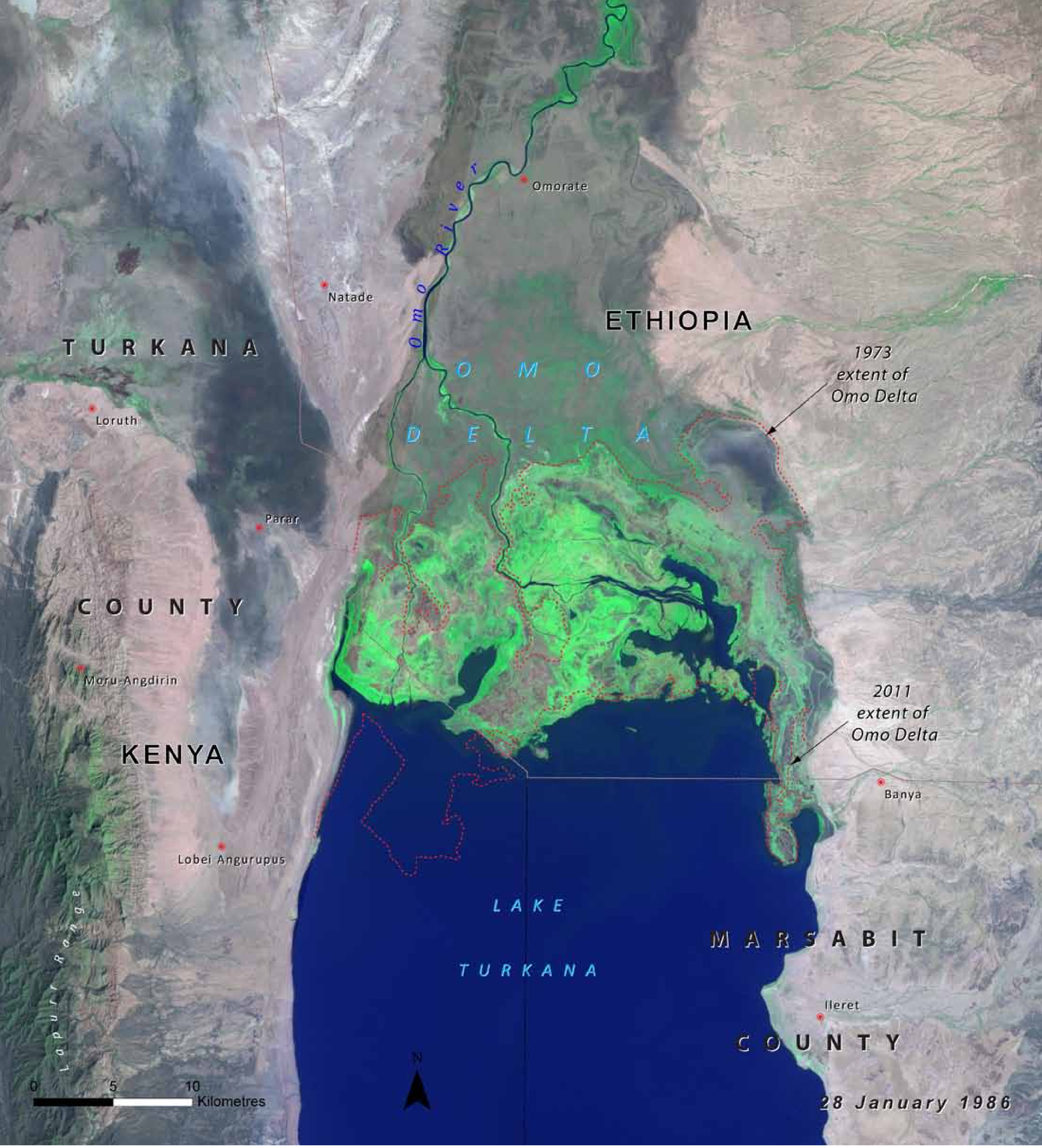
Another key issue concerns the damming of the Omo River. In a bid to ensure hydro energy-self-sufficiency and to generate a surplus for export, the Ethiopian government has embarked on an ambitious project to construct a series of dams (Gibe I to III; Gibe IV and V under planning) on the Omo River. While Kenya is keen to import some of the surplus power generated in order to meet the widening electricity deficit, some scientists fear that construction of Gibe III to V will lead



to the impoundment of the water that currently flows to Lake Turkana. This would diminish the flow, causing Lake Turkana's water level to decline by up to 2 metres (Avery 2010, Velpuri and Senay 2012). It is therefore important to urgently address these concerns.

Discovery of Oil in Turkana County

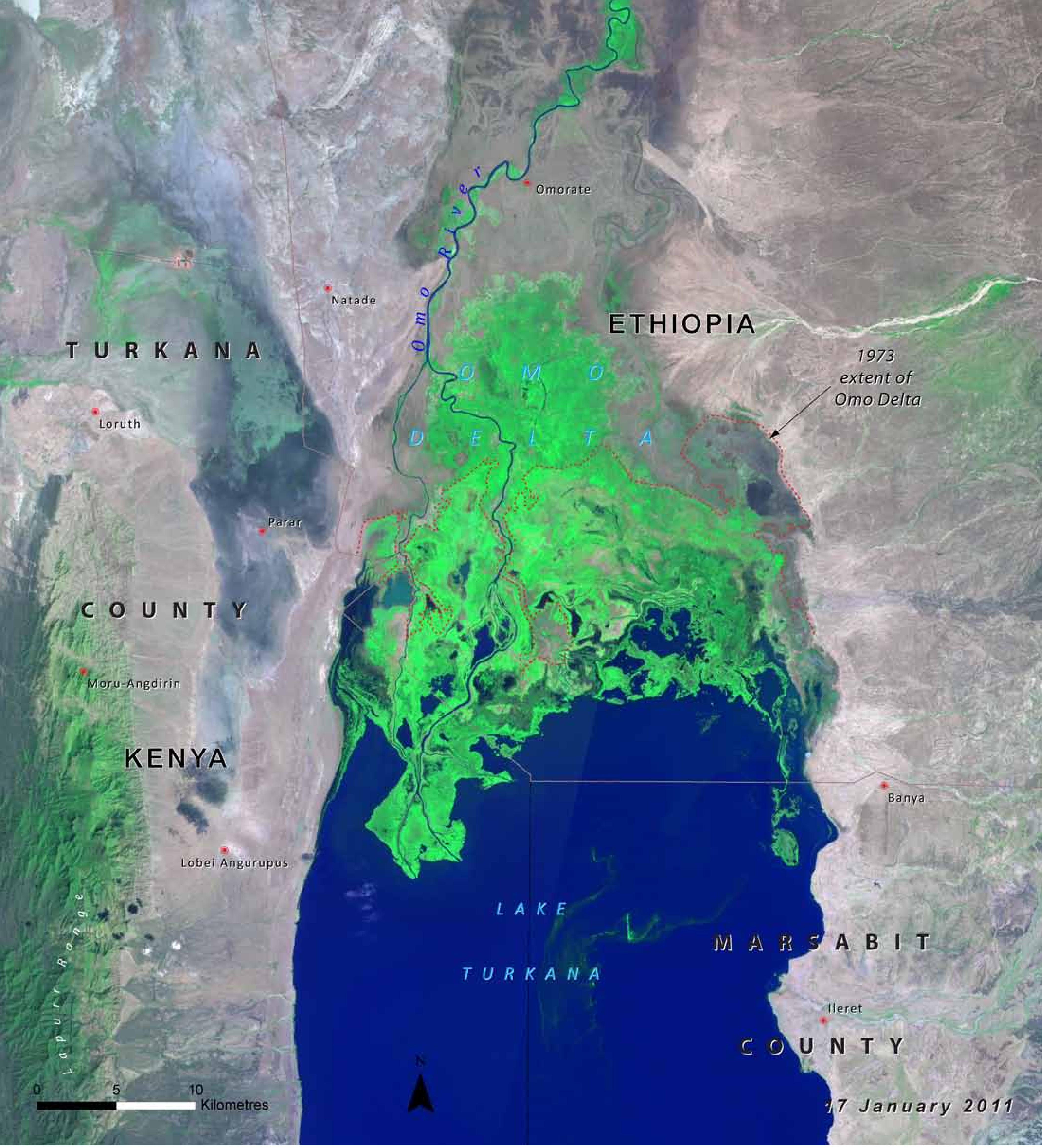
In March 2012, it was officially announced that high quality deposits of light crude had been discovered in Turkana County (Standard Media Group 2012a and 2012b). Although the commercial viability of the oil find is yet to be established, given that the attendant prospecting



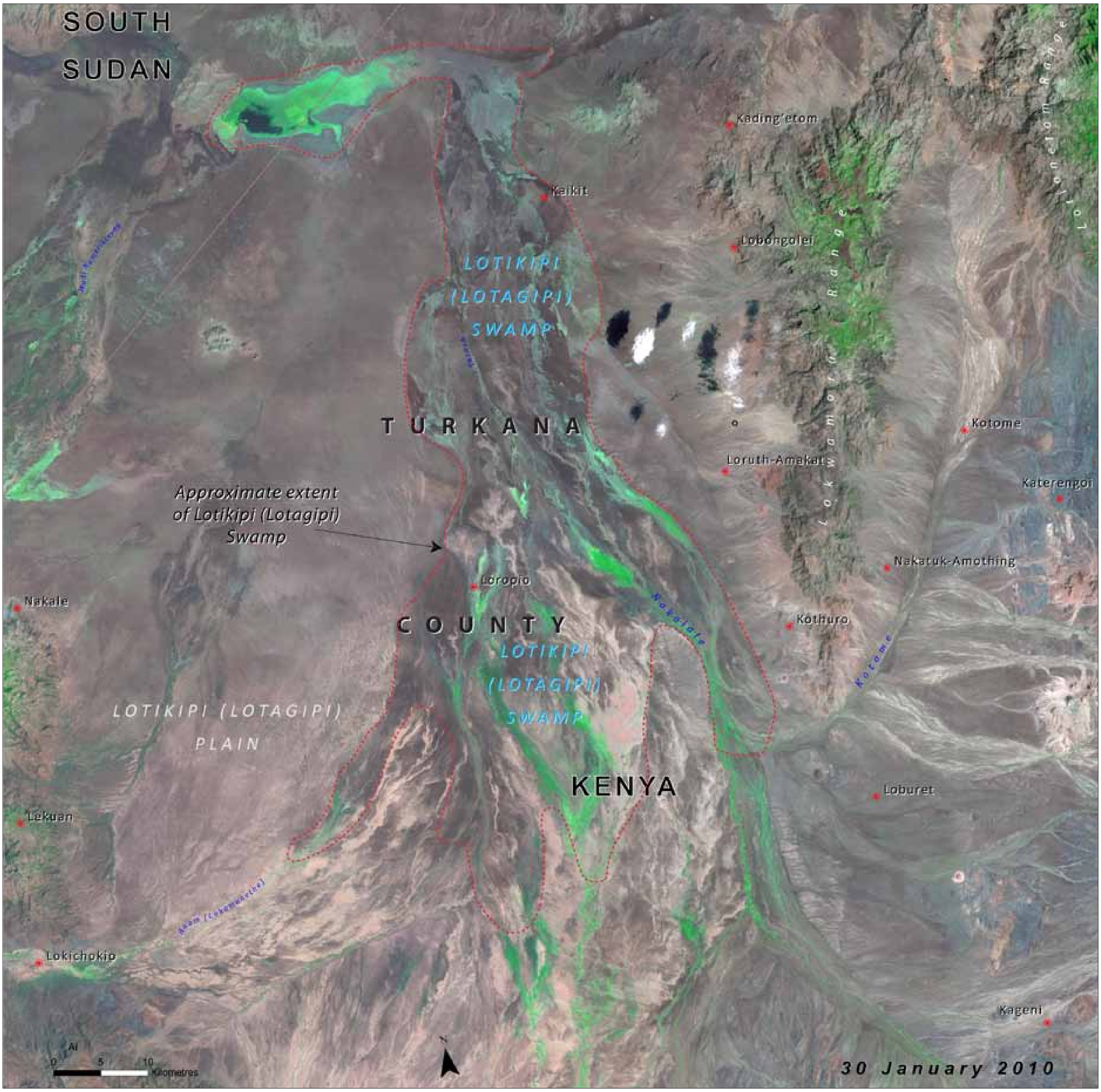
Lake Turkana

Lake Turkana receives over 90 per cent of its water from the Omo River. This river flows for approximately 1 000 km in Ethiopia before finally forming the expansive Omo Delta and draining its waters into Lake Turkana.

This series of images show how Omo Delta has changed over the last four decades. In 1973, the Delta was entirely within the boundaries of Ethiopia. It started to extend into Kenya by 1986, and by 2011, the southernmost portions of the delta are well within Kenya and in fact cover most of eastern and western Lake Turkana.



The expansion of the delta is mainly attributed to reduced lake levels and an increase in sediment inflow. Apart from the decreased rainfall and increased evaporation due to higher temperatures, other developments within the Omo River basin itself may have direct impacts on the water flow into the lake. The most important of these is the construction of the Gibe hydroelectric projects alluded to elsewhere in this chapter. With scientific projections indicating that the lake's water level could dip by two metres, it could pose a threat to the region's fisheries and agro-pastoralism.



Lotikipi Swamp

Lotikipi Swamp, also known as Lotagipi Swamp, is located within the vast Lotikipi (Lotagipi) plain, around 90 km to the west of Lake Turkana. This plain is a flat endorheic basin composed of young soils which have been developed on alluvium of recent origin. A large permanent swamp zone resides where the Tarach and Narengor Rivers run along the lowest part of the plain. It is situated in a semi-arid zone, with direct annual precipitation close to 250-500 mm. Lotikipi is a grassy floodplain with reeds and papyrus in the wettest sites, and scattered Acacia and Balanites trees.

Since time immemorial, the wetland resources within this plain have been shared by the communities in Kenya (Turkana), Uganda, South Sudan (Didinga, Topasa, and Nyangatom), and Ethiopia (Nyangatom, Dassanetch). Although to visitors it is a vast wasteland, to these communities, Lotikipi Swamp's dry season pastureland is a cherished resource, and indeed there have been numerous conflicts over its control.

Hydrology

Lotikipi Swamp is flooded during the rains to depths in excess of one metre. It is fed by six seasonal rivers: the Kotome, Narengor, Tarach, Napass, Natira and Nanam Rivers. The Kotome drains the Lokwamoru and Lorionetom Ranges to the northeast. The Narengor drains the Pelekech Range in the south, and enters the southern end of the plain, as does the Tarach River which drains the Murua Nigithigerr and Mersuk Hills. The Napass, Natira and Nanam Rivers drain the highlands along the Uganda border in the west. Some of these retain pools of water in their beds during the dry season.

Should these rivers flood simultaneously, they could inundate 720 000 ha of the plain. However, the rivers do not always flood together, and indeed may not flood at all in dry years. Thus the area of the plain that is inundated is usually far less than 720 000 ha (Ramsar Convention Secretariat n.d.).


Boats on the lake shore along Ferguson's Gulf.

Manohar Velpuri

activities were carried out by Tullow Oil, which discovered viable oil reserves in Uganda's Albertine region earlier, the cautious optimism with which the development was greeted appears to have been well-founded. And from the perspective of the inhabitants of the Turkana County, the discovery has the potential to lift them out of poverty. Nevertheless, it will be important to ensure that sound production methods and systems are employed in order to avert despoiling the county's most famous and critically important wetland.

Conclusion

The Chapter has outlined the largest and most significant of Kenya's transboundary wetland portfolio. Highlighting these ecosystems is important for two principal reasons. First, some of these wetlands, such as Lake Victoria, Lake Turkana and the Mara River play critical roles at the subsistence, county and national economy levels. Second, because these wetlands lie astride at least one of Kenya's international boundaries, they are governed by fragmented and sometimes incompatible national policies, laws and practices.

The combined effect of the above two factors is that unless bilateral and regional wetland management initiatives for managing the shared ecosystems are urgently strengthened or fast tracked, these resources are likely to become increasingly prone to conflict particularly at the local community and national levels. And, it is imperative that these bilateral and regional initiatives are undergirded by the principles of integrated ecosystem management and of wise use.

The sense of urgency with which the proposed initiatives should be devised or ratcheted up is informed by the mounting pressure that is being exerted on these fragile resources by the exponential increases of wetland-dependent populations as is evident throughout the Chapter. Climate change, the proliferation of invasive alien species and other localized pressures—such as the eagerly anticipated commencement of commercial oil production in Turkana County—will compound the wetlands' vulnerabilities and threaten to irremediably compromise the breadth of ecosystem services they provide.

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Beautiful beaches along the Kenyan Coastline are a major tourist attraction providing income to the local communities and the government.

CHAPTER 4

HUMAN WELLBEING, ECOLOGICAL AND NATIONAL DEVELOPMENT ROLES OF KENYA'S WETLANDS

Introduction

As has been discussed in Chapters 2 and 3, Kenya is blessed with a wealth of internal and transboundary wetland ecosystems. This Chapter examines the ecological, social, and economic values of the country's wetlands which are, of course, inextricably linked. For example, compromising the ecological role of wetlands will concomitantly imperil livelihoods of wetland-adjacent communities and push them further into the poverty trap. The synergy of the dysfunctional wetlands and the increased incidence of poverty will jeopardize the attainment of the Millennium Development Goals (MDGs) and Kenya's development aspirations that are articulated in Vision 2030, the country's long term development blueprint. However, in order to interrogate their specificities, these value categories are as far as possible, discussed separately in this chapter.

Wetlands and Human Wellbeing

Wetlands provide humans with a range of important provisioning, regulating, supporting and cultural services that the Millennium Ecosystem Assessment collectively refers to as 'ecosystem services' (Millennium Ecosystem Assessment 2005). These services are tabulated in Table 4.1 while Figure 4.1 demonstrates how these contribute to human wellbeing .

KEY MESSAGE

Kenya's wetlands are an important part of the country's natural capital. They provide multifarious ecosystem goods and services that are indispensable to life on Earth, ensure environmental integrity and contribute to human wellbeing as well as poverty alleviation. As such, they implicitly support the attainment of the MDGs and the Vision 2030 goals. Yet despite their critical role, according to the Millennium Ecosystem Assessment, world over, wetlands are being degraded and lost more rapidly than other ecosystems. This is primarily because these functions are not adequately quantified with the corollary that they are given little weight in policy decisions. In the context of Kenya, this threatens livelihoods, economic growth and the very survival of wetland-dependent species. Corrective policy and legal interventions therefore need to be urgently instituted in order to roll back these losses before the tipping point is reached.

Provisioning Services

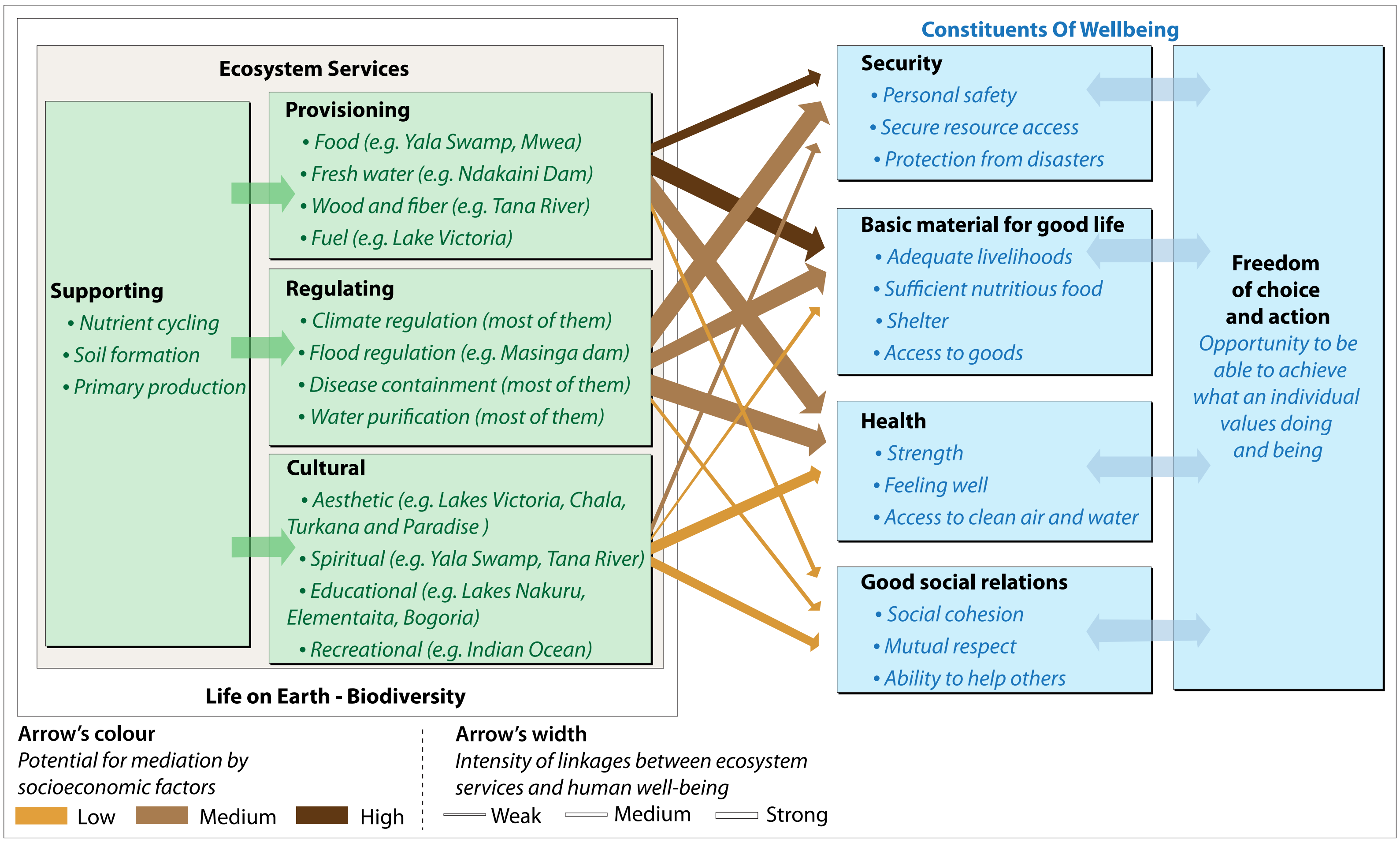
The most important provisioning services procured from Kenya's wetlands are food, freshwater, fuel and raw materials. Wetlands are an important source of fish protein for adjacent communities. Lake

Table 4.1: Ecosystem services provided by or derived from wetlands.

Wetland - Ecosystem Services	Benefits to Human Wellbeing
Provisioning	
Food	Production of fish, wild game, fruits, and grains
Fresh water	Storage and retention of water for domestic, industrial, and agricultural use
Fibre and fuel	Production of logs, fuelwood, peat and fodder
Biochemical	Extraction of medicines and other materials from biota
Genetic materials	Genes for resistance to plant pathogens; ornamental species, etc.
Regulating	
Climate regulation	Source of and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes
Water regulation (hydrologic flows)	Groundwater recharge/discharge
Water purification and waste treatment	Retention, recovery, and removal of excess nutrients and other pollutants
Erosion regulation	Retention of soils and sediments
Natural hazard regulation	Flood control and storm protection
Pollination	Habitat for pollinators
Cultural	
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	Opportunities for recreational activities
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	Opportunities for formal and informal education and training
Supporting	
Soil formation	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling, processing, and acquisition of nutrients

Source: Millennium Ecosystem Assessment 2005

Figure 4.1: Interlinkages between wetland ecosystem services and human well-being.



Victoria is, for instance, well known for its tilapia and Nile Perch (Goudswaard and others 2002) while Lake Naivasha is a good source of large mouth bass (*Micropterus salmoides*) and Common carp (*Cyprinus carpio*) (Mergeay and others 2004). Moreover, some of the fish species that predominate in the country's mangrove estuaries include Clupeidae, Gerreidae and Atherinidae (Kimani and others 1996).

Kenya's wetlands are, in addition a source of cooking energy and herbal remedies. For example, the water berry (*Syzygium guineense*) which occurs in the Kingwal Swamp, and the country's mangroves which are a common feature in the marine wetlands are prized as sources of fuel wood, charcoal and herbal medicine (Ambasa 2005; Taylor and others 2003). Mangroves are also an important source of construction materials for coastal populations (Rönnbäck and others 2007) while papyrus reeds are frequently harvested in order to make woven handicrafts (Osumba and others 2010; Terer and others 2012; Perbangkhem and Polprasert 2010). Other provisioning services that Kenya's wetlands provide include water supply for the country's rural and urban human as well as livestock and wildlife populations (Keter 1992; Postel and Thompson Jr. 2005), and hydroelectricity power generation (Schuyt 2005). Large wetlands such as the Lake Victoria shorelines, Yala Swamp and Tana River are also an important mode of mass transportation (Kansiime and others 2007; Abila 2002; Terer and others 2004).

Regulating Services

Regulating services are the values human beings obtain from natural management of the diverse wetland ecosystem processes (Carpenter and Folke 2006). These services include climate regulation, controlling the hydrological flows of water, water purification, soil erosion control and providing a habitat for pollinators (Millennium Ecosystem Assessment 2005). Kenya's wetlands influence the micro and regional climate by controlling evapotranspiration and precipitation (Gichuki 2000; Hamerlynck and others 2010) and may well explain why wetlands are increasingly taking centre stage in the climate change discourse (Dessler and Parson 2010). The country's wetlands also regulate hydrological flows with groundwater recharge generally taking place in topographically high areas and groundwater discharge in the lower-lying areas (Winter 1998). Moreover, some wetland plants are capable of changing the ionic composition of water, thereby reducing its salinity, particularly in arid or semi-arid areas.

A dhow like this one is a major means of transportation within the Lamu Archipelago.

chefmoamba/Flickr


Valentina Storti/Flickr

The hot springs of Lake Bogoria are a wonder to many but a medicinal spa to the local community and the lake's regular visitors. This lake is also an important flamingo habitat.

Wetland vegetation purifies water by uptaking nitrates, phosphates and toxins from the water flowing through, thereby lowering the nutrient load (Verhoeven and others 2006). This function is important in the country's large wetlands such as the Tana Delta and Yala Swamp that are exposed to considerable non-point source pollution from human waste disposal and agrochemical runoff (Gichuki and others 2001; Lalah and others 2003). Owing to this important regulating service, wetlands are often referred to as 'the kidneys of the Earth.'

Wetland vegetation foliage and dense roots also help to brake the speed of floodwaters thereby limiting the detrimental effects of floods and controlling soil erosion (Uluocha and Okeke 2004). The indirect but considerable benefit of flood control could be that of damage avoided (Emerton 1998) stabilizing the reduced tax burden because less investment is needed to repair damaged infrastructure and to erect buffers (Novotny and others 2001). Soil erosion control on the other hand ensures retention of fertile topsoil and in turn ensures the sustainability of agriculture, one of the larger sectors of the Kenyan economy and whose success is crucial to the delivery of the Vision 2030 economic goals (GoK 2007).

Wetlands also provide a habitat for beneficial insects such as pollinators. Pollination is an essential aspect of the lifecycle of flowering plants (Feinsinger 1987) which are, in turn, an important source of food for human beings and herbivores. Wetlands in Kakamega in western Kenya are, for example, an important habitat for bees which support maize crop production which is also an important source of household income (Kasina and others 2009).

However, although the above regulating services are indispensable to their provisioning counterparts discussed earlier on in the chapter, because yearly changes in these services tend to be miniscule, they tend to be ignored by policy makers (Carpenter and others 2006). This therefore needs to be urgently addressed.

Supporting Services

One of the important supporting services that is associated with Kenya's wetlands is soil formation. This primarily results from the comingling of decomposing organic material with weathering rock (Costanza and others 1997), mineral matter (Nyman and others 1993) and sediment. The profiles of these soils vary depending on whether these occur in the wetland itself, on the wetland fringes, in the transition zone to dryland or the dryland with the former two being more amenable to hydric soil indicators (Vepraskas and others 1999). Wetland vegetation also traps and retains sediments transported by the runoff and in so doing, controls siltation downstream (Girel and Pautou 1996).

Another vital supporting service that Kenya's wetlands provide is nutrient recycling with this being largely attributable to the immensely complex chemistry of wetland ecosystems. Although nutrient recycling is largely plant-mediated (Aerts and others 1999) principally on account of the fact that vegetation is one of the principal characteristics of wetlands as described in Chapter 1, aqua fauna such as fish (Hood and others 2005) as well as bacteria and sediment (Carpenter and Cottingham 1997) all play their parts. And as would be expected, the nutrient throughput rates are positively correlated with water turnover levels (Lugo and others 1990).

Cultural Services

Owing to their aesthetic appeal, Kenya's wetlands are associated with a range of recreational activities such as wildlife safaris, bird spotting, sailing, swimming and picnics (Emerton 1998). The magnitude of the importance of wetlands is demonstrated by the fact that wetlands such as the Mara River catchment and Lake Nakuru are the country's premium national parks (Udoto 2012) and rake in considerable foreign exchange earnings (GoK 2011). Other Ramsar Sites such as Lakes Bogoria , Elementaita and Naivasha—which were designated as World Heritage Sites owing to their exceptional natural beauty (UNESCO 2011)—also feature prominently on the Rift Valley tourism circuit.

Hippopotami cooling off in the waters of Lake Naivasha.

The country's wetlands have left a considerable imprint on the culture of several communities because they influence their food choices, traditional art and crafts, mythology and traditional religious practices as well as cultural activities (Ndaruga and Irwin 2003). They even determine dominant livelihood choices (Thenya 2001) especially for fishing communities.

Wetlands are important for conservation education (Fanshawe and Bennun 1991) and also serve as critical areas of research. For example, the Kenya lake system consisting of Lakes Nakuru, Bogoria and Elementaita is considered a crucial research area for those interested in scientifically investigating birds as well as regional and multi-continent bird migration and studying a high concentration of biodiversity within a small geographic area (GoK 2010b).

Ecological Role of Wetlands

There are striking linkages between the ecosystem services provided by wetlands to improve human wellbeing and their ecological role in general. The latter include playing an important role in Kenya's hydrologic regime, acting as a reservoir of biodiversity, biomass storage, maintenance of the nutrient cycle/food web and providing a crucial flyway for migratory waterbirds (Goodwin and Niering 1974). Equally, deltaic, estuarine and coastal wetlands are essential to the maintenance of various fish and invertebrate stocks while freshwater wetlands are essential spawning grounds for many fish, amphibian and invertebrate species.

Wetlands also support a range of large fauna. For example, the Amboseli National Park is home to some of the largest elephant herds in the world while Lake Nakuru is an important watering point for several dozen endangered white and black rhinos. Saiwa wetland is also a critical breeding ground for the threatened Sitatunga antelope (Mohamed 2002). Some Kenya animals such as the hippopatamus and crocodile permanently live in or around wetlands (Grey and Harper 2002; Terer and others 2004).

Wetlands and National Development

The wise use and conservation of Kenya's wetlands will ensure the sustainability of the human welfare and ecological benefits they provide to the country. These goods and services will in turn help to alleviate poverty and hunger and to deliver the relevant Millennium Development Goals (MDGs) and the ambitious Vision 2030 goals.

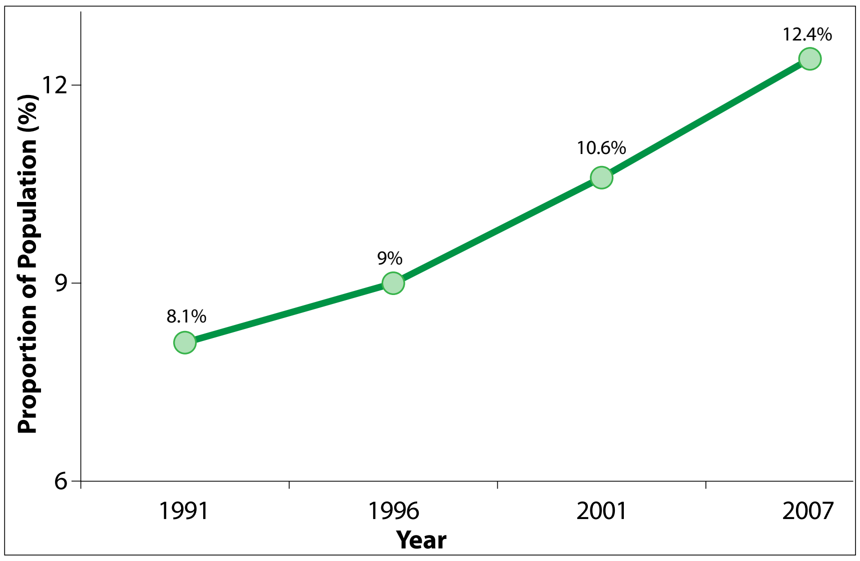
Attainment of MDGs

The UN Summit on the Millennium Development Goals adopted a global action plan to achieve eight development goals by 2015. These MDGs touch on women's and children's health and other initiatives against poverty, hunger and disease. Kenya has adopted these goals and the active conservation and management of wetlands can undoubtedly help the country to attain some of them.

MDG 1: Eliminate Extreme Poverty and Hunger

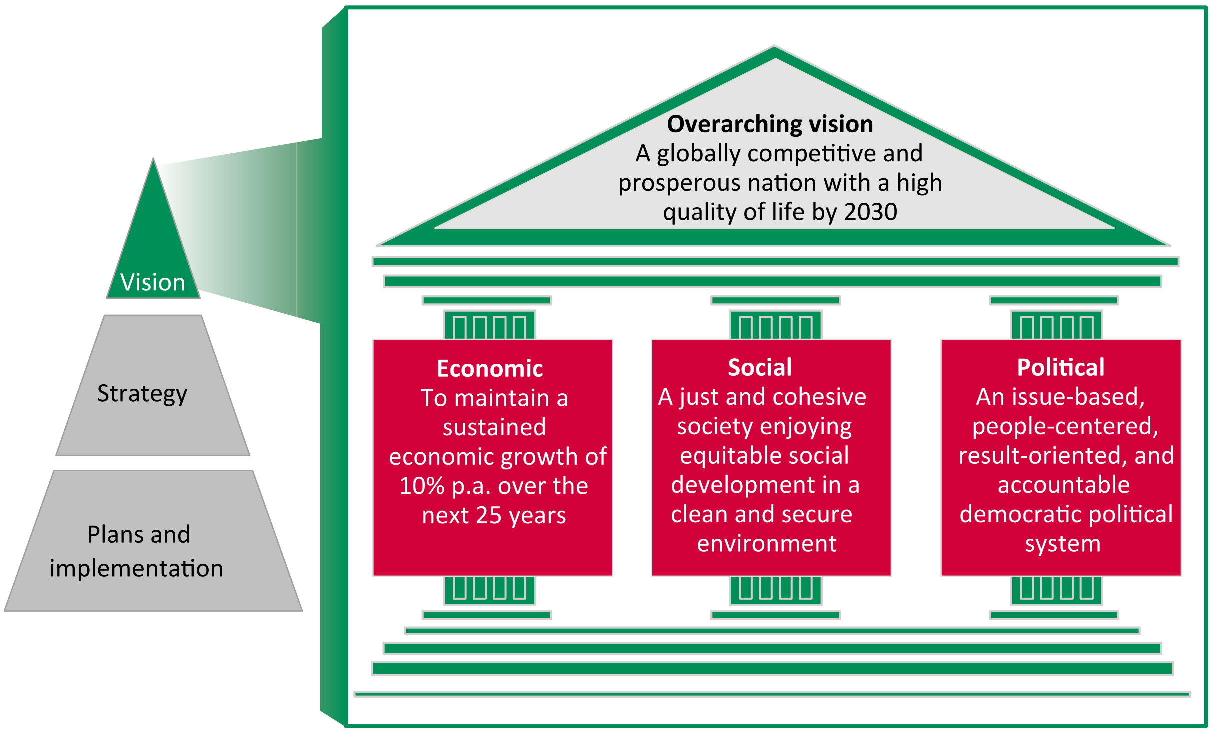
The proportion of Kenyans that survive on an inadequate diet has increased since the early 1990s as is clear from Figure 4.2. Sustainable use of wetland resources can therefore address this problem because

Figure 4.2: Proportion of population below minimum level of dietary energy consumption.



Source: United Nations Statistics Division 2012

Figure 4.3: Thematic overview of the Kenya Vision 2030.



Source: GoK 2007

these ecosystems offer an array of sustenance and livelihood products and services such as fish, water, grazing land, medicinal plants and tourism opportunities. Moreover, the diversification of wetland products and services into aquaculture, agriculture, and community based ecotourism provide impoverished communities with a practical way to minimize incidences of famine and to break out of the crippling cycle of poverty.

MDG 7: Ensure Environmental Sustainability

As discussed above, wetlands play an important role in ensuring environmental sustainability. Indeed, they sequester carbon, which helps to mitigate climate change; they regulate hydrologic cycles, protect shorelines; and provide a haven for flora and fauna; and slow flood waters. While these are free services, compromising the ability of wetlands to provide them would raise the tax burden in order to ensure that broken down infrastructure is repaired and that artificial buffers against natural disasters are constructed. This underlines the need to use the country's wetlands resources wisely so that both present and future generations can benefit from them.

MDG 8: Enhance International Development Partnerships

International conventions such as Ramsar, CBD, AEWA, UNCCD and the World Heritage Convention provide the framework for management of internal and transboundary wetlands. In addition, coordinated wetlands management, research and funding as well as information sharing is especially essential to the sustainable management of transboundary wetlands. Therefore management of both internal and shared wetlands can help to promote partnerships with bilateral, multilateral and multi-agency international developmental partners as envisaged by MDG 8.

Attainment of Vision 2030 Goals

Kenya's long-term economic development aspirations are contained in Vision 2030 (GoK 2007) whose principal objective is to transform Kenya into a globally competitive and prosperous nation whose citizens enjoy a high standard of living by 2030. The country's development blueprint encompasses flagship projects and priority programmes that are undergirded by social, political and economic pillars as is illustrated in Figure 4.3.

Significantly, all earmarked 120 flagship projects to date directly or indirectly impact wetlands with the implication that the achievement of the development goals will be determined by the extent of wise use of these important natural resources. The relationships between wetlands and the Vision 2030 goals are highlighted below.

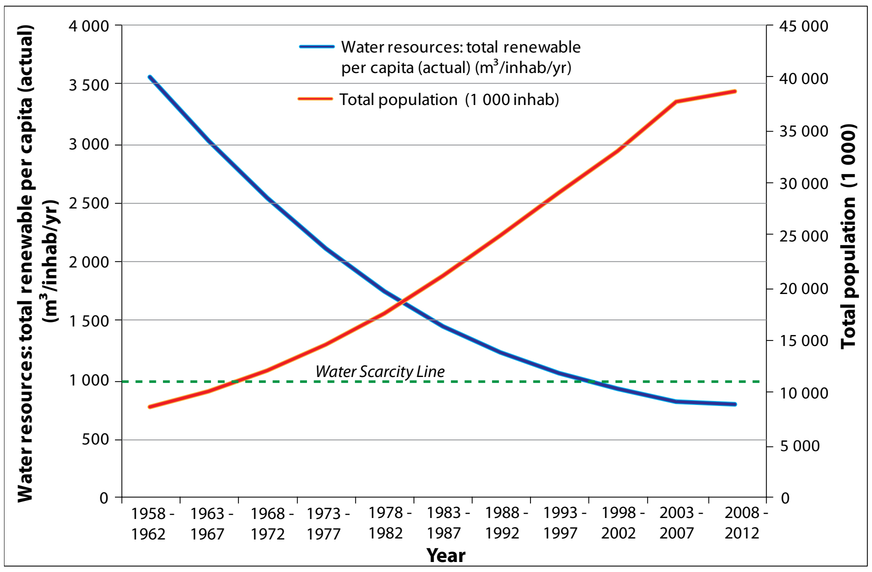
Poverty Alleviation

As already indicated, poverty reduction and social inclusion are priority goals of Vision 2030. Further, wetlands provide a number of ecosystem services that are vital for human wellbeing . The projected loss and degradation of wetlands (Millennium Ecosystem Assessment 2005) is likely to adversely affect human health and wellbeing with the vulnerable segments of society being particularly affected. Therefore, in order to ensure that wetlands continue to contribute to poverty reduction, sustainable use and restoration of wetlands as well as strengthening of robust, participatory and gender-sensitive governance structures are key. Moreover, wise use of wetlands should be prioritized in national development and environment policies (Ramsar Convention Secretariat 2005)

Fishing in Lake Victoria is an important economic activity for the population surrounding the lake.

sarahemcc/Flickr

Figure 4.4: With less than 1 000 m³/inhabitant/year total renewable water, Kenya is regarded as a water scarce nation.



Source: FAO 2012

Water Provision

The social pillar of Vision 2030 seeks to transform eight vital social sectors, including water. As discussed above, wetlands are important natural water reservoirs and they are associated with important hydrological functions such as recharging groundwater, filtering water and alleviating floods. Yet despite these vital roles, Kenya's wetlands continue to be lost and degraded at an alarming rate, cementing the country's status as a water-scarce nation (Figure 4.4). Indeed, per capita availability is projected to fall to 359 m³ by 2020 (UNEP 2009) as is detailed in Table 4.2, well below the United Nations recommended minimum of 1 000 m³. Implementation of Vision 2030 is likely to exacerbate this already grave situation since all its flagship projects such as tourism, agriculture, industry, hydropower, wildlife, and livestock production are heavily reliant on water and are likely to increase abstraction levels.

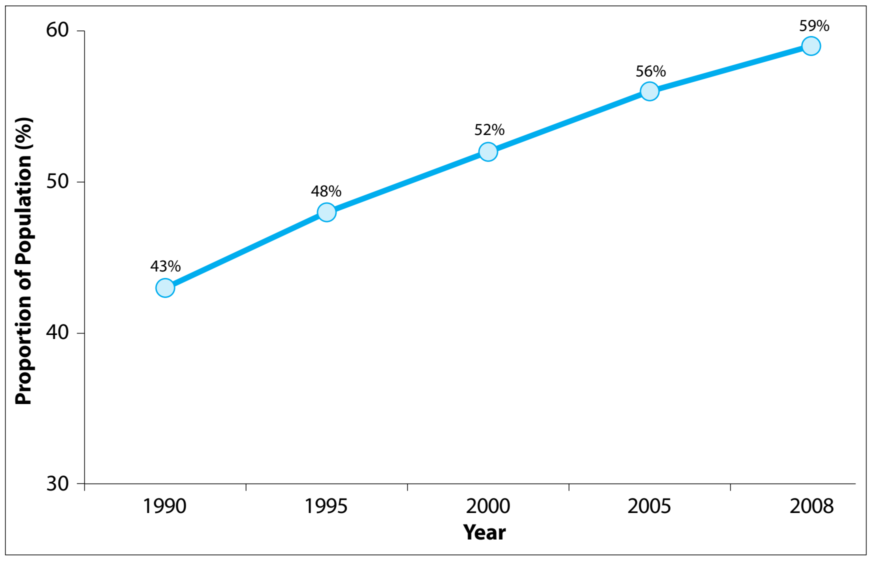
Table 4.2: Trend in water availability per capita.

Year	Population	Per capita water availability (m³/yr)
1969	10 942 705	1 853
1979	15 327 061	1 320
1989	21 448 774	942
1999	28 686 607	704
2010	40 311 794	503
2020	56 481 427	359

Source: GoK 1992 and GoK 2010a

Vision 2030's goal for the water and sanitation sector is 'to ensure water and improved sanitation availability and access to all by 2030.' Nevertheless, as is depicted in Figure 4.5, the majority of Kenyans do not have access to clean potable water. Wetlands afford direct access

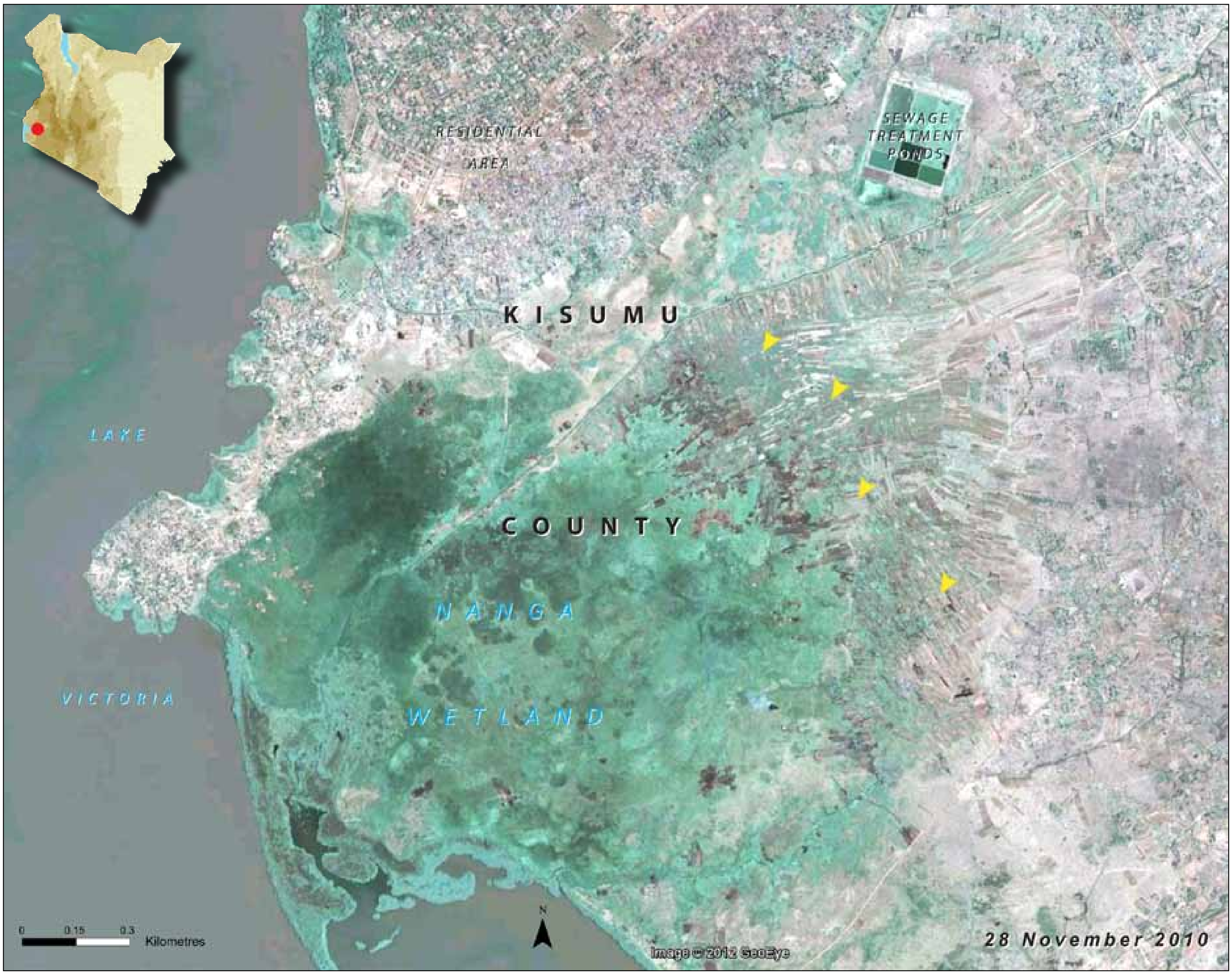
Figure 4.5: Trend in the proportion of Kenya's population using an improved drinking water source.



Source: United Nations Statistics Division 2012

Ahero irrigation scheme used for rice production in Kisumu County is an example of how a wetland area has been converted to agricultural use.

A high resolution satellite image of Nanga Wetland, South of Kisumu town. Farm fields (yellow arrows) can be seen expanding into the eastern edge of the remaining wetland while residential areas are also expanding in the northern side.



to clean freshwater to many Kenyans, since wetland functions include purifying water by filtering pollutants. These functions also reduce incidences of disease associated with water pollution, including heavy metals and other agro-based pollutants (Knight 1992). Wise wetland ecosystem management would ensure that these ecosystems continue to provide water security to many Kenyans, especially in the arid and semi-arid lands (ASALs) where water paucity inordinately burdens the residents of these areas especially women and girls (Businge and Maina 2011).

Agriculture

Agriculture (whose major components include industrial crops, food crops, horticulture, and livestock production) continues to be the mainstay of the Kenyan economy and in 2010, it accounted for a considerable 21.5 per cent of the country's GDP (GoK 2011). More than one third of Kenya's agricultural produce is exported while about 18 per cent of total formal employment is in the agricultural sector. Wetlands support commercial and subsistence agriculture through natural flooding, flood-recession agriculture and irrigation. The stature of the latter has risen in recent years when unpredictable rainfall patterns have had a negative impact on rain-fed agriculture and national food security. Irrigation has also boosted Kenya's horticultural crop production raising the potential for foreign exchange earnings. In fact, it is hardly surprising that horticulture dominates the local economy around Lake Naivasha, one of Kenya's Rift Valley wetlands (Becht and Harper 2002).

Farmers across the country are currently using lacustrine and riverine wetlands to ensure food security. However, some farming practices pose a threat to these fragile ecosystems as they lead to over-abstraction of the wetland waters, encourage use of poor irrigation methods such as overhead sprinklers and even encroach on wetlands. These negative activities have degraded wetlands and jeapordized their traditional roles of purifying water, retaining sediments as well as recharging water tables and aquifers.

The wise use of wetlands, including conservation and the use of proper irrigation and land use practices, appropriate technologies, extension services and market-diversification and value addition would help to secure the livelihoods of those employed in the sector and increase Kenya's gross domestic product (GDP).

Table 4.3: Quantity and value of fish landed by water body, 2006-2010.

Quantities – Tonnes	2006	2007	2008	2009	2010*
Freshwater fish					
Lake Victoria	143 908	117 231	111 369	108 934	113 041
Lake Turkana	4 559	5 122	8 070	9 445	8 123
Lake Naivasha	189	203	225	688	693
Lake Baringo	68	173	262	191	198
Lake Jipe	109	96	109	109	111
Tana River	1 024	1 112	1 302	584	596
Fish Farming	1 012	4 245	4 452	4 895	12 153
Other areas	842	706	883	828	869
TOTAL	**151 711**	**128 888**	**126 672**	**125 674**	**135 784**
Marine fish	6 023	6 355	7 561	7 024	7 600
Crustaceans	436	618	578	407	549
Other marine products	500	494	597	495	572
GRAND TOTAL	**158 670**	**136 355**	**135 408**	**133 600**	**144 505**
Value – KShs. Million					
Freshwater fish	8 071	8 029	10 718	12 274	16 905
Marine fish	335	422	541	557	614
Crustaceans	123	145	147	127	173
Other marine products	38	43	49	44	50
TOTAL	**8 567**	**8 640**	**11 455**	**13 002**	**17 742**

* provisional

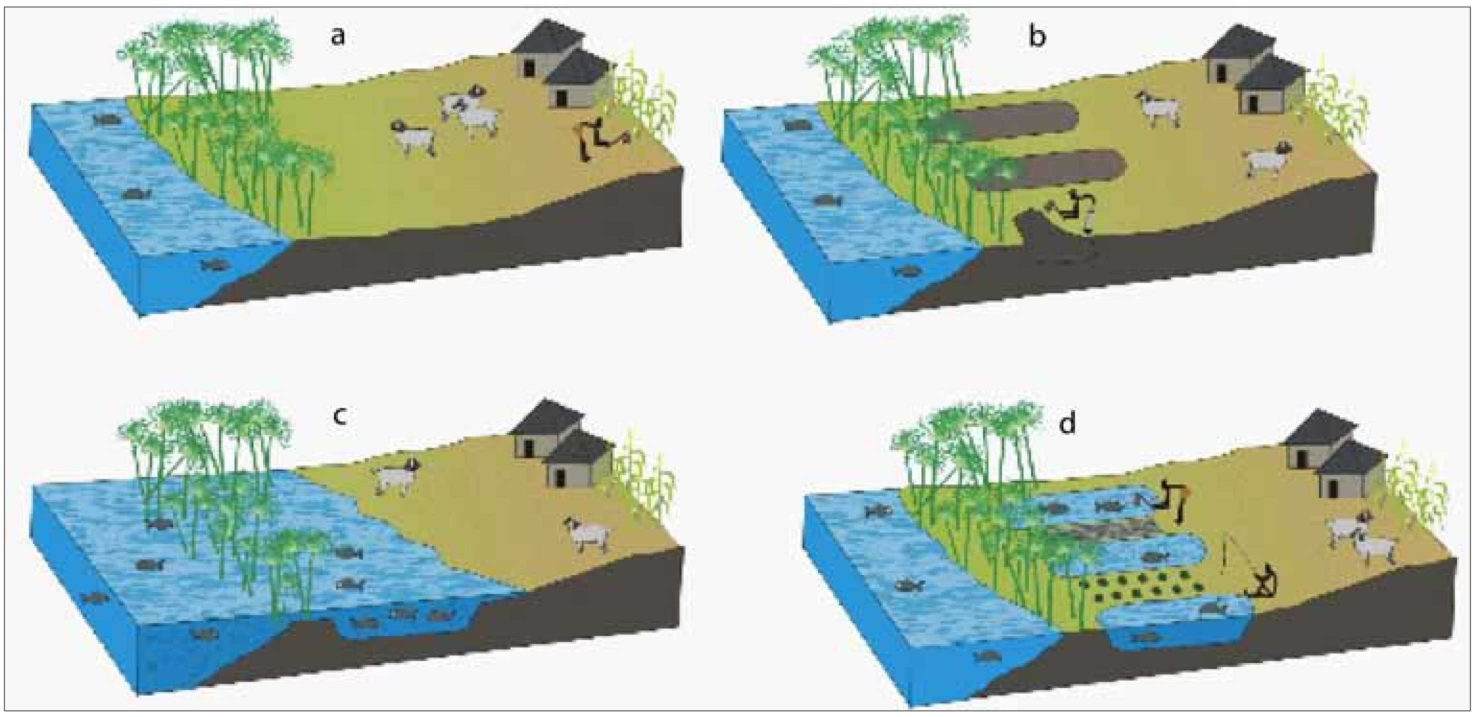
Source: GoK 2011

Fisheries

Although Vision 2030 does not specifically enumerate fishing as one of its priority sectors, it can have positive outcomes for the country's development because it is a rich source of protein and livelihood for many communities which live around the large wetlands such as Lake Victoria, Lake Turkana, Lake Naivasha and the Tana River. As is demonstrated by Table 4.3, freshwater and marine fisheries constitute an important economic sub-sector in Kenya.

One way to enhance, extend and diversify food production from wetlands is to adopt the practice of finger ponds especially during the dry season (Denny and others 2006). Finger ponds (Figure 4.6) are an environmentally sustainable means of enhancing fisheries production

Figure 4.6: A diagram of the sequence in finger-pond construction.



Source: Adapted from Denny and others 2006

Sequence:

a) The land/swamp interface at the height of the dry season when water tables are at their lowest.

b) The digging of the ponds and preparation of the agricultural area when water levels are still low.

c) The finger pond system becomes flooded during the ensuing rains and fish migrate into the floodplain.

d) On recession of the floodwaters, the fish becomes trapped in the ponds and is cultured while the land between the ponds is cultivated.


Artisanal fishermen in Lake Victoria.

James Harris/Flickr

in swampy areas adjacent to large water masses without destroying the wetlands.

Coastal and Marine Resources

Owing to the outstanding beauty and biodiversity of Kenya's coastal belt, Vision 2030 places considerable emphasis on enhancing the appeal of the region's tourism niche by spotlighting the coastal beaches, marine parks and the largely untapped potential for water sports. Wetlands provide suitable spots for these activities, especially within Tana River and around the Indian Ocean's coral reefs. It is evident, therefore, that conserving these wetlands and their catchment areas is vital to the country's lucrative tourism industry.

Coastal wetlands occur at the interface of land and marine environments providing important goods and services to both terrestrial and marine biodiversity. They have complex connections to inland water sources, coastal fisheries, coastal hydrology and traditional livelihoods. The Watamu Marine National Reserve captures some of this diversity and many of these interactions. As is evident


Tiwi beach, Mombasa, Kenya.

Francois/Flickr

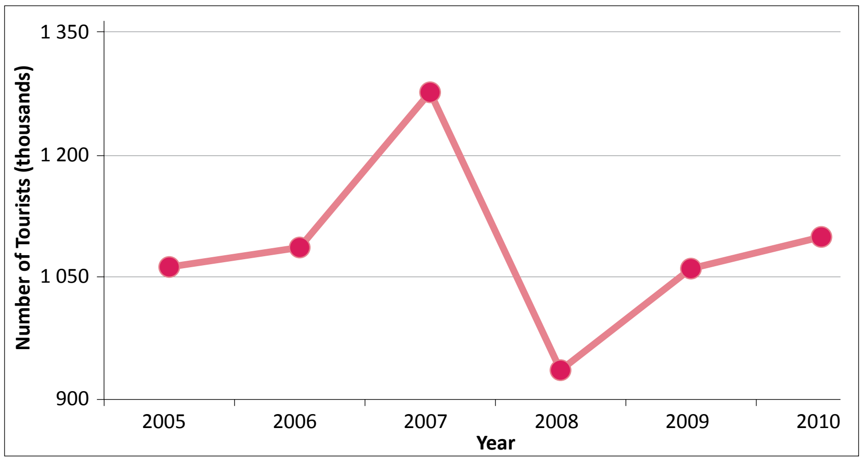
A view of the Watamu Marine National Reserve area showing both the Mida Creek Mangrove area and the Coral Reef area.

A high resolution satellite image view of the Watamu Marine National Reserve Coral Gardens.

in the satellite image, the reserve includes mangroves at Mida Creek, fringing reefs and coral gardens, sea grass, coral cliffs, as well as intertidal areas of rock, sand and mud (Fondo 2003).

Mangroves and other coastal wetlands also play an important role in sustaining commercial and artisanal fisheries by providing habitat and nursery grounds (McLanahan and Mangi 2000). They are also a source of fuel wood, herbal medicine, food and construction materials as is detailed earlier in this chapter. Further, their capacity to sequester carbon (Laffole and Grimsditch 2009) qualifies them as potential sources of carbon trading income (Grimsditch and others 2012) via mechanisms such as Reducing Emissions from Deforestation and Forest Degradation, Forest Conservation, Sustainable Management of Forests and Carbon Stock Enhancement (REDD+).

Figure 4.7: Trend in holiday tourist arrivals, 2005-2010.



Source: GoK 2011

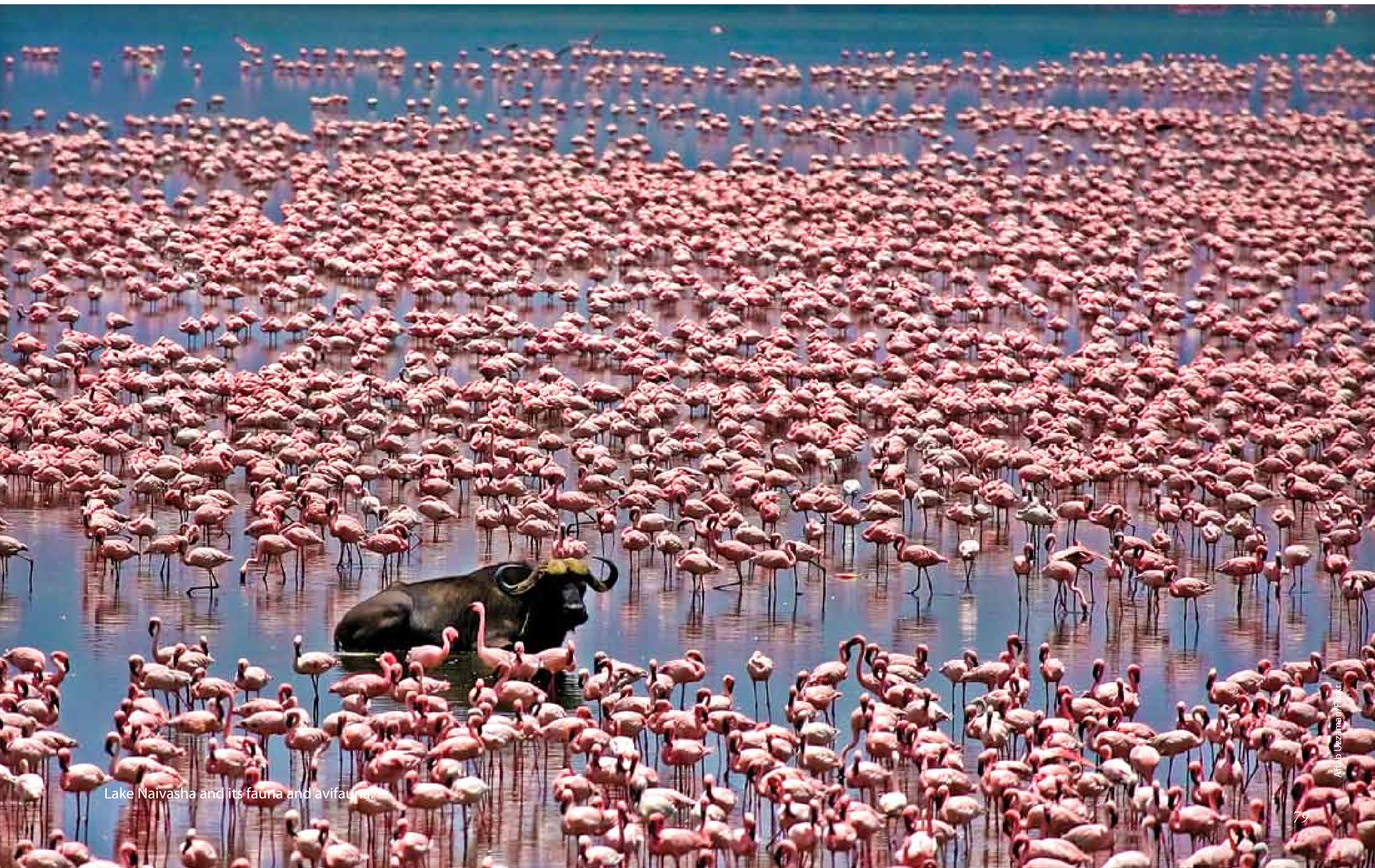
Tourism

Tourism is one of the sectors that Vision 2030's economic pillar identifies to deliver the ten per cent annual economic growth rate in order to transform Kenya into a mid-industrializing country by 2030. Vision 2030's flagship tourism projects related to wetlands include the development of three resort cities, two on Kenya's coast and one in Isiolo in northern Kenya. These resort cities will raise demand for water in already water-scarce areas compounding the stress that resident communities already have to contend with.

Kenya is one of Africa's leading international tourist destinations with holiday tourist arrivals reaching 1.1 million in 2010 as illustrated in Figure 4.7. Tourism is the leading source of foreign exchange for the country. Indeed, earnings from the sector leapt 17.9 per cent from KSh 62.5 billion (US$ 735 million) in 2009 to KSh 73.7 billion (US$ 867 million) in 2010 (GoK 2011).

Kenya's wetlands have intrinsic worth and many tourists visit these on account of this fact alone. The country's leading wetland tourist destinations, many of which fall within the country's portion of the Great Rift Valley, are shown in Figure 4.8. However, wetlands also play an important ancillary role by forming dispersal areas and migration corridors for areas bordering national parks and reserves thereby enabling tourists to experience Kenya's iconic wildlife.

Figure 4.8: Kenya's major wetland tourism destinations.



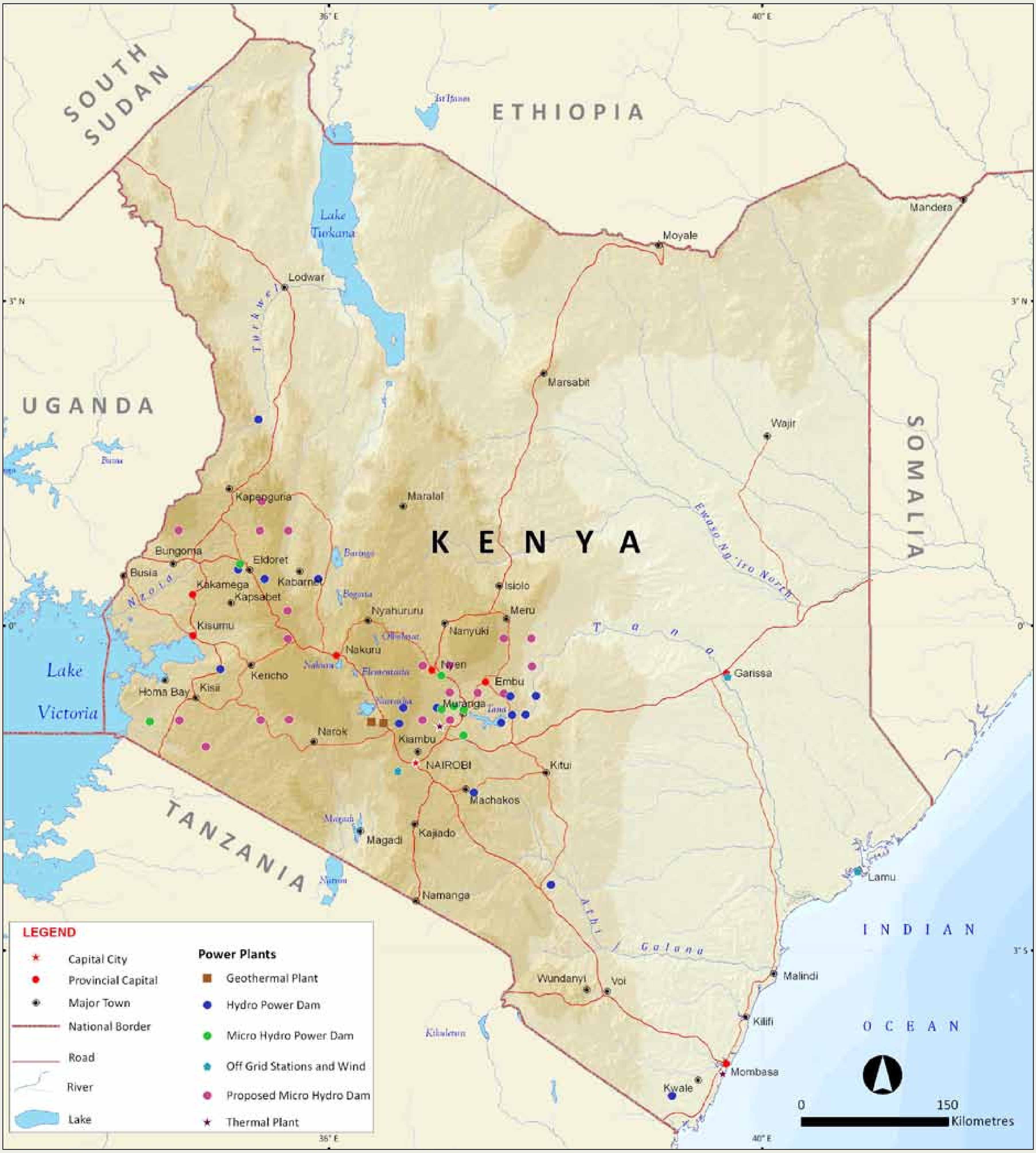
Lake Naivasha and its fauna and avifauna.

Wetlands and Electricity Generation: Sondu Miriu Hydro Power Plant

Sondu Miriu River, one of the six major rivers in the Lake Victoria basin, drains a total area of 3 470 sq. km. in the Western part of Kenya. The river originates from the western slopes of the Mau Escarpment and flows through a narrow gorge, penetrating the Nyakach Escarpment. It then meanders into the Odino Falls before entering the flood plains of Nyakwere where it drains into the Winam Gulf of Lake Victoria. The Sondu Miriu Hydro Power Plant is a 60MW power plant based on a run-of-the-river diversion

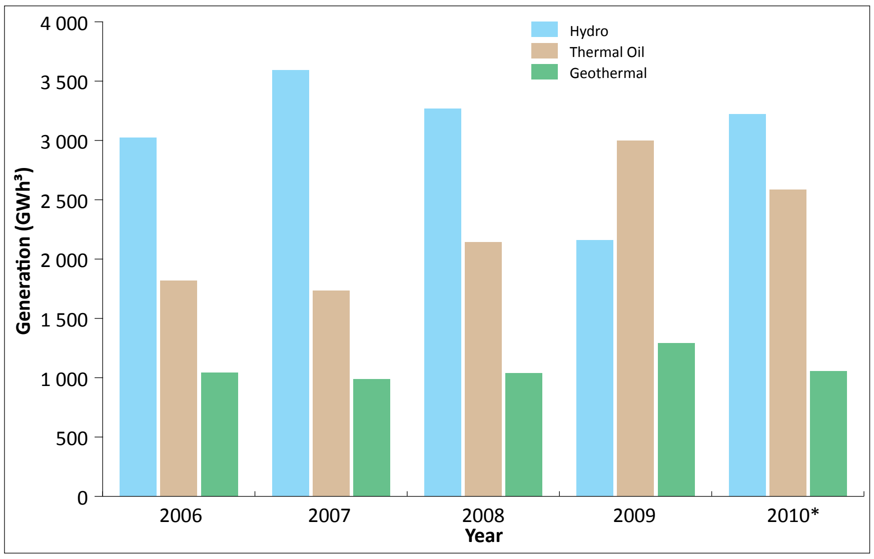
from the weir structure on the Sondu Miriu River above the Nyakach Escarpment. The water from the intake weir is conveyed via a 6.2 km underground tunnel before dropping to the power station via a 1.2 km penstock. The tail water then passes through an open channel for about 5 km to the proposed 20MW Sang'oro power plant before discharging back to the Sondu Miriu River.Unlike other hydropower projects in Kenya, Sondu Miriu Hydro Power Project does not have a major dam and associated large reservoir but relies on the flow of the river with only a small storage capacity at the intake, thus reducing its environmental impacts (KenGen 2012).

Figure 4.9: Location of major hydroelectric power dams in Kenya.



Source: KENGEN 2012

Figure 4.10: Generation of electricity by source, 2006-2010.



* Provisional

Source: GoK 2011b

Manufacturing

The manufacturing sector is expected to play a critical role in the delivery of the Vision 2030 goals as it is expected to contribute to the anticipated 10 per cent economic growth rate, create jobs, generate foreign exchange and attract foreign direct investment (GoK 2007). It is also envisaged that the sector will develop global niche products especially those that are agro-based.

Water is, of course, a key requirement for manufacturing. It isn't just a direct raw material in beverages for example, it is also used to generate hydroelectric and geothermal energy that power many of the country's industries. Figure 4.10 shows the country's electricity generation by source.

Riverine (notably River Tana) and constructed wetlands (notably Turkwell and Masinga dams) are the major water sources that support Kenya's hydroelectric power production. These are complemented by smaller hydro power plants, such as the Sondu Miriu which is considered to be less environmentally intrusive. Figure 4.9 shows the location of Kenya's major hydroelectricity dams.

Given the variety of functions that Kenya's wetlands provide directly and indirectly to the economy, the current trend of their loss and degradation could slow down Kenya's projected economic growth and jeopardize the attainment of several Vision 2030 goals. The importance of ensuring judicious use of these wetlands and their resources cannot therefore be over emphasized.

Conclusion

Kenya's wetlands play a number of crucial but interrelated human wellbeing , ecological and national development goals. Many of these are vital to enhancing human health and welfare and helping to meet a number of MDGs and a range of Vision 2030 goals. These ecosystems' critical roles however sharply contrast with their waning biophysical status as Kenya's wetlands are being lost and degraded at a worrying rate. These concomitantly compromise these important functions and chain off a destructive, self-perpetuating spiral. This worrying state of affairs needs to be urgently stemmed by instituting a series of comprehensive and coordinated policy, legal and institutional interventions.

Eliye hot springs by Lake Turkana.

Elin Reitehaug/Flickr

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Sunrise over Lake Baringo.

Aftab Uzzaman/Flickr.com

CHAPTER 5

WETLAND PRESSURES, IMPACTS, CONSTRAINTS AND OPPORTUNITIES

Introduction

In spite of the critical functions wetlands provide which are discussed in detail in Chapter 4, they are constantly under threat and many continue to be degraded and even lost at an alarming pace worldwide, and Kenya is no exception. This is despite the fact that the majority of the world's countries, including Kenya, have ratified the Ramsar Convention. Using a case study approach, this chapter discusses the gamut of pressures on Kenya's wetlands and their impacts. These pressures include agriculture; urbanization, human settlements and pollution; deforestation of the principal water catchment areas; overgrazing and sedimentation; invasive alien species; over exploitation of wetland goods and services; and hydropower development. The chapter also discusses regulatory and institutional constraints to better wetland management such as the poor integration of sustainable wetland management values in the operative policy and legal frameworks and lack of coordination among the various lead agencies mandated to oversee programmes and policies that touch on wetlands. Finally, the chapter enumerates the breadth of opportunities that can be tapped to improve the sustainable management of these vital ecosystems in Kenya.

KEY MESSAGE

Kenya's wetlands are vital ecosystems which are indispensable to human health, wellbeing , national development and ecological integrity. Ironically however, because of these multifaceted roles as well as the associated threats and regulatory challenges, they continue to be degraded or lost at an alarming rate, adversely impacting livelihoods of entire communities and large wildlife populations. Unless these challenges are urgently and holistically addressed, they have the potential to hinder the attainment of a range of MDGs and Vision 2030 goals. However, despite the seemingly gloomy outlook, various opportunities in fact exist. These can be harnessed to ensure the wise use of these important ecosystems for improved livelihoods, environmental integrity and sustainable development.

Aquaculture in a wetland.

Judith Nyunja/KWS

Pressures on Kenya's Wetlands and their Impacts

As is depicted in Figure 5.1, population is a major driver of the multifarious pressures exerted on Kenya's wetlands. The pressures themselves emanate from the fact that wetlands collectively rank as one of the Earth's most productive ecosystems (Kansiime and others 2007). This is primarily because, as discussed in Chapter 4, they provide a range of ecosystem goods and services that are the basis of many local livelihoods and which are essential to the national development processes. Thus, owing to their hydrological and chemical functions, they are referred to as 'the kidneys of the Earth' and as 'biological supermarkets' because of their extensive food, medicinal and other provisioning services (Barbier and others 1997).

Nevertheless, it is the above functions that paradoxically expose wetlands to a number of destructive human activities. These direct human pressures on wetlands along with their impacts are summarized in Box 5.1 but discussed in detail in the proceeding sections. Although climate change is exacerbating these pressures and impacts, it is examined in more detail in Chapter 6.

Agriculture

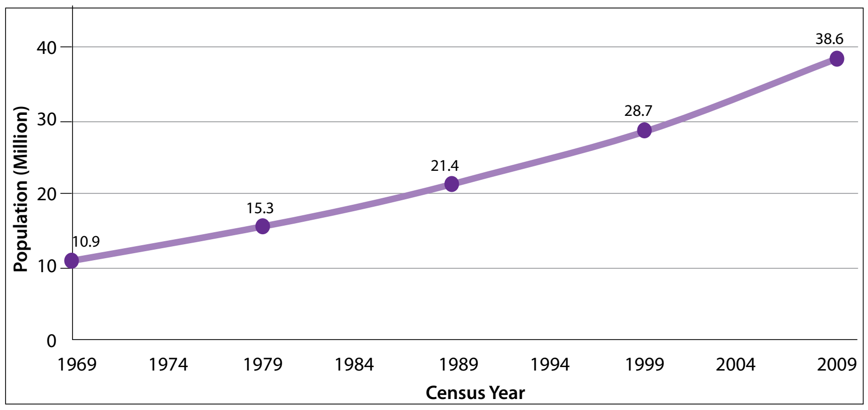
Agricultural activities are increasingly encroaching on wetlands, contributing to a reduction in water levels, the destruction of fragile ecosystems and their services as well as agrochemical pollution. The agriculture sector in Kenya has grown considerably in the past few decades.

In addition to the above national average population growth around wetlands, various policy incentives have stimulated production in the agricultural sector. For example, besides favourable weather, the improved agricultural production in 2010 was attributed to provision of subsidized seed and fertilizer by government under the Economic Stimulus Programme (ESP) one of whose projects was to increase maize and rice production by increasing the acreage under irrigation in Ahero, Bunyala, Bura, Hola, Kano, Kibwezi, Mwea, Pekera and Tana Delta (GoK 2010). Maize, wheat, rice, tea and sisal production increased while coffee, tea, sisal, pyrethrum and tobacco recorded favourable international prices which boosted earnings.

Other positive developments included marketing support as well as research and development. Figure 5.2 contains the estimated production of selected agricultural commodities, 2007-2011. Although the data are not disaggregated to a level where we can tell which percentage was grown in the wetlands, owing to the country's receding wetlands, it is reasonable to assume that the higher production was partly achieved by encroaching on these vital ecosystems.

Weak policies and short-sighted government decisions have also influenced agriculture's impact

Figure 5.1: Trend in Kenya's population growth, 1969-2009

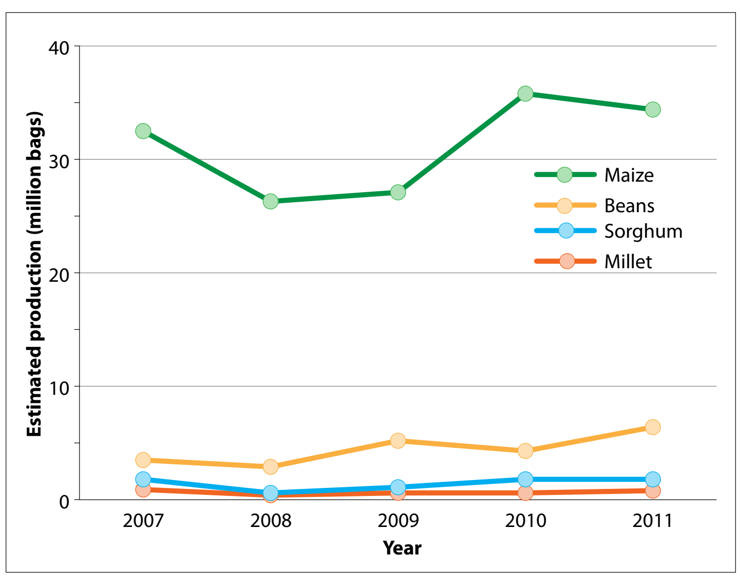


Source: Adapted from various GoK census reports

Box 5.1: Summary of pressures and impacts on Kenya's wetlands.

Pressures	Impacts
Expansion of agriculture into wetland areas	• Reclamation and draining of wetlands (e.g. Yala swamp and Tana Delta) • Agrochemical pollution • Reduction in subsistence activities that rely on wetland goods
Urbanization and expansion of human settlements into wetlands	• Encroachment on wetlands (e.g. Lake Ol Bolossat) • Loss and degradation of Nairobi River Basin wetlands • Declining water levels • Degraded water quality (pollution) • Increased water abstraction • Loss of wildlife habitats and species biodiversity
Deforestation of major water catchment areas e.g. Mau Forest Complex, Mount Kenya, Aberdare Range, Mount Elgon and the Cherangani Hills	• Hydrological changes in Lakes Victoria, Nakuru, Naivasha and Baringo as well as the Tana River Delta, Ewaso Ng'iro North River and Lorian Swamp • Loss of resources, increased poverty and unsustainable development
Pollution consisting of industrial effluent and, agricultural and domestic wastes in wetlands	• Water pollution (e.g. domestic waste from the Kibera informal settlements) • High nutrient loadings resulting in dense colonies of water hyacinth in e.g. the Nairobi dam and algal blooms in e.g. Yala Swamp
Overgrazing	• Soil erosion, siltation and sedimentation (e.g. Lake Baringo)
Invasive alien species (e.g. Nile perch in Lake Victoria, water hyacinth)	• Threats to indigenous species • Water hyacinth stifles wetlands, making fishing difficult and thereby threatening local livelihoods
Overexploitation of wetland goods, such as fish, plants, etc.	• Decline in biodiversity • Increased extinctions and number of threatened species
Over abstraction of ground and surface water	• Drying up of wetlands
Climate change and variability	• Changes in weather patterns such as decreased rainfall levels • Coral bleaching • Threats to wetland species
Hydropower development	• Reduced peak flows • Displacement of people

Figure 5.2: Estimated production of selected agricultural commodities, 2007-2011.



Source: GoK 2012

on wetlands. For example, some wetlands have been used solely to achieve economic objectives, without paying proper attention to ecological imperatives. The case study of the Yala Swamp, detailed below, epitomizes this point particularly well.

Figure 5.3: Location of Yala Swamp

Case Study: Yala Swamp

The Yala Swamp and associated wetlands (Figure 5.3) are located on the northeastern shoreline of Lake Victoria in the Siaya and Busia Counties. These are collectively one of the most important riparian and floodplain wetland areas in Kenya. They contain three freshwater lakes: Kanyaboli, Sare and Namboyo. With the exception of Lake Kanyaboli, which was gazetted as a national reserve in 2010 (KWS 2010), the rest of the swamp is unprotected.

Yala Swamp performs major ecological and hydrological functions and is the main source of livelihoods for neighbouring communities (Kinaro 2008). It biologically filters the pollutants and silt loads of the waters that flow into Lake Victoria from the Nzoia and Yala Rivers (Aloo 2003; Mavuti 1992) thereby reducing the extent of Lake Victoria's eutrophication (Riedmiller 1994).

This highly productive ecosystem also provides an important habitat for refugee populations of certain fish species, which have otherwise disappeared from the main lake basin. These include three species of tilapia: *Oreochromis esculentus, Oreochromis leucostictu* and *Oreochromis variabilis* and several haplochromine cichlids species which include *Astatoreochromis alluaudi, Lipochromis maxillaris, Astatotilapia nubile, Xystichromis phytophagus* and *Lipochromis maxillaris* (Abila and others 2008; Abila and others 2004). The critically endangered Sitatunga antelope (*Tragecephalus spekei*) still lives in the wetland system's papyrus vegetation (Abila 2005).

Owing to its profuse birdlife, Yala Swamp is recognized as one of Kenya's 60 Important Bird Areas (Awange and On'gan'ga 2006; Bennun and Njoroge 1999). The swamp also provides a habitat for several bird species that are papyrus endemics such as the White-Winged Warbler (*Bradypterus carpilis*), Papyrus Yellow Warbler (*Chloropeta gracilirostris*) and Papyrus Gonolek (*Laniarus mufumbiri*) (Kenya Wetlands Forum 2006; Mavuti 1992).

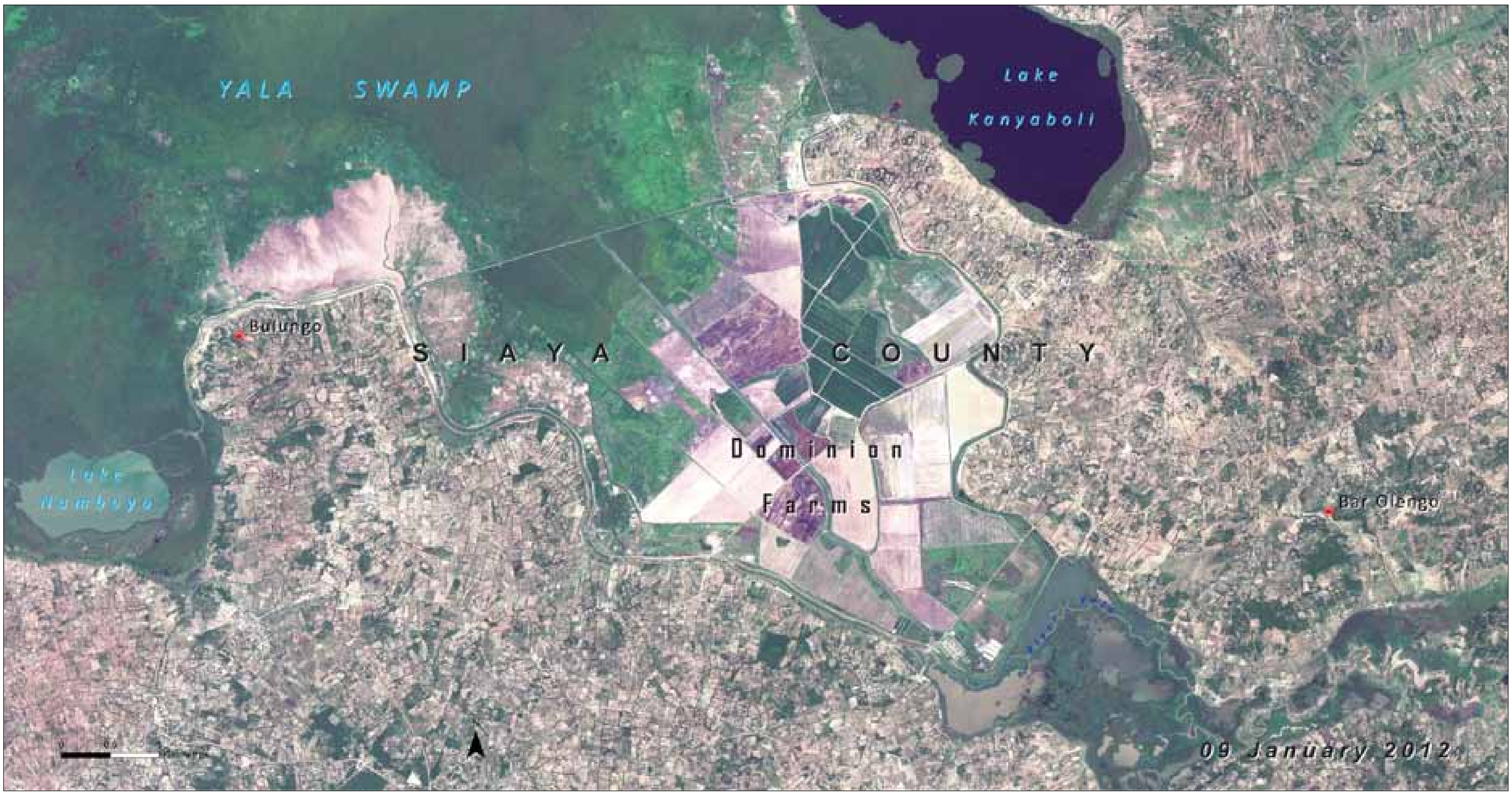
<u>Pressures</u>

Agriculture poses the greatest threat to Yala Swamp. About 6 900 ha in the upper part of the wetland have been leased to private companies, with detrimental environmental impacts. A case in point is Dominion Farms Limited's intensive agricultural activities that include rice irrigation. These have resulted in encroachment on wetland areas,

A *Papyrus Gonolek* on a tree branch.

Michale and Helen Cox/Flickr

Dominion Farms Limited has converted large parts of the southeastern corner of Yala Swamp to large scale agriculture. The project has altered the hydrology of the swamp because channels and barriers have been constructed to manage the flow of water, including, crucially, on the mouth of the Yala River.



the flow of fertilizers and pesticides into the ecosystem (Muyodi and others 2011) and changes to the wetland ecology, predisposing the area to flooding (Kiluva and others 2011). Other ecological threats include invasive alien species, and industrial effluent and waste water discharge (Kairu 2001) particularly from fish factories. In addition, the Yala River has been dammed and diverted, which is affecting downstream ecosystems such as the Yala Swamp.

Impacts

The introduction of large scale agricultural activities and the privatization of more than one-third of the total Yala Swamp area have adversely affected local communities. These no longer have access to resources such as water, fish, papyrus, clay, fuel wood, grazing land and medicinal herbs (Waititu 2009; von Post 2006). In addition, spiritually sacred sites have been closed off (Janak 2011). Rice irrigation and the attendant construction of water reservoirs have also resulted in a higher incidence of water-borne diseases such as malaria, bilharzia, dysentery and typhoid fever (Cultural Survival 2007).

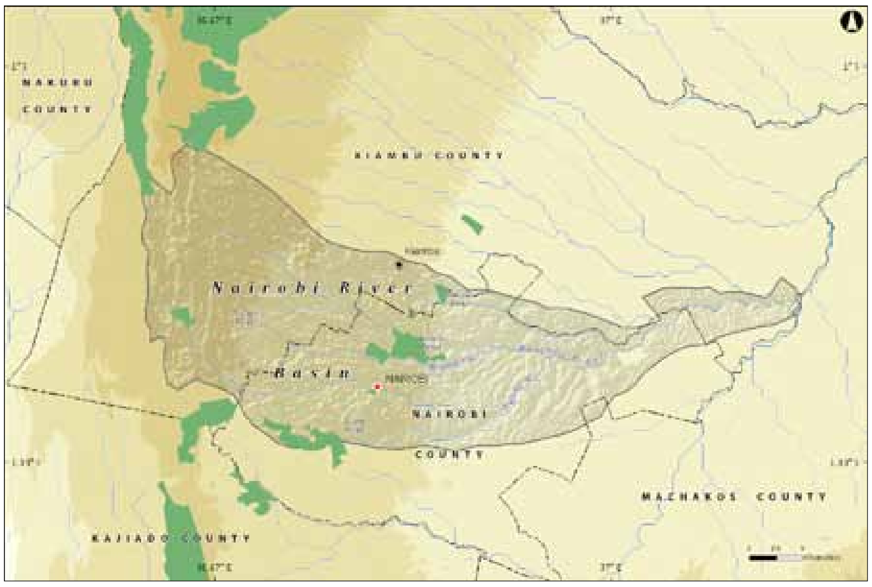
Urbanization, Human Settlements and Pollution

Kenya's high population growth rates (depicted in Figure 5.1) and large-scale in-country migration have drastically increased the pressure on the country's wetland systems and associated biodiversity. Rising population numbers have also led to extensive urban development, growth of human settlements, increased land fragmentation, retention of idle land, cultivation of riverbanks, deforestation and encroachment onto catchment areas and wetlands.

Aerial spraying of pesticides in a rice farm.

Judith Nyunja/KWS

Figure 5.4: Nairobi River basin.



Case Study: Nairobi River Basin

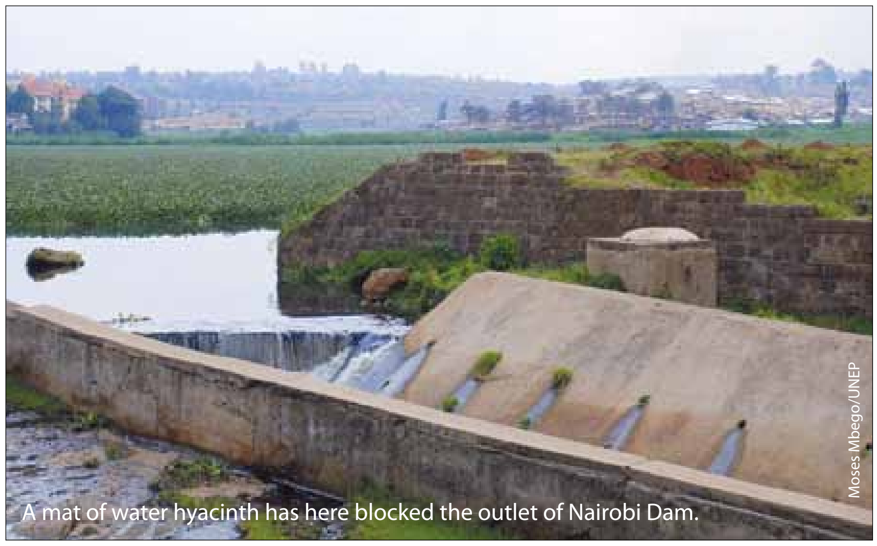
The Nairobi River basin (illustrated in Figure 5.4) traverses the Kiambu, Kajiado, Nairobi and Machakos Counties and encompasses several tributaries and their associated wetlands. The river originates from the Ondiri Swamp which is located beneath the Aberdare Ranges (Macharia and others 2010; Kahara 2002). Although the river comprises several small tributaries, the main ones are the Mathare, Ngong and Nairobi Rivers (Ndiritu and others 2003). These tributaries flow through Nairobi City before draining into Athi River which empties into the Indian Ocean.

Humans benefit from the waters of the Nairobi River and associated wetlands in several important ways. Besides providing water for domestic use and water-intensive enterprises such as car washes, as well as regulating the city's micro climate, the river is a source of timber for construction and foliage for zero-grazed animals (Macharia and others 2010; Wandiga and Madadi 2009; Ndaruga 2003).

Most of the Nairobi River basin's wetlands have been lost to property development. However, a number of natural wetland remnants still persist around the Mathare, Nairobi and Motoine tributaries. The largest of these remaining swamps occur in the Ondiri Swamp in the Kikuyu and Kuna Estate (Ng'weno 1992). There are also constructed wetlands, such as the Nairobi Dam along the Motoine River, extensive sewage treatment works at Dandora, and disparate waste water treatment ponds (UNEP n.d.; Quiroga 2011; Kahara 2002; Gichuki and others 2001).

The forested segments of the Nairobi River basin support a wealth of biodiversity. For example, the Ngong and Dagorreti forests provide a habitat to both natural and agroforestry trees such as *Croton, Cyprus, Eucalyptus, Grevillea* and bamboo. Other floral species that proliferate in the mid-catchment include *Cyperus sp*., Napier grass and Typha. The area also harbours many fauna and avifauna species with some of the mammals that are hosted there including the African hare, bushbuck, mongoose and unstriped ground squirrel.

It is also home to a variety of primates that include the black and white colobus monkey, Sykes monkey and the Vervet monkey (UNEP n.d.). Fish that have been recorded in the forests include catfish, Barbus, mudfish and Tilapia. And, because the Nairobi River basin lies within the migratory route of thousands of bird species, hundreds of migratory bird species have been spotted there during their north and south bound stopovers. These include the Sacred ibis, Cattle egrets, pied kingfisher and African Fish eagle (UNEP n.d.).


A mat of water hyacinth has here blocked the outlet of Nairobi Dam.

Moses Mbego/UNEP

Around Dagorreti town, the basin's associated wetlands support critical vegetation and fauna, including important plant species, such as Typha, *Cyperus sp,* and Napier grass that grows in the surrounding drainage canals.

Pressures

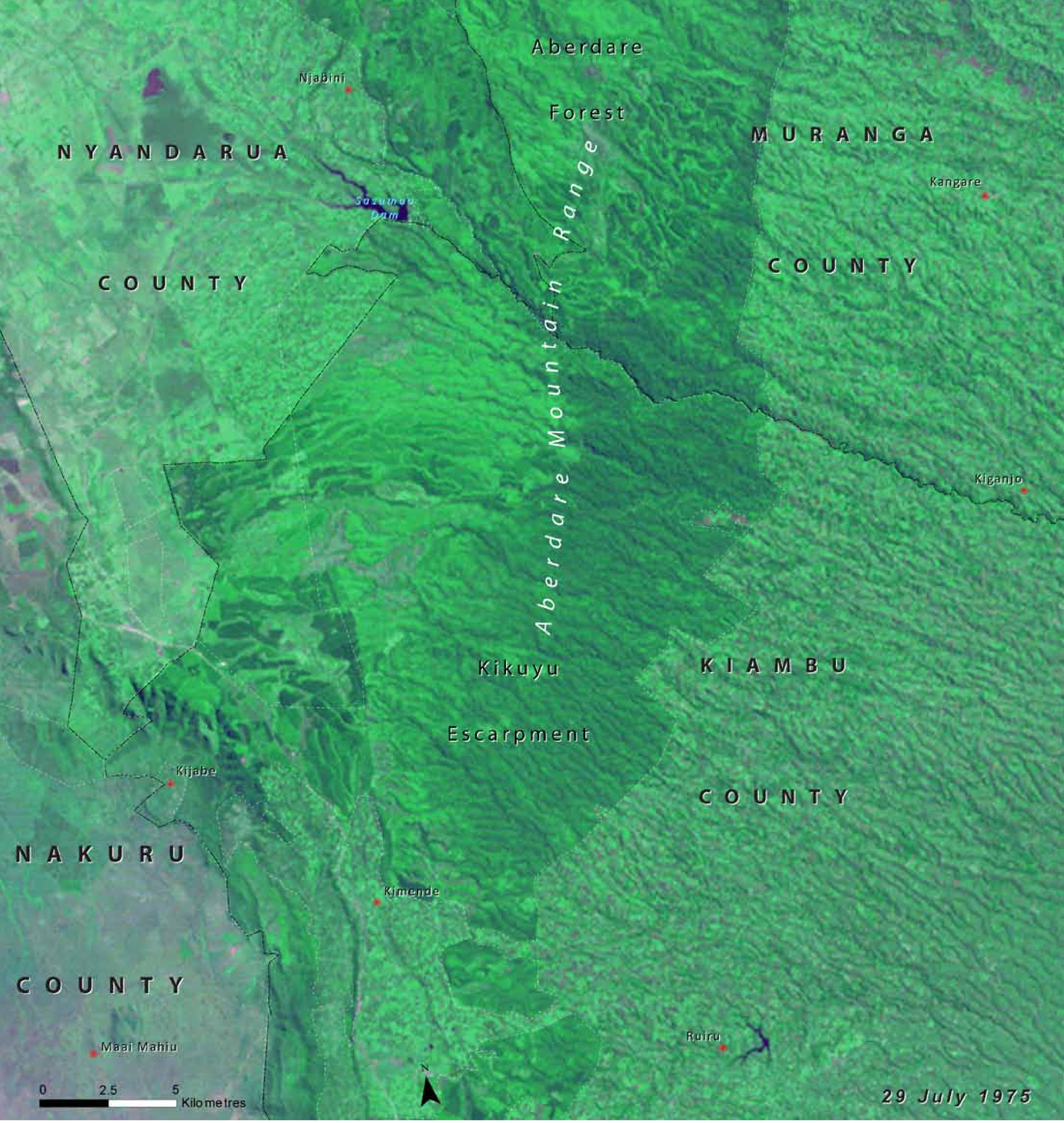
The ecological integrity of the Nairobi River basin and its associated wetlands has been compromised through encroachment of urban agriculture and human settlement (Ye and others 2009; Kahara 2002). The main human activities carried out around the basin's wetlands include subsistence farming of kale, Irish potatoes, arrowroot and maize (Hide and others 2001). Other activities include clothes washing, livestock grazing, quarrying and garbage dumping, all of which have the potential to pollute the river and the basin's wetlands (UNEP n.d.).


Garbage disposal along the riparian zone of Nairobi River.

Moses Mbego

Impacts

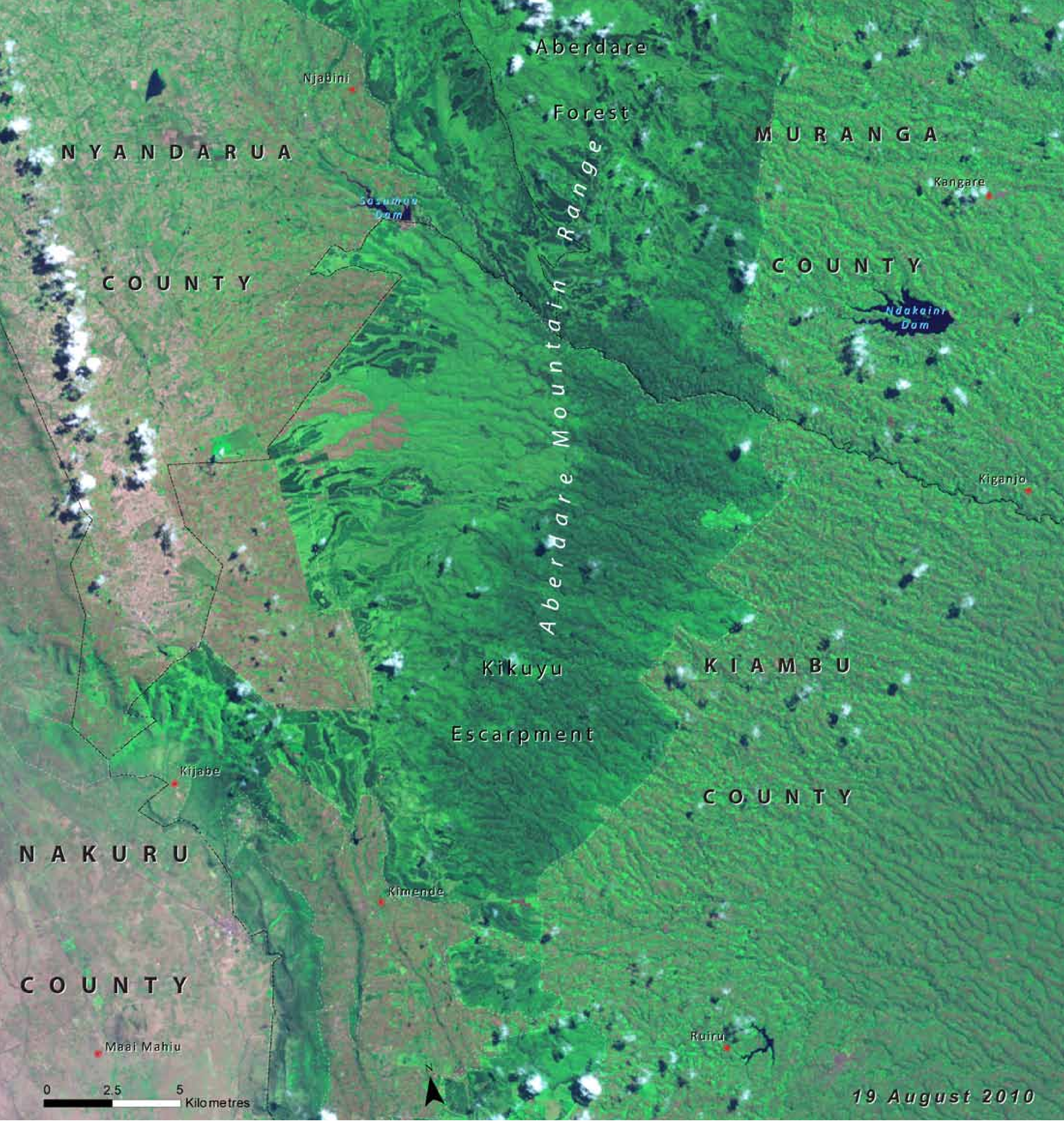
Due to considerable anthropogenic pressure, many of Nairobi's wetlands have been lost. For instance, formerly extensive wetlands along the Nairobi, Gatharaini, Motoine and Mathare tributaries have been drained in order to create space for shopping malls, buildings, roads, car parks and recreational facilities. As a result, the number and variety of avifauna in the city is on a steady decline (UNEP n.d.). Further, virtually all the tributaries of the Nairobi River are heavily polluted (Budambula and Mwachiro 2006; Ndiritu and others 2003), predisposing them to colonization by the water hyacinth, *Eichhornia crassipes* (Akendo and others 2008; Mailu and others 2000). As such, these wetlands are unable to carry out their traditional ecosystem functions and their waters are unfit for both domestic and industrial use. Canalizing and draining several portions of the Nairobi River basin have also adversely altered its hydrology (UNEP n.d.).



Impact of Deforestation in the Aberdare Mountain Range on the Nairobi River Basin

Besides the Nairobi River system, the Aberdare mountain range forms the upper catchment of the Athi, Ewaso Ng'iro North and Malewa Rivers. In addition, the Aberdare range, which is one of Kenya's five water towers, feeds several downstream natural and artificial wetlands. These include the Ondiri Swamp which is the source of Nairobi River, Ndakaini Dam which accounts for most of Nairobi City's water supply and the Seven Forks Hydropower scheme along Tana River which generates a considerable proportion of the country's hydropower.

Despite the invaluable ecosystem services it provides, the Aberdare forest was retreating owing to mounting anthropogenic pressure. This was largely manifested through illegal logging, charcoal production,



quarrying, human settlement, agriculture, marijuana cultivation and livestock grazing in the forest. These in turn threatened the country's water security and economic development as well as biodiversity conservation. These two images show the extent of the largely human-induced forest loss in the southern section of the range between 1975 and 2010.

Construction of a 400 km fence around the Aberdare National Park under the auspices of the Rhino Ark was completed in 2009. Its main purposes are to curtail the above illegal human activities and to stop wildlife from straying out of the protected ecosystem to raid and destroy crop farms, thereby averting human-wildlife conflict. An ancillary benefit of stopping these illegal activities will be the faster replenishment of the dependent wetlands, including the Ondiri Swamp and Nairobi River.

Restoring the Nairobi River

Owing to rapid urbanization, growth of the manufacturing sector and poor enforcement of environmental laws and regulations, the Nairobi River has traditionally faced a range of environmental problems. These include illegal dumping of untreated effluents, raw sewage and solid wastes into the river, causing serious environmental degradation.

In order to restore the ecological integrity of the river and the associated wetlands and enhance the socio-economic development of the river basin, the government

spearheaded the creation of the Nairobi River Basin Programme which oversaw the rehabilitation of segments of the river.

These satellite images depict the transformation of an iconic section of the river between Kijabe Street and what used to be the Globe Cinema roundabout before the construction of the Nairobi-Thika Superhighway.

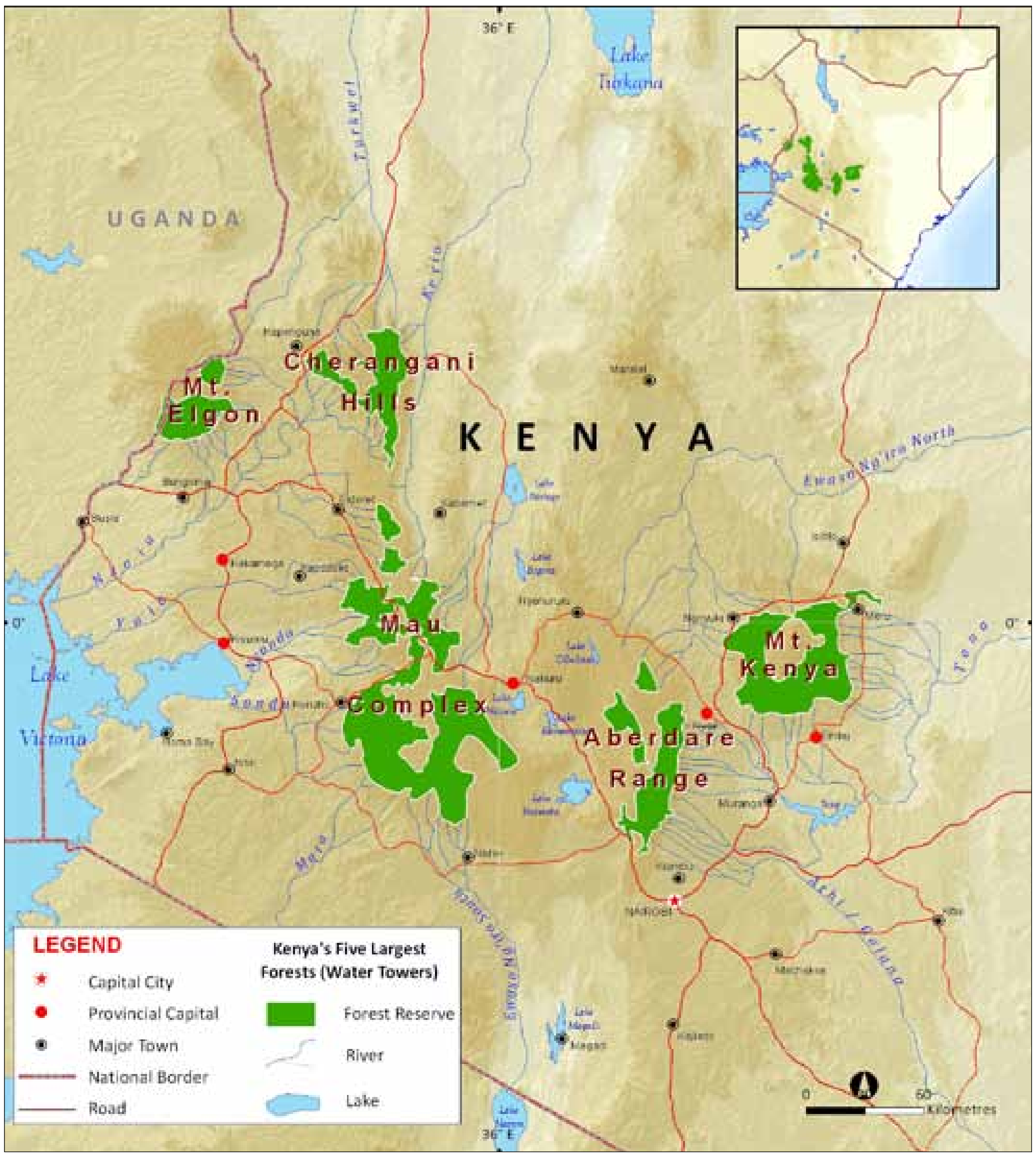
Manual removal of solid wastes from the area with yellow arrows, and its conversion into a recreation park has been hailed as an environmental success. It is also a testament to the possibility of restoring considerably degraded, urban wetlands.

Large portions of the Mau Forest Complex have been converted to tea farms.

Deforestation in Major Water Catchment Areas

The rapid loss of forest cover in Kenya's major upper water catchment areas referred to as 'water towers' has had a negative effect on the country's major wetlands. These water towers are Mount Elgon, Cherengani Hills, Aberdare Mountain Range, Mount Kenya and Mau Forest Complex (Figure 5.5). Their destruction has appreciably reduced hydrological flows in virtually all the country's main rivers: Mara, Nzoia, Yala and Tana Rivers as well as Lakes Victoria, Nakuru and Baringo (UNEP 2009). The impacts of these land-cover changes have been the dramatic loss of ecosystem services and increased poverty.

Figure 5.5: Kenya's five water towers.



Case Study: Mau Forest Complex

The Mau Forest Complex, the largest of Kenya's water towers consists of 22 coterminous forest blocks that collectively cover an area of over 403 775 ha (KFWG 2009). The forest complex plays a range of economic, ecological and cultural roles. It provides forest dependent communities with food, construction materials and medicinal herbs and is a site for several spiritual and traditional ceremonies. The forest complex is also the upper catchment of most of the rivers in the country such as Ewaso Ng'iro, Kerio, Makalia, Mara, Molo, Naishi, Nderit, Njoro, Nyando, Nzoia, Sondu and Yala. Figure 5.6 contains an illustration of the major rivers flowing from the Mau Forest Complex and the lakes in which they drain.

The Mau forest is also a habitat for many faunal and floral species. The latter include *Acacia spp, Bamboo spp, Dombea goetzenii, Olea Africana* and *Podocarpus*. Mammalian species include the buffalo, colobus monkey,

The striped hyena is endemic to the Mau Forest Complex.

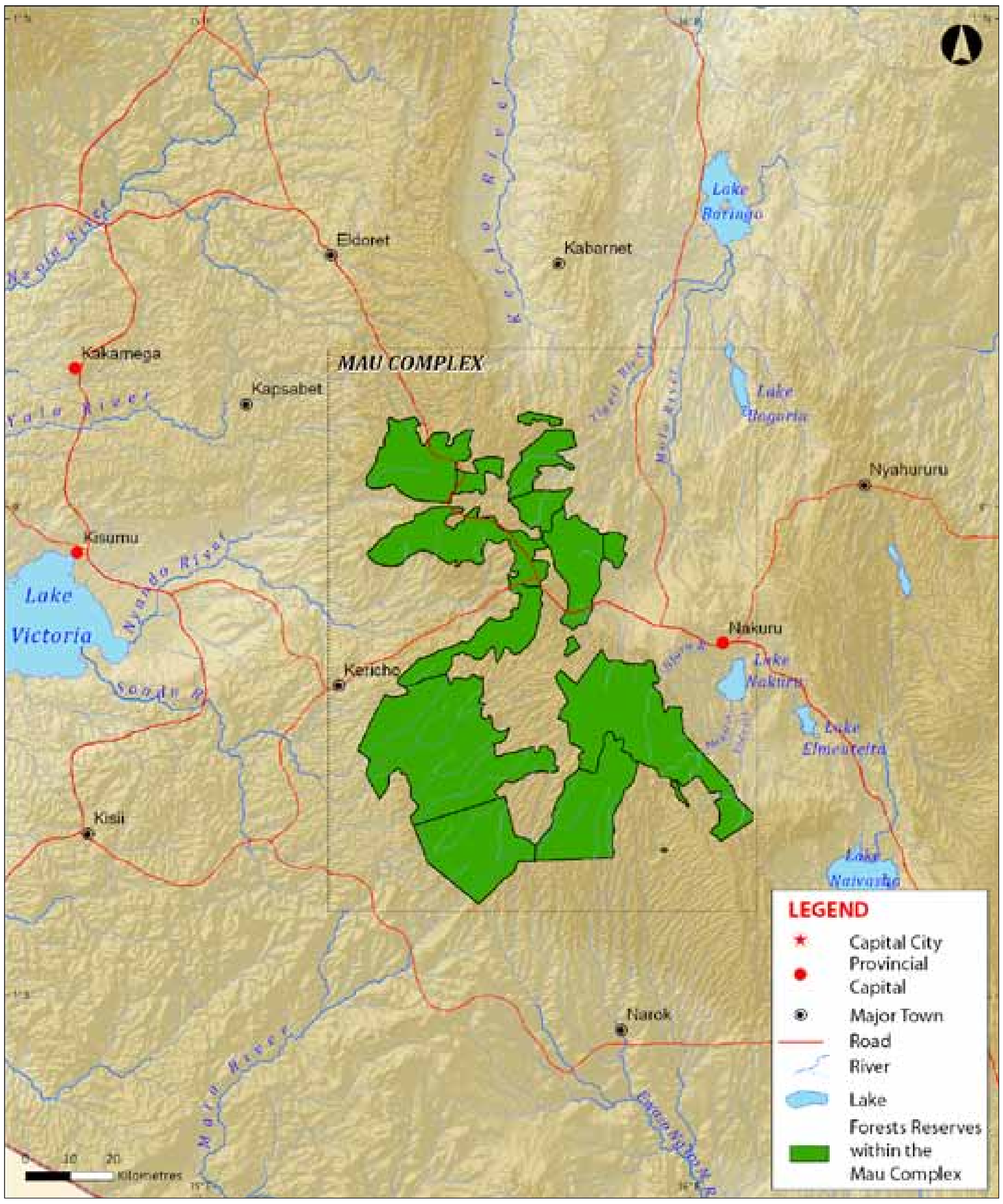
giant forest hog, impala, yellow backed duiker, golden cat, potto, spotted necked otter, and the striped hyena with the latter three being endemic to the forest complex. The forest also hosts rich montane birdlife (GoK 2009).

Pressures

Despite its vital roles, the Mau Forest Complex has witnessed decimation of 25 percent of its forest area in the last 15 years alone (GoK 2009). This has largely been attributed to large-scale encroachment for settlement and agriculture, and illegal logging of its indigenous trees in order to provide timber and to make charcoal which is the dominant form of cooking energy in the country's urban areas.

Large scale government excisions have constituted some of the largest threats to the forest complex in the past two decades (UNEP and others 2005). For instance, the 2001 degazettement of 67 000 ha of forest land mostly affected the Mau forests, especially the Eastern Mau Forest Reserve.

Figure 5.6: Rivers flowing from the Mau Forest Complex and the lakes in which they drain.

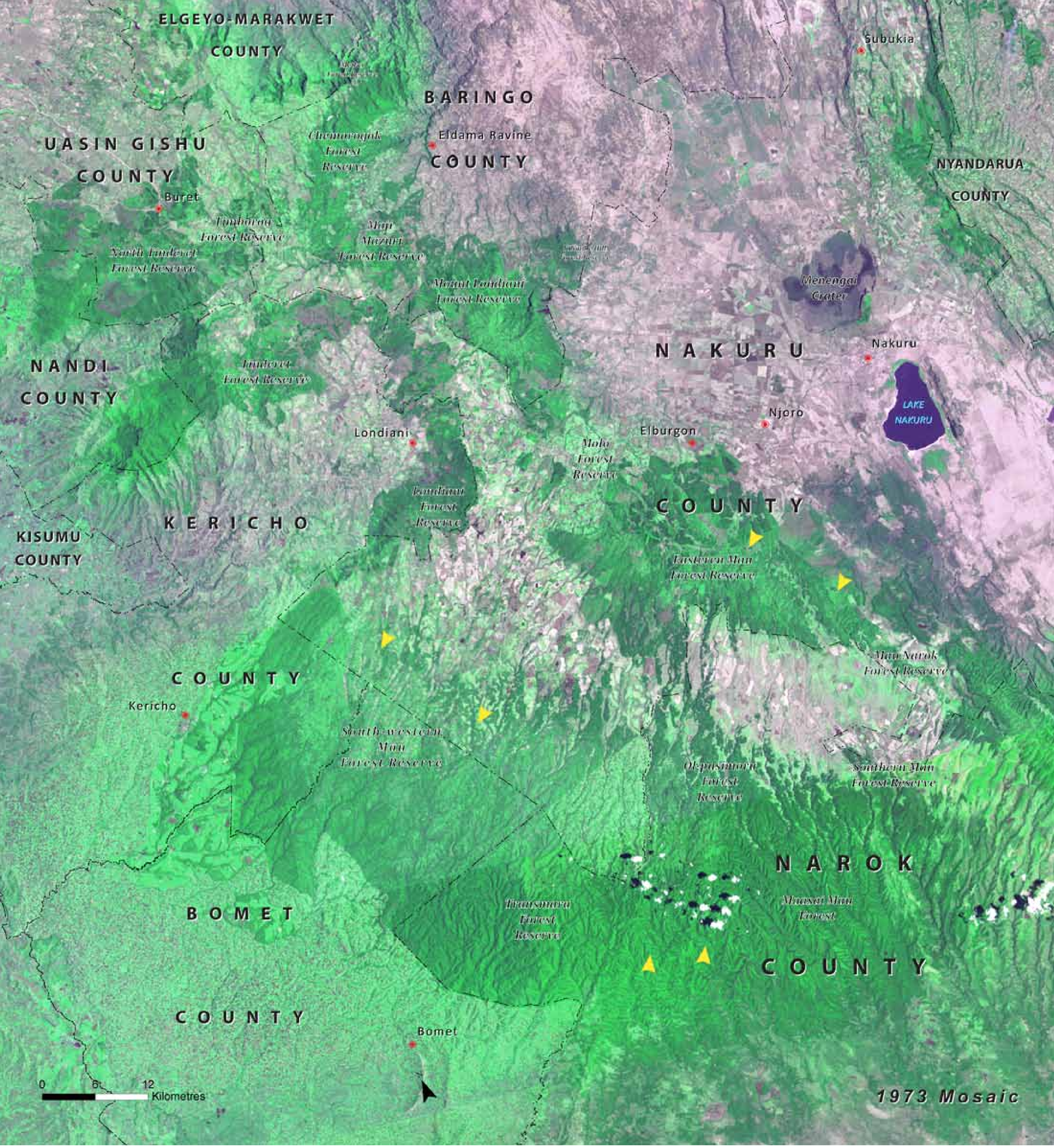


Impacts

As mentioned earlier, these pressures continually diminish the forest's capacity to provide its traditional ecosystem services. For example, because the Mau Forest is the lifeblood of the Maasai Mara National Reserve and Lake Nakuru National Parks, which are two of the premium wildlife parks in Kenya, its continued deforestation is expected to gradually lead to a significant loss of biodiversity within these protected areas as well as the Mau forests themselves.

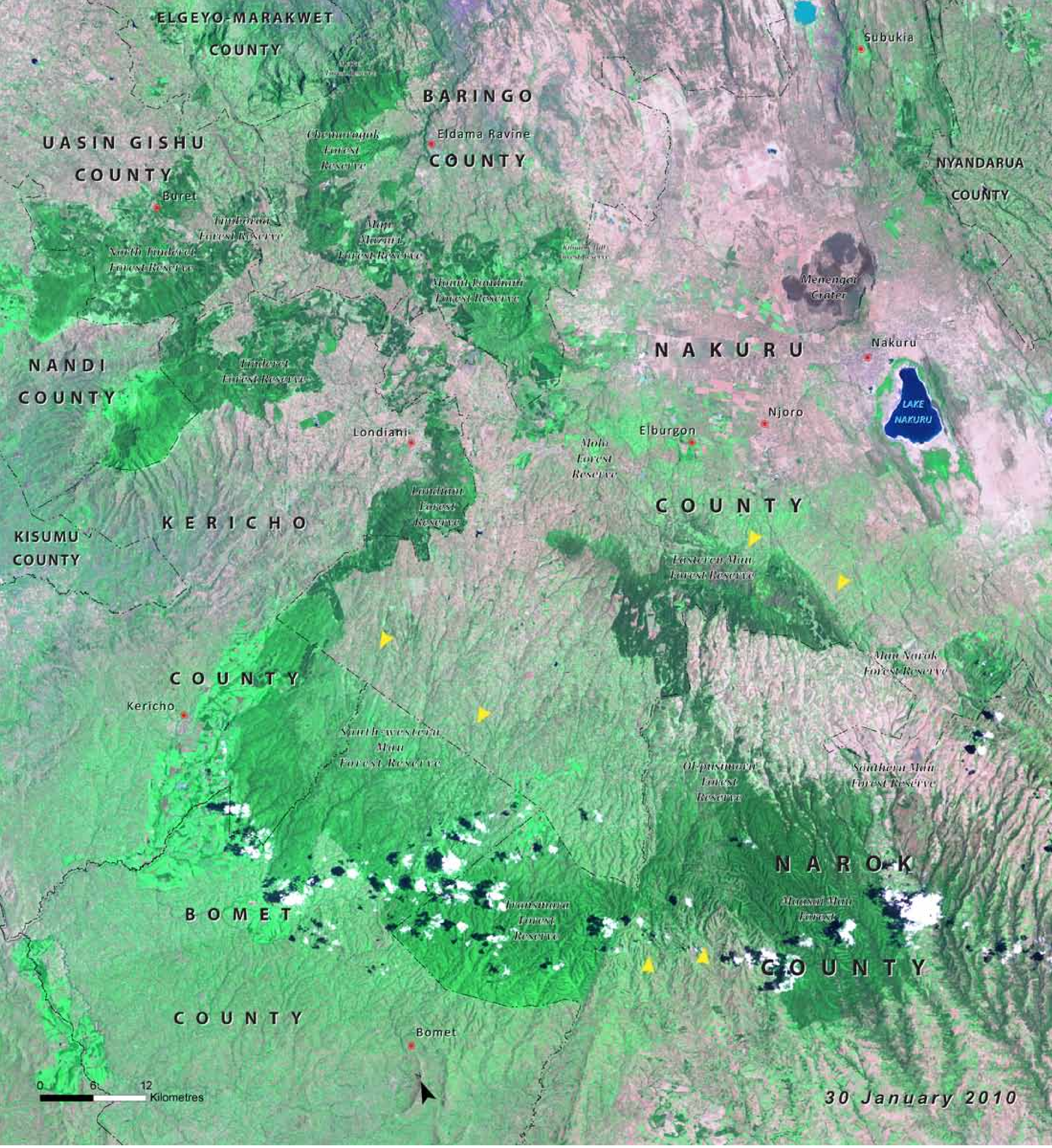
In addition, these excisions and subsequent deforestation have adversely impacted the country's water resources. Groundwater resources around the affected forests have diminished, resulting in dried up boreholes and reduced flows of the Molo and Njoro Rivers. Further, the deforestation of the Mau Forest Complex has had a negative effect on the distribution and hydrology of the Lake Naivasha and Lake Nakuru catchments (Hesslerová and Pokorný 2011) while the destruction of the Eastern Mau has led to a 49 per cent decrease in dense vegetation of the Lake Nakuru catchment (UNEP and others 2005).

Agricultural fields in the Mau Forest Complex.

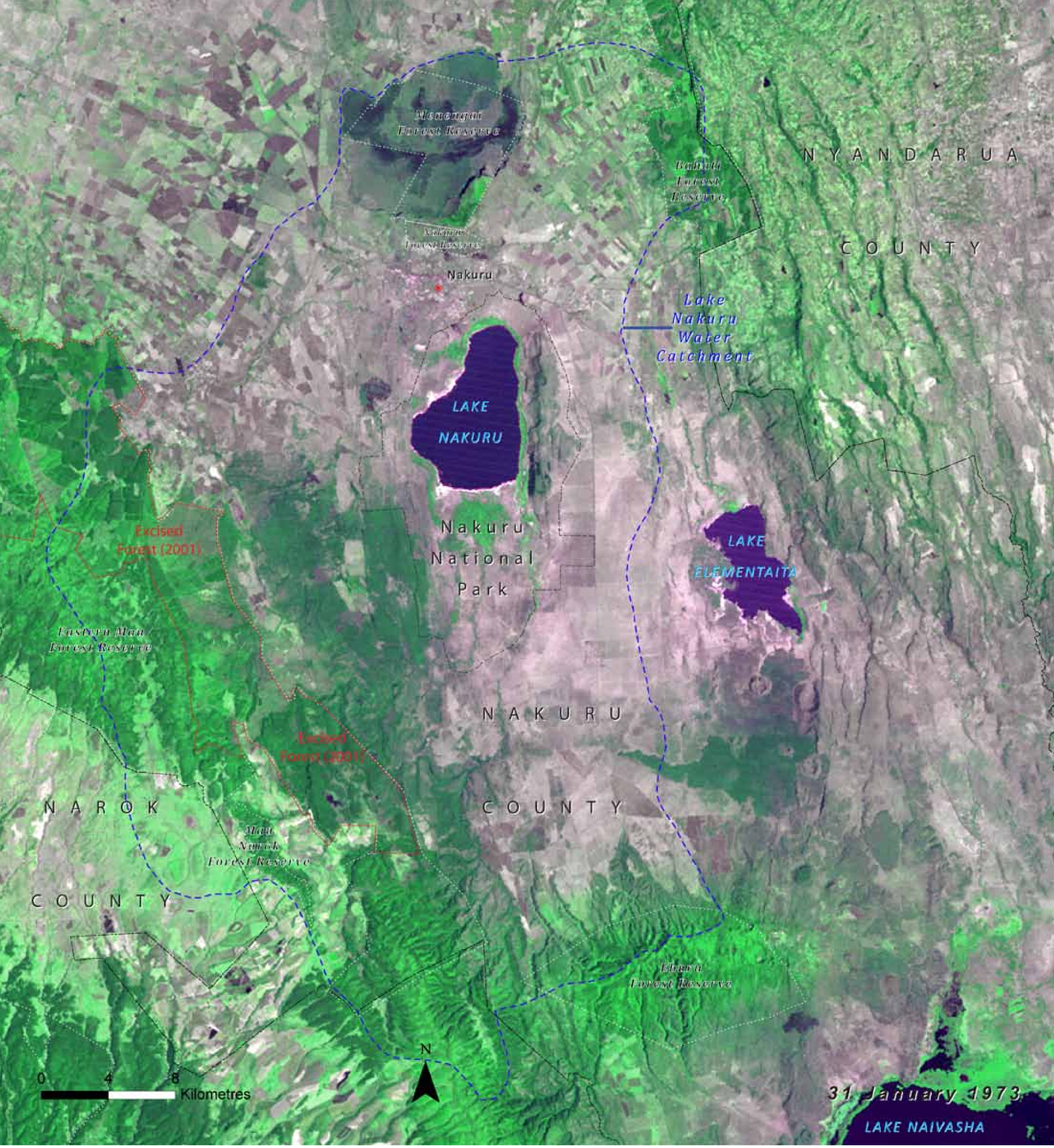


Deforestation of the Mau Forest Complex

The Mau Forest Complex is situated in the Rift Valley area and straddles the Kericho, Nakuru, Bomet, Transmara and Narok Districts in south western Kenya. It covers a combined area of over 403 775 hectares, making it East Africa's largest closed canopy forest. The forest complex comprises 22 coterminous blocks of forest: Chemorogok, Eastern Mau, Eburu, Kilombe Hill, Lembus, Londiani, Maasai Mau, Maji Mazuri, Mau Narok, Metkei, Molo, Mount Londiani, Nabkoi, Northern Tinderet, Ol Pusimoru, Southern Mau, Southwest Mau, Timbaroa, Tinderet, Transmara, Western Mau and West Molo. The individual forest blocks were gazetted as forest reserves between 1919 and 1939.



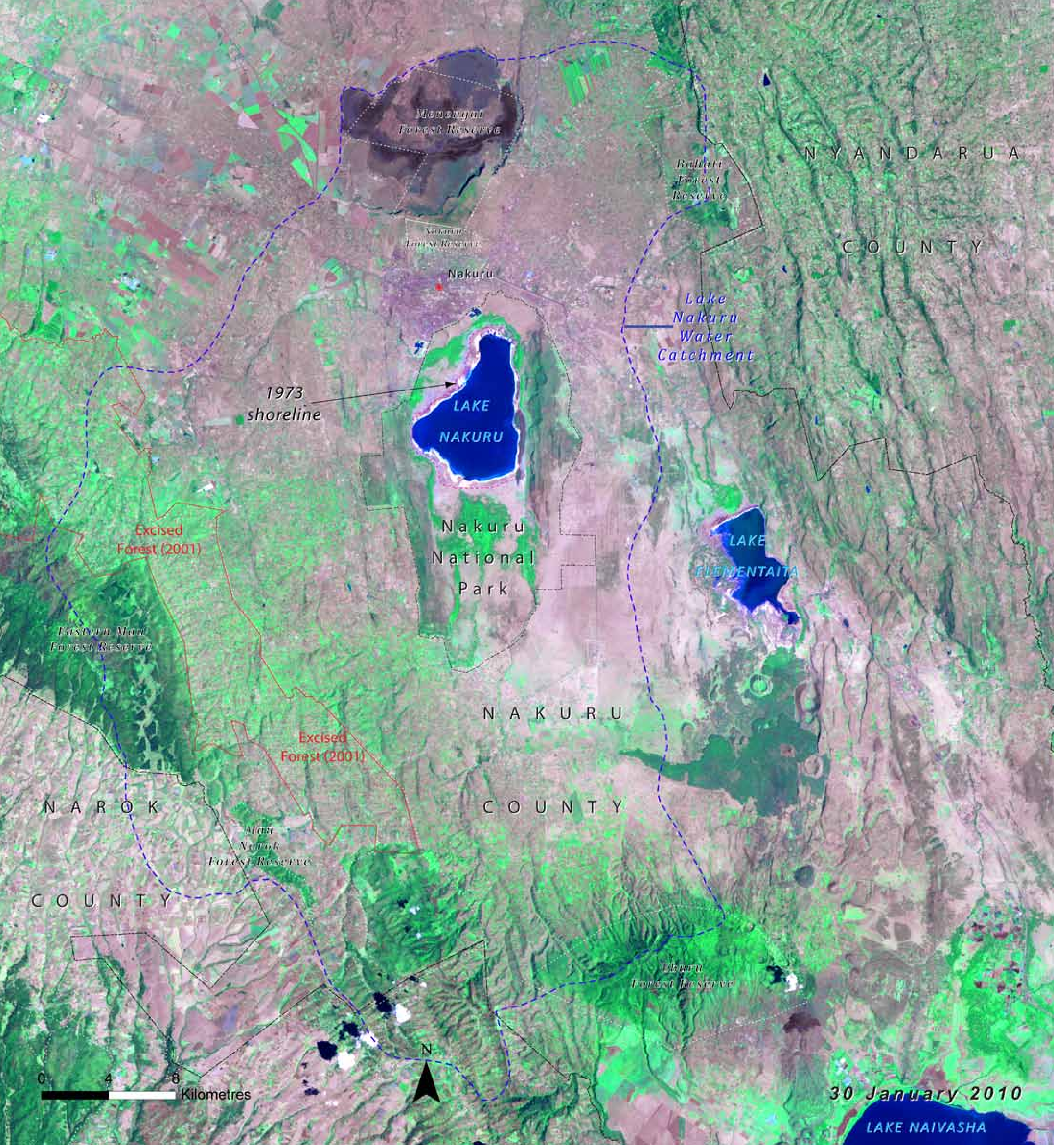
Deforestation of the Mau Forest Complex has occurred over many decades and by 1973, large swathes of the forest had already been cleared for human settlement and agriculture. Farm fields are depicted as light and dark patches with straight edges between the dark green forest areas. In the two and a half decades since the first image was taken, forest cover erosion gathered pace with the additional deforestation being indicated by yellow arrows in the 2010 image. Since 2010, several public-private partnerships have initiated concerted conservation and reforestation efforts although it will take time for the forest cover to be restored.



Changes in the Vegetation Cover of the Lake Nakuru Catchment

Lake Nakuru is a shallow, alkaline-saline water body in the Eastern section of Kenya's Rift Valley. The lake is wholly encircled by the 188 sq. km. Lake Nakuru National Park, a protected area which is regarded as one of Kenya's premium wildlife parks. The park's vegetation consists of grasslands interspersed with acacia, euphorbia and other woodlands

Lake Nakuru National Park harbours over 450 bird species with the most famous of these being the lesser flamingo which flock to the lake in their millions in order to feed on its profuse algae. The park also provides a habitat



for 56 mammal species that include the African lion, leopard, buffalo, the threatened Rothschild giraffe and the critically endangered black and white rhinoceros species.

The two satellite images depict the extent of natural vegetation loss within the lake's catchment that has occurred over the past four decades. Excision of large swathes of the Mau Forest has taken its toll on the western section of the catchment and in the 2010 image, the vegetative loss is strikingly evident.

Overgrazing and Sedimentation

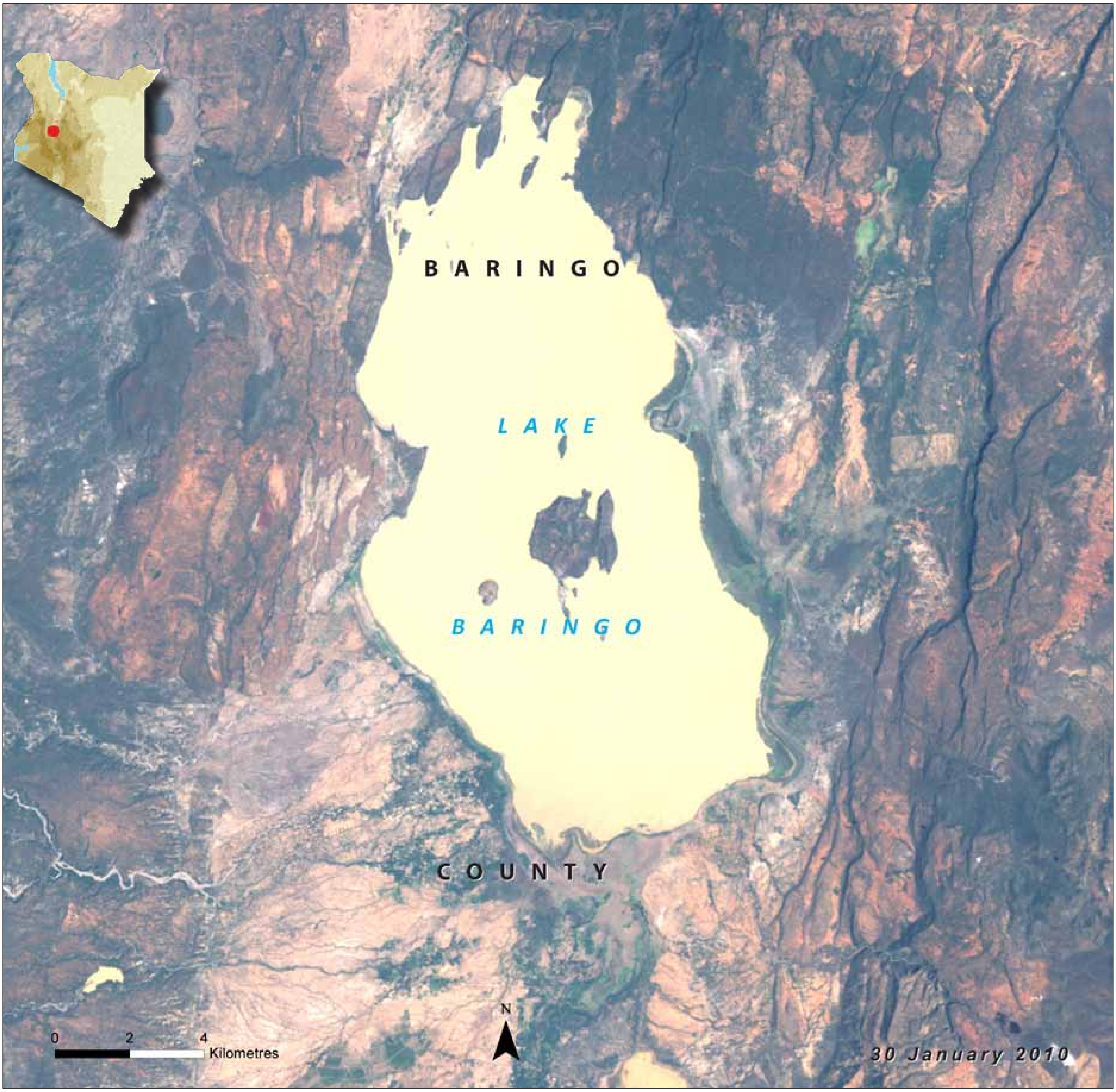
Besides supporting 90 per cent of the country's wildlife, Kenya's arid and semi arid lands (ASALs) also support 50 per cent of the country's livestock population (Gachimbi 2011). As livestock is a valued store of wealth and status symbol (Barett and others 2001), these marginal lands are prone to overstocking and in turn, overgrazing and environmental degradation. This is compounded by the fact that the authority of many traditional structures for controlling overgrazing such as councils of elders has been largely eroded (Gichuki and Macharia 2003; Kareri 1992).

Overgrazing causes the degradation of the already sparse vegetative cover in the ASALs through herbivore feeding, trampling, soil compaction and interference with root systems, making it harder for vegetation to regenerate (Macharia and Ekaya 2005). And, because livestock needs to be continually watered, herds tend to be concentrated around the ASALs' wetlands. The denudation of vegetative cover leads to soil erosion and flooding during the rainy seasons, which in turn lead to sedimentation and siltation of these wetlands.

Case Study: Lake Baringo

Located in the Kenyan Rift Valley to the north of Lake Bogoria, Lake Baringo is one of the country's largest freshwater lakes. Formed as a result of volcanic action, the lake has an area of approximately 140 sq. km. and lies at an altitude of 900 metres above sea level (Hickley and others 2004). The lake basin is an important habitat for the giraffe, hippopotamus, Nile crocodile and several fish species, including the

Sedimentation of Lake Baringo: This satellite image of Lake Baringo shows the extent of sedimentation of the shallow lake. Under normal circumstances when lake water is clear, its area exhibits a dark blue or black coloration in a satellite image. Increased sedimentation nonetheless increases the reflectance of water and hence the brightly coloured water in this satellite image.



endemic *Oreochromis niloticus baringoensis*. As such, the lake is an important source of animal protein (Johansson and Svensson 2002) for neighbouring communities.

The Lake Baringo catchment is also renowned for its diverse avifauna and at least 500 bird species have been recorded there (Kiage and others 2007). The area is an internationally recognized bird breeding site and wintering ground for a number of migratory waterbird species (Aloo 2004). The lake's tourism earnings are therefore important and make significant contributions to the country's foreign exchange earnings. Lake Baringo was designated as a Wetland of International Importance (Ramsar Site) in January 2002 (Ramsar Convention Secretariat 2011).

Pressures

Overgrazing around Lake Baringo results from livestock overstocking. Indeed, the area's livestock population stood at a considerable 900 000 goats, 300 000 cattle and 200 000 sheep in 2004. Overgrazing has stripped the lower catchment around the lake of its hitherto perennial vegetative cover. The pressure is especially evident during the dry season (Johansson and Svensson 2002). The situation has been compounded by deforestation of the highlands, leading to soil erosion during intense, sporadic rainfall.

Impacts

Overgrazing and deforestation have resulted in severe soil erosion, particularly on the shores of Lake Baringo. The resultant heavy sedimentation has led to a contracted, shallower lake (Johansson and Svensson 2002). In fact, the mean depth dropped from 8 m in the 1970s to 2.65 m in 2003 (Hickley and others 2004). In addition, the heavy siltation has considerably degraded Lake Baringo's water quality. Not only is the turbid water unsafe for drinking, it has had a detrimental effect on the once thriving fisheries sector. Researchers have attributed the lake's small fish community of only seven fish species to the low light penetration and reduced water inflows resulting from siltation. Although community-led programmes are attempting to reverse this degradation through promoting agro-forestry as well as awareness about optimum livestock levels and closed fishing seasons (Hickley and others 2004), it will take time for these efforts to bear fruit.

Invasive Alien Species

Many of Kenya's wetlands are infested with invasive alien species. These have altered the wetlands' ecosystem goods and services. For example, the introduction of the Nile perch virtually eliminated the indigenous fish species of Lake Victoria. In addition, the water hyacinth (*Eichhornia crassipes*), *Salvinia sp,* and *Typha sp*. have invaded numerous wetlands.

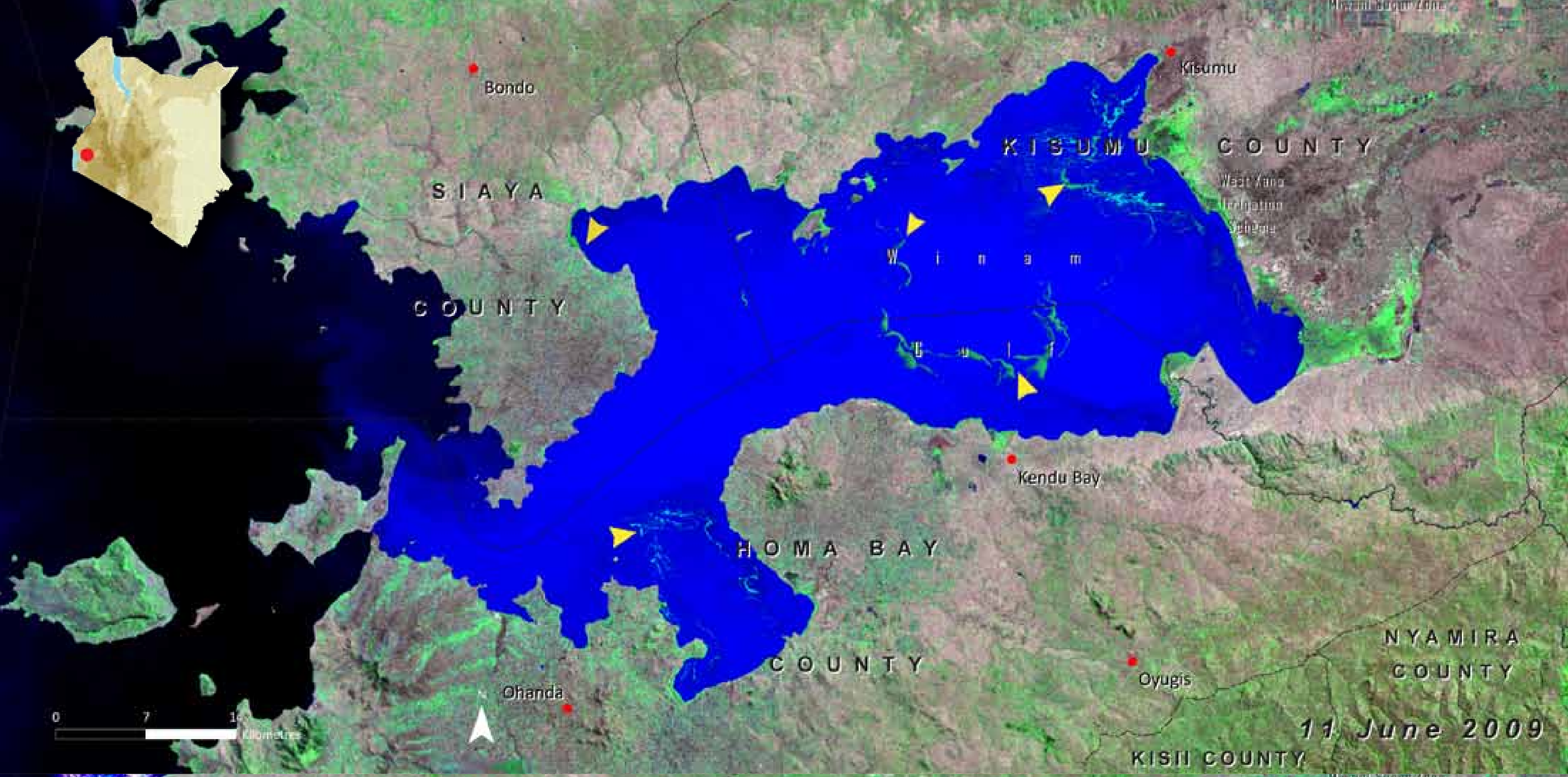
Case Study: Winam Gulf of Lake Victoria

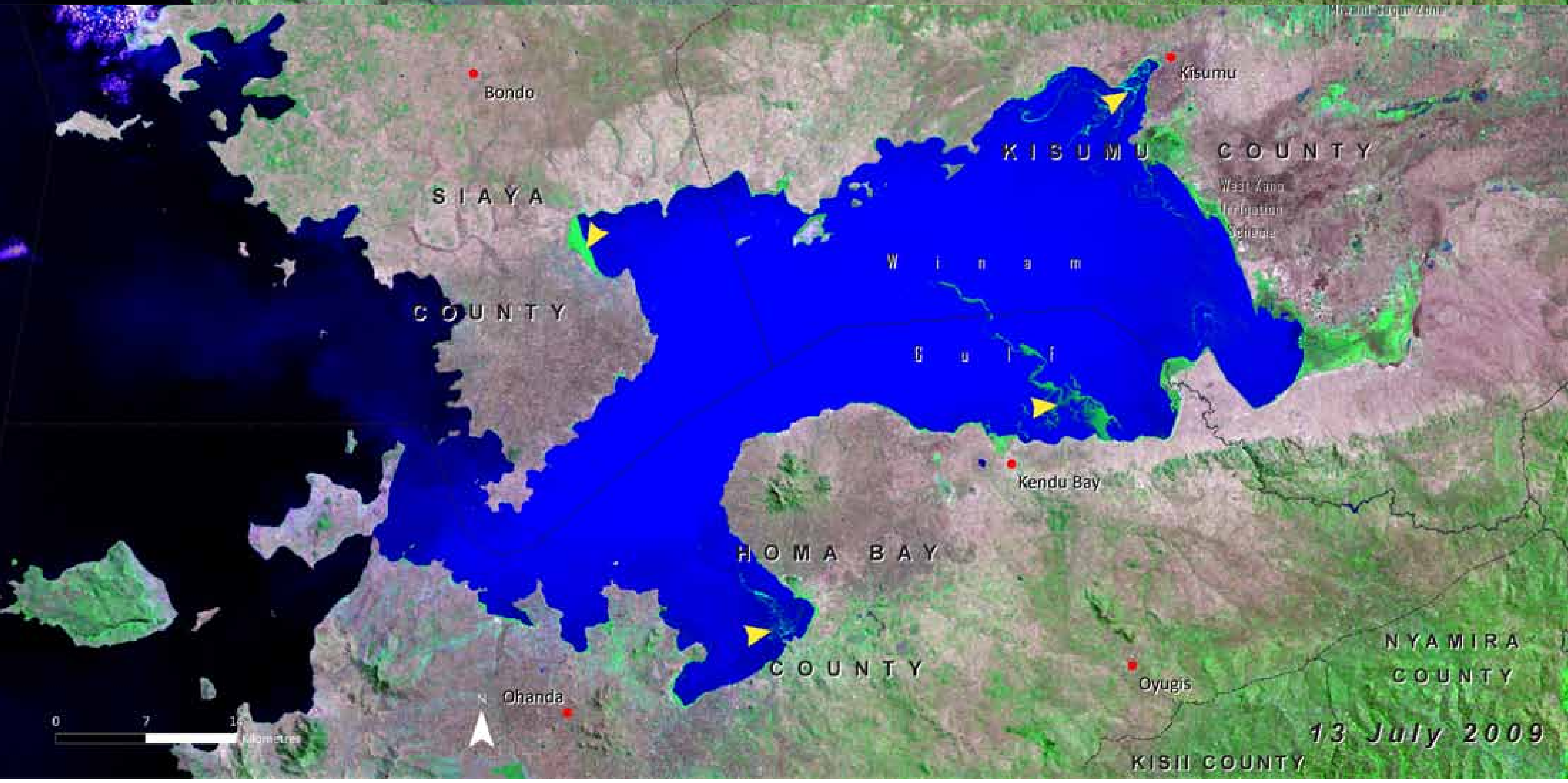
Pressures

The water hyacinth (*Eichhornia crassipes*) is a floating perennial aquatic weed that is native to South America's Amazon Basin. It is a prolific bloomer and is therefore difficult to eradicate. It invaded Lake Victoria in the 1990s, and Winam Gulf became one of the most severely affected portions of the lake. Attempts to eradicate the hyacinth biologically using the Chevroned water hyacinth weevil (*Neochetinabruchi*) and the water hyacinth weevil (*Neochetinaeichhorniae*) largely proved futile. Efforts to manually remove the weed in order to use it to make handicrafts were only partially successful as its regeneration rate far outstripped the harvesting rate. Many of the successes recorded in controlling the water hyacinth have therefore been due to mechanical removal.


sarahemcc/Flickr

A dense mat of water hyacinth (*Eichhornia crassipes*) has immobilized these artisanal fishing boats on Lake Victoria.





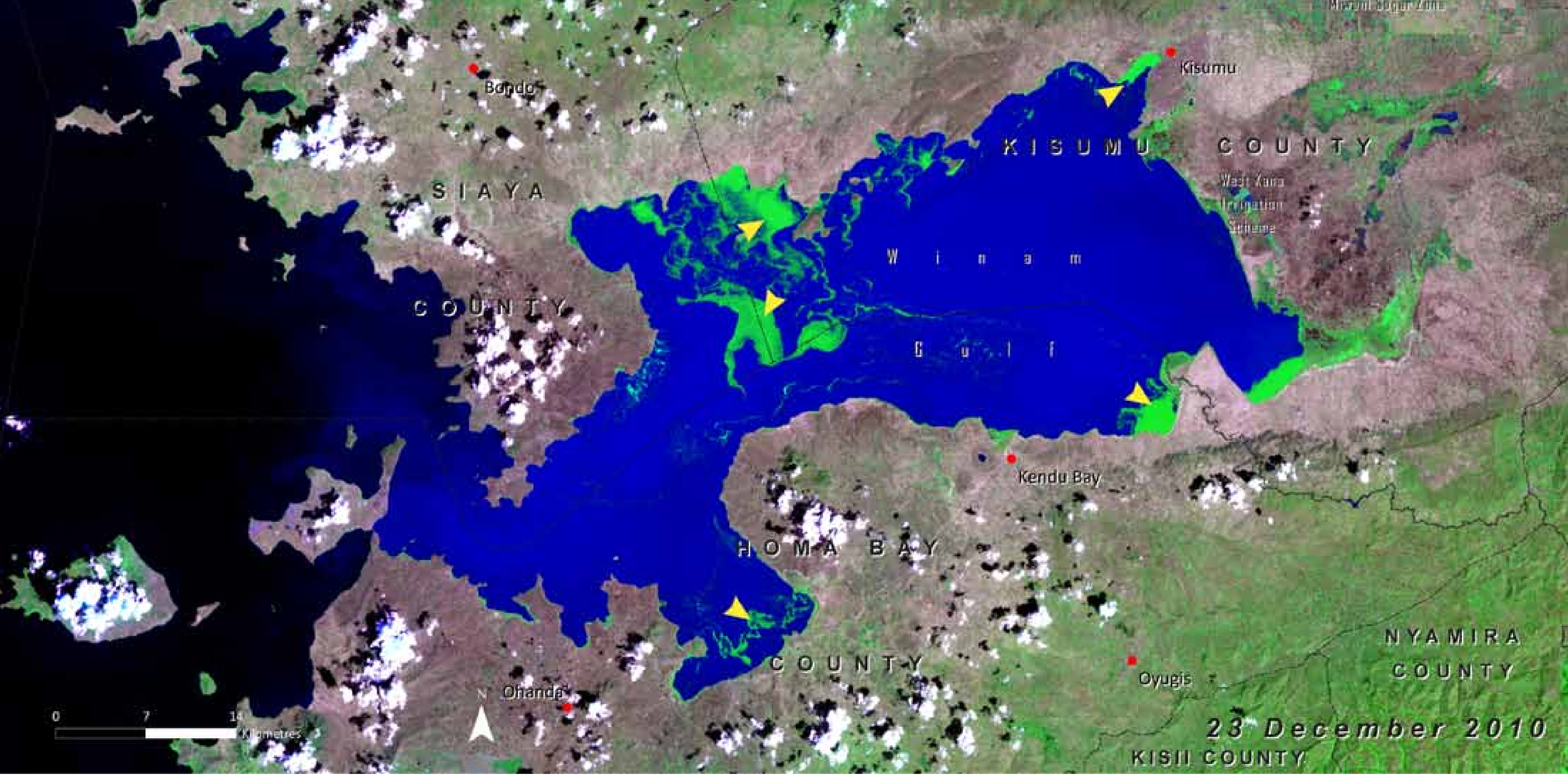
The water hyacinth (*Eichhornia crassipes*) was first observed on Lake Victoria in the 1990s and the Winam Gulf stood out as one of the most infested areas. While the location and thickness of the weed are always in a constant state of flux as is clear from the images, the hyacinth infestation (marked by yellow arrows) is noticeably more widespread in the 2010 image.

Impacts

The impacts of water hyacinth infestation are multifaceted. Its dense mats can completely clog entire lake and river sections. This inhibits marine transportation and hydroelectric power production (Odada and Olago 2006) principally because the turbines for the latter continually break down.

The water hyacinth also has many deleterious effects on the livelihoods of local communities. Its infestation of the Winam Gulf has eroded Lake Victoria's aesthetic beauty, negatively impacting tourism and local household incomes (Mailu 2002). The weed also deoxygenates water, killing substantial fish communities and jeopardizing artisanal fisher folk's livelihoods. Further the substantial suspended matter it generates adversely affects water quality, making it harder for poor communities which live adjacent to the lake to access safe drinking water.

The invasive weed has also had negative implications for biodiversity. As it chokes off all competing plant life, the water hyacinth makes the aquatic environment inhospitable to fish species such as cichlids that are already threatened.




A dense mat of water hyacinth (*Eichhornia crassipes*) has immobilized these artisanal fishing boats on Lake Victoria.
Richard Portsmouth/Flickr


Clearing and burning of a wetland for agriculture.
Judith Nyunja/KWS

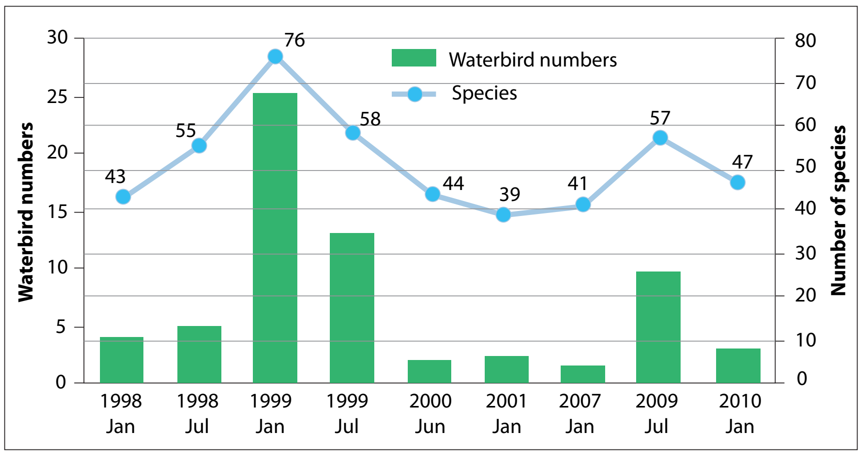
Over-exploitation of Wetland Goods and Services

As most Kenyan communities remain highly dependent on natural resources for their livelihoods, over-harvesting of these resources is a major concern. This is particularly true for wetlands where unclear tenure arrangements, growing populations and lack of alternative livelihoods are fuelling over-dependence on these open access resources. Felling of mangroves and riverine forests along the Kenyan coast, unsustainable sand harvesting along riverbeds and coastal estuaries as well as slash and burn agriculture pose threats to wetlands. These largely unregulated activities lower river productivity, alter the wetlands' hydrological and substrate compositions, and destroy essential plant and animal habitats, jeopardizing the survival of faunal and floral species that already have to contend with a range of growing pressures. The case studies of Lake Ol Bolossat and Kimana Wetland illustrate the issue of over exploitation of wetland resources particularly well.

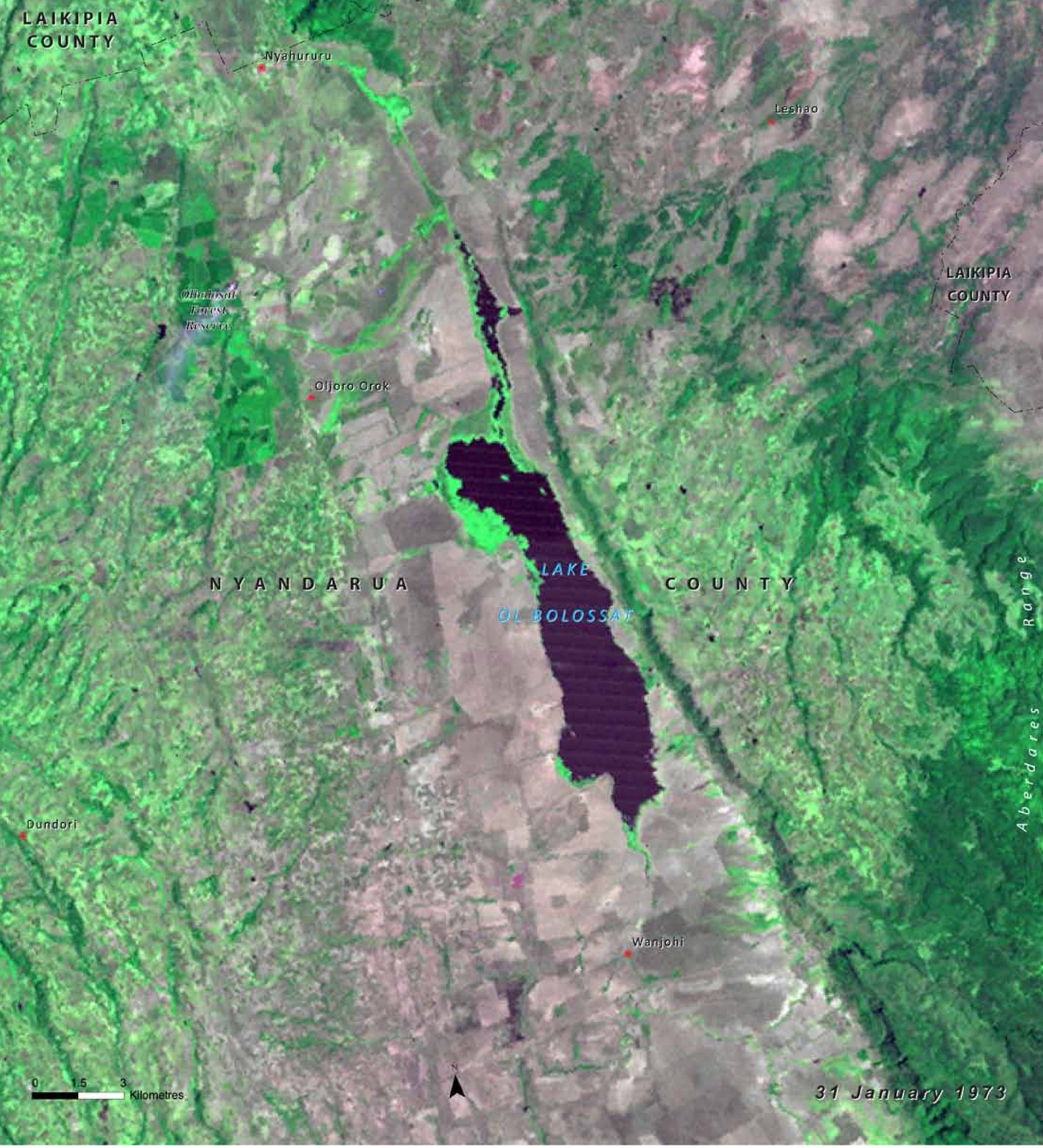
Case Study: Lake Ol Bolossat

Since 1998, 99 waterbird species consisting of 64 935 individuals have been recorded in Lake Ol Bolossat. Worryingly, the number of bird species and individuals recorded has generally been decreasing as is evident in Figure 5.7. The red-knobbed coot, African spoonbill, Little grebe, African fish eagle as well as ducks and geese have been especially hard hit.

Figure 5.7: Trend of waterbird species recorded at Lake Ol Bolossat.



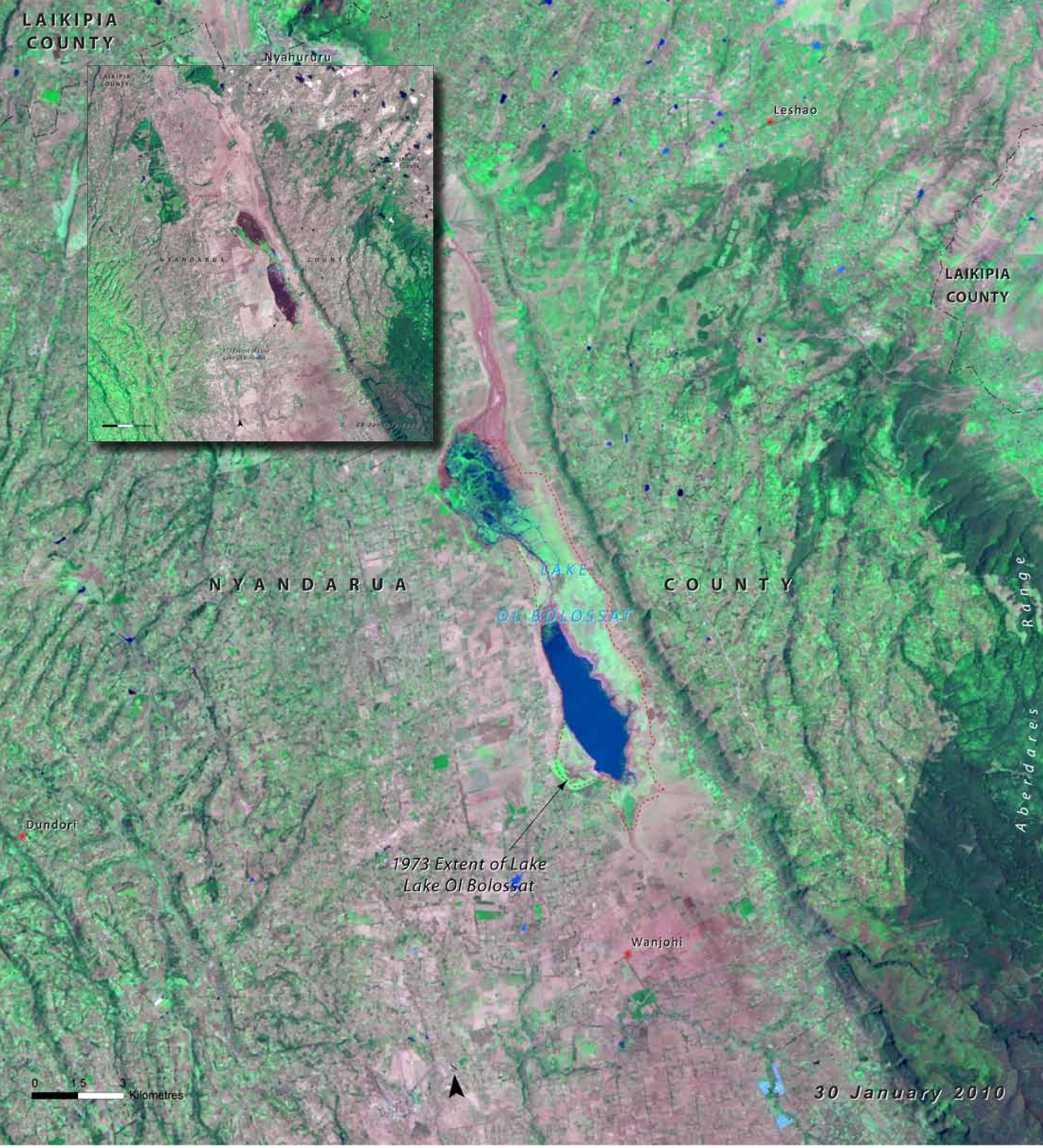
Source: National Museums of Kenya n.d.



Lake Ol Bolossat

Lake Ol Bolossat, with an area of approximately 43 sq. km. is a freshwater lake situated on a flat plain northwest of the Aberdare Mountain Range in Nyandarua County. Located within the Ewaso Ng'iro North basin, the lake and its catchment provide a variety of important habitats that include open water, floating swamps and marshes, savanna and riverine forests and feeder springs. It is a biodiversity haven and hosts numerous species of rare or threatened waterbirds.

Increasingly however, the sustainable use of the lake's resources is threatened by growing anthropogenic

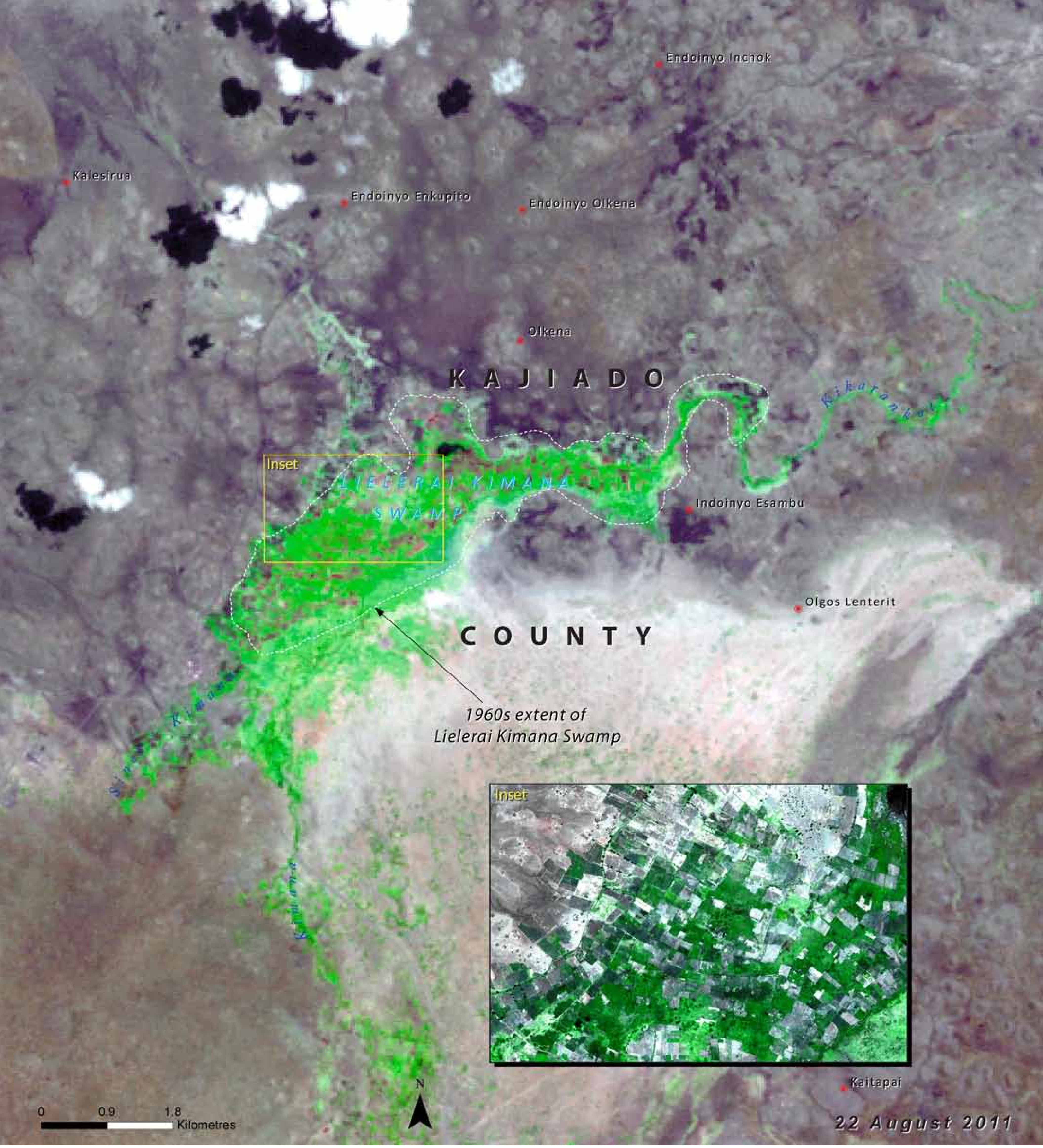


disturbances, which essentially stem from an exponentially rising population. These negative impacts include catchment degradation, siltation, overgrazing, encroachment on riparian land, agrochemical pollution and excessive water abstraction.

As is evident in this set of satellite images, the lake's surface area fluctuates over time. In fact, it has even dried up and re-emerged in the past. There is growing concern among environmentalists that the increasing number and intensity of pressures it has to contend with may imply that it may soon dry up for good.

Kimana Wetland

The Kimana wetland is part of the larger Amboseli ecosystem and is located in the semi-arid Loitokitok region. It is endowed with a wealth of biodiversity. In the wet season, mammals disperse out of Amboseli National Park, move through the Kimana Sanctuary, which forms the core area of the Kimana wetlands to the Chyulu West National Park. This strategic linkage is critical to the viability of Amboseli's elephant population and other mammals.



The wetland is an important dry season grazing, foraging and watering area for livestock and wildlife. However, due to rising demand for land and water, the area's streams and swamps are continuously drained. As a result, the Kimana Swamp has dwindled to less than 20 per cent of its original size with this being evident in the satellite images above. A continuous green mat of wetland vegetation characterizes the centre of the 1987 image. However, in the 2011 image, brown patches, representing areas reclaimed for agriculture, are evident. The extent of degradation of the wetland is more perceptible in the high resolution inset.

Case Study: Kimana Swamp

The Kimana Swamp is situated at the confluence of the Kimana and Isinet Rivers. It is an important dispersal area for wildlife in the Tsavo West and Amboseli National Parks a well as Chyulu West National Park and is vital to the survival of the mammals in the latter two smaller protected areas. Underground aquifers, which supply the swamp's water, are fed by runoff during the rainy seasons and melting snow from Mount Kilimanjaro. The wetland is also an important dry-season foraging and watering area for both wildlife and livestock (Okello and Kioko 2011).

At least 13 large mammal species frequent the swamp with the most common being the Grant gazelle (*Gazella granti*), white bearded wildebeest (*Connochaetes taurinus*), common zebra (*Equus burchelli*), impala (*Aepyceros melampus*), common waterbuck (*Kobus elliprymnus*) and African elephant (*Loxodonta Africana*).

The Kimana and Mbiri-Kani Maasai Group Ranches occupy the area and use it to cultivate rain-fed crops but also for dry season grazing. They also use the wetlands to obtain construction materials and to meet other domestic needs (Okello and Kioko 2011).

<u>*Pressures*</u>

The number of farmers who occupy the Kimana wetland is on the rise. This is probably due to a combination of poverty, a rising human population and the increased frequency of droughts (Okello and Kioko 2011). Due to the rising demand for irrigation water, the area's streams and swamps are continuously drained. As a result, most of the wetland area has been converted to small-holder farms as can be seen in the February 2011 image. This environmental pressure is compounded by the periodic influx of nomadic pastoralists who move from one place to another in search of water and pasture during dry spells (AWF 2008).

<u>*Impacts*</u>

Some of the impacts of increased pressure on the Kimana wetlands include a declining quantity and quality of water for humans, livestock and wildlife. In addition, only 15.7 per cent of the original Kimana Swamp remains as the rest has been converted to agriculture (Okello and Kioko 2011). The above impacts are themselves a reminder that non-wise use of wetlands and their resources inevitably jeopardizes both local livelihoods and wildlife conservation.

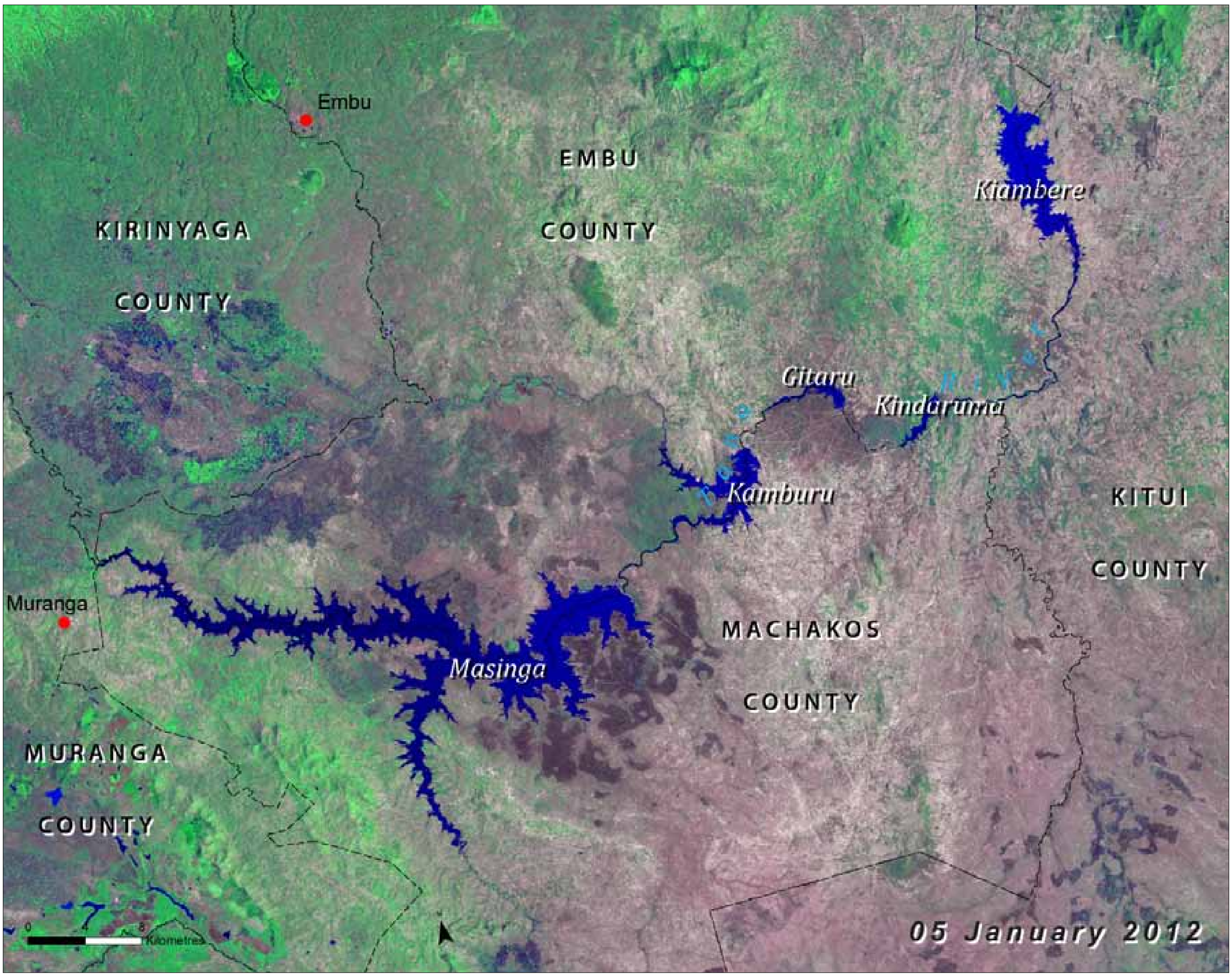
Hydro Power Developments and Dams

Many wetland areas depend upon wet season water flows and their productivity is dependent on the level and duration of the attendant inundation. Changes to flood heights and duration due to the construction of dams and reservoirs and related hydro power developments can result in seasonal wetlands not filling up, or in previously permanent wetlands drying out.

<u>*Pressures*</u>

Kenya's hydro power developments and dams are situated along major rivers such Tana and Sondu Miriu. But they also include small scale hydro dams and barrages built for irrigation and flood management. Increased demand for power and irrigation water is also driven by the implementation of Vision 2030, which identifies manufacturing and agriculture as priority areas for growth.

A view of Kenya's largest source of Hydro-electric power—the Seven Forks scheme along the Tana River.




A polluted stretch of the Nairobi River.

Impacts

Hydro power developments typically result in reduced peak flow or increases in dry-season flow in rivers as a result of dam releases. Other potential impacts include a reduction in downstream water flows, alteration in suspended load sediments, bed load transport, oxygenation, alteration of temperature regimes and micro climates, and the displacement of people into new ecologically-sensitive habitats. Dams and reservoirs can also isolate wildlife populations, leaving them particularly vulnerable to demographic changes and inbreeding and to the impacts of human development and catastrophic environmental events. These effects are bound to be more severe if the hydro power developments are badly constructed and poorly managed.

Systemic Constraints to Better Wetland Management

This section looks at the various obstacles that have hindered better wetland management and the sustainable use of wetland goods and services in Kenya.

Legal and Policy Vacuums

Legal and policy vacuums imply that there is little awareness of wetland values and functions in the country. As such, these tend to be ignored in development plans thereby leading to the loss of wetlands and the biodiversity they sustain. Therefore, there is need to develop comprehensive national policies on wetlands, biodiversity and access to genetic resources and equitable benefit sharing. To ensure national ownership, the government would be well-advised to ensure local community participation in wetlands management and to provide for the use of indigenous knowledge.

Uncoordinated Implementation of Sectoral Plans

A coherent and coordinated institutional framework for wetland management is lacking in Kenya. Government agencies, which are largely organized along single sectoral lines, have overlapping jurisdiction over wetlands, leading to conflict and contradictory decisions. When developments are planned, little or no consideration is given to the potential impacts on wetlands. Moreover, macroeconomic and sectoral policies continue to favour wetland-degrading sectors, and to employ fiscal and market instruments that encourage activities and land uses that lead to wetland modification and conversion. Investment in wetland management continues to be regarded as an uneconomic use of land and as a waste of financial and other resources.

Inadequate Information Base

The information base on wetlands, their values, functions and issues are fragmented and limited in their coverage. In addition, the data are of varying quality, are often out of date, unavailable or under-utilized. As a result, few policy makers and decision-makers are cognizant of the rationale for, as well as, the economic, ecological and hydrological processes that underpin the wise use of wetlands.

Low Local Community Participation in Wetland Management

Many local communities, particularly wetland-dependent indigenous communities, have weak, singular and insecure local livelihoods based on the direct exploitation of natural resources. Lack of access and ownership over the resources and few opportunities to develop sustainable management practices imply that although local communities are conscious of their detrimental actions, over-harvesting of wetland resources continues apace. The situation is compounded by the exclusion of these communities from the management of these fragile resources.

Opportunities to Improve Wetland Sustainability

Kenya has ratified a number of Multilateral Environmental Agreements (MEAs) that have implications for wetland management. It is also involved in several regional initiatives and has developed a number of local instruments to protect the country's wetlands. Scaling up the implementation of these international and regional programmes would help to improve wetland management. These MEAs and national polices and laws are extensively discussed in Chapter 1. Implementing these would help to ground the concept of wise use and to achieve the Vision 2030 goals and the MDGs as discussed in Chapter 4. A key challenge however is to convince macroeconomic planners and sectoral-line ministries of the benefits of promoting wetland and wetland biodiversity conservation.

Conclusion

Kenya's wetlands provide a range of critical ecosystem services that are vital to other ecological processes, human wellbeing and national development as discussed in Chapter 4. Yet despite this, the country's wetlands are subjected to a range of pressures whose impacts effectively negate the attainment of environmental, social and economic development goals. A range of command and control measures (such as a national wetlands policy and statutory law) complemented with participatory wetland management programmes and economic incentives would be needed to stimulate a paradigm shift towards the wise use of these vital but fragile natural resources.

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Grazing land around Lake Naivasha turned barren by the 2009 drought.

Care of Creation/Flickr

CHAPTER 6

CLIMATE CHANGE AND VARIABILITY, AND KENYA'S WETLANDS

Introduction

Climate change and variability as well as the attendant adaptation and mitigation efforts have collectively been described as the defining environmental challenge of our time (Bantjes 2011). This is principally because of the alarming pace at which climate change and variability are accelerating. Wetlands are particularly vulnerable to climate change because they occupy the transition zone between aquatic and terrestrial environments. Slight alterations in precipitation and groundwater levels can therefore have dramatic effects such as completely drying up, contraction in size or conversion to uplands. Yet, because they are fragile natural resources, they deliver a suite of ecosystem services that are indispensable to life on Earth although these are largely under appreciated. As a consequence of the latter, wetlands already face considerable pressure from several anthropogenic activities and their consequences such as pollution, overfishing, overgrazing and soil erosion that are detailed in Chapter 5. Climate change and variability then don't just aggravate these pressures (Gitay and others 2011), their far reaching effects threaten the very continued existence of these vital ecosystems. These phenomena also jeopardize human welfare, environmental integrity and the delivery of a range of development targets articulated in the MDGs and Vision 2030.

KEY MESSAGE

It has already been seen that wetlands are some of the Earth's most productive ecosystems. And, because climate change has been described as the defining contemporary environmental challenge, its pervasive effects are already compromising the integrity of these important ecosystems in Kenya. These effects are projected to worsen rapidly, imperilling human wellbeing , environmental integrity and national development unless adaptive and to some extent, mitigative measures are urgently taken. A rigorous wetland governance regime would also enable the country to tap a potentially lucrative wetland carbon market in the event that this is established.

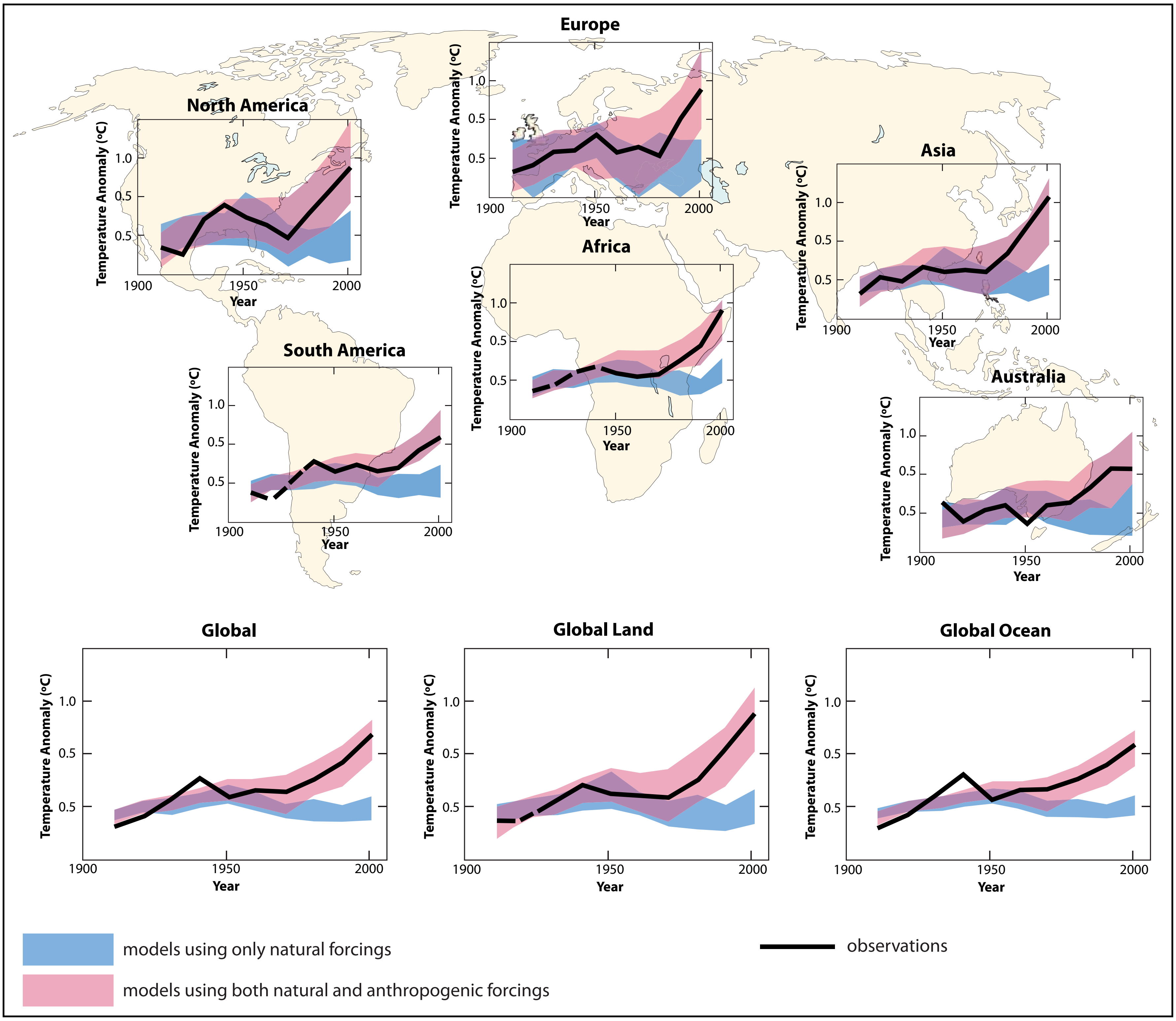
A view of Lake Elementeita's wetlands and the surrounding hills.

Xiaojun Deng/Flickr

Climate Change as a Global Phenomenon

According to the Intergovernmental Panel on Climate Change (IPCC), global climate change is now unequivocal and will have disproportionate impacts on some regions with Africa being the most vulnerable (Parry and others 2007). This has serious implications because the dominant socio-economic activities on the continent are climate-dependent. As such, understanding climatic conditions such as the occurrence of extreme weather events (EWEs) would benefit early warning programmes as well as mitigation procedures for food security.

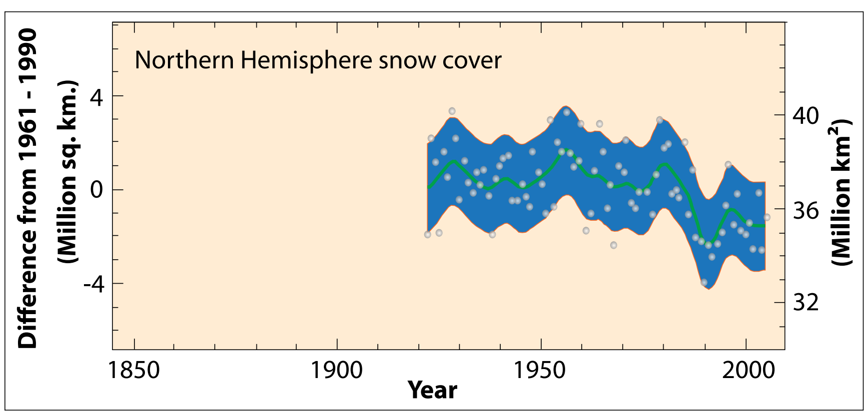
Figure 6.1: Comparison of observed regional and global-scale changes in surface temperature.



Note: Results are simulated by climate models using either natural (blue colour) or both natural and anthropogenic (pink colour) forcings.

Figure 6.2: Glacial and sea level changes.

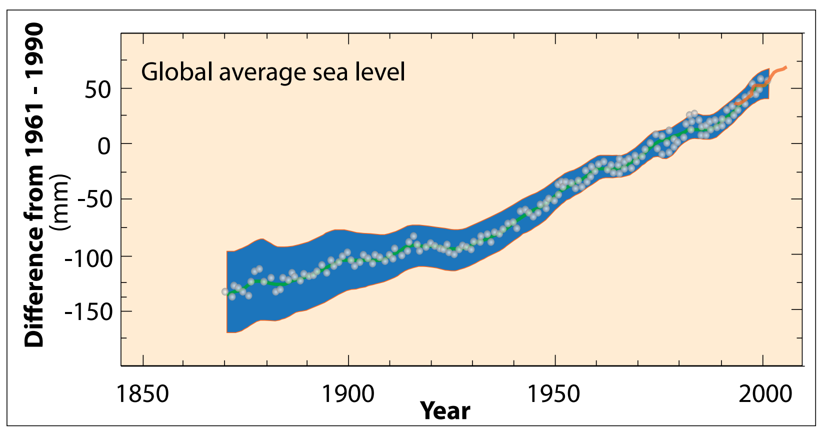
a) Glacial observations



• Mountain glaciers and snow cover have declined in both hemispheres contributing to the sea level rise in many places.

Source: IPCC 2007

b) Sea Level Observations



• Observations show that the average temperature of the global ocean has increased.
• Such warming causes seawater to expand, contributing to sea level rise.

Source: IPCC 2007

Climate change and variability are likely to take their toll on marine biodiversity.

its_me_laura/Flickr.com

Climate information constitutes a valuable resource for understanding the past space-time characteristics of all the weather parametres that impact national development. The widely accepted climate indicators that are increasing are: land, ambient, ocean and stratospheric temperatures as well as sea levels and humidity. Conversely, the indicators that are on the decline are glacial areas, Arctic sea ice and the winter snow cover in the Northern Hemisphere (NOAA 2010). Evidence indicates that these changes, particularly temperature increases which are reflected in Figure 6.1 and glacial and sea level changes which are illustrated in Figure 6.2, are having cataclysmic effects on many ecosystems around the world (Solomon and others 2007).

Evidence of Climate Change in Kenya

Several studies reviewed in the Kenya State of the Environment and Outlook 2010 (NEMA 2011) documented climate change and variability in Kenya. For example, a study on the economic impacts of climate change projected that mean annual temperatures will rise by 1-3.5°C by 2050. Weather stations in Kenya have recorded temperature and rainfall trends that are indicative of climate change. Temperatures are generally rising while monthly and seasonal rainfall patterns are becoming more unpredictable. Other manifestations of climate change are the retreating glaciers on Mount Kenya (Barker and others 2001; Hastenrath and Krus 1992) and the increased frequency of EWEs.

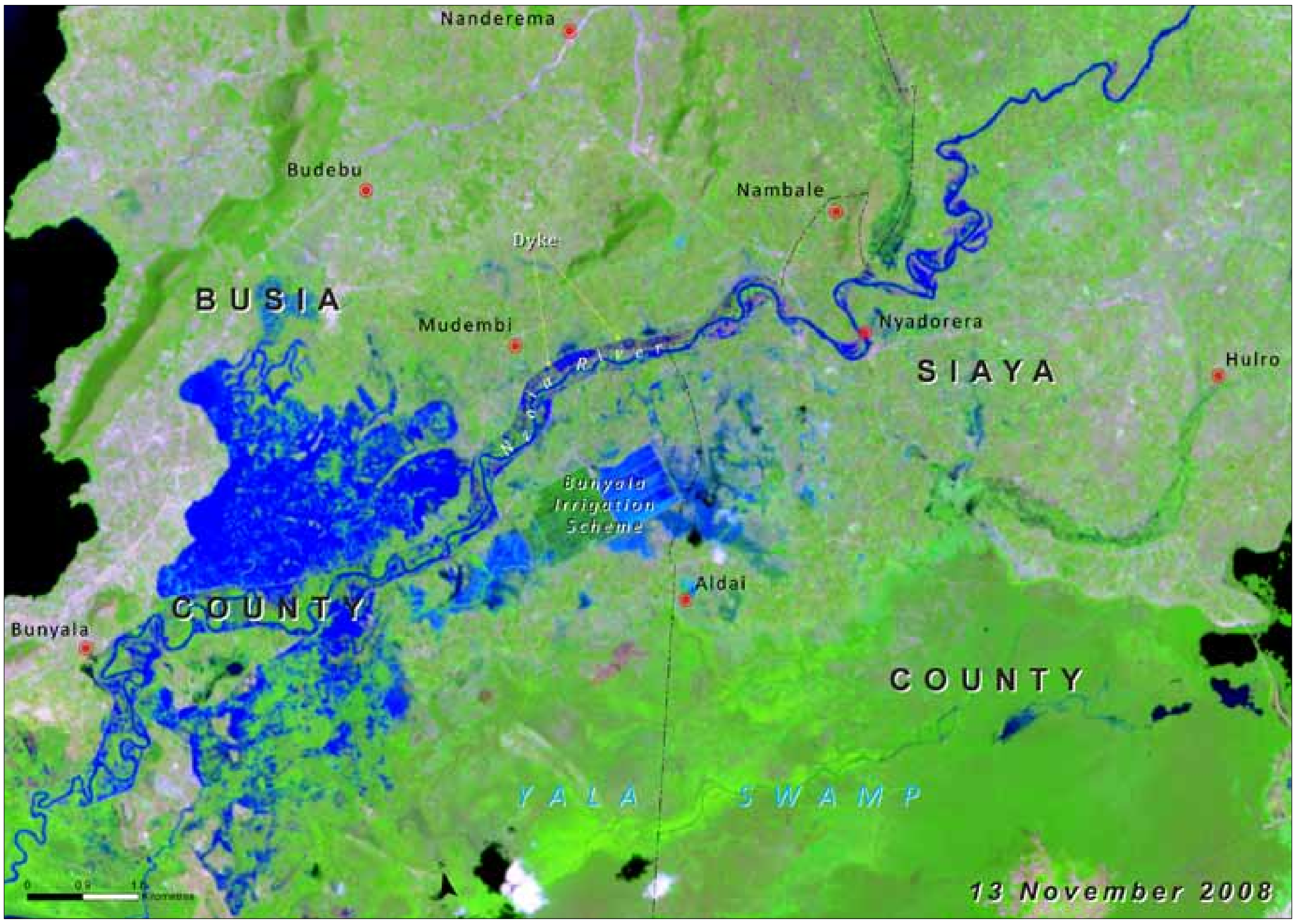
Evidence of warming trends has been observed over land stations with some cooling over coastal locations and near large water bodies in Eastern Africa, including Kenya. The results indicate a statistically significant relationship between sea-surface temperature (SST) gradients in the tropical Indian Ocean and short October, November and December (OND) rains over East Africa, which are typical of circulation patterns associated with extreme flood and drought disasters in Kenya (Hastenrath 2001; Hasternrath and others 2010).

In Kenya, rainfall is a sensitive climatic element. Thus a thorough investigation of past, present and future rainfall characteristics is required so as to better plan and manage most socio-economic activities. The temporal and spatial characteristics of climate in the Greater Horn of Africa, of which Kenya is an integral part, are complex. Like many other parts of the tropics, the region is prone to EWEs such as drought and floods (Shongwe and others 2010). These events have had severe negative impacts on important socio-economic aspects. For example, the devastating floods of 1997/98 claimed lives, damaged property and infrastructure while the 2011 drought led to famine as well as severe water and hydroelectric power shortage. These, along with social, economic and environmental factors are likely to exacerbate the region's vulnerability to climate change impacts in future, fomenting water and food insecurity, diseases, conflict and natural-resource degradation.

Drought kills off a field of maize in Mwingi.

Eugene Apindi Ochieng

Although flooding of the Nzoia River occurs annually, the extent fluctuates widely. The government has constructed dykes in order to protect adjacent communities, property and infrastructure. However, the river's water occasionally breaches these dykes, as is evident in this 2008 image.



The Role of Wetlands in Climate Regulation

Carbon Sequestration

Carbon is stored in wetland sediments over the long term with this process being referred to as sequestration. Short term carbon, on the other hand, is stored in existing biomass (plants, animals, bacteria and fungi) and dissolved components in the surface and groundwater (Wylynko 1999). In addition, open freshwater wetlands acquire substantial carbon from neighbouring cities and farm watersheds (Reddy and others 2002). Upon decomposition, carbon produces carbon dioxide and methane, which are two of the most potent greenhouse gases (GHGs) that are responsible for climate change. The effects of this process on future climate change will largely depend on the scale on which they differ from historical rates of carbon production. The level of carbon storage is determined by several factors that include the wetland type, vegetation composition and depth, gradient, salinity, temperature, hydrologic conditions and adjacent land use. Nevertheless, the exact extent of wetland carbon storage capacity is unknown (Wylynko 1999).

Wetlands in the Hydrological Cycle

As discussed in Chapter 1, wetlands are highly diverse ecosystems and include freshwater swamps, bogs, saltwater marshes, lakes and rivers. Although wetlands occupy a relatively small portion of the Earth's surface, they play an extremely important role in the biosphere. Their roles in human wellbeing , ecological and national development are

Wetlands are a significant source of methane, a potent GHG.

Lauren Pressley/Flickr

A dry water reservoir.

Waterdotorg/Flickr

enumerated in Chapter 4. Nonetheless, in this section, it is important to elaborate on wetlands' role in the hydrological cycle in order to appreciate the significance of climate change and variability impacts on their functioning.

As detailed in Chapter 4, wetlands influence water flows by intercepting surface runoff from the surrounding land, storing the water like a sponge and then releasing it slowly, thereby reducing flooding. They also stabilize stream banks, lakeshores and coastlines from the impacts of flowing water and from waves, thereby protecting shorelines and stream banks from erosion. In addition, wetlands contribute to groundwater recharge and discharge by absorbing surface water and letting it seep into the groundwater. This helps to reduce flood damage, minimize erosion, maintain aquifers and ensure that streams continue to flow during dry seasons, which is vital for many aquatic species and for humans who depend on them for their water needs and livelihoods (Botkin and Keller 2003; Chiras and Reganold 2005). In so doing, wetlands attenuate the impacts of climate change and variability. Because it is widely accepted that wetlands have a significant influence on the hydrological cycle, they have become important elements in water management policy at the national, regional and international levels (Bullock and Acreman 2003).

Greenhouse Gas Emissions

Standing water, a typical characteristic of non-tidal wetlands, creates a special sediment environment with little or no oxygen where sulphur bacteria survive. Chemical reactions occur in these bacteria, producing methane and hydrogen sulphide, which have important effects in the biosphere, including contributing to the GHGs implicated in climate change (Botkin and Keller 2003). Data from measurements of sediment gases are therefore critical to understanding the cycling of carbon (CH_4 and CO_2) and nitrogen in these lakes and wetland systems (Adams and Ochola 2002).

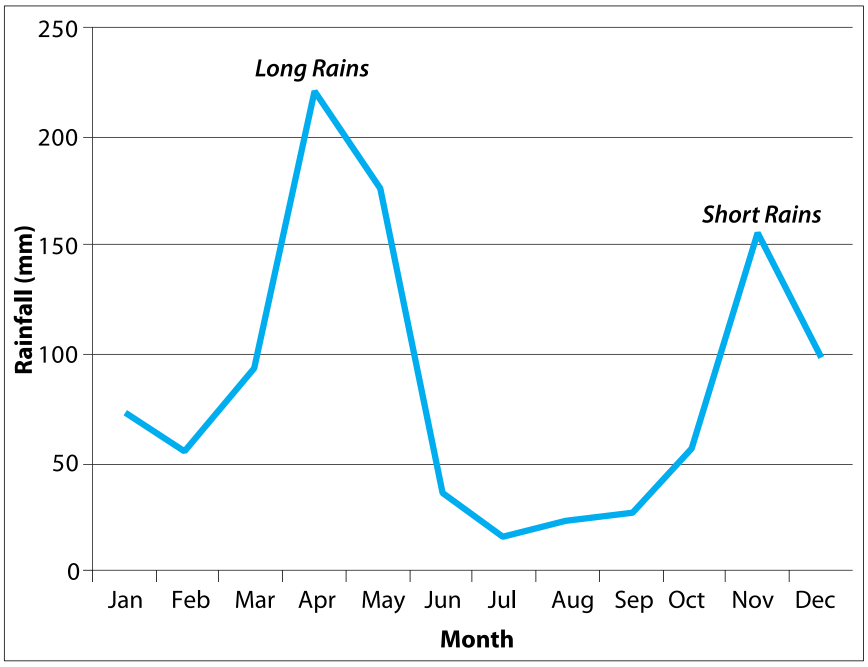
Kenya's Changing Climate

Background Climatic Characteristics

Rainfall

Lying astride the equator, Kenya generally experiences two seasonal (bimodal) rainfall peaks (Figure 6.3). Some parts of the western and central Rift Valley however experience a tri-modal rainfall pattern (Thuo and others 2012; Githui and others 2009). The bimodal nature

Figure 6.3: Data from Nairobi's Dagoretti station displaying the bimodal distribution of rainfall.



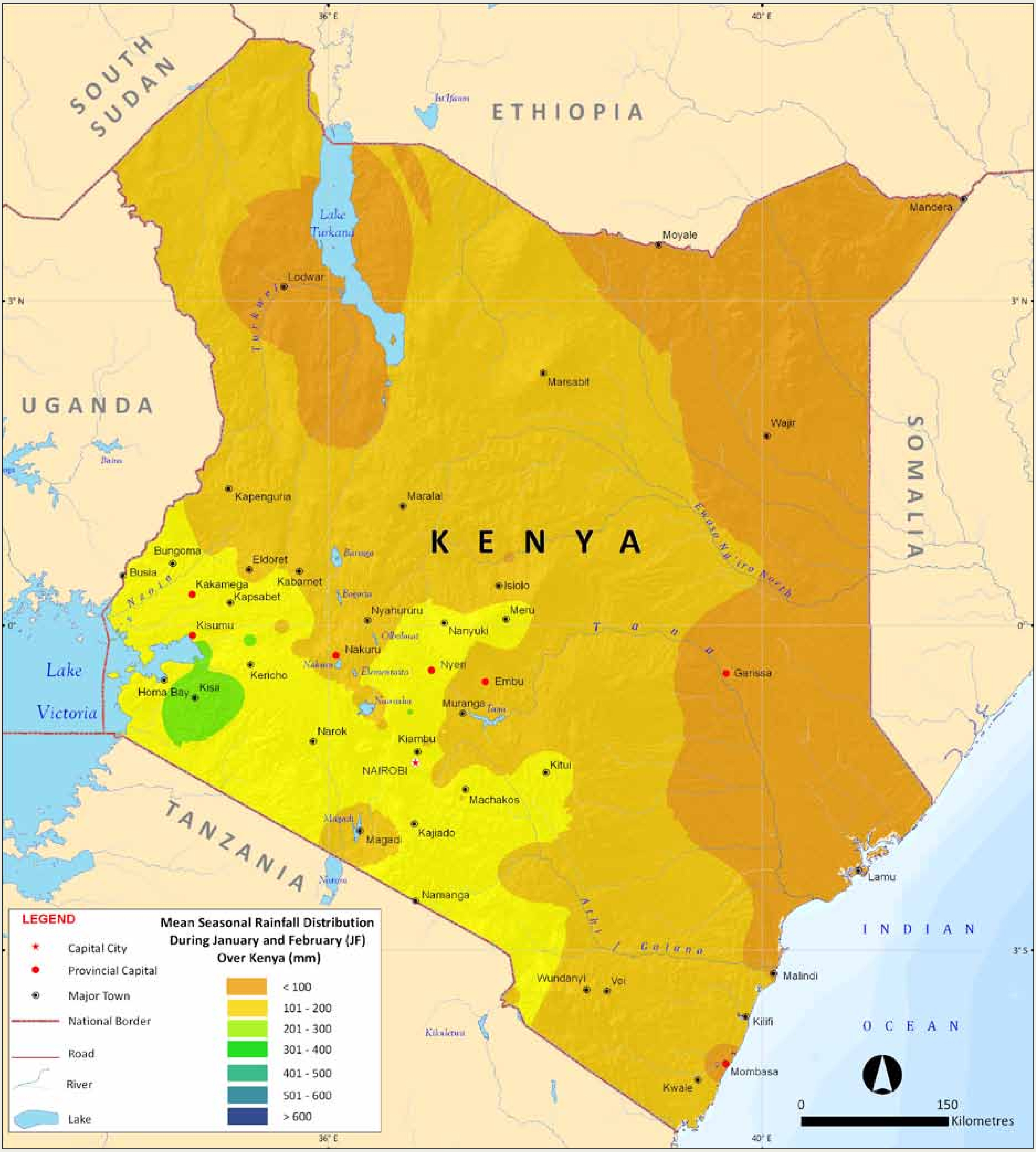
Source: Kenya Meteorological Department n.d.

of rainfall corresponds with the northward and southward migration of the Inter-Tropical Convergence Zone (ITCZ) (Mugalavai and others 2008). The first peak or season, known as the 'long-rains' in East Africa, occurs from March to May (MAM) while the second season, referred to as the 'short rains' runs from October to December (OND). The western parts of the country also receive considerable rainfall from June to September (JJAS) on account of the arrival of the Congo air mass (Ntale and others 2003).

The January-to-February (JF) period is generally dry over most parts of the country as the northeasterly monsoons, which are dominant at this time, are diffluent and dry (Camberlin and Wairoto 1997). The annual rainfall ranges from less than 250 mm in the Northern, Eastern and southeastern parts of Kenya to over 2 000 mm in the central highlands, western highlands and the Lake Victoria basin.

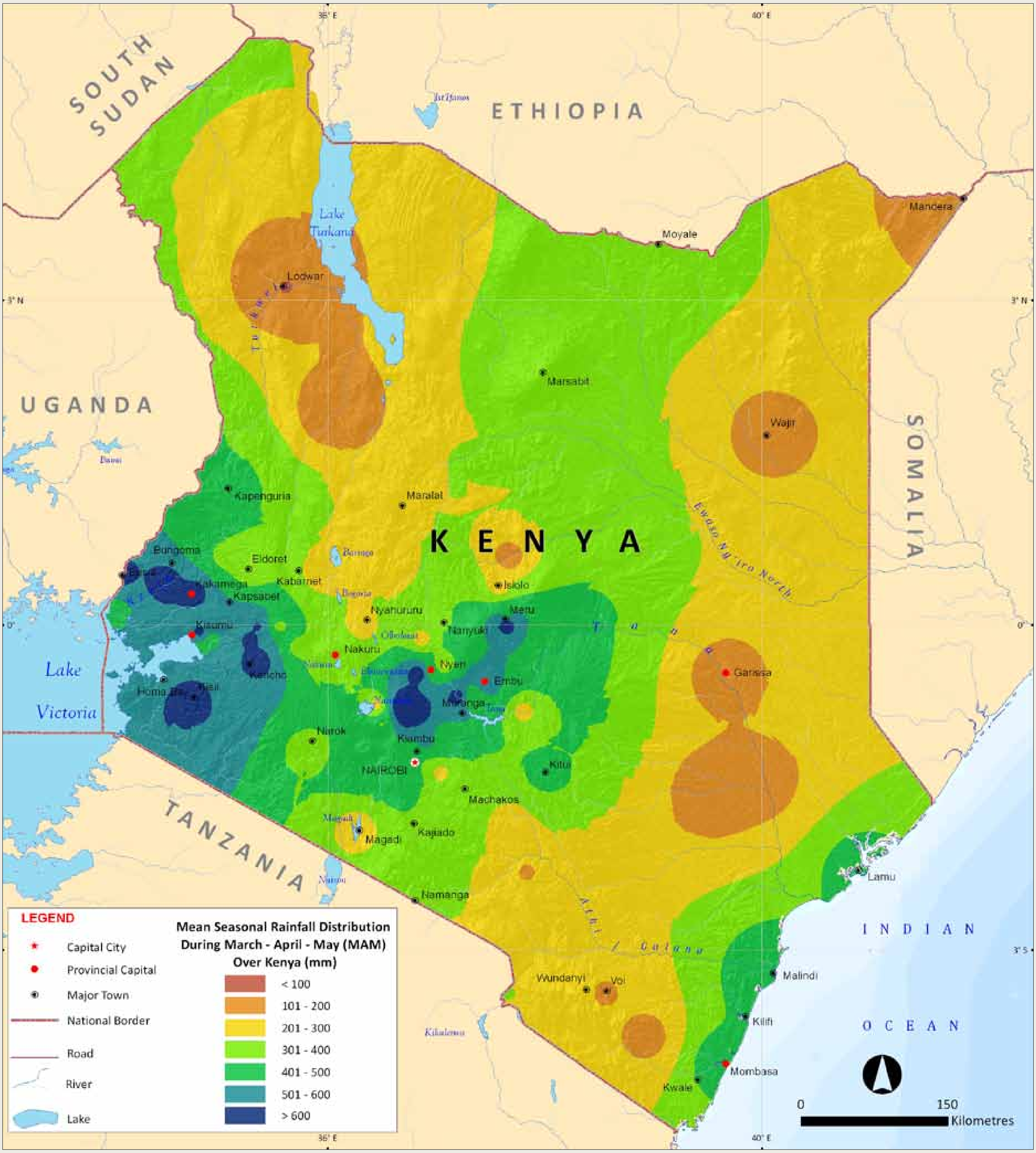
A number of regional factors modify and further complicate rainfall patterns over most parts of Kenya, including large water bodies such as Lake Victoria (Indeje and others 2000), the complex topography of the Great Rift Valley and high mountains notably Mount Kenya and Mount Elgon, and local influences like land-sea breezes and vegetation. Figures 6.4 to 6. 7 show the mean rainfall distribution during different seasons and Figure 6.8 shows the overall mean annual rainfall distribution.

Figure 6.4: Mean rainfall distribution during January - February (JF).



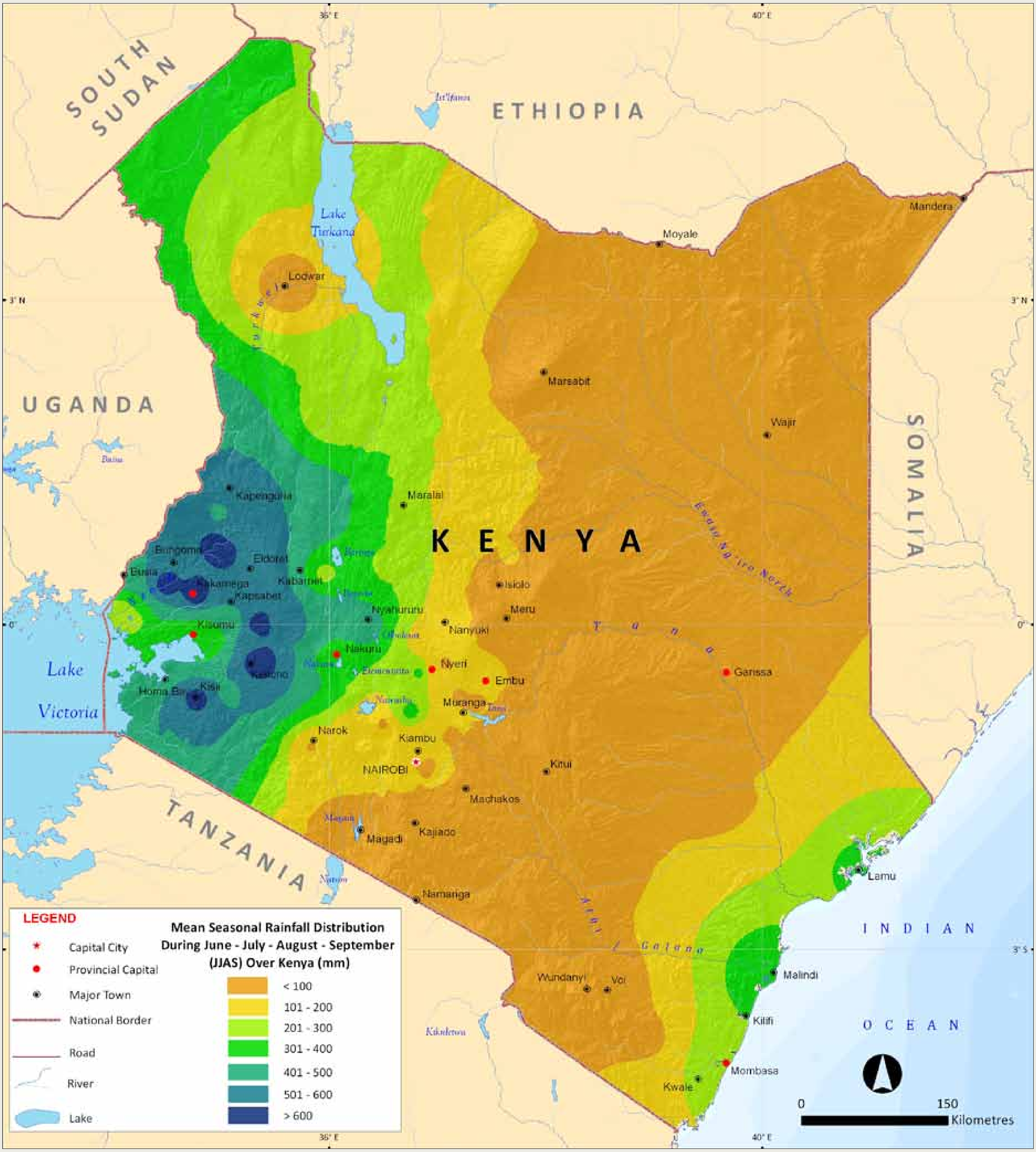
Source: Kenya Meteorological Department n.d.

Figure 6.5: Mean rainfall distribution during March – April – May (MAM).



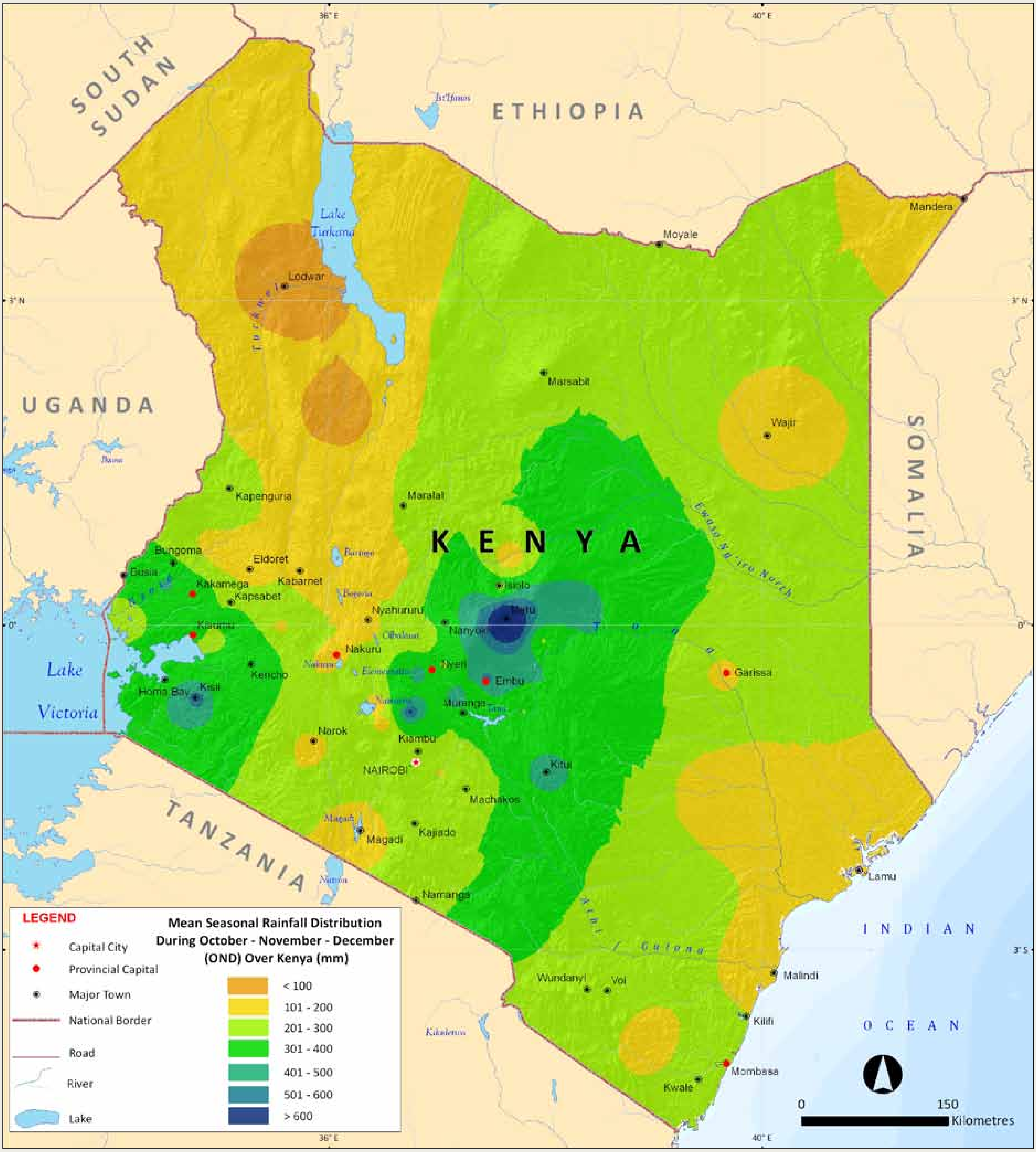
Source: Kenya Meteorological Department n.d.

Figure 6.6: Mean rainfall distribution during June – July – August - September (JJAS).



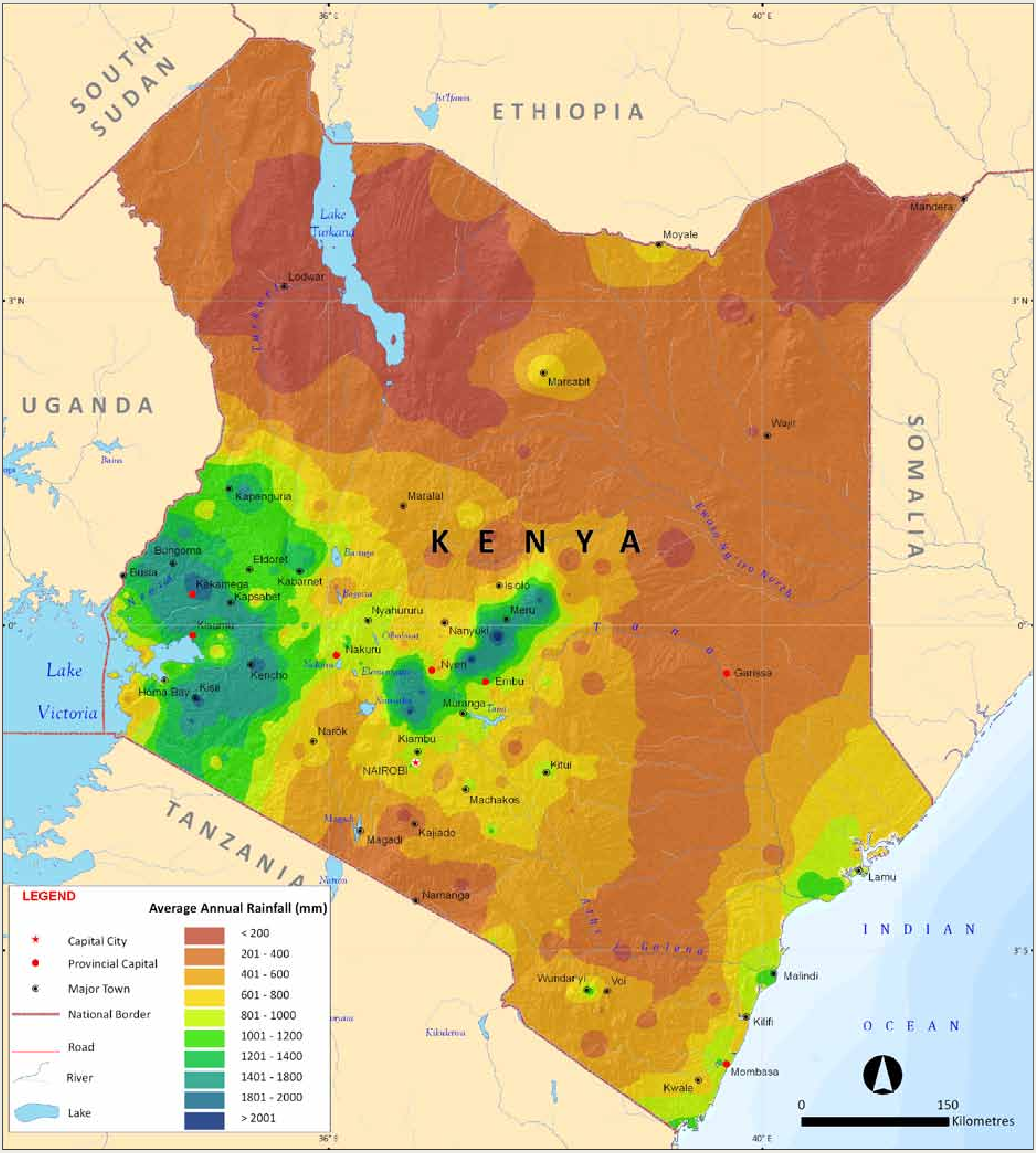
Source: Kenya Meteorological Department n.d.

Figure 6.7: Mean rainfall distribution during October – November – December (OND).



Source: Kenya Meteorological Department n.d.

Figure 6.8: Mean annual rainfall distribution.



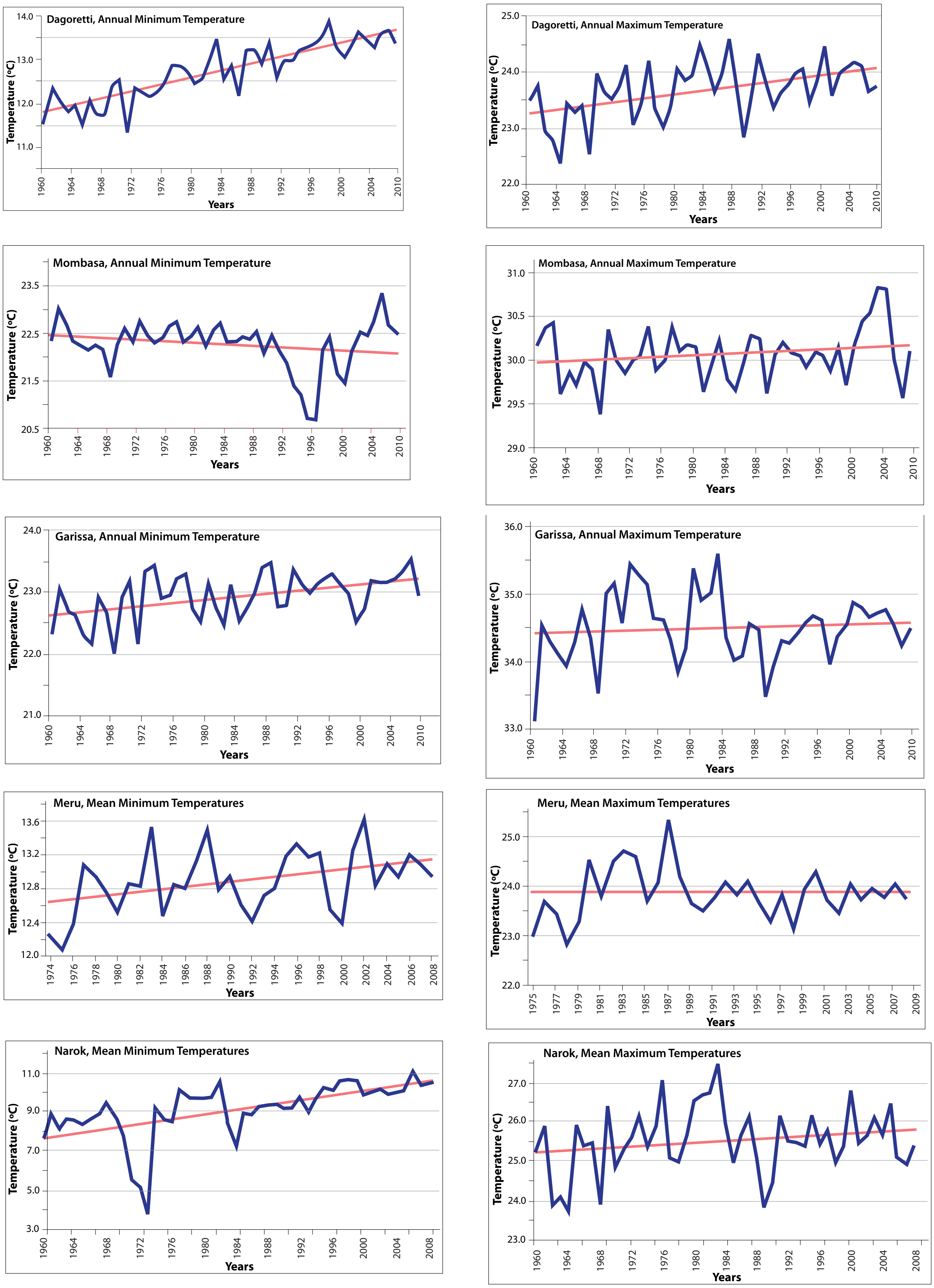
Source: Kenya Meteorological Department n.d.

Recent Climate Trends in Kenya

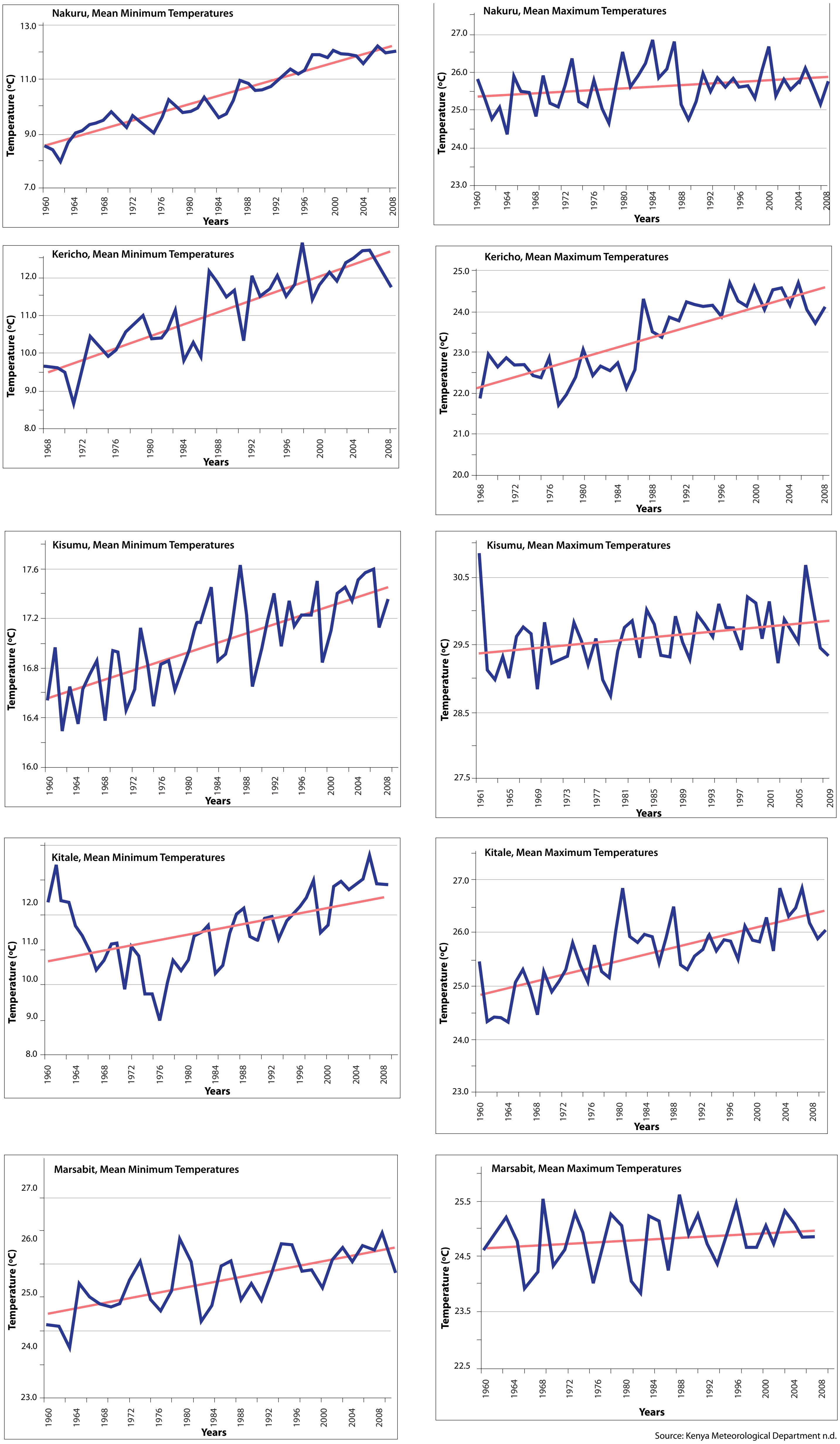
Temperature

Analysis of temperature trends from the early 1960s indicates that Kenya has experienced generally increasing temperatures over vast areas (GoK 2010). Over inland areas, the trends in both minimum (night-time/ early morning) and maximum (day-time) temperatures depict general warming over time. Nevertheless, the increase in minimum temperatures is steeper than it is for maximum temperatures. The result of the increase in both minimum and maximum temperatures is a reduction in the temperature range (the difference between the maximum and minimum temperatures). The areas near large water bodies and the coastal strip in particular, however, have a different pattern. In these areas, the minimum (night-time/early morning) temperatures show no change or a slight decreasing trend, while the maximum temperatures show a slight increasing trend since the early 1960s (GoK 2010). The temperature trends at selected stations in Kenya are depicted in Figure 6.9.

Figure 6.9: The temperature trends at selected weather stations in Kenya.



(cont.) Figure 6.9: The temperature trends at selected weather stations in Kenya.

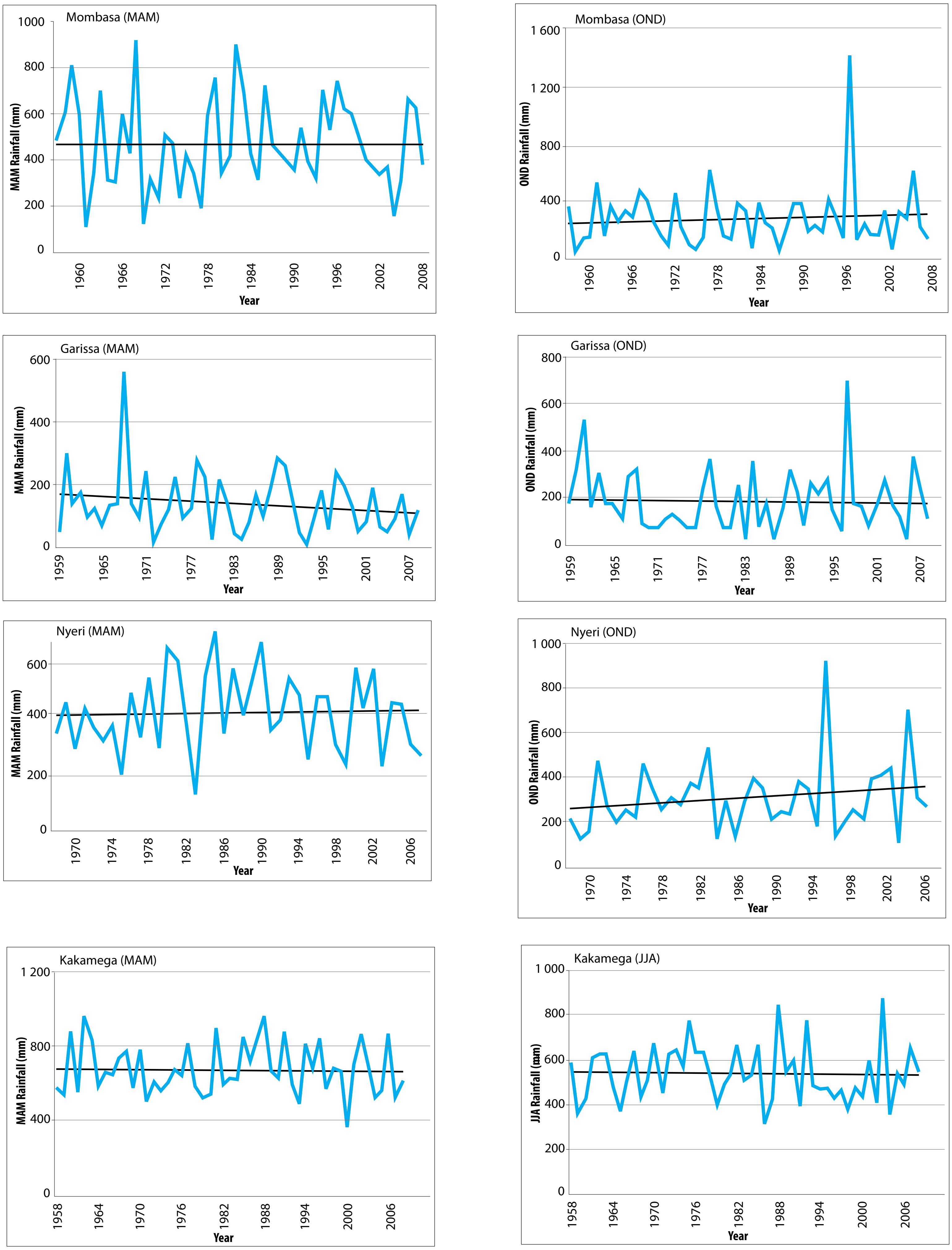


Source: Kenya Meteorological Department n.d.

Rainfall

The trends in seasonal rainfall for the standard seasons of March-April-May (MAM), June-July-August (JJA) and October-November-December (OND) indicate that there has been a general decline in March-April-May rainfall (the 'long rains') and a tendency towards a general positive trend (increase) in rainfall during the October to December (OND) (the 'short rains') period (Figure 6.10).

Figure 6.10: Trends in seasonal rainfall at selected weather stations.



The Impacts of Climate Change and Variability on Kenya's Wetlands

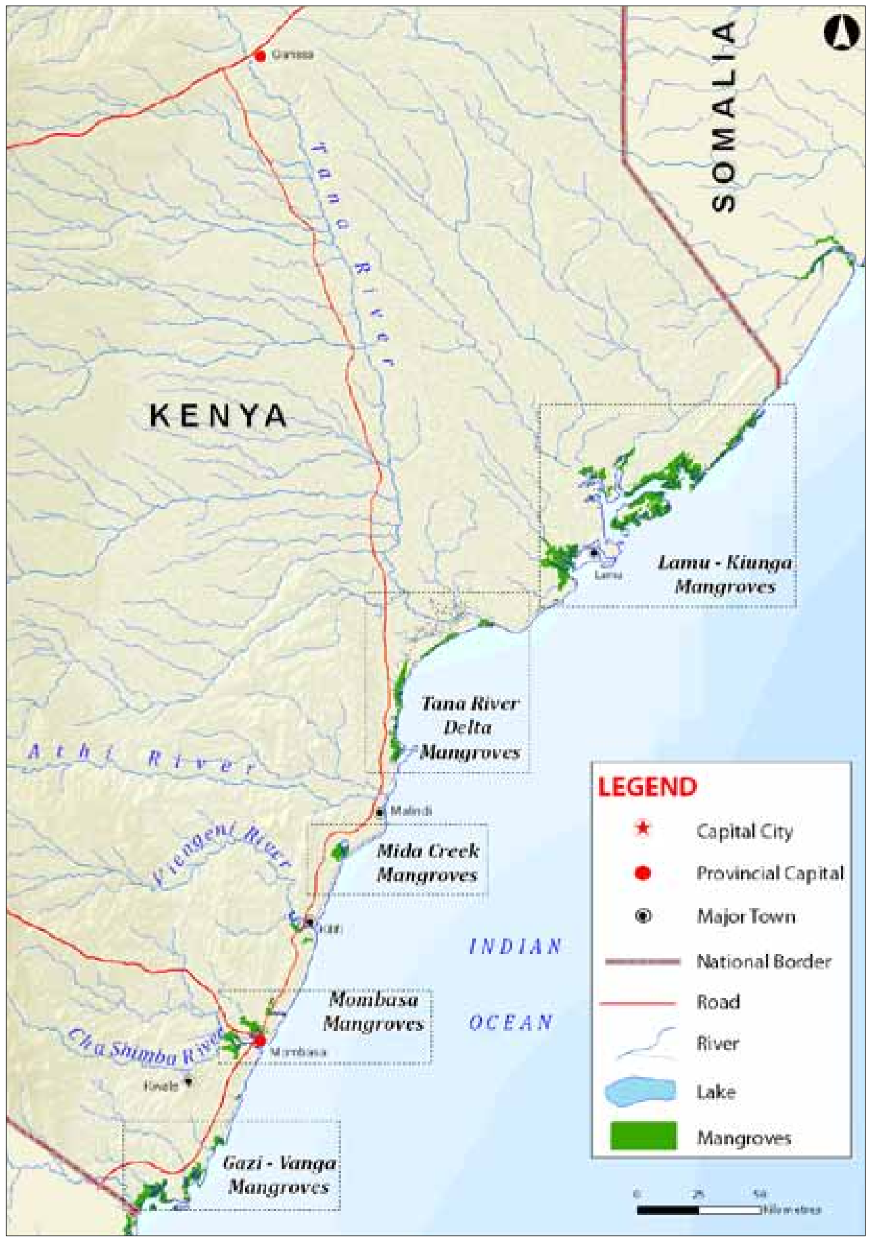
Local Ecological Impacts of Climate Change

Even though the entire spectrum of climate change impacts has not yet been fully documented, as with the rest of the world, there is unanimity that Kenya is experiencing an unprecedented rise in the occurrence and severity of EWEs. The manifestations of this phenomenon include surface water and ocean warming, coral bleaching, severe droughts, increasing desertification, contracting forests, flashfloods and more frequent landslides (GoK 2010). Other compelling evidence of climate change relates to Mount Kenya, Lake Victoria and rising sea levels. These are briefly expounded on in the proceeding paragraphs.

Mount Kenya is the country's highest and Africa's second highest mountain. Its ice and glaciers are receding at an alarming rate (Barker and others 2001; Hastenrath and Krus 1992) and it has been projected that the imminent temperature increases could see its peaks completely denuded by as early as 2020 (Kennedy 2004; Kaser and others 2004, Beniston 2003). Proactive measures therefore need to be urgently instituted to shield the wetlands and other ecosystems which depend on tropical mountain glaciers for replenishing from the attendant environmental fallout (Lovejoy 2008) by attenuating other anthropogenic pressures. Failure to establish these measures is likely to have dire food security and human health impacts on a large population of the country (Patz and others 2005).

The importance of Lake Victoria is epitomized by the fact that it is Africa's largest and the world's second largest lake after Lake Superior. Over the last 112 years, the striking water-level changes and regimes in Lake Victoria (whose shallow portions qualify as wetlands in line the Ramsar Convention definition) and the adjacent wetlands have been widely researched and discussed as is detailed in Chapters 2 and 3. The research findings generally point to dropping lake levels partly due to lower precipitation levels and concomitant severe drought (Mubiru 2006; Kull 2006; Nicholson and Yin 2001). The lower lake levels have also been attributed to outflows to the Nalubaale and Kiira hydroelectric power dams in Uganda and further downstream along the White Nile (Kiwango and Wolanski 2008; Sene and Plinston 1994). Nevertheless, some spikes such as those associated with the 1961-1964 and 1997/98 heavy rainfall (Conway 2004; Talbot and Laerdal 2000) occasionally occur.

Figure 6.11: Mangrove occurrence along the Kenyan coast.



In 2003, heavy flooding led to the collapse of the Sasumua dam causing major water shortages in Nairobi.

The Kenyan coast is prized for its rich assemblage of rich fauna and flora that include colourful fish shoals, coral reefs and mangrove forests. The occurrence of the latter is illustrated in Figure 6.11. Sea-level rise is regarded as one of the more certain consequences of global climate change. During the past 100 years, the sea level has risen at an average rate of about 1-2 mm per year (or 4 to 8 inches per century). The projected two-fold to five-fold acceleration of global average sea-level rise over the next 100 years will inundate low-lying coastal wetlands (Burkett and Kusler 2000) submerging mangroves especially in Dondori Creek, Gazi Bay, Mwache Creek, Ngomeni and Tana River Delta which cannot retreat inland owing to the flourishing human activity and settlement there (GoK 2010).

Climate change induced sea level rises would threaten Kenya's rich and colourful marine life

Economic Impacts

Relative to the global average, GHG emissions of Kenya's economic-related activities are insignificant. Nonetheless, the country's economy is extremely vulnerable to the effects of climate change and variability as this section demonstrates.

Agriculture is the mainstay of the Kenyan economy as it accounts for 18 per cent of formal employment in the country (GoK 2007) and is a major source of raw materials for the country's industries, the majority of which are agro-based (GoK 2011). Because the performance of the sector is inherently dependent on favourable weather and abundant water supply, these factors are natural determinants of economic activity in the country. As climate change gathers pace as anticipated, the pressure on existing wetlands for increasingly scarce arable land is likely to intensify (Henry and Semili 2005; Odada and others 2004; Thenya 2001; Thenya and others 2005; Torrison 2002). Indeed, it has already been projected that climate change-induced losses could amount to nearly three per cent of GDP by 2030 (SEI 2009).

As discussed in Chapter 4, one of the functions of wetlands is to lessen the impacts of floods and storms. The intensity of climate change-induced EWEs is increasingly overwhelming the traditional flood defences of wetlands, leading to substantial destruction of infrastructure and buildings (Huq and others 2007) as well as water storage and purification facilities. This is an especially likely risk in developing countries such as Kenya which are already struggling to modernize their road and railway networks. The country's poor are disproportionately exposed to the risks of inundated houses because they already live in squalor, often in flood-prone areas.

Health Impacts

The resurgence of malaria, Rift Valley fever, dengue and trypanosomiasis (sleeping sickness) in Kenya has been linked to climate change (GoK 2010; Patz and others 2007; Hay and others 2002; Githeko and Ndegwa 2001). This is principally because rising temperatures encourage the breeding of these diseases' vectors in expanding habitats. The country has also witnessed an increase in the incidence of water-borne diseases such as diarrhoea, cholera and schistomiasis (bilharzia) (GoK 2010) during the increasingly unpredictable wet seasons. This is because, on the one hand, the excessive dampness encourages faster breeding of the vectors of these water-borne diseases while on the other hand, sedimentation compromises the traditional buffering capacity of wetlands (Lara 2006).

In addition, the reported cases of pulmonary illnesses such as asthma are on the rise (Esamai and others 2002; Bartlett 2008) owing to the growing demand for fossil fuels, and increased dust levels from more frequent dry spells. These in turn lead to higher levels of atmospheric suspended particulate matter but also compromise the capacity of wetlands to function as 'the kidneys of the Earth.'

The receding wetlands aggravate the incidence of these diseases because herbal remedies used to treat the above and other ailments such as measles, rheumatism, intestinal worms, cough and dysentery are not readily available when their traditional habitats are wiped out. Moreover, climate change-induced temperature rises lead to drops in wetland water levels, degradation of wetlands and algal blooms (Vilhena and others 2010). Blue-green algae which are forms of cynobacteria, are significant propagators of fevers, dizziness and allergenic diseases such as asthma and are believed to have been behind an outbreak of these diseases in Homa Bay on the shores of Lake Victoria in 1998 (Stewart and others 2006).

Wetlands and Carbon Markets

Although wetlands are both GHG sources (notably methane) and sinks (notably carbon dioxide) (Whiting and Chanton 2001), there is growing interest in the potential of these ecosystems for the carbon market (Emmett-Mattox and others 2010). This is predicated on research that shows that tidal wetlands especially store vast amounts of carbon which has been sequestered from the atmosphere in the biomass, roots and other organic matter (Smith and others 2003). The concerted conservation, restoration and avoided loss of wetlands can, in fact, mitigate climate change (Whigham 1999) provided that any gains made are not offset by new wetland loss. From an environmental standpoint, it would also be vital to ensure that wetlands that are rich biodiversity repositories which are nevertheless carbon-poor are not sacrificed for financial gain (Emmett-Mattox and others 2010). While a regime for trading in carbon that is sequestered in tidal wetlands has not yet been established, setting up an unequivocal policy framework on these issues would position Kenya to tap this potentially lucrative market if and when it becomes operational.

Conclusion

Climate change is expected to have far reaching impacts on virtually all facets of Kenya, including its wetlands. The sheer magnitude of these projected changes calls for decisive and proactive initiatives. The broad objectives of these initiatives should be three-pronged. First, to as far as is possible, mitigate these impacts. Second and more practically, to help the country, particularly its vulnerable populations, to adapt to the inevitable forecast changes as there are currently no known solutions that can protect wetlands as a whole from increased temperatures, changes in precipitation or rapidly rising sea levels. Third, to position the country to tap potentially lucrative wetland carbon markets. In essence therefore, there is need to build climate-change and variability risk screening into development planning, at the national, county and grassroots levels. This should be complemented by addressing the raft of wetland-specific pressures discussed in Chapter 5 through a wetland-specific national policy and legal instruments.

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A geyser spurting hot water in Lake Bogoria.

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CHAPTER 7

TOWARDS SUSTAINABLE MANAGEMENT OF KENYA'S WETLANDS

Introduction

Kenya's internal and transboundary wetlands, which are profiled in Chapters 2 and 3 are integral to ecological processes and provide an array of ecosystem services that contribute to human wellbeing and national development as discussed in Chapter 4. However, unless decisively addressed, anthropogenic pressures (examined in Chapter 5) and climate change and variability induced impacts (detailed in Chapter 6) could jeopardize the integrity of the country's wetlands. In order to raise the stature of these fragile ecosystems and ensure their sustainable management, it would be important to expedite the implementation of the three pillars of the Ramsar Convention namely: the concept of wise use, designation of Wetlands of International Importance (Ramsar Sites) and international cooperation. This chapter briefly discusses what implementing each of these pillars would entail. Issues that require urgent attention are also highlighted.

KEY MESSAGE

Measures need to be urgently instituted to ensure the sustainable management of Kenya's wetlands by accelerating the implementation of the three pillars of the Ramsar Convention. These are: the concepts of wise use; designation of Wetlands of International Importance (Ramsar sites); and international cooperation. The synergy of these measures would enhance the capacity of wetlands to support human wellbeing and national development, to perform their conventional ecological processes as well as to act as biomes of nature.

The Concept of Wise Use

Broad Strategies

A revised definition of the concept of wise use of wetlands that reflects the objectives of the Ramsar Convention, the Convention on Biological Diversity (CBD), the Millennium Ecosystem Assessment and the Brundtland Commission's definition of sustainable development is 'the maintenance of [wetlands'] ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development' (Ramsar Convention Secretariat 2010). Use of traditional knowledge, poverty alleviation, climate change mitigation and adaptation as well as prevention of natural disasters and diseases are key tenets of ensuring wise use of wetlands (Ramsar Convention Secretariat 2008).

Paul Mannix /Flickr

Elephant-bird symbiosis at work in a swamp within Amboseli National Park.

As reaffirmed in the 2008 Changwon Declaration on human wellbeing and wetlands and as discussed in Chapter 4, because wetlands provide a range of ecosystem and ecological services that are vital to human beings, their wise use is especially important. The Ramsar Strategic Plan 2009-2015 (Ramsar Convention Secretariat 2008) lays out 10 broad strategies for achieving this. These are set out in Box 7.1.

Box 7.1: Strategies for achieving wise use of wetlands.

1 *Wetland inventory and assessment* – describe, assess and monitor the extent and condition of all types of wetlands.

2 *Global wetland information* – develop a global wetland information system in order to increase accessibility to wetlands information and data.

3 *Policy, legislation and institution*s – develop and implement policies, legislation and practices, and establish appropriate institutions to ensure effective implementation of Ramsar Convention provisions on wise use.

4 *Cross-sectoral recognition of wetland services* – increase stature of wetlands in decision-making owing to the varied benefits these ecosystems provide.

5 *Recognition of the role of the Convention* – raise the profile of the Convention by highlighting its unique capacity to enhance wetland ecosystem management and promote the potential of the Convention to meet the targets of other international conventions.

6 *Science-based management of wetlands* – ensure that national policies and wetland management plans are based on the best available scientific knowledge, including technical and traditional knowledge.

7 *Integrated Water Resources Management (IWRM)* – ensure that IWRM, which applies an ecosystem-based approach, is included in the planning and decision-making processes, particularly concerning groundwater management, catchment/river basin management, coastal and nearshore marine zone planning, and in climate change mitigation and adaptation.

8 *Wetland restoration* – identify wetland sites and systems where restoration or rehabilitation would be beneficial and yield long-term environmental, social, or economic benefits, and implement the necessary measures to recover them.

9 *Invasive alien species* – develop a national inventory of invasive alien species that currently or potentially impact the ecological character of wetlands, especially Ramsar sites and promote actions to prevent, control or eradicate such species in wetland systems.

10 *Private sector* – encourage the involvement of the private sector in the conservation and wise use of wetlands.

Source: Abridged from Ramsar Convention Secretariat 2008

Urgent Issues

Policy and Legal Framework

As discussed in Chapter 1, Kenya has made some strides in putting in place a wetland regulatory framework. In addition to ratifying the Ramsar Convention in 1990 and enacting EMCA which contains general provisions on wetlands in 1999, the 2009 EMCA Wetland Regulations contain a set of wide-ranging measures on these important ecosystems.

However, while these regulations are comprehensive, their effective implementation is hampered by the fact that as subsidiary legislation, they do not enjoy the same prominence and legal authority as Acts of parliament. The country therefore needs to urgently formulate a national wetlands policy which would set out broad strategic goals to ensure wise use of the country's wetlands, and enact a statutory wetlands law. The policy and law should be cross-cutting and address the mandates of the ministries and institutions responsible for the environment, natural resources, water, irrigation, agriculture, fisheries and national planning that impinge on the wise use of wetlands. These ministries and institutions are detailed in Table 7.1.

Wetland Inventory

Kenya is in dire need of a wetlands inventory. Developing a comprehensive and technically proficient database on the country's wetlands and wetland resources such as faunal and floral species would serve a range of objectives. First, the pioneer wetlands inventory would form an important baseline against which future changes can be identified and trends assessed. Second, it would make the classification of the country's wetlands possible. Third, mapping these ecosystems would draw attention to those that are in pressing need of protection or rehabilitation.

Fourth, the inventory would highlight threatened or endangered water-dependent biodiversity populations, enabling targeted and timely corrective measures to be taken. Fifth, a widely disseminated inventory would rouse the interest of a range of stakeholders, including the general public, to advocate for actions that promote wise use. It would also increase public scrutiny of decisions that concern wetlands. Should human and financial resources permit, the inventory should be GIS-based to facilitate the easy capturing, storage and analysis of data.

Integrated Water Resources Management (IWRM)

Integrated water resources management (IWRM) is a framework for the sustainable development, apportionment and monitoring of water resources in order to ensure that economic, social and environmental imperatives are adequately balanced (GWP 2000; Cap-Net 2007).

Box 7.2: The Dublin Principles.

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2. Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
3. Women play a central part in the provision, management and safeguarding of water.
4. Water has an economic value in all its competing uses and should be recognized as an economic good.

Source: WMO 2012

Table 7.1: Ministries and institutions whose mandates affect wetland use.

Ministry/ institution	Main roles and responsibilities	Legislative framework
Ministry of Water and Irrigation	Formulate water and irrigation policies, initiate and oversee drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation.	• Water Act (No. 8 of 2002).
Water Resources Management Authority (WRMA)	Develop procedures for water allocation; reassess the national water strategy; issue water permits; protect water resources quality from adverse impacts; manage and protect water catchments; gather and maintain water information; liaise with other actors for better management of water resources.	• Water Act (No. 8 of 2002).
Catchment Area Advisory Committees (CAACs)	Advise WRMA on water conservation, use and apportionment; issue water permits at catchment level.	• Water Act (No. 8 of 2002).
Water Resources Users Associations (WRUAs)	Ensure cooperative management of water resources at the catchment level; conflict resolution.	• Water Act No. 8 of 2002).
Water Services Regulatory Board (WASREB)	Promote water conservation and demand management; periodically reassess water management strategy; issue licences and determine water standards.	• Water Act (No. 8 of 2002).
Water Services Boards (WSBs)	Ensure efficient and economical provision of water and sewerage services.	• Water Act (No. 8 of 2002).
Water Service Providers (WSPs)	These local bodies are set up for the provision of water and sewerage services under licence from WSBs.	• Water Act (No. 8 of 2002).
Water Services Trust Fund (WSTF)	Finance provision of water and sanitation to disadvantaged groups.	• Water Act (No. 8 of 2002).
Water Appeal Board (WAB)	Determine disputes in the water sector.	• Water Act (No. 8 of 2002)
National Water Conservation and Pipeline Corporation (NWCPC)	Construct dams and drill boreholes.	• State Corporations Act (Cap.446).
Kenya Water Institute (KEWI)	Carry out training, research and consultancies in the water sector.	• Kenya Water Institute Act (No. 11 of 2001).
National Irrigation Board (NIB)	Develop irrigation infrastructure and manage irrigation schemes.	• Irrigation Act (Cap 347).
Ministry of Forestry and Wildlife	Formulate forestry and wildlife policies, initiate and oversee drafting of relevant legislation, sector coordination and guidance, monitoring and evaluation.	• Forests Act (No. 7 of 2005) • Wildlife (Conservation and Management) Act (Cap 376).
Kenya Wildlife Service (KWS)	Conserve wildlife and their ecosystems; National Ramsar administrative authority.	• Wildlife (Conservation and Management) Act (Cap 376).
Kenya Forestry Service (KFS)	Conserve, develop and sustainably manage Kenya's forest resources for the country's social-economic development.	• Forests Act (No. 7 of 2005).
Kenya Forestry Research Institute (KEFRI)	Carry out research in forestry and related natural resources.	• Science and Technology Act (Cap. 250).
Ministry of Environment and Mineral Resources	Formulate environmental laws and policies, monitor, protect, conserve and manage the environment and natural resources by ensuring sustainable utilization.	• Environmental Management and Coordination Act (No. 8 of 1999).
National Environment Management Authority (NEMA)	Coordinate environmental management; provide guidance on the development of wetland management plans; ensure compliance of environmental laws.	• Environmental Management and Coordination Act (No. 8 of 1999).
Department of Resource Surveys and Remote Sensing (DRSRS)	Collect, store, analyse and disseminate geo-spatial information on natural resources to facilitate informed decision-making for sustainable management of these resources.	• Environmental Management and Coordination Act (No. 8 of 1999).
Ministry of Fisheries Development	Formulate policies, oversee drafting of relevant legislation, policy formulation, sector coordination and guidance, monitoring and evaluation.	• Fisheries Act (Cap 378).
Kenya Marine and Fisheries Research Institute (KMFRI)	Conduct aquatic research in the country's waters and the corresponding riparian areas including the Exclusive Economic Zone.	• Science and Technology Act (Cap. 250).
National Museums of Kenya (NMK)	Promote Kenya's heritage by collecting and preserving artefacts and research.	• National Museums and Heritage Act (No. 6 of 2006).
Ministry of Public Health and Sanitation	Develop and implement public health and sanitation policies and establish primary health care interventions at individual, household, community and primary health facility levels in order to make the country free from preventable diseases and ill health.	• Public Health Act (Cap. 242).
Ministry of Lands	Formulate and implement the national land policy, oversee drafting of land laws, register land transactions, undertake physical planning, land surveys and mapping, land adjudication and settlement, land valuation and administration of state and trust land.	• Land Registration Act (No. 3 of 2012) • The Land Act (No 6 of 2012).
District Environmental Committees (DECs)	Provide technical support for environmental management including all ecosystems and integrate wetland protection into district development plans.	• Environmental Management and Coordination Act (No. 8 of 1999).
Civil Society Organizations (CSOs)	Implement community and government projects and programmes; lobby for policy and legal reform; mobilize technical and financial support for programmes.	• NGO Coordination Act (No. 19 of 1990).
Development partners	Mobilize resources for implementation of various projects in priority sites and implement activities through counterparts and local partners.	

The concept is predicated on the perception of water as a natural resource, as a vital component of ecosystems and as an economic and social good (UNDP 1990). The four Dublin Principles which are contained in the Dublin Statement on Water and Sustainable Development (Box 7.2) are central to IWRM. Because wetlands act as natural water infrastructures, utilizing the IWRM approach would facilitate the wise use of wetlands.

Figure 7.1: Application of the IWRM concept to manage the competing uses of water.

Source: Adapted from GWP 2000

The IWRM concept is also based on the realization that besides the environment, water is often used by several competing interests. This state of affairs is illustrated in Figure 7.1.

Invasive Alien Species

Chapter 5 has flagged invasive alien species as one of the major threats to Kenya's wetlands. As already discussed, some of these species include the Nile Perch, whose introduction in Lake Victoria in the 1960s has led to near-extinction of the lake's endemic cichlid species. The Common carp (*Cyprinus carpio*) also preys on Lake Naivasha's indigenous fish species and is therefore reducing the water body's biodiversity. *Salvinia sp.*, a floating fern and bulrush (*Typha sp.*) have also invaded many of the country's wetlands.

However, the invasive alien species that has proved hardest to eliminate is the water hyacinth (*Eichhornia crassipes*) which has colonized many of the country's natural and artificial wetlands. It has also proved difficult to eliminate from important transboundary water bodies such as Lake Victoria and concerted regional efforts are needed to weed it out.

Wetlands of International Importance (Ramsar Sites)

Broad Strategies

The second pillar provided for by the Ramsar Convention is raising the area occupied by Ramsar Sites by implementing the *Strategic framework and guidelines for the future development of the list of Wetlands of International Importance*. As such, as a Contracting Party to the Convention, it is incumbent upon Kenya to identify suitable wetlands—such as those that are important for supporting human life and migratory biodiversity such as waterbirds and fish—for designation as Ramsar Sites. Once these wetlands are added to the Ramsar List, the country is obligated to routinely monitor and effectively manage the designated sites.

The current *Ramsar Strategic Plan* outlines several strategies for achieving this goal. These are summarized in Box 7.3.

A woman fetching water from an unimproved water source.

Box 7.3: Strategies for developing and maintaining Ramsar Sites.

1. To step up identification of potential Ramsar Sites by applying the relevant guidelines and Strategic Framework.
2. Management planning of new Ramsar Sites – encourage the preparation of wetlands that are proposed for addition to the Ramsar List.
3. Maintain the Ramsar Site ecological character through planning (e.g. preparation of effective management plans) and management (e.g. zoning and establishment of cross-sectoral site management committees).
4. Review Ramsar Site management effectiveness – periodically review all existing Ramsar Sites to determine the effectiveness of management measures.
5. Ramsar site status – monitor the condition of Ramsar sites and tackle deterioration in their ecological character, and notify the Ramsar Secretariat of these changes.
6. Management of other internationally important wetlands – apply best practices achieved for Ramsar Sites for undesignated but internationally important wetlands.

Source: Abridged from Ramsar Convention Secretariat 2008

Urgent Issues

Designation of New Ramsar Sites

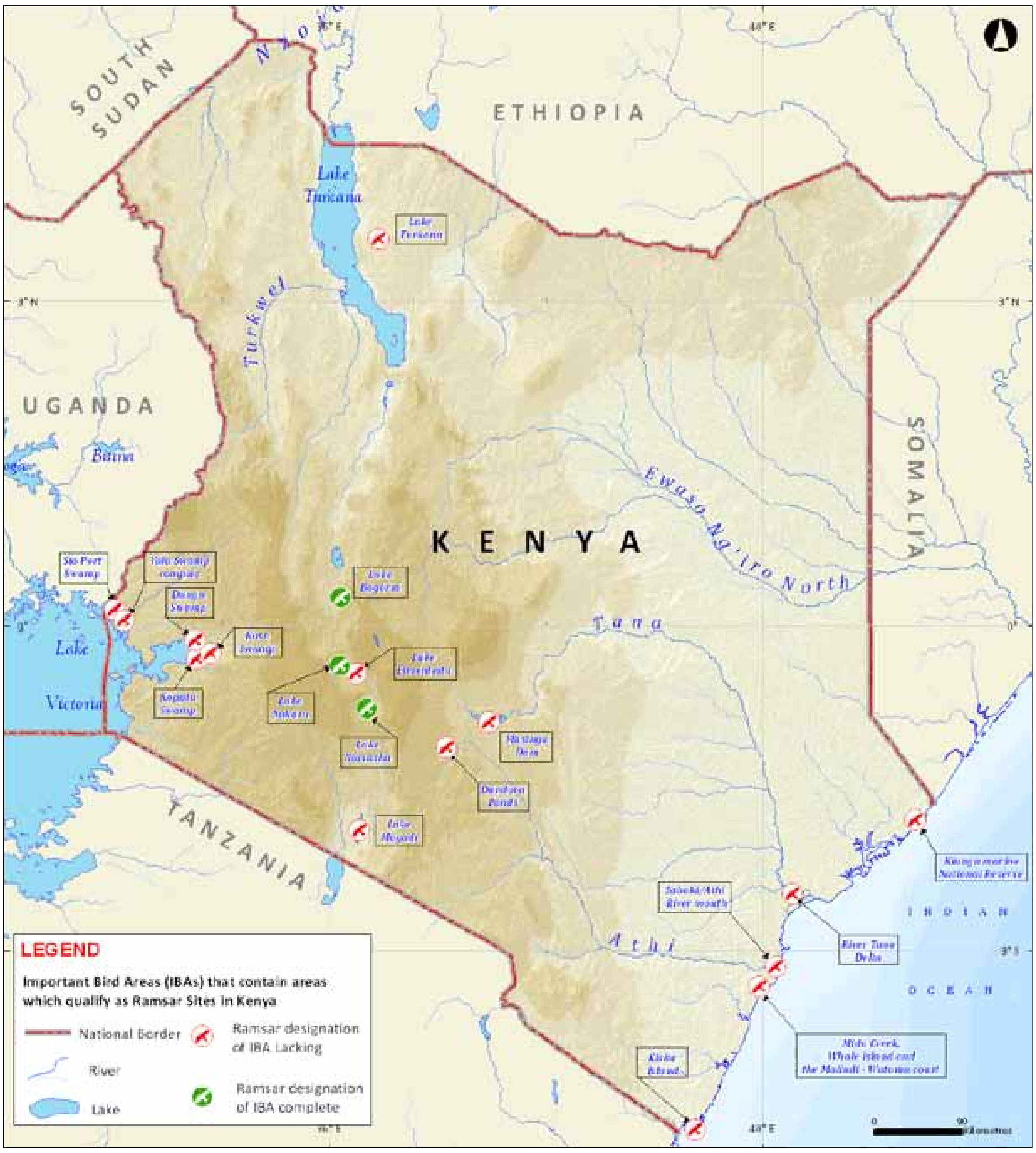
Kenya should intensify efforts to identify new sites for designation as Wetlands of international Importance (Ramsar Sites) in order to increase the country's Ramsar Sites from the current five. This would help to augment the global ecological network.

Large wetlands that are important migratory flyways that are nevertheless undesignated are Yala Swamp, Tana River Delta, Saiwa Swamp and the Sio-Siteko wetland system (Kenya Wetland Forum 2010). Birdlife International recommends designation of an additional 15 important bird areas (IBA) which contain three of the wetlands recommended by the Kenya Wetlands Forum and 12 others (Birdlife International 2002). The listed sites as well as those recommended for listing by Birdlife International are contained in Figure 7.2 and Table 7.2.

Degraded Wetland Restoration

Efforts should be made to restore and rehabilitate degraded wetlands because in their current state, they are unable to perform their ecological functions and provide the breadth of ecosystem services that support life.

Figure 7.2: Map of Important Bird Areas (IBAs) that are designated as Ramsar Sites and those recommended for designation.



Source: Birdlife International 2002

Table 7.2: List of Important Bird Areas (IBAs) that are designated as Ramsar Sites and those recommended for designation.

Important Bird Area (IBA) name	IBA area (ha)
Ramsar designation of IBA complete	
Lake Bogoria National Reserve	10 700
Lake Naivasha	23 600
Lake Nakuru National Park	18 800
Ramsar designation of IBA lacking	
Kisite island	1
Kiunga Marine National Reserve	25 000
Mida Creek Whale Island and the Malindi–Watamu coast	26 100
Sabaki River mouth	20
Tana River Delta	130 000
Lake Turkana	756 000
Masinga reservoir	100 000
Dandora ponds	300
Dunga swamp	100
Koguta swamp	200
Kusa swamp	350
Yala swamp complex	8 000
Lake Elementaita	7 200
Lake Magadi	10 500
Sio Port swamp	400

Source: Birdlife International 2002

Table 7.3: Challenges affecting water management in the six catchment areas.

Catchment area	Primary challenges
Athi (67 337 sq. km.)	• Acute water scarcity due to demand exceeding availability • Pollution of water resources from agro-industries and waste disposal • Catchment degradation due to overgrazing and sand harvesting • Over-exploitation of surface and ground water resources.
Ewaso Ng'iro North (213 731 sq. km.)	• Acute water scarcity due to demand exceeding availability • High salinity of groundwater in certain areas underlain by basement rocks and colluvial deposits • Catchment degradation due to overgrazing, poor farming practices and encroachment into wetland areas.
Lake Victoria South (18 613 sq. km.)	• Degradation of water resources from both point and non-point sources of pollution • Degradation of water catchment areas as a result of deforestation of water towers • Frequent flooding along the shores of Lake Victoria.
Lake Victoria North (32 384 sq. km.)	• Degradation of water resources from both point and non-point sources of pollution • Catchment degradation through soil erosion, siltation, landslides, deforestation, destruction of springs and human encroachment into the watershed • Depletion of water resources through planting of exotic trees • Flooding in the lower reaches of the Nzoia and Yala Rivers, and the Namanjalala area in Trans Nzoia District.
Rift Valley (138 459 sq. km.)	• Degradation of water resources from both point and non-point sources of pollution • Illegal abstractions and over-exploitation • Quarrying and mining along river banks • Human encroachment into and destruction of the watershed.
Tana (120 925 sq. km.)	• Acute water scarcity • Degradation of water resources from both point and non-point sources of pollution • Catchment degradation in Mount Kenya and the Aberdare Range slopes, soil erosion and overgrazing in the lower parts of the region • Human encroachment into the watershed • High salinity of ground water (due to salt water intrusion) in the lower Tana due to over-exploitation • Increased water resource demand owing to urbanization and industrialization.

Source: WRMA 2009

The problems that bedevil the country's main water sources, many of which are wetlands, in the six catchment areas are listed in Table 7.3.

Some of the severely degraded wetlands that need to be urgently rehabilitated are the Kimana wetlands and Lake Bogoria. The main challenges faced by the Kimana wetlands are excessive water abstraction and over-cultivation (Wetlands International 2012). As detailed in Chapter 5, some of the factors that have led to the degradation of Lake Bogoria are livestock over-stocking and concomitant over-grazing as well as massive deforestation on the slopes of the highlands that are adjacent to the lake leading to heavy siltation of the wetland (Johansson and Svensson 2002).

International Cooperation

Broad Strategies

The third pillar of the Ramsar Convention is international cooperation with the Ramsar-stipulated strategies being set out in Box 7.4. As a signatory to the Convention, Kenya is encouraged to, relying on among others, the *Guidelines for international cooperation under the Ramsar Convention*, foster international cooperation that results in the wise use and conservation of the country's wetlands.

Box 7.4: Strategies for enhancing international cooperation.

1. Synergies and partnerships with MEAs and intergovernmental agencies – strengthen partnerships with secretariats of regional and international MEAs (e.g. CBD, UNCCD and UNFCCC) and other intergovernmental agencies (e.g. UNEP, UNDP, FAO, WHO, EAC, NEPAD and the European Community).
2. Regional initiatives – establish new and strengthen existing initiatives.
3. International assistance – seek international assistance for the conservation and wise use of wetlands, and ensure that environmental assessments and other safeguards are an integral component of all development projects that affect wetlands, including foreign and domestic investments.
4. Sharing information and expertise with the Ramsar Secretariat and other Contracting Parties to the Convention.
5. Shared wetlands, river basins and migratory species – promote cooperation for the management and monitoring of shared wetlands, hydrological basins, and wetland-dependent species.

Source: Abridged from Ramsar Convention Secretariat 2008

Rhinoceros at Lake Nakuru.

Patrick Meier/Flickr

The international cooperation pillar is especially relevant to the management of transboundary wetlands and hydrological systems such as Lake Victoria, Lake Turkana and Lake Chala as besides promoting collective action on these resources, handling wetland issues through regional and international mechanisms will help to avert conflict over these ecosystems and their resources.

Urgent Issues

Regional Initiatives

A number of regional initiatives, such as the Lake Victoria Basin Commission (LVBC), Lake Victoria Fisheries Organization (LVFO) and the Nile Basin Initiative (NBI) have been formulated in order to foster regional cooperation for the management of several wetlands including Lake Victoria. A management plan for the Sio-Siteko wetlands was also jointly formulated by Kenyan and Ugandan stakeholders (NBI 2009).

The challenge is to replicate these initiatives to encompass other critical wetlands that are shared by Kenya and the neighbouring countries. Possible candidates for this are the Mara river system which is the lifeblood of the coterminous Maasai Mara and Serengeti protected areas, as well as Lake Turkana.

Lake Turkana's future continues to be uncertain following the decision by Ethiopia to proceed with the construction of the Gibe III Hydroelectric dam on River Omo which is the lake's primary inlet. Equally, the consequences for wetland integrity of the recent discovery of oil in Ngamia-1 well on Block 10BB, in the Lokichar basin of Turkana County by Tullow Oil could be of concern to Ethiopia and South Sudan. Establishing a regional body that addresses environmental concerns as they arise would enhance good neighbourliness but also help to avert conflict at the community and national levels.

Partnerships with MEAs and Intergovernmental Agencies

As Kenya does not yet have a national wetland policy and statutory law in place, it will have to surmount a steep learning curve in order to ensure wise use of its wetlands. Forming partnerships and increasing collaboration with the secretariats of MEAs such as Ramsar, CBD, UNCCD and UNFCCC and intergovernmental agencies such UNEP, UNDP and EAC would enable national institutions to quickly replicate proven international best practices.


Cape Buffalo at Lake Nakuru.

Ross Pollack/Flickr

International Assistance

The country's capacity to ensure sustainable wetland management may continue to be hindered by resource and capacity constraints as well as scientific knowledge and technology gaps. As Kenya embarks on the path to wetland wise use, it may be necessary to mobilize international assistance to help address many of the pressing issues. Drafting the national wetlands policy and law may, for example, require capacity building of legislative drafters and facilitation of consultative forums at the national, county and grassroots levels. Developing a comprehensive wetlands inventory, on the other hand, may require both capacity building and technology transfer. International assistance may have to be sought because it may not be possible to accommodate these needs in a national budget.

Conclusion

As is demonstrated in this Atlas, Kenya is endowed with a wealth of wetland types and sizes. These wetlands are vital to assuring sizeable portions of the country's population, particularly the poor, of water, food and nutrition security as well as sources of livelihood. However, owing to lack of an authoritative and comprehensive regulatory framework, many of these wetlands are beset with a series of formidable anthropogenic and climate change and variability induced challenges. In order to reverse these worrying trends and ensure sustainable management of the vital ecosystems, the country needs to embrace a raft of measures under the Ramsar Convention's main pillars of wise use; designating and managing Wetlands of International Importance; and international cooperation.

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