KENYA

Atlas of Our Changing Environment

UNEP

RCMRD

USGS
science for a changing world

Government of Norway

ISBN: 978-92-807-2995-5

Job Number: DEW/1129/NA

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For bibliographic and reference purposes this publication should be referred to as:

UNEP (2009), "Kenya: Atlas of Our Changing Environment."
Division of Early Warning and Assessment (DEWA)
United Nations Environment Programme (UNEP)
P.O. Box 30552
Nairobi 00100, Kenya

This book is available from Earthprint.com, http://www.earthprint.com

Printed by ProgressPress Co. Ltd., Malta

Distribution by SMI London

The following organisations collaborated on this Atlas:

- United Nations Environment Programme (UNEP)
- Government of Kenya (GoK)
- Regional Centre for Mapping of Resources for Development (RCMRD)
- United States Geological Survey (USGS)

The funding support for this Atlas was provided by the Government of Norway. United States Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, the host of UNEP/GRID-Sioux Falls, provided all the necessary support needed for visiting scientists and production of this Atlas.

Special thanks are extended to the United States Department of State, the National Aeronautics and Space Administration (NASA), the US National Geospatial-Intelligence Agency (NGA), Planet Action Initiative, ©CNES 2008, Distribution Spot Image S.A., France, and Google Earth for providing access to satellite data. Appreciation is also extended to Environmental Systems Research Institute (ESRI) for software support.

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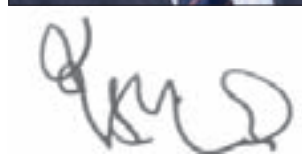
MINISTRY OF ENVIRONMENT AND MINERAL RESOURCES



Honorable John Michuki, EGH, MP
Minister for Environment and Mineral Resources

Kenyan's livelihoods are closely linked to their access to natural resources. As our population increases and environmental quality continues to decline, there is an increased risk of social and economic destabilization, which will have significant impacts on overall national security. Rural people are among the most vulnerable and insecure in terms of poverty, health, food security, economic losses, and conflicts resulting from competitive access to natural resources, among other factors.

The country is already witnessing an increased frequency of resource-use conflicts in the north-eastern and north-western regions. There are tensions among downstream and upstream communities in some river systems, for example. Extreme climatic events such as floods and drought are affecting an increasingly larger proportion of the rural population and introducing shocks into Kenya's macro-economy. The overall success of Vision 2030 therefore hinges on how well we manage the environment over the next 25 years.

Now is the time for strategic thinking and planning. To do this in a rapidly evolving situation demands the provision of credible and timely environmental information. This information should be easily understood and used by every Kenyan who makes daily decisions related to managing his or her environment. The Ministry of Environment and Mineral Resources is thus very pleased to launch *Kenya: Atlas of Our Changing Environment*, which gives every Kenyan and all our development partners a vivid picture of what is happening to our ecosystems, which are the basis of our very survival.

The government of Kenya is extremely indebted to UNEP for its support in preparing this Atlas. Indeed, it is honoured to host this very important global institution at a critical time when decisions about how we manage the global environment can determine humanity's continued existence. As a nation, we are determined to take full advantage of UNEP's presence in Kenya to fortify our capacity in environmental management and take full charge of our destiny.

I would like to congratulate all those experts, national and international, as well as development partners whose dedication and contribution has made this stunning publication possible in record time!

The value of the information in this publication is priceless, but can only be demonstrated through the actions we will take as individuals and as a nation to restore the integrity of our natural resources. It is my sincere hope that what we read and see in this report will inspire all of us into action. "Seeing is believing". I wish you a good reading.

Foreword

UNEP

Achim Steiner
United Nations Under Secretary-General, and Executive Director, United Nations Environment Programme

Economic development in Kenya is largely underpinned by the quality and integrity of the country's rich natural resource base, which has also helped it maintain a strategic position in the region. The country is renowned for its nature-based tourism and has some of the world's best and most-visited national parks. The climate supports a vibrant agricultural sector and its forests and savannas are rich in biodiversity and impressive wildlife numbers, which support the profitable tourism sector. Environmental change in the form of degradation is threatening the natural resource base, however, and therefore affecting Kenyan livelihoods.

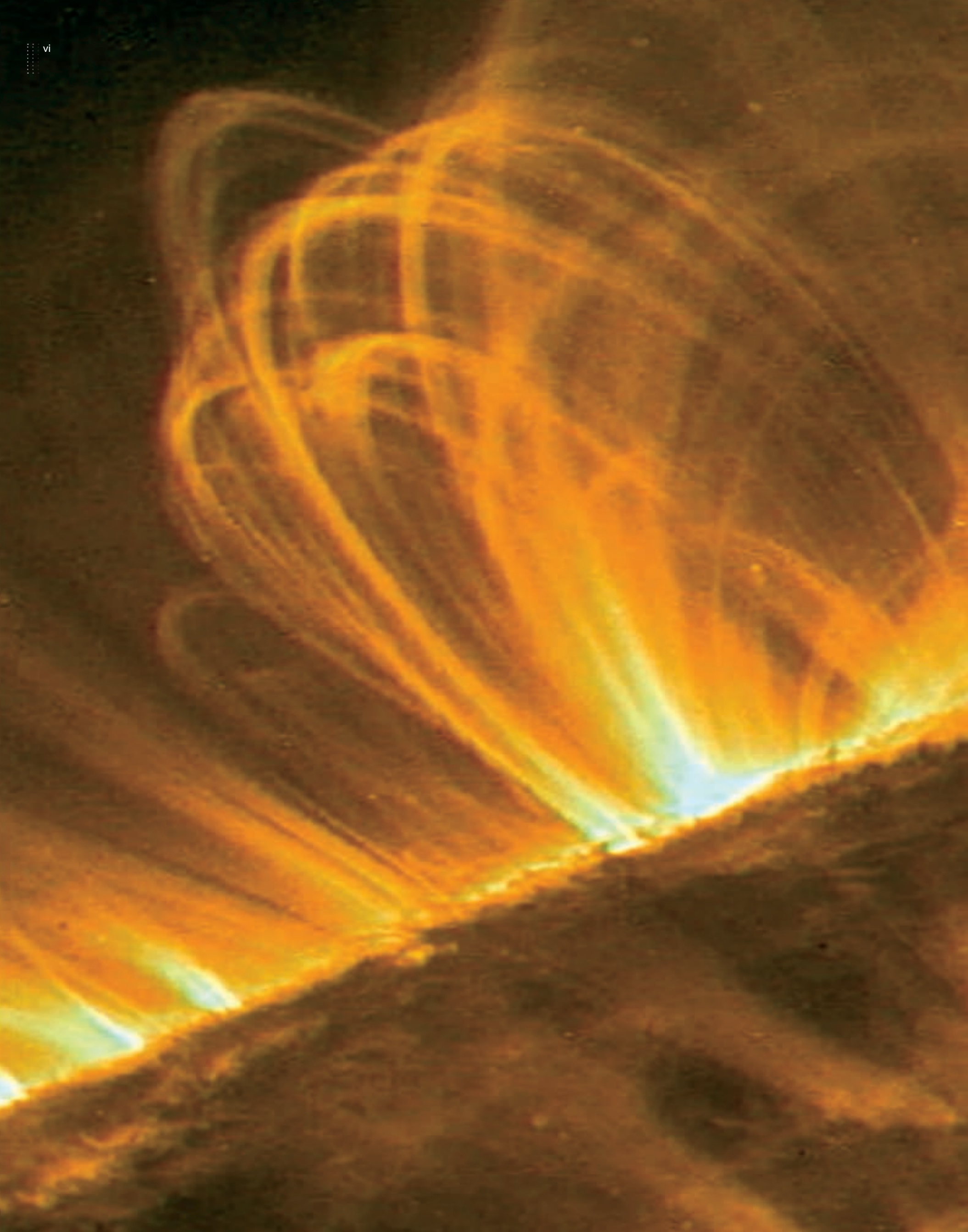
Kenya: Atlas of Our Changing Environment, produced at the request of the Kenya Government, provides visual and compelling evidence of the rapid changes taking place in the country's critical ecosystems due to pressures from human activities. The side-by-side display of historical and current remote-sensing images highlight forest degradation, wetland drainage, and shrinking lakes to the impacts of refugees on fragile ecosystems and signs of coastal degradation. The Atlas provides a good evidence base for strategic intervention by the government and communities.

The Atlas is thus an important resource for setting the context and establishing a baseline for the realization of Kenya's Vision 2030. Among the ways it does this are the following:

- Discussing the contribution of key natural resources to the achievement of Vision 2030 by describing the interlinkages between major socio-economic activities in the country to the environment. Examples include the link between energy supplies, which underpin industrial development including tourism, and forest ecosystems that collect and store water in Kenya's five "water towers," and the link between agricultural productivity and forests, which regulate the micro-climates that make farming possible.
- By focusing on Kenya's progress towards achieving Millennium Development Goal 7, which aims to ensure environmental sustainability, it provides an opportunity for the country to re-examine practical strategies for making rapid progress towards achieving this goal. It can do this by addressing salient environmental challenges explored in the Atlas, such as protecting water sources from point-source pollution and conserving water catchments, among others.

The Kenya government's request for support to produce this Atlas, which came immediately after the launch of *Africa: Atlas of Our Changing Environment*, demonstrates the government's desire to bring scientific evidence of environmental change derived from Earth observation science to the fore of Kenya's natural resources management to help make decisions that will stand the test of time. This national Atlas for Kenya is the latest in a series of UNEP Atlases of environmental change, following the aforementioned Africa atlas and the highly successful global atlas, *One Planet Many People*.

UNEP would like to thank the government of Kenya for taking the initiative, the government of Norway for its generous financial contribution, our United Nations partners in Kenya, as well as the United States government whose support through agencies made the satellite data analysis possible.

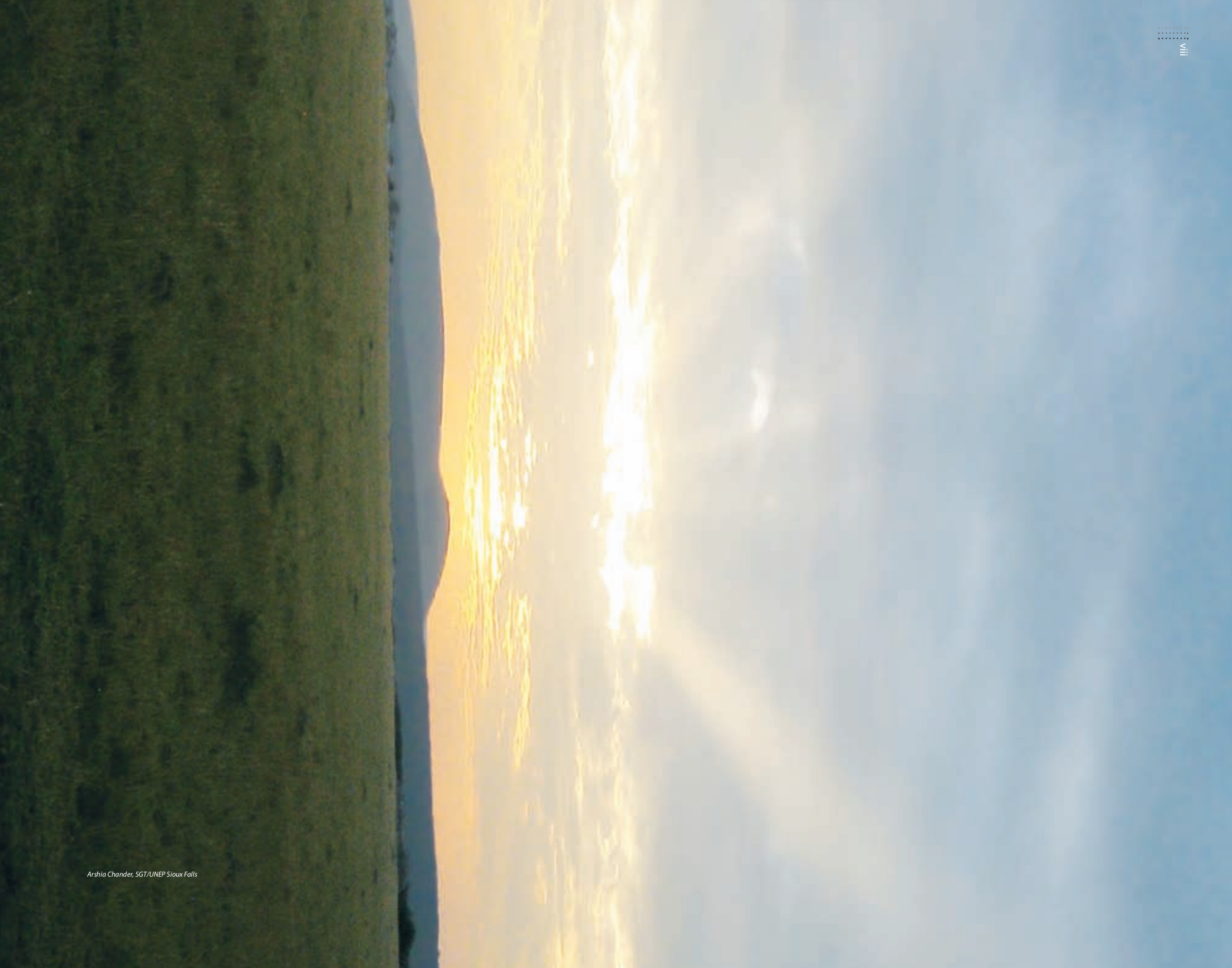


The Sun

The Sun drives most of the processes that make life on Earth possible. In fact, the Sun helped create our planet. The Earth is composed of matter collected around the Sun over billions of years due to the Sun's gravity. Even from some 149 million kilometres away, the sun warms the Earth's surface by 250ºC. It drives our weather, ocean currents, and photosynthesis. Its no wonder many ancient societies revered it.

The Sun's effect on Earth varies with location. For example, at the poles, the Sun's rays hit the Earth at an indirect angle. The Sun disappears for weeks during the winter but shines 24 hours a day during the summer. Kenya, on the other hand, straddles the equator, where the sun's rays strike at an angle of nearly 90º. It drives the rainy season and makes plant life possible, including Kenya's forests and crops.

http://www.gsfc.nasa.gov/gsfc/spacesci/sunearth/tracecl.htm



Arshia Chander, SGT/UNEP Sioux Falls

"Kenya aims to be a nation living in a clean, secure, and sustainable environment by 2030"

-Kenya Vision 2030
(GoK 2007)

Chapter 1: Environment and Vision 2030

As a newly industrializing country, Kenya faces the challenge of improving its economic performance and the lives of its citizens without undermining the environment upon which so much of its national earnings and individual people's livelihoods depend. This chapter introduces the theme of environmental change in Kenya through the lens of the country's long-term national development plan known as Kenya Vision 2030. It looks at a select number of salient and emerging issues that need to be considered to achieve the Vision's goals and targets, including how to protect the country's water sources that feed hydropower, support wildlife and tourism destinations, irrigate both export and small holder farms, and nurture grazing areas. It also highlights the importance of planning for weather-related disasters to enable development goals to be achieved.

Kenya's Vision 2030

Kenya Vision 2030 is the country's new development blueprint for the period 2008 to 2030. It aims to make Kenya a "middle income country providing high quality life for all its citizens by the year 2030". The first phase of the Kenya Vision 2030 covers the period 2008 to 2012 during which a number of "flagship" projects will be implemented. Vision 2030 is based on three pillars: the economic pillar, the social pillar, and the political pillar. In one way or another, these pillars are all interrelated and the fibre that binds them together

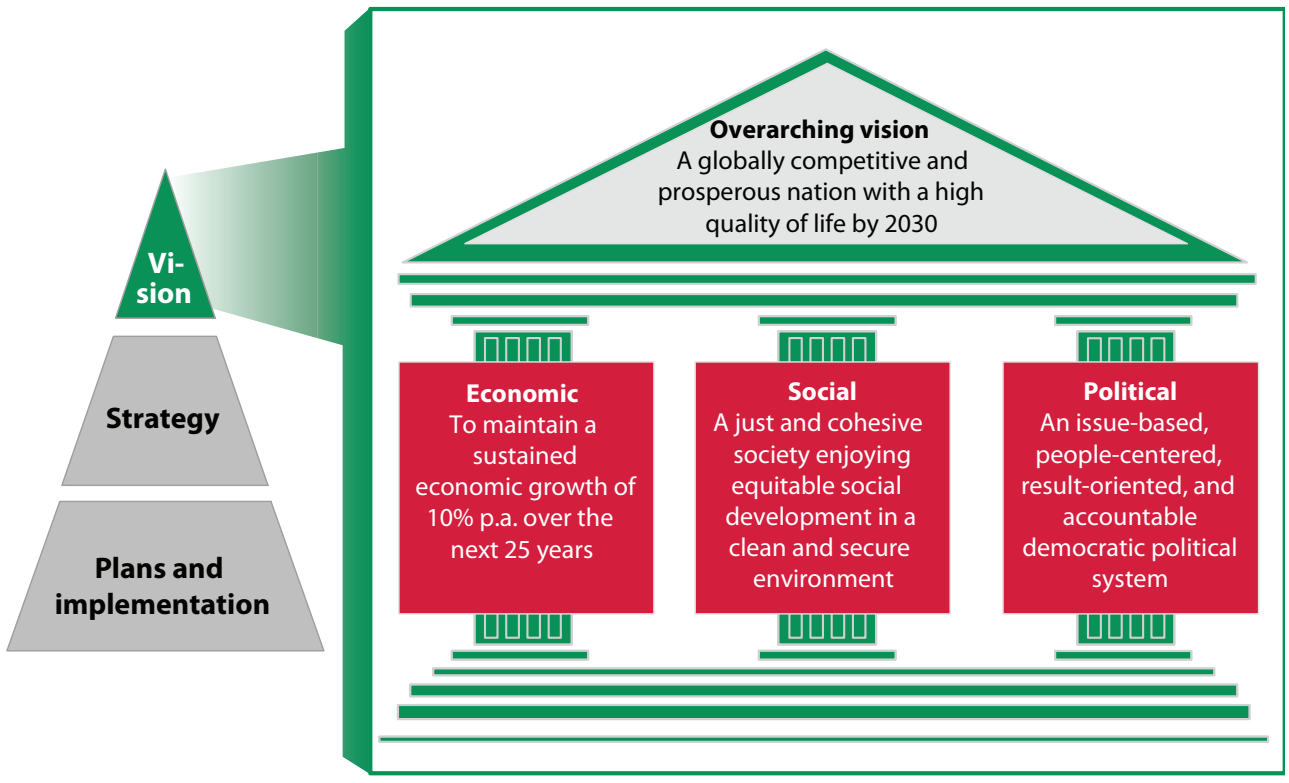
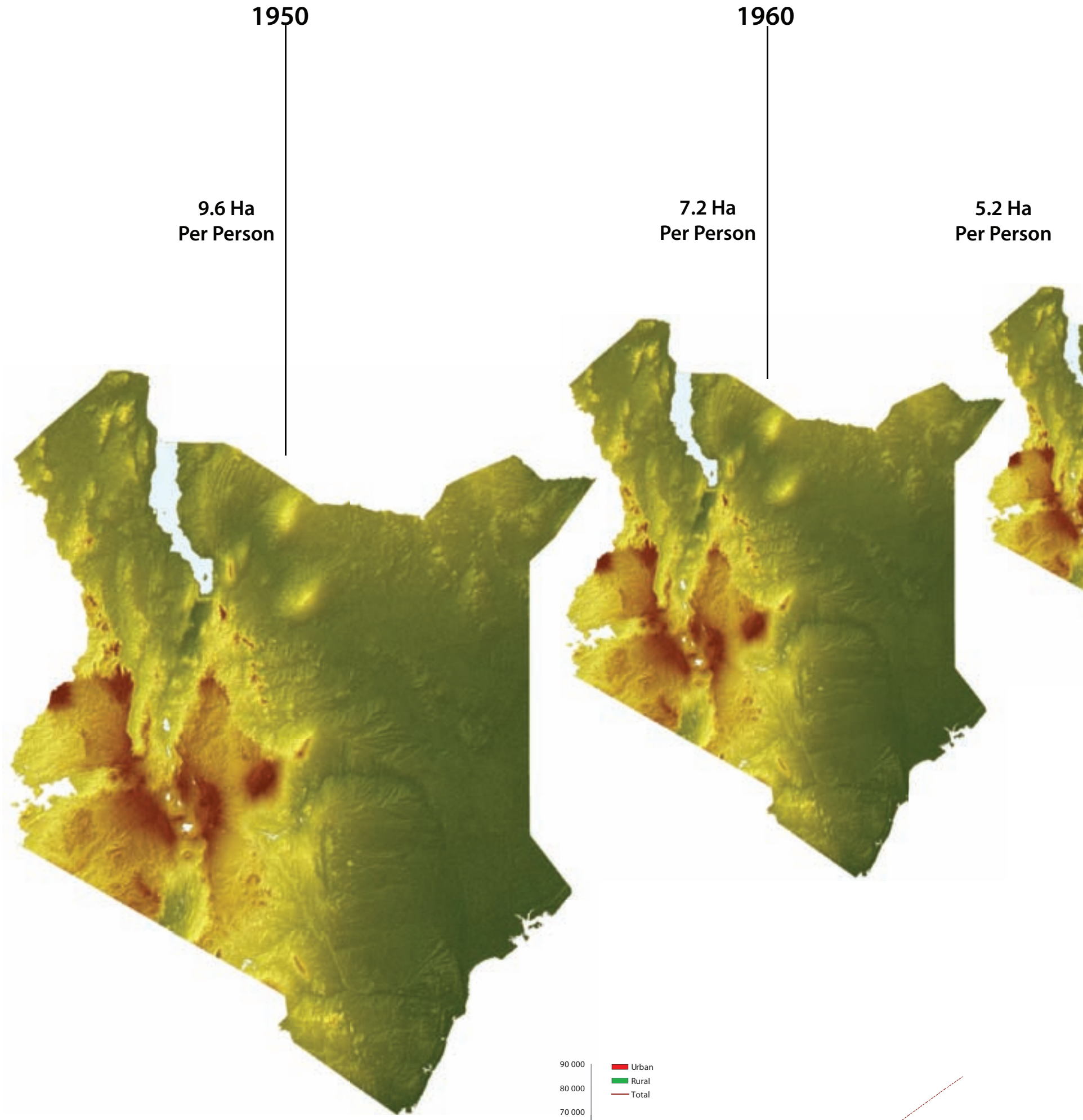


Figure 1: Thematic overview of the Kenya Vision 2030 (Source: GoK 2007)

Sunrise Over Maasai Mara

The 1 510 km² Maasai Mara Game Reserve is one of the greatest regions of migrating wildlife in the world. It is shared by Kenya and the United Republic of Tanzania. Every year, herds of wildebeest, zebras and other herbivores migrate between Maasai Mara and Serengeti National Park (Tanzania) during the Great Migration (July - October)



is the natural environment, with its inherent supply of renewable and non-renewable goods and services.

Development objectives and the need to protect and maintain the natural environment must go hand in hand. This is because environmental sustainability, including the conservation of biodiversity, underpins human well-being (UN 2005). Our natural environment not only provides us with the basic goods needed for sustenance, such as water, food, and fibre, but it also purifies the air and water, produces healthy soils, cycles nutrients, and regulates the climate. These ecosystem services provided by the environment

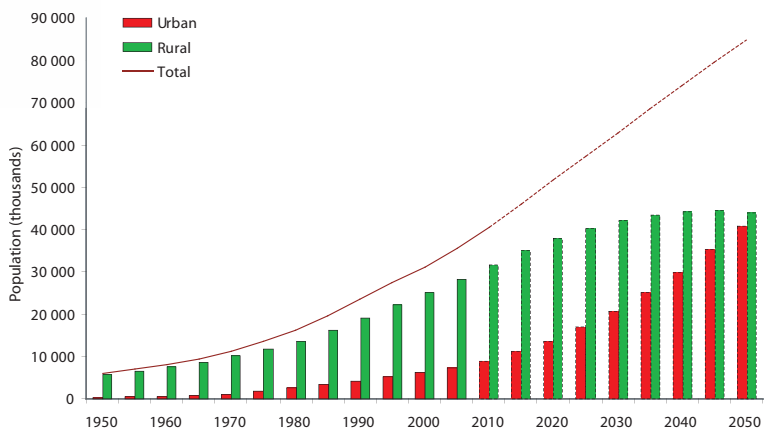
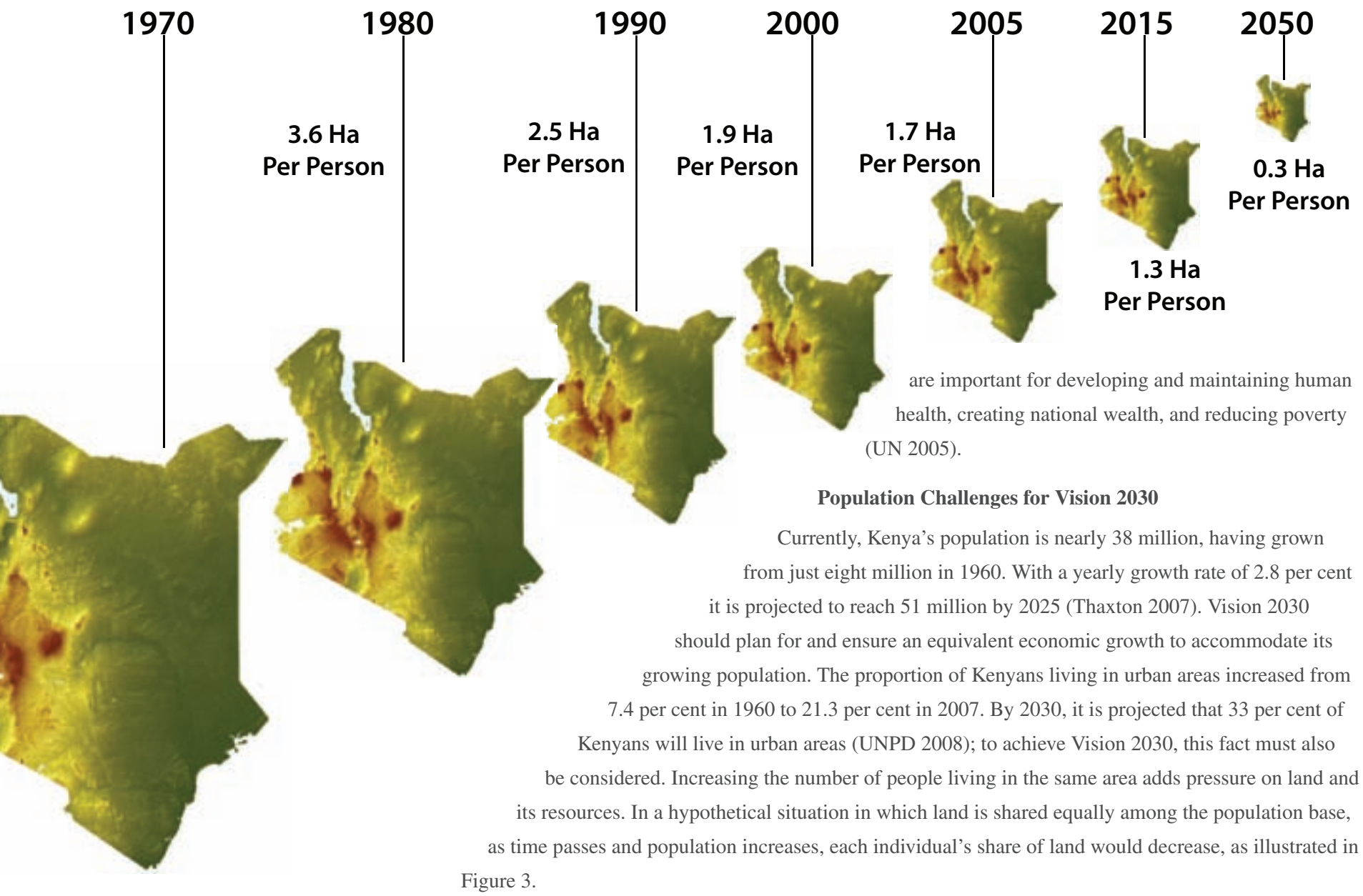


Figure 2: Kenya's projected rural and urban population, 1950-2050 (Source: UNPD 2008)



are important for developing and maintaining human health, creating national wealth, and reducing poverty (UN 2005).

Population Challenges for Vision 2030

Currently, Kenya's population is nearly 38 million, having grown from just eight million in 1960. With a yearly growth rate of 2.8 per cent it is projected to reach 51 million by 2025 (Thaxton 2007). Vision 2030 should plan for and ensure an equivalent economic growth to accommodate its growing population. The proportion of Kenyans living in urban areas increased from 7.4 per cent in 1960 to 21.3 per cent in 2007. By 2030, it is projected that 33 per cent of Kenyans will live in urban areas (UNPD 2008); to achieve Vision 2030, this fact must also be considered. Increasing the number of people living in the same area adds pressure on land and its resources. In a hypothetical situation in which land is shared equally among the population base, as time passes and population increases, each individual's share of land would decrease, as illustrated in Figure 3.

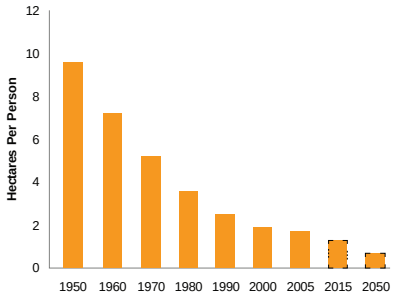


Figure 3: Kenya's shrinking land base (Source: UNPD 2008)

The amount of land available to each person in Kenya has decreased from 9.6 ha in 1950 to 1.7 ha in 2005. It is projected that available land will further decline to 0.3 ha per person by 2050

Environmental Goals for 2012

The Government of Kenya understands and appreciates the important function that the environment plays in underpinning development. It is cognizant that achieving Vision 2030 depends on maintaining the natural systems that support agriculture, energy supplies, livelihood strategies, and tourism. Table 1 on the following page illustrates how the environment cuts across Vision 2030's pillars.

To support the social pillar, Kenya aims to provide its citizens with a clean, secure, and sustainable environment by the year 2030. To achieve this, the nation has set goals such as increasing forest cover from less than three per cent of its land base at present to four per cent by 2012 and to lessen by half all environment related diseases by the same time (GoK 2007).

Among the strategies for achieving these goals are the following: promoting environmental conservation to help achieve the Millennium Development Goals (MDGs); improving pollution and waste management through the design and application of economic incentives; and commissioning public-private partnerships (PPPs) for improved efficiency in water and sanitation delivery. Kenya will enhance disaster preparedness in all disaster-prone areas and improve the capacity for adaptation to the impacts of global climate change. In addition, the country will harmonize environment-related laws for better environmental planning and governance (GoK 2007).

Smoke rises from farmers clearing small patches of land

Pillars	Sectors	2012 Targets	Environmental Challenges and Benefits
Economic	Tourism	• Increase number of visitors from 1.8 million per year to 3 million	• Develop tourism infrastructure (accommodation, transport) with light environmental footprint so as to preserve the natural assets
	Agriculture	• Add value to crop, livestock, and fish products by processing domestically • Cultivate idle land and open up new agricultural lands	• Plan processing plants to avoid environmental impacts • Ensure lands, weather conditions and water availability are suitable for cultivation; plan ahead to adapt to climate change in these areas • Avoid encroachment on sensitive ecosystems and marginal lands
Social	Health, water, and sanitation	• Lessen by half all environment related diseases • Improve access to safe water and sanitation • Increase irrigation and drainage levels to promote agricultural productivity	• Be proactive in preventing disease (instead of end-of-pipe solutions) by protecting and improving access to water sources and providing adequate sanitation facilities • Conserve water sources • Introduce innovative water harvesting and drainage schemes
	Environment	• Increase forest cover from less than three per cent to four per cent	• Increase forest cover, which will help sustain water catchments for hydropower, agriculture, municipalities, wildlife and tourism, etc • prevent erosion • increase biodiversity • sequester carbon • provide timber to local people, among other environmental, social, and economic benefits
	Housing and urbanization	• Increase annual housing unit production from 35 000 to 200 000	• Ensure urban plans are environmentally sustainable in terms of building materials, location, transport options, etc.
	Equity and poverty elimination	• Reduce the number of people living in poverty to a tiny proportion of the total population	• Ensure the equitable access of all people to the environmental resources they need to sustain their livelihoods, and that these resources are managed sustainably

Table 1: The crosscutting nature of the environment that underlies Vision 2030's pillars

Kenya's Forests and the Economic and Social Pillars

Forests cover only about three per cent of Kenya's land area, yet they provide crucial direct and indirect goods and services to its people and make a significant contribution to the national economy. About 70 per cent of Kenya's domestic energy comes from wood, for example, and out of the 20 million m^3 of fuelwood consumed annually, 95 per cent is collected from forests and rangelands (MENR 1994). In addition to providing a variety of wood and non-timber products, Kenya's forests provide the following ecosystem services: they trap and store rain water; regulate river flows and prevent flooding; help recharge ground-water tables; improve soil fertility; reduce soil erosion and sediment loads in river water; help regulate local climate conditions; and act as carbon reservoirs and sinks.

Many forests serve as essential wildlife habitats, and are traditionally important for cultural ceremonies and as sacred sites to local communities. It is estimated that 530 000 forest-adjacent households (which amount to 2.9 million people living within five kilometres from forests) derive direct benefits from indigenous closed-canopy forests. This amounts to about eight per cent of Kenya's population. Estimates indicate that in some areas, the forestry sector contributes about 70 per cent of the cash income of forest adjacent households (Wass 1995).

Forests play a critical role as water catchments. In addition to retaining and filtering water for human uses, forests contribute to the availability of water for hydro power, which supplies Kenya with close to 60 per cent of its electricity generation. Forests also help to reduce siltation in hydroelectric empoundments.

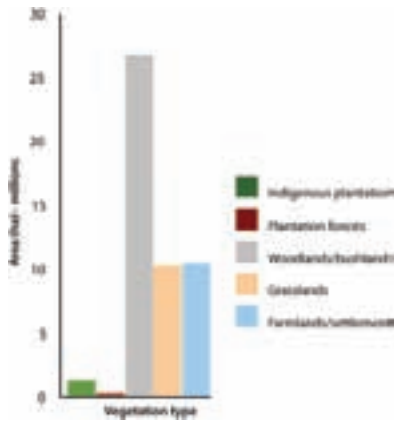


Figure 4: Land use area, 2005 (Source: KFS 2006)

Kenya's land cover is dominated by woodlands, grasslands, and farmlands

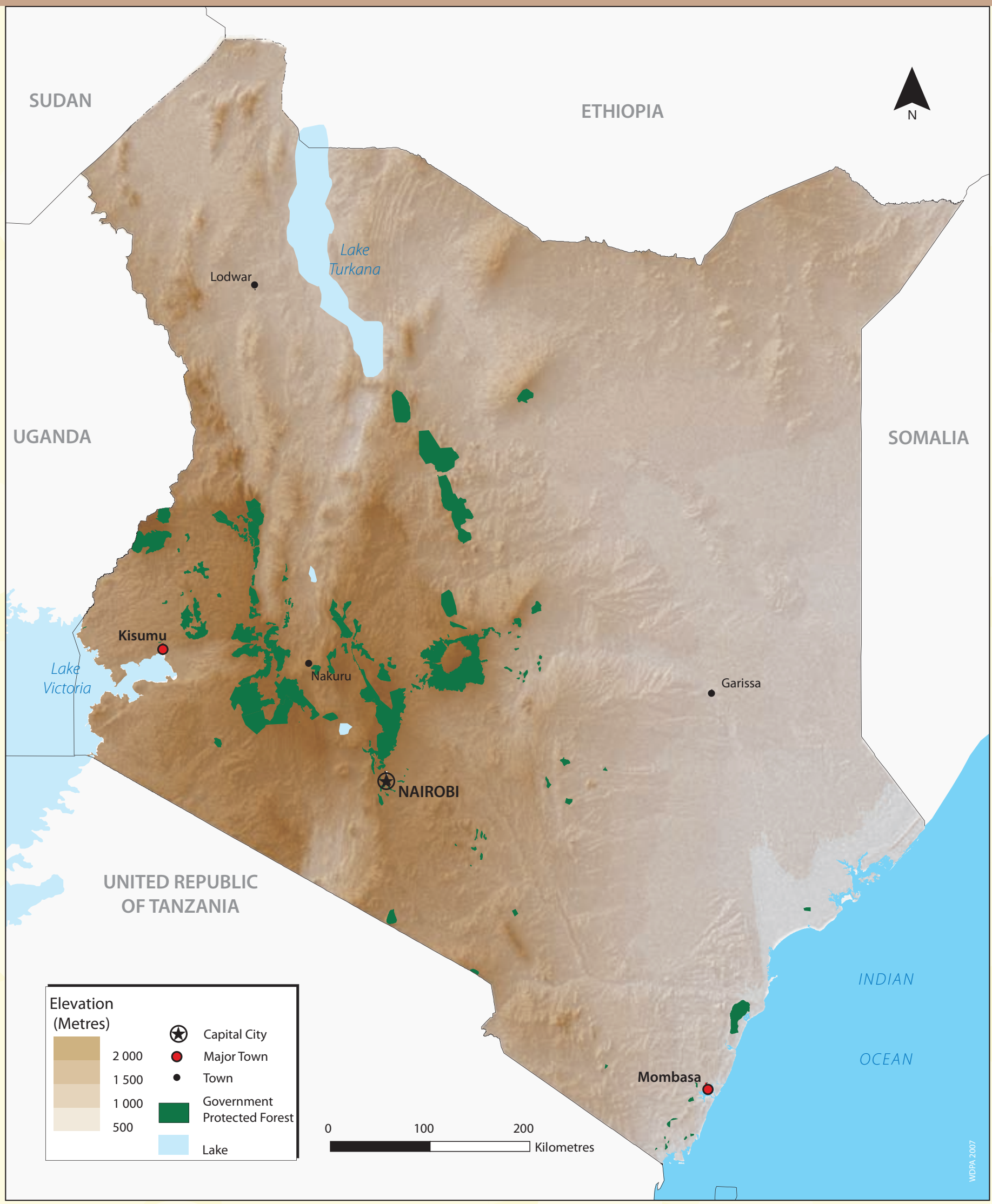


Figure 5: Forests are concentrated in Kenya's moist highlands where human populations and agricultural production are also concentrated. In the extensive semi-arid regions, forests are mainly found on isolated hills and in discontinuous narrow bands along riverbeds. Kenya has 258 forest reserves.

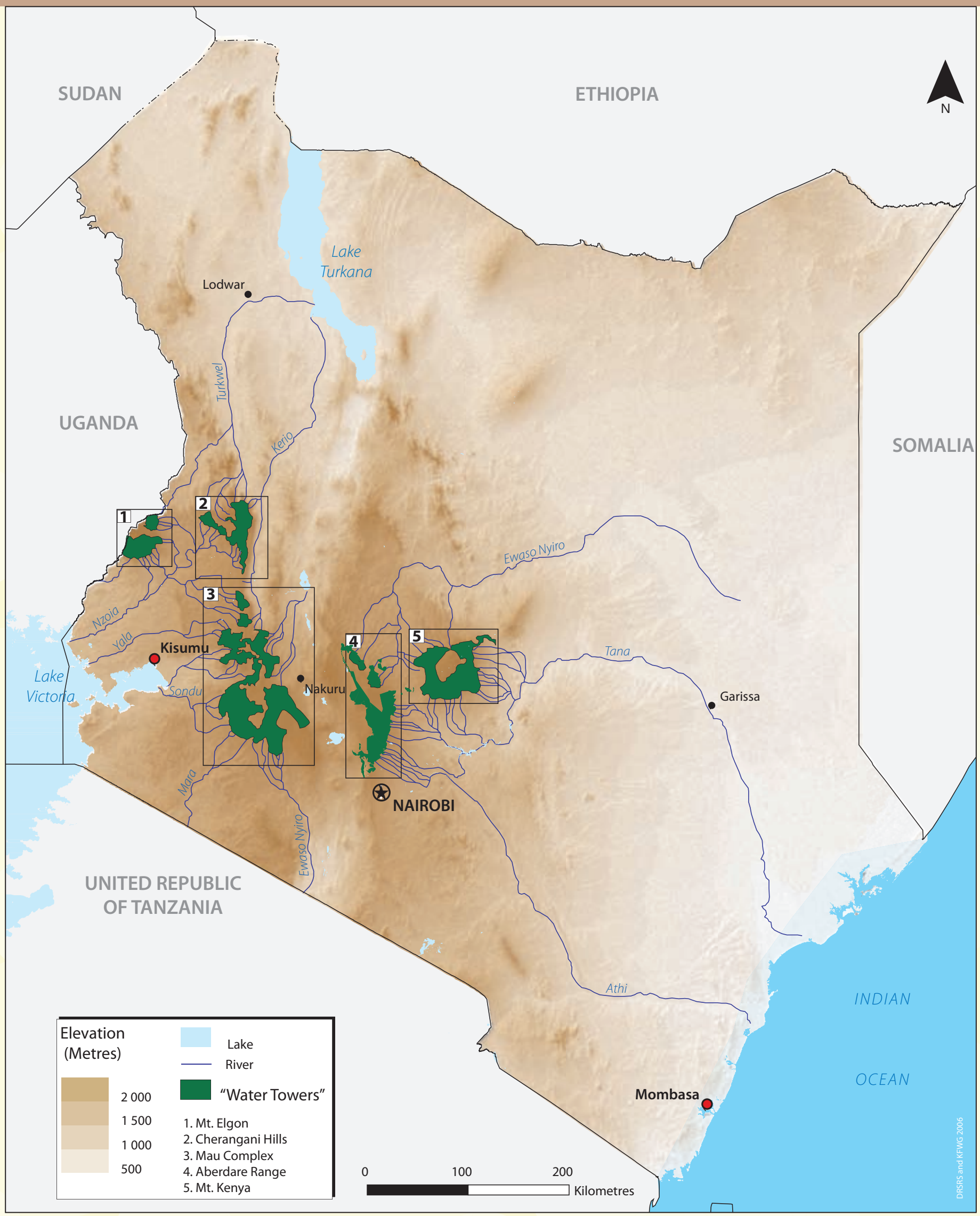


Figure 6: The five water towers of Kenya

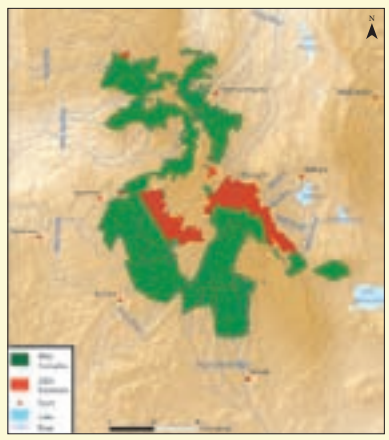

Christian Lambrechts/UNEP

Five water towers: Kenya's water catchments—a flagship project for 2012

The five "water towers" of Kenya—Mount Kenya, the Aberdare Range, the Mau Forest Complex, Mount Elgon, and the Cherangani Hills—are montane forests and the five largest forest blocks in the country. They form the upper catchments of all the main rivers in Kenya (except the Tsavo River originating from Mt. Kilimanjaro). The "water towers" are sources of water for irrigation, agriculture, industrial processes, as well as to all installed hydro-power plants, which produce about 60 per cent of Kenya's electricity output.

These montane forests are also surrounded by the most densely populated areas of Kenya, because they provide enough water for intensive agriculture and urban settlements (DRSRS and KFWG 2006). Their importance in the supply of timber and non-timber products to the communities living within their surroundings cannot be over emphasized. As such these forests are important and support livelihoods for all Kenyans in one way or another. At the same time, however, they are being lost or degraded by extensive illegal, irregular, and ill-planned settlements and illegal forest resource extraction. Such extensive and on-going destruction of the country's natural assets and their economic value is a matter of national concern.

This section presents each of the five "water towers" and describes their changing physical conditions over time. Assessing changes in these five regions is important not only for ensuring the livelihoods of millions of Kenyans, but also for preserving their intrinsic beauty and richness.



Mau Complex

The Mau Complex, the largest of the five water towers, feeds major water arteries that extend as far as lakes Turkana, Natron, and Victoria, and support critical economic activities including hydropower, tourism, and agriculture.

Mount Kenya

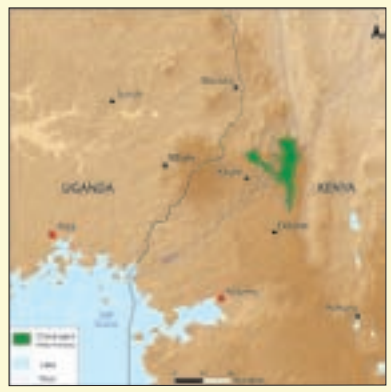
Mount Kenya was designated a UNESCO World Heritage Site in 1997 for its remarkable ecosystems and natural beauty. Its forests are critical water catchments for Kenya, delivering an estimated 40 per cent of the country's water needs.

Aberdare Range

Located on the eastern edge of the Rift Valley, the Aberdare Range forests cover over 250 000 ha and form part of the upper catchments of the Tana River, and the Sasumua and Ndakaini dams, which provide most of Nairobi's drinking water.

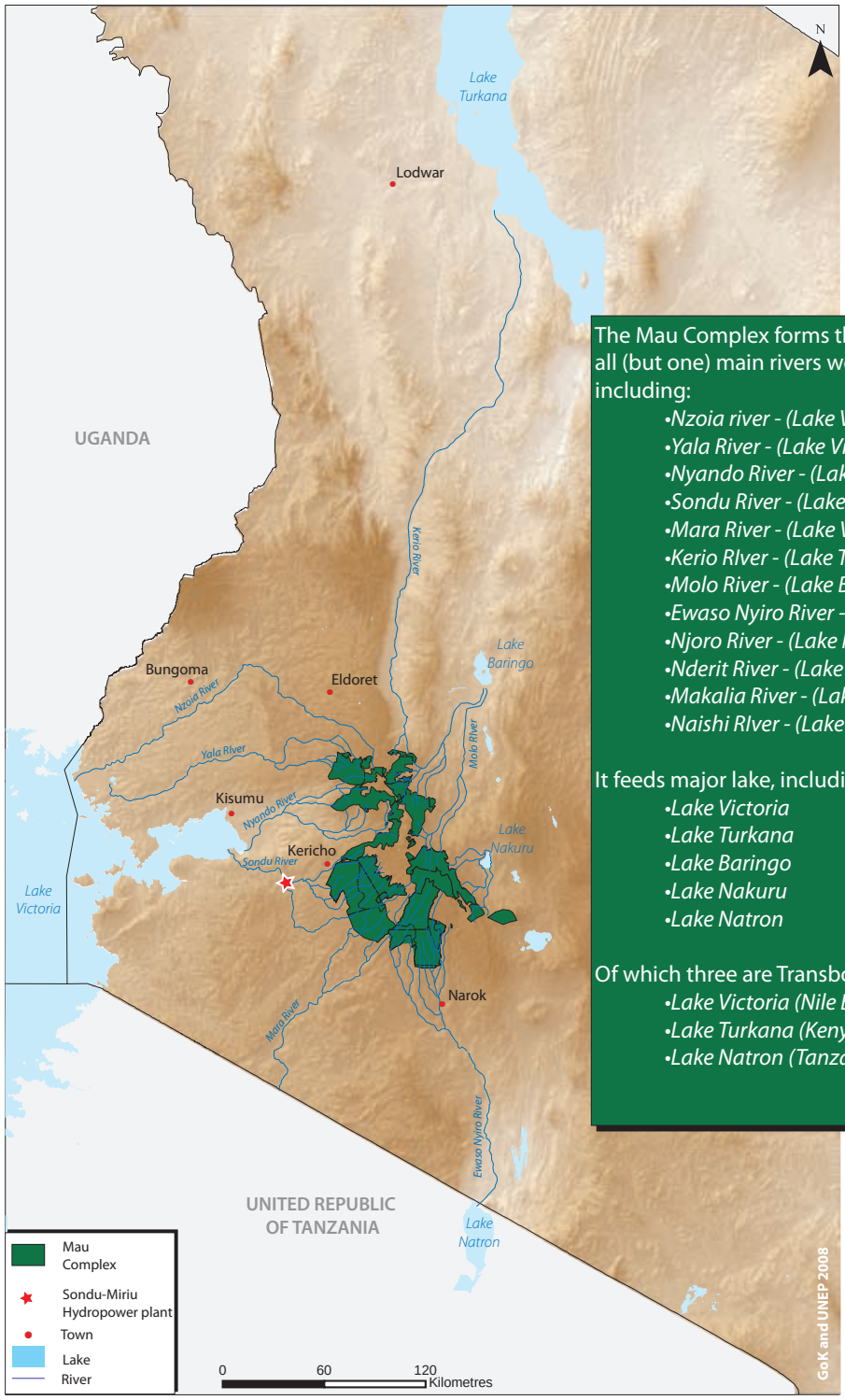
Mount Elgon

This 73 706 ha national park forms the upper catchment area for the Nzoia and Turkwel rivers, providing water to Malakisi River that crosses farming areas south of the mountain before entering Uganda.



Cherangani Hills

The Cherangani Hills forest, located on the western ridge of the Great Rift Valley, covers an area of some 120 000 ha and forms the upper catchments of the Nzoia, Kerio, and Turkwel rivers.



The Mau Complex forms the upper catchments of all (but one) main rivers west of the Rift Valley, including:

- *Nzoia river - (Lake Victoria)*
- *Yala River - (Lake Victoria)*
- *Nyando River - (Lake Victoria)*
- *Sondu River - (Lake Victoria)*
- *Mara River - (Lake Victoria)*
- *Kerio RIver - (Lake Turkana)*
- *Molo River - (Lake Baringo)*
- *Ewaso Nyiro River - (Lake Natron)*
- *Njoro River - (Lake Nakuru)*
- *Nderit River - (Lake Nakuru)*
- *Makalia River - (Lake Nakuru)*
- *Naishi RIver - (Lake Nakuru)*

It feeds major lake, including

- *Lake Victoria*
- *Lake Turkana*
- *Lake Baringo*
- *Lake Nakuru*
- *Lake Natron*

Of which three are Transboundary

- *Lake Victoria (Nile Basin)*
- *Lake Turkana (Kenya/Ethiopia)*
- *Lake Natron (Tanzania/Kenya)*

Figure 7: Critical water catchments, Mau Complex

The Mau Forest Complex

The Mau Forest Complex is Kenya's largest closed canopy forest ecosystem and the single most important water catchment in the Rift Valley and western Kenya. The Mau Complex forms part of the upper catchments of all but one of the main rivers on the west side of the Rift Valley. These rivers act as arteries carrying the Mau's waters throughout western Kenya—from Lake Turkana in the north to Lake Natron in the south as well as to Kenya's most populous rural areas in the Lake Victoria basin.

The Mau Complex covering over 400 000 ha, is the largest of the five "water towers" of Kenya. Its montane forests are an important part of water-flow regulation, flood mitigation, water storage, groundwater recharge, water purification, micro-climate regulation, and reduced soil erosion and siltation. The forests also provide other major environmental services, including nutrient cycling and soil formation. In addition, their role in storing carbon makes the Mau Forest globally important for mitigating climate change.

The Mau Complex supports key economic sectors in Kenya including energy, tourism, agriculture, and water supplies for settlements. The catchment's potential hydropower generation capacity is approximately 535 megawatts, which represents 57 per cent of Kenya's current total electricity generation. To date, projects that have already been developed, are under construction, or are proposed within the Mau catchment will generate only about 190 MW (GoK and UNEP 2008).

Tea estate

Woman picking tea leaves

The Mau Complex is particularly important for two of Kenya's largest foreign currency earners: tea and tourism. Kenya's most important tea-growing areas are located in the excellent growing conditions of the highlands adjacent to the forests of the five "water towers." In addition to approximately Kshs 12 billion in foreign currency, the tea sector brings 50 000 jobs and supports 645 000 dependants in western Kenya. It is estimated that two-thirds of the tea produced in western Kenya is grown in areas that benefit from the ecological functions of the Mau Complex, including the maintenance of favourable micro-climatic conditions.

In recent years, the tourism industry has been one of Kenya's three largest foreign currency earners. Kenya's wildlife and natural areas are the key attraction for most of those tourists. The rivers flowing from the Mau Complex are the lifeline for major tourism destination areas including: Maasai Mara National Reserve and Lake Nakuru National Park.

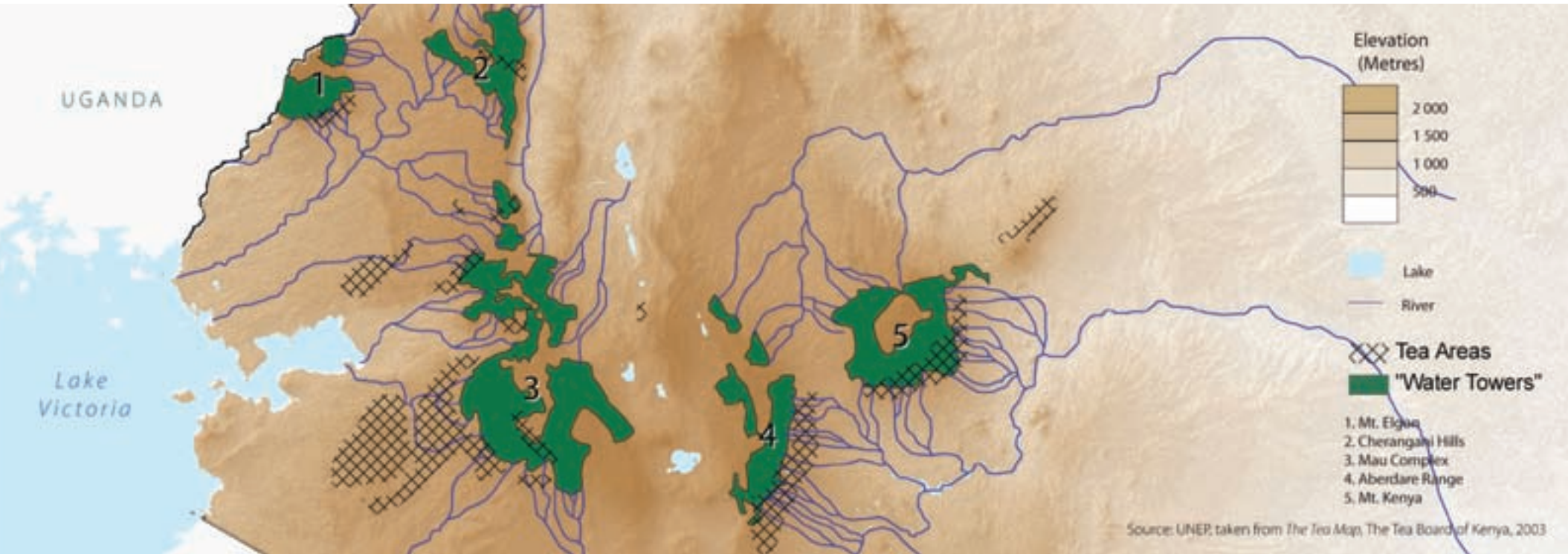


Figure 8: Kenya's tea growing areas and the five "water towers" (Source: UNEP, taken from The Tea Map, The Tea Board of Kenya, 2003)

The Mau Forest Complex: Degrading Forests

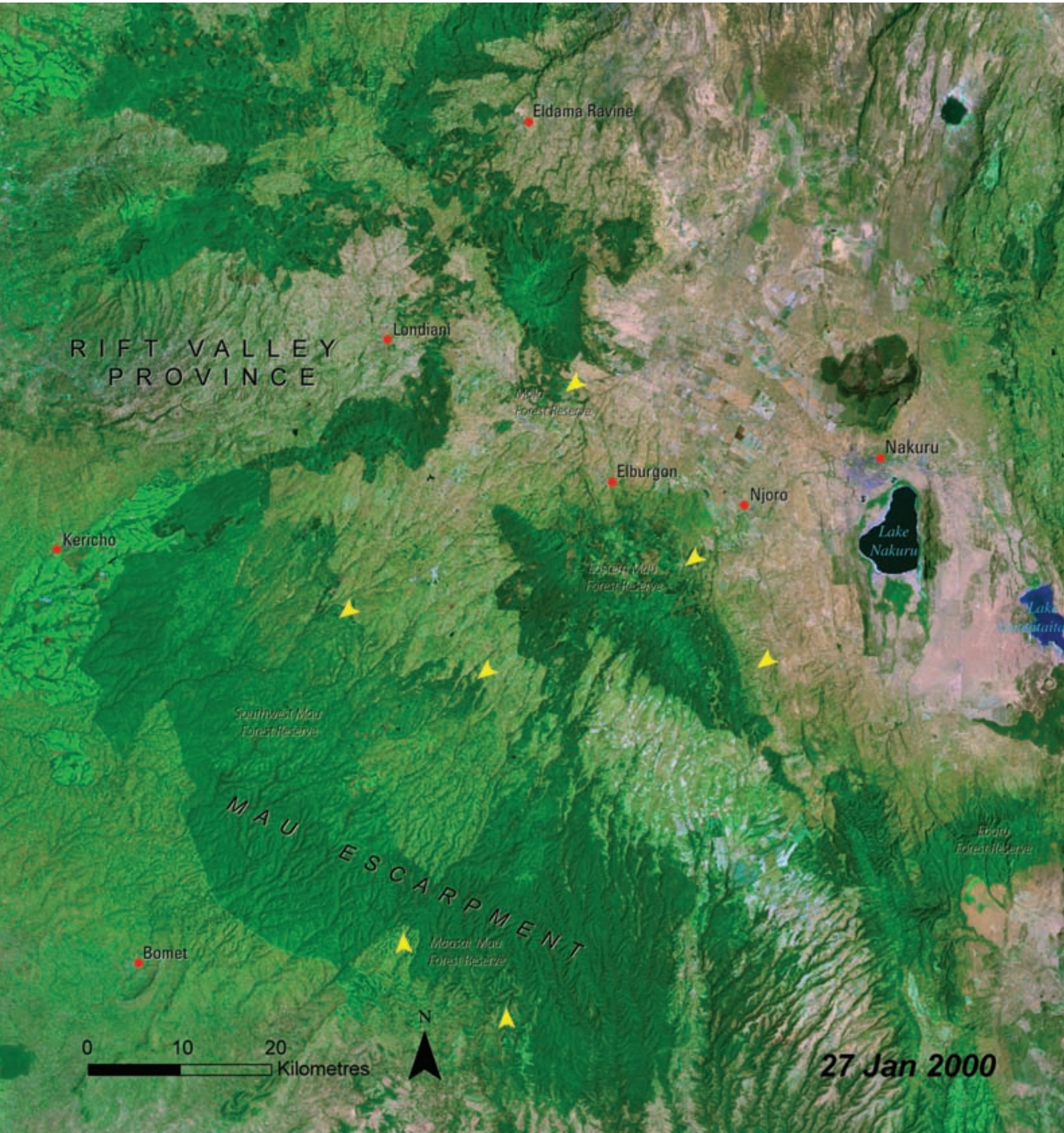
In spite of its national importance, many areas of the Mau Forest Complex have been deforested or degraded; much of this damage taking place in the past few decades. Degazettement of forest reserves and continuous widespread encroachment have led to the destruction of over 100 000 ha of forest since 2000, representing roughly one-quarter of the Mau Complex's area (yellow arrows). This series of satellite images documents 35 years of incremental destruction of forest area, punctuated by dramatic excisions.

In 2001, 61 023 ha of forest in the Mau Complex were excised including over half of Eastern Mau Forest Reserve. Eastern Mau Forest is the headwaters for the Njoro River which drains its eastern slopes into Lake Nakuru, one of Kenya's prime tourist attractions. One quarter of South West Mau Forest Reserve was excised. The Southwest Mau Forest is the primary source of the Sondu River, site of the future Sondu-Miriu hydro-power plant. All of Molo Forest Reserve was excised.

Between 1973 and 2005, Maasai Mau Forest lost over 8 214 ha of forest within its official boundaries, which were established to protect the forest. Almost 43 per cent of that loss occurred in just two years from 2003 to 2005. Just outside the

gazetted boundaries of Maasai Mau Forest nearly 32 000 ha were lost during the same time period. The eastern slopes of the Maasai Mau are a crucial catchment for the Ewaso Nyiro River, as the western slopes are for the Mara River. Forest loss in critical catchment areas for the Sondu, Mara, Molo, Naishi, Makalia Nderit, and Njoro Rivers will result in ecological and hydrological changes, which threaten the sustainable future of areas downstream.

In addition, people have encroached into some 43 700 ha in the Mau Complex's remaining protected forests. The desirability of many of these areas for agriculture attracts a rapidly growing population and has led to rapid conversion of large areas of forest to farmland. Extreme land cover changes such as these can have serious consequences both within the forest and downstream in the form of water shortages, health risks, desertification,



habitat destruction, sedimentation, erosion and even alteration of the micro-climate.

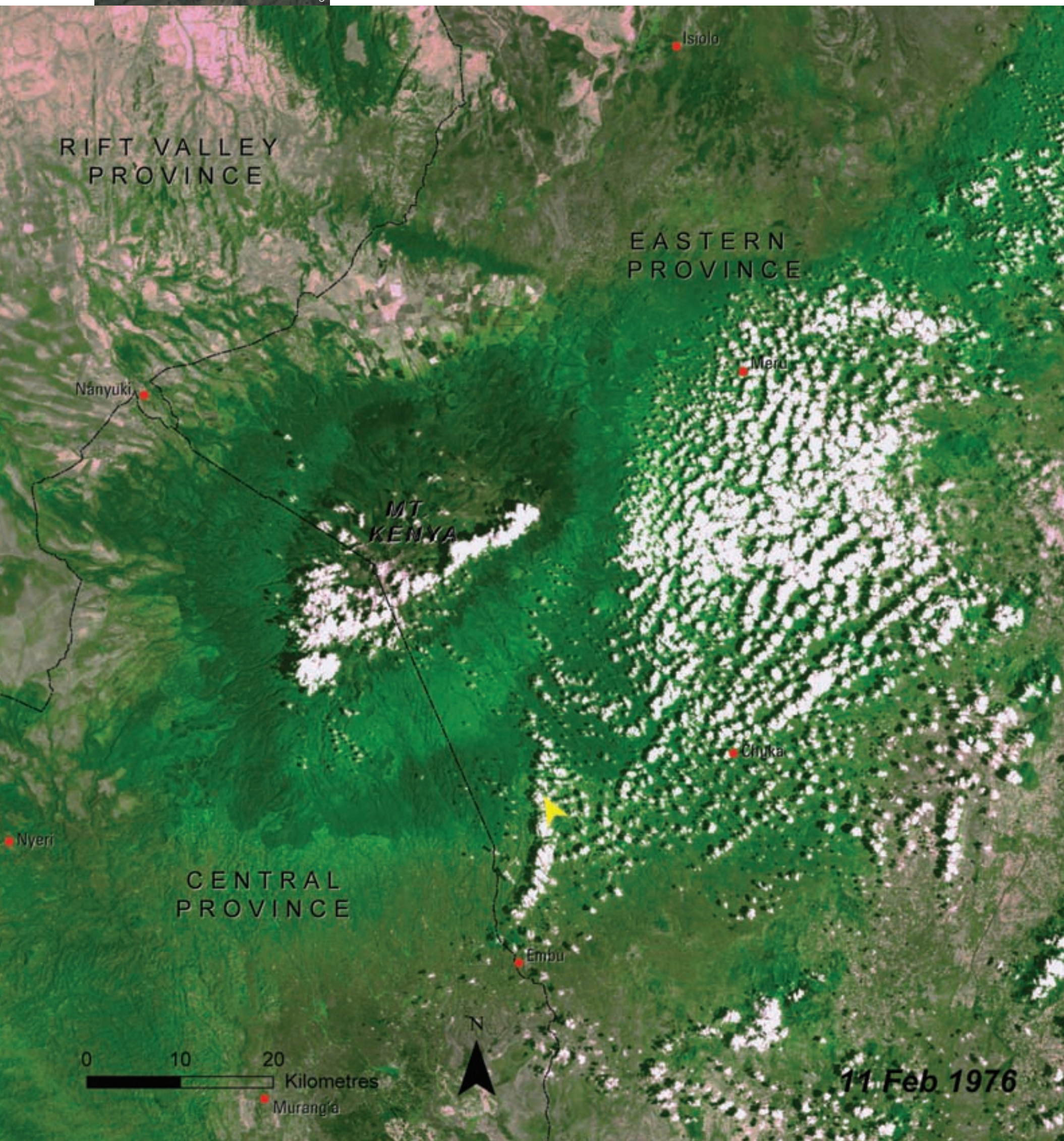
Loss of forest at this rate is unsustainable and threatens the security and future development of Kenya. Realizing the goals of Vision 2030 will depend in a very significant way upon the sustainable management of Kenya's natural assets. Kenya's five "water towers" are key among those assets.

In the mid-1980s, Kenya's Nyayo Tea Zones were created to form a clear boundary and a buffer between the indigenous forest and surrounding land uses. They have not been particularly successful in meeting that aim and many hectares of indigenous forest were cleared for their creation (Birdlife International 2008a, GEF 2008).

Christian Lambrechts/UNEP

Mount Kenya: Disappearing Glaciers

Mount Kenya lies directly on the equator, 180 km north of Nairobi. Its scenic snow-cap, rising above the surrounding savanna, can be seen for hundreds of kilometres. It is an iconic symbol of Kenya known around the world. In addition to its beauty, Mt. Kenya's slopes are valuable for timber, farmland, and tourism and as a critical water catchment for much of the country. From the forest belt growing between 3 000 and 4 000 m to the

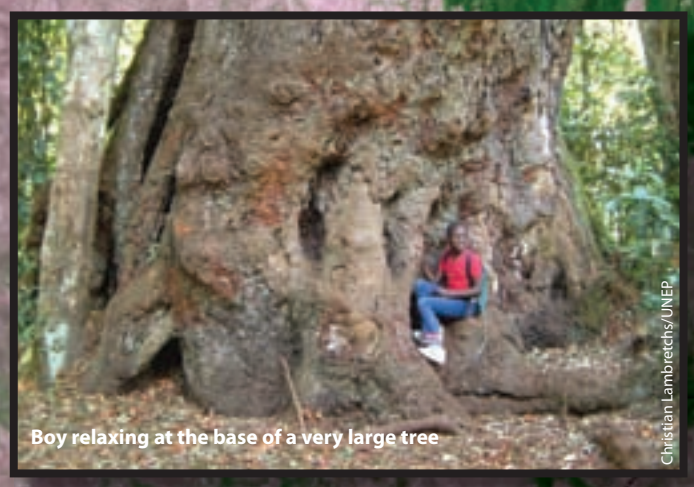


glacial summit at 5 199 m, Mt. Kenya receives over 2 000 mm of precipitation annually. This water feeds the Ewaso Nyiro River and the Tana—Kenya's largest rivers. Mount Kenya's contribution to the Tana provides roughly half the water needed for its crucial hydropower facilities.

Its wide range of altitude and rainfall gives rise to eight ecological zones ranging from a cultivated zone below 1 800 m to the Afro-alpine (areas above 3 800 m) and the Nival zone, found above most vegetation. Some of these zones can be seen in distinctly different shades of green in the satellite images.

Only 11 of the 18 glaciers that covered Mount Kenya's summit a century ago remain, leaving less than one third of the previous ice cover. The ice on Mount Kenya has also become thinner. While this trend dates to the late 1800s, emerging evidence suggests that it has accelerated since the 1970s.

Intense population growth around Mount Kenya between the 1960s and 1990s, along with unsustainable exploitation of forest resources, further threatened its integrity. Large areas of indigenous forest have been cleared for tree plantations, extensive illegal logging of valuable species, and small-



Boy relaxing at the base of a very large tree

Christian Lambrechs/UNEP

scale illegal activities such as charcoal production, marijuana growing, and unauthorized farming. These activities have degraded many areas of natural forest, new management policies and practices, and improved enforcement put in place since 2000 have significantly reduced these threats.

Mount Kenya vegetation


Christian Lambrechts/UNEP

The Aberdare Range: Forest Devastation

The Aberdare Range spans the equator west of Nairobi rising over 4 000 m at its highest peak, Oldonyo Lesatima. Its western escarpments drop dramatically toward the Rift Valley. To the east it slopes gradually, carrying water into the Tana River and to the Seven Forks hydropower plants where over half of Kenya's electricity is generated. On their way into the Tana, the Chania River flows into Sasumua Dam and the Thika River into Ndakaini Dam, from which Nairobi's more than three million people obtain most of their water. The Aberdares also form part of the upper catchments of the Athi, Ewaso Nyiro, and Malewa Rivers.


Nation Media Group

Ndakaini Dam

RIFT VALLEY PROVINCE

Nanyuki

EASTERN PROVINCE

MT. KENYA

ABERDARE RANGES

Nyeri

CENTRAL PROVINCE

Murang'a

Naivasha

Lake Naivasha

RIFT VALLEY PROVINCE

0 10 20 Kilometres

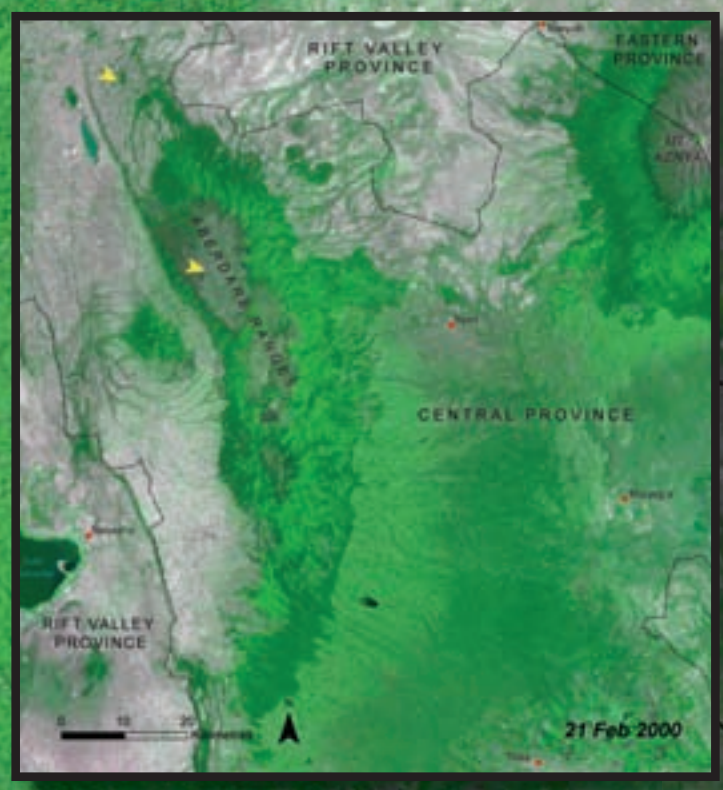
N

25 Feb 1987

Reserves protect the forest belt of the Aberdare Range, including Aberdare, Kikuyu Escarpment, Kijabe Hill, Kipipiri, and Nyamweru and 760 km^2 of the forest falls under the protection of Aberdare National Park. The forests cover over 250 000 ha. The Range is characterized by a high diversity of forest types due to the wide altitudinal range (1 800 to 3 600 metres) and climatic differences between slopes.

The forests are being devastated by large-scale, uncontrolled, irregular, or illegal human activities, in particular charcoal production, logging, encroachment and settlements, cultivation of marijuana and other crops, and livestock grazing. The assault on these forests poses a grave threat to Kenya's water security, biodiversity conservation, and economic development.

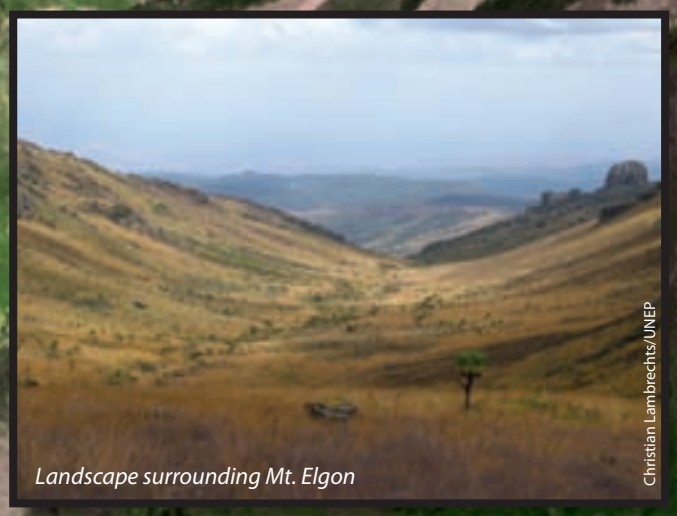
RIFT VALLEY PROVINCE
Nanyuki
EASTERN PROVINCE
MT. KENYA
ABERDARE RANGES
Nyeri
CENTRAL PROVINCE
Naivasha
Lake Naivasha
RIFT VALLEY PROVINCE
0 10 20 Kilometres
N
27 Jan 2006
Thika



Christian Lambrechts/UNEP

Mount Elgon: Legal Logging

Mt. Elgon lies north of Lake Victoria on the Kenya-Uganda border. Its Kenyan side is protected by Mt. Elgon National Park, Chepkitale National Reserve, and Mt. Elgon Forest Reserve; the latter covers 73 706 ha. Mt. Elgon forms the upper catchment area for two major rivers, the Nzoia and Turkwel. The forest contains globally threatened species, including some endemic to the Afro-montane region and others endemic to Mt. Elgon alone, making the area a priority for species conservation and a major attraction for tourists. A rapidly growing population of around two



Landscape surrounding Mt. Elgon

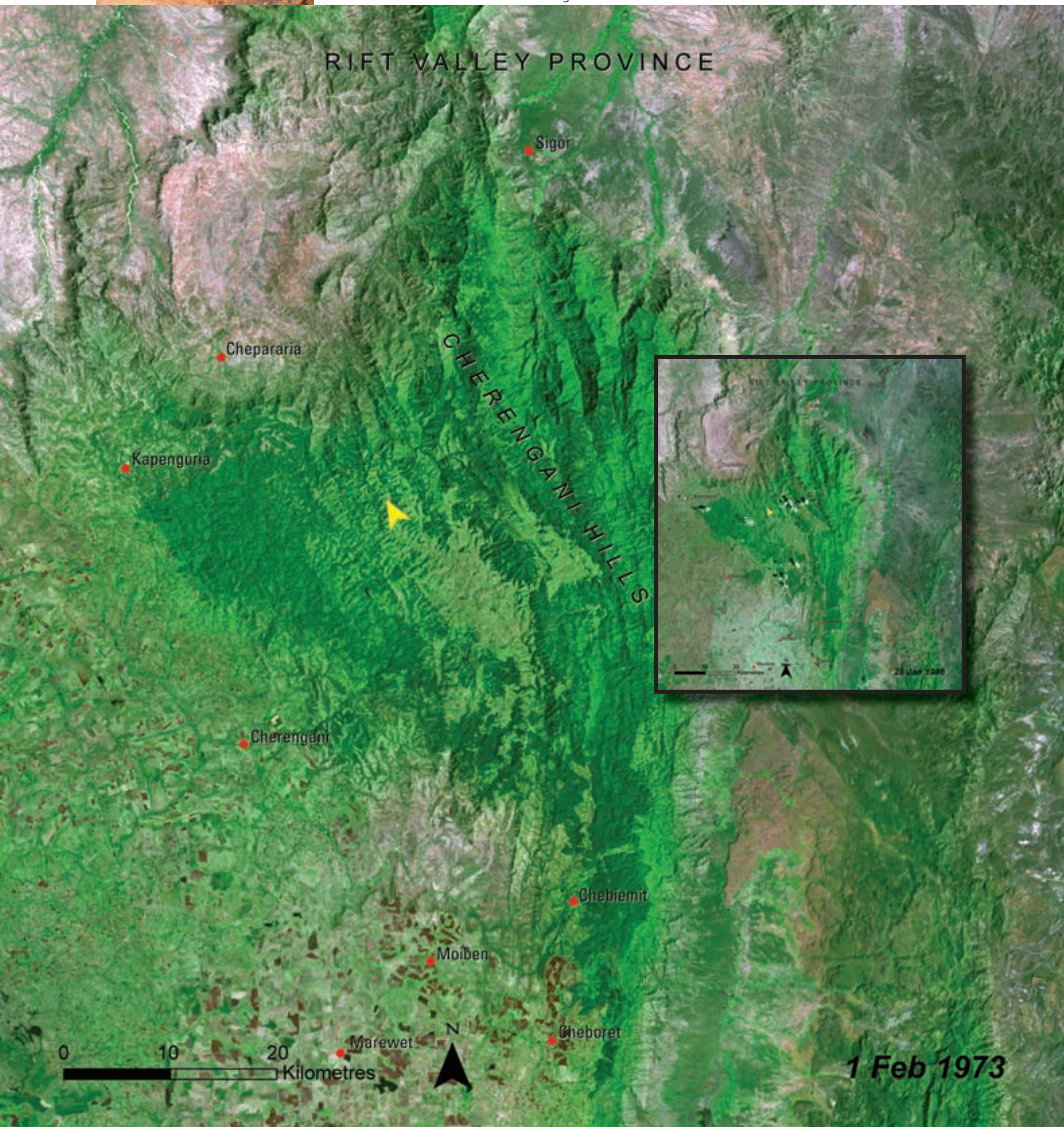
Christian Lambrechts/UNEP

million people in the area around the mountain puts very high pressure on this unique ecosystem. Authorized logging has been practiced in Mt. Elgon since at least the 1930s. In the 1970s, land was excised from the Mt. Elgon Forest around Chebyuk where 600 families were settled to make way for a national game reserve. While a 1986 Presidential Decree banned all logging in Kenya's natural forests, it excluded Mt. Elgon where legal logging continues. Agricultural encroachment and charcoal production are degrading the forest in many areas as well. In many cases forest has been cleared for crops on slopes that are not suitable, making them susceptible to erosion and landslides. Continued degradation and forest loss on Mt. Elgon threatens to undermine the area's crucial role as a water catchment for the surrounding region and will reduce the viability of the ecosystem itself.


Christian Lambrechts/UNEP

The Cherangani Hills: Indigenous Forests

The Cherangani Hills, an ancient fault-block formation of non-volcanic origin, are a series of gently rolling hills that form an undulating upland plateau on the western edge of Kenya's Rift Valley. They lie between the Elgeyo Escarpment to the east and Mt. Elgon to the west, rising to 3 365 m above sea level at Cheptoket Peak in the north-central section. Located on the Cherangani escarpment, the hills are largely covered by a series of gazetted indigenous Forest Reserves. River Nzoia has its source in these Hills. Over the last 20 years, local inhabitants have encroached on the forest land converting it to farmlands.



Because the Cherangani Hills are one of the five most important water catchment areas in Kenya, a joint project of UNEP and the Department of Resource Survey and Remote Sensing monitored the change in forested area between 2000 and 2003. It found that the Cherangani Hills were the least affected of the five forested water towers, with 174.3 ha deforested. Since this forest cover is indigenous, however, it was recommended that the area be closely watched to prevent further destruction.

The forests of the Cherangani Hills bear scenic features suitable for ecotourism and are home to the rare De Brazza's Monkey. The Hills are also classified as an Important Bird Area (IBA) with over 73 forest-dependent species recorded of which four species are regionally threatened.

Deforestation in the Cherangani Hills

Christian Lambrechts/UNEP

RIFT VALLEY PROVINCE

Sigor

Chepararia

CHERENGANI HILLS

Kapenguria

Cherengani

Chebiemit

Moiben

Marewet

Cheboret

N

0 10 20 Kilometres

5 Feb 2001

Arshia Chander/SGT/UNEP

Tourists on safari view a large herd of African elephants

Tourism

Since 2002, the tourism industry has been one of Kenya's three largest foreign exchange earners. In 2007, consolidated earnings from tourism amounted to Ksh. 65.4 billion. Tourism is also a major source of employment, providing at least 400 000 jobs in the formal sector and over 600 000 in the informal sector (GoK and UNEP 2008). Tourism is targeted as the leading sector in achieving the goals of the Vision 2030. The Vision's economic pillar aims for the country to be among the top 10 long-haul tourist destinations in the world, offering high-end, diverse, and distinctive visitor experiences that few competitors can offer. Preserving the environment is essential if this goal is to be realized.

Kenya will need to improve the infrastructure in and around its tourist attraction sights, including airports/airstrips and road networks, in order to achieve its goals of quadrupling tourism's annual GDP contribution to over Ksh. 80 billion, raise international visitors from 1.8 million in 2006 to three million in 2012, increase hotel beds from 40 000 to about 65 000, and provide high quality service. The challenge is to do this without destroying the very environment that visitors come to see. As can be seen in Figure 9, there are already many airstrips within protected areas and some parks have high densities of these strips. Building more of them in such sensitive areas will destroy wildlife habitat and endanger the animals that attract tourists to Kenya.

Wildife conservation

Kenya's game parks and spectacular wildlife attract nearly two million tourists each year (UN-Water 2006). Wildlife conservation is thus a high priority. Formed in 1946, Nairobi National Park, just outside the city, was the country's first protected area (Chapter 5). By 2008, 75 237.9 km^2 of the nation's land area had been set aside as national parks and game reserves (WDPA 2007).

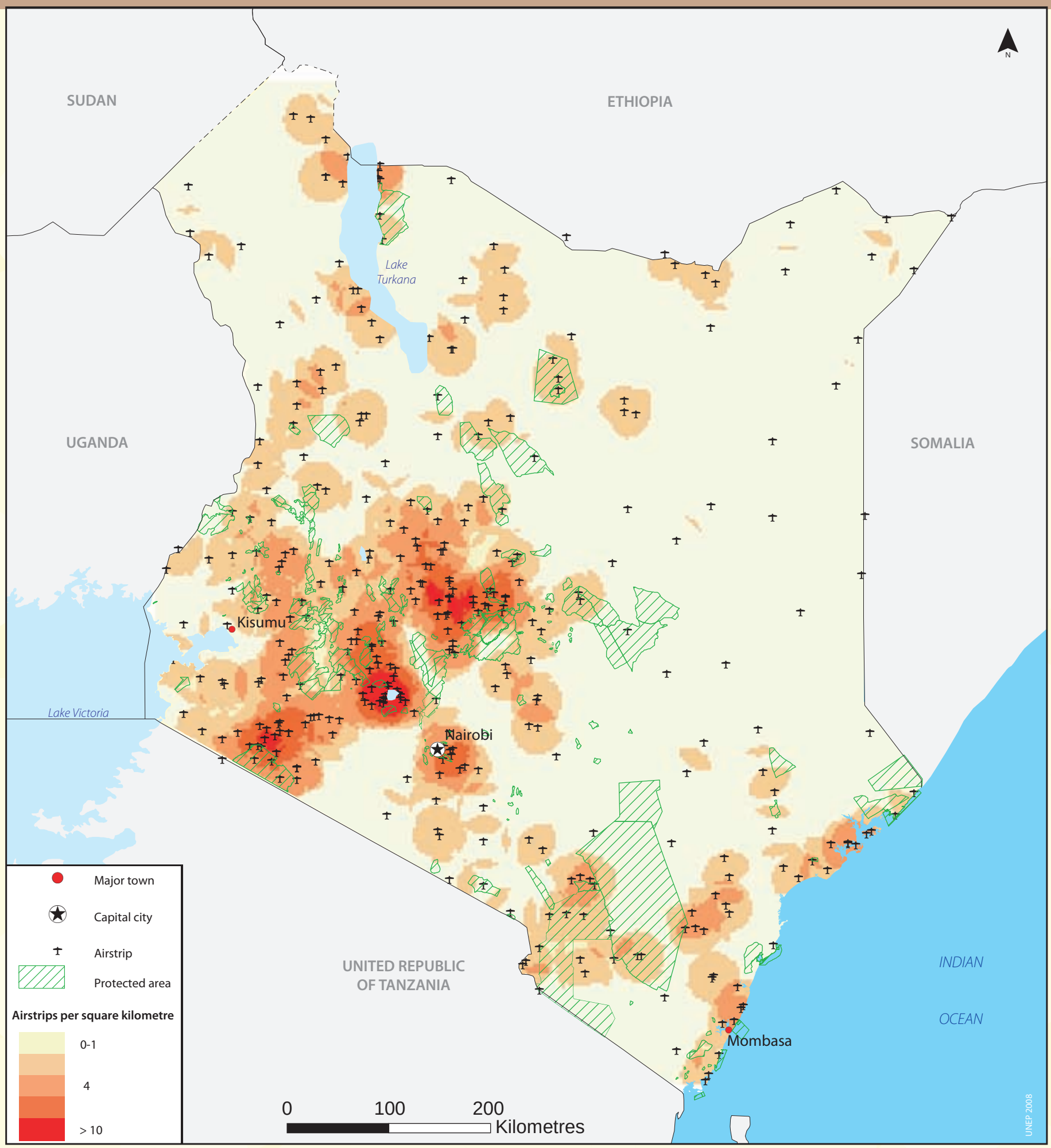


Figure 9: Most airstrips, with the exception of those within or close to the capital city, are located within or very close to protected areas, especially those of international repute like the Maasai Mara Game Reserve

Christian Lambrechts/UNEP

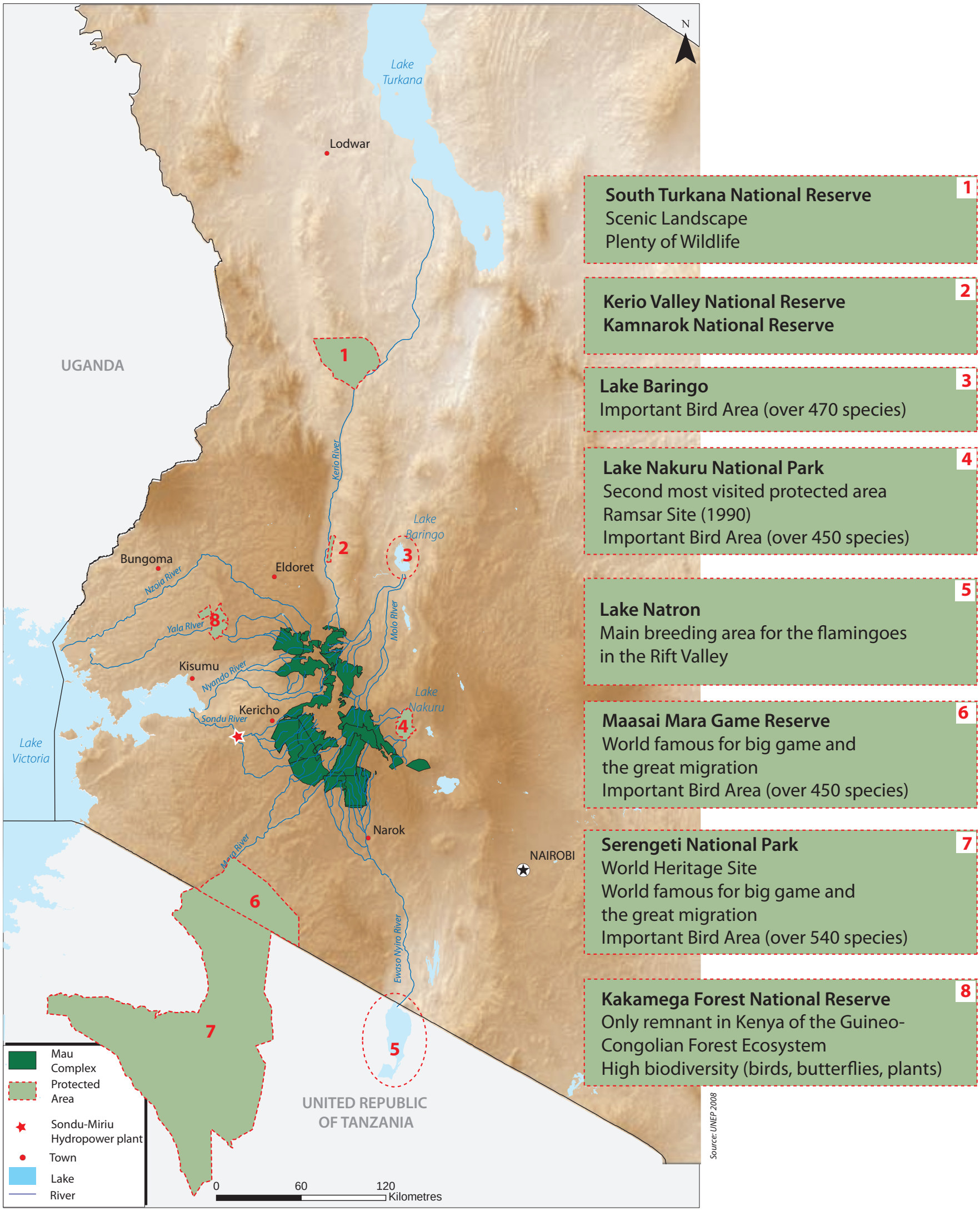
Flamingos and other birds wade in the shallow water along the northwest shores of Lake Nakuru

The environment underpins economic vitality, including future tourism growth. For example, the rivers flowing from the Mau Complex are the lifeline for major tourism destinations including the Maasai Mara Game Reserve and Lake Nakuru National Park (Figure 10). In 2007, revenues from entry fees alone amounted to Ksh. 650 million and Ksh. 513 million for the Maasai Mara and Lake Nakuru respectively (GoK and UNEP 2008). The annual indirect revenues from tourism in these two conservation areas are estimated to be in excess of Ksh. 5 billion. The rivers are also the lifeline for a number of other conservation areas where tourism potential is not yet fully developed, including Kakamega National Reserve, Kerio Valley National Reserve, South Turkana National Reserve, Lake Baringo, and Lake Natron.

These conservation areas host a high diversity of fauna and flora. For example, three of them — Kakamega, Baringo, and Natron — are classified as Important Bird Areas, with Kakamega and Baringo each hosting over 450 bird species, while Natron is the main breeding area for the Lesser Flamingoes in the Rift Valley. Other Important Bird Areas (IBA) that depend on rivers flowing from the Mau Complex include: Koguta Swamp (Kenya–Sondu River); Kusa Swamp (Kenya–Nyando River); Serengeti National Park (Tanzania–Mara River), Mara Bay, and Masirori Swamp (Tanzania–Mara River).

Lip Kee/Flickr.com

Flamingoes in Lake Nakuru



1 South Turkana National Reserve
Scenic Landscape
Plenty of Wildlife

2 Kerio Valley National Reserve
Kamnarok National Reserve

3 Lake Baringo
Important Bird Area (over 470 species)

4 Lake Nakuru National Park
Second most visited protected area
Ramsar Site (1990)
Important Bird Area (over 450 species)

5 Lake Natron
Main breeding area for the flamingoes in the Rift Valley

6 Maasai Mara Game Reserve
World famous for big game and the great migration
Important Bird Area (over 450 species)

7 Serengeti National Park
World Heritage Site
World famous for big game and the great migration
Important Bird Area (over 540 species)

8 Kakamega Forest National Reserve
Only remnant in Kenya of the Guineo-Congolian Forest Ecosystem
High biodiversity (birds, butterflies, plants)

Figure 10: Major tourism destinations
The rivers flowing from the Mau Complex are the lifeline for major tourism destinations.

Goliath heron, Lake Baringo

Located in the Rift Valley, Lake Baringo is a critical habitat and refuge for a variety of birds and fish species. Today, fish stocks in the lake have decreased, and so have water levels as a results of droughts and over-irrigation.

The Aberdare National Park receives an average 50 000 visitors annually. The scenery is spectacular and the high upland waterfalls are a special attraction. The north and southeast of the park are as yet undeveloped but have unique attractions. Kenya Wildlife Service (KWS) has identified sites in the south with potential for forest walks and hiking routes to Kinangop peak. In the north, areas for fishing, hiking, and horse riding have been identified. Thus, the tourism potential of the Aberdares remains largely untapped.

The rivers flowing from the Marmanet forests provide water to five major conservation areas: Lake Baringo, Lake Bogoria National Reserve, Samburu National Reserve, Buffalo Springs National Reserve, and Shaba National Reserve (Figure 11). In 2007, the entry fees alone in these five conservation areas generated revenues in the range of Ksh. 100 - 200 million (GoK and UNEP 2008).

Biodiversity attractions and threats

Kenya ranks second highest among African countries in bird and mammal species richness. It has an estimated 6 506 higher plant species, 359 mammals, 1 079 birds (of which 344 are breeding birds), 61 reptiles, 63 amphibians, and 34 fish species (Survey of Kenya 2003, WRI 2003). In addition, there are an estimated 21 575 insect species for a total of 29 673 species excluding molluscs and other invertebrates (Survey of Kenya 2003).

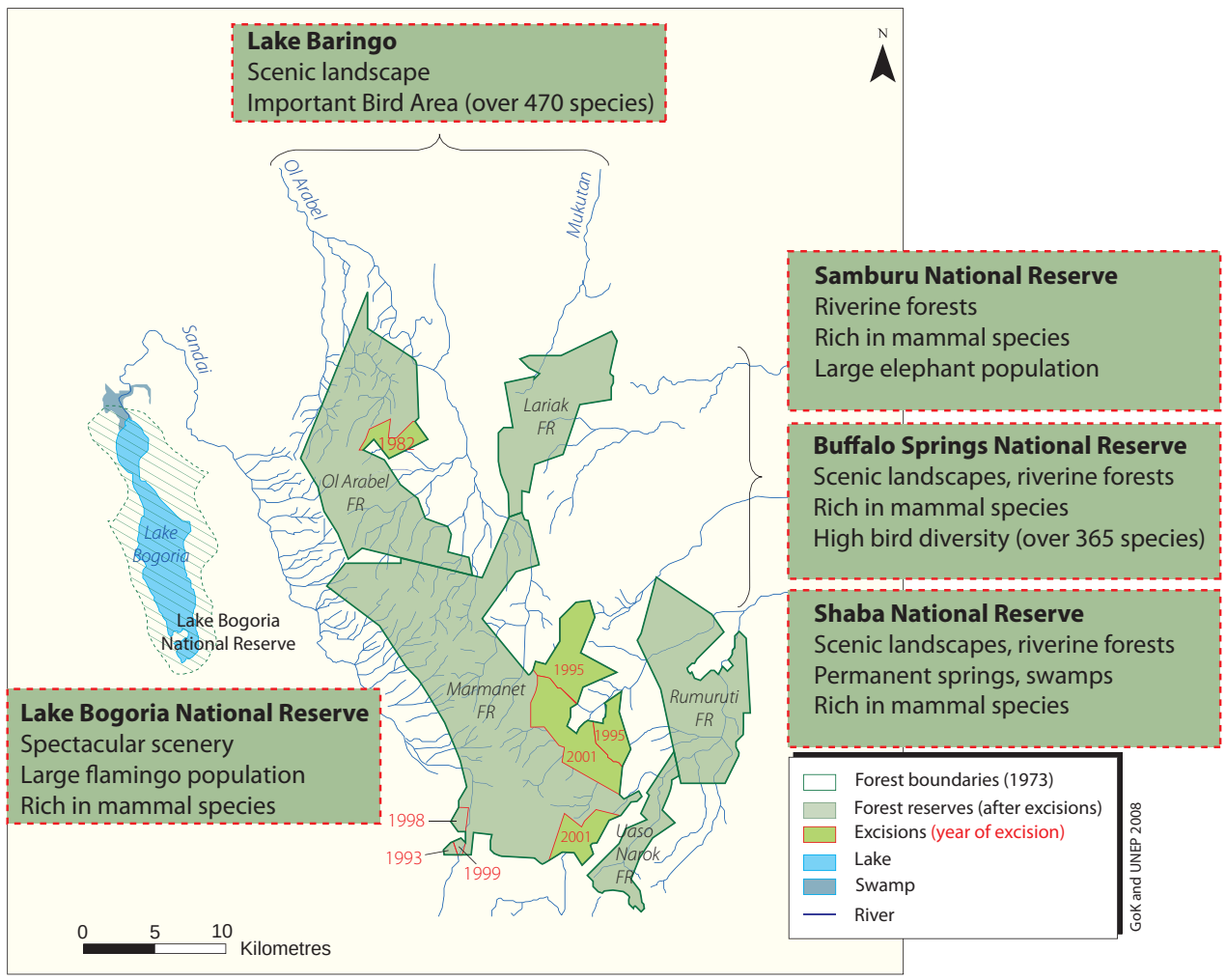


Figure 11: Marmanet forests are critical to major conservation areas

Threatened Species

The closed canopy forests are major habitats for a disproportionately large percentage of the country's wildlife and other biodiversity. Though forests cover about three per cent of Kenya's area, they contain 50 per cent of the nation's tree species, and it is estimated that they harbour 40 per cent of the larger mammals, 30 per cent of birds, and 35 per cent of the nation's butterflies. The indigenous forests have both endemic and threatened species (KFWG 2008).

About half of Kenya's threatened mammals and birds are found in its forests (Survey of Kenya 2003). According to the 2006 International Union for Conservation of Nature and Natural Resources (IUCN) report, Kenya's threatened species include 33 species of mammals, 28 breeding bird species, five species of reptiles, four of amphibians, 29 of fish, 16 molluscs species, 11 species of other invertebrates, and 103 plant species.


Christian Lambrechts/UNEP


Johannes Akiwumi/UNEP


Christian Lambrechts/UNEP

Endangered *Species* of Kenya


Lukas Vermeer / Flickr.com

African Elephant

(Loxodonta africana)

The African elephant is the largest land animal on Earth. It is listed as Endangered under IUCN. African elephants are threatened by poaching and habitat loss. Their tusks have been used in jewelry, piano keys, hanko (personalized signature seal used in Japan), and other items. Local people consume their meat and trade their hides and other parts, which are highly prized among big game hunters. From 1979 to 1989, Kenya's elephant population declined from about 130 000 to less than 17 000. Management and anti-poaching measures implemented through the ivory ban in 1989 has helped to increase and stabilize their population.


Tiswango / Flickr.com

Grevy's Zebra

(Equus grevyi)

Grevy's zebras have suffered one of the most substantial reductions of range of any African mammal. A few decades ago, more than 15 000 Grevy's zebra inhabited Africa. Today in Kenya alone, the population estimates are between 1 838 and 2 319. The Grevy's Zebra is listed as Endangered under the IUCN. The greatest threats facing the species today are habitat fragmentation and loss as more land is converted to agricultural use. Overgrazing by livestock is leading to significant environmental degradation. Grevy's zebra compete with the ever-increasing livestock population and agricultural crops for water.


Ryan Harvey / Flickr.com

Black Rhino

(Diceros bicornis)

The black rhinoceros population was nearly wiped out by poachers in the 1970s and 80s. Today its population stands at 540 in Kenya (AWF 2008). Poaching activities for horn trade, believed to have medicinal value, along with habitat loss, have put the black rhinoceros on the Critically Endangered list of the IUCN.


birdfinders.co.uk

Sokoke Scops Owl

(Otus ireneae)

The Sokoke Scops owl's population is estimated at about 1 000 pairs over about 220 km^2 of forest in the Arabuko-Sokoke forest. Unsustainable (and often illegal) deforestation for wood-carving and firewood may substantially reduce the species breeding success. Government owned forest reserves suffer from pit-sawing of timber and pole-cutting. The Sokoke Scops is listed as Endangered under the IUCN.


aluka.org

Gigasiphon

(Gigasiphon macrosiphon)

The gigasiphon is listed as Endangered under the IUCN. Native of the tropical forest, this plant is threatened by anthropogenic activities. Threats originate from habitat destruction or loss, deforestation — where land is cleared for agriculture, development, and population resettlement — competition from introduced species, pollution, global warming, and plant hunting, collecting, and harvesting.

Mangabey

(*Cercocebus galeritus)*

As one of the world's top 25 most endangered primates, the Tana mangabey inhabits the lower Tana River where its decreasing population is estimated between 1 000 and 1 200 according to old data. There is no current accurate estimate of the mangabey population. Their survival is directly correlated to the tree density and the forest area, which decreased by a third since the latest population census. Moreover, mangabey-human conflicts, such as crop raiding and traps, continue to threaten their survival (Wieczkowski 2005).

Cheetah

(*Acinonyx jubatus)*

Already extinct in most of Asia, there are now only two remaining cheetah population strongholds: Namibia/Botswana in southern Africa, and Kenya/ Tanzania in East Africa. The cheetah population in Kenya is not well-known, but is approximately 1 000 individuals. Cheetahs are endangered because of decline in prey, loss of habitat and poaching. They are often disliked because of their predatory lifestyle. Also, predation of cheetahs by both lion and hyenas in protected game reserves is forcing larger numbers of cheetahs to live outside protected areas where they come into contact with humans. Other threats facing cheetahs include diseases and low genetic diversity. The cheetah is classified as an endangered species, and listed in Appendix I of the Convention of International Trade in Endangered Species (CITES).

Green Sea Turtle

(*Chelonia mydas)*

The Green Turtle is listed as Endangered under the IUCN. Despite the protection of the Green Sea Turtle under Kenyan law, their survival is still precarious. The harvesting of turtle eggs, demands for its meat and oil, habitat destruction of nesting and foraging grounds by human encroachment (coastal and tourism development), pollution and beach erosion are all disturbances affecting their already fragile survival. Another threat is posed by fishing trawlers and drift nets, which accidentally catch sea turtles and drown them in fishing gear. One of the most worrying threats in recent years has been an increase in fibropapillomas, which are fibrous tumours that can grow on almost any part of the turtle's body, impeding movement or sight, and often leading to death. Kenya created a Turtle Conservation Committee to generate public support for this endangered turtle.

Hawksbill Turtle

(*Eretmochelys imbricata)*

Classified as Critically Endangered under the IUCN, Hawksbill turtles have been commercially exploited for thousands of years for their particularly attractive shell (tortoiseshell). Other major threats to their survival come from a substantial market for eggs, meat and even stuffed juveniles as exotic gifts in some parts of the world. Additional pressure on the global population comes from the loss of nesting sites, accidental entanglement in fishing lines and the deterioration of coral reef systems, which act as feeding sites for these turtles.

Tana River Red Colobus

(*Procolobus rufomitratus)*

The Tana River red colobus population decline was fuelled by bushmeat hunting and habitat degradation. Today, protected by only a few square kilometres of riverside forest, the red colobus is now threatened by a new sugar-cane plantation and the flood of settlers it will bring (IUCN 2008). It is listed as Endangered under the IUCN.

African Lion

(Panthera leo)

The lion is listed as vulnerable under the IUCN. In Africa, a population reduction of 30 to 50 per cent is suspected to have occurred over the last 20 years mainly due to hunting, poisoning and habitat loss. Kenya's lion population is estimated at 2 280.

Christian Lambrechts/UNEP

Women carrying fuelwood

Energy

Adequate and reliable sources of energy are essential for any country's security and economic development. To achieve a ten per cent annual GDP growth rate for the next 25 years as outlined in Vision 2030, Kenya needs to secure and maintain sustainable supplies of energy. Kenya's energy sources are broadly classified into traditional biomass-based energy sources such as fuel wood and charcoal, and conventional sources such as petroleum products and electricity. The former is mainly used in rural areas and to some extent in poor urban situations, while the latter are viewed as "modern" energy forms.

Kenyan energy sources have been typically derived from the domestic environment rather than from imports. Fuelwood accounts for 70 per cent of all energy consumed (in rural areas, it accounts for as much as 90 per cent of energy use) while electricity supplies six per cent of the country's energy, of which hydropower sources represent more than 64 per cent (Figure 12) (GoK and UNEP 2002, GoK 2002). Figure 16 shows the location of power stations and illustrates the environmental base of power supplies. Hydropower, for example, is derived directly from the forested catchments of Kenya's five "water towers." Deforestation of their slopes has a direct impact on the amount of water available to generate power.

Kenya's energy supply needs to continue growing as the population increases. At the same time, the environmental sources of power are diminishing as forests are felled and water catchments threatened. In addition, as poverty levels grow, so increasing numbers of people can ill afford conventional forms of energy and turn to wood for fuel (GoK 2002).

When energy supply is inadequate and poor populations have limited access to energy, hardship sets in and meaningful social and economic development is hampered. Electricity power rationing due to prolonged droughts, for example, often leads to the closure of several industries with negative consequences on employment and Gross Domestic Product (GDP).

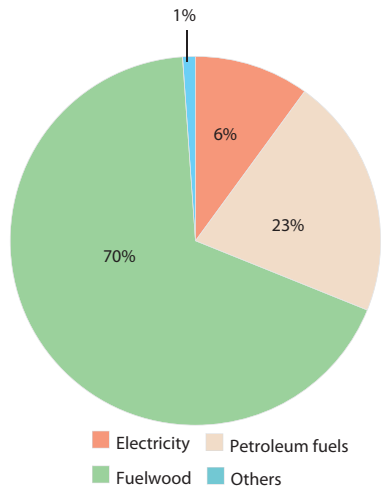


Figure 12: Sources of national energy (Source: Economic Survey 2000/2008)

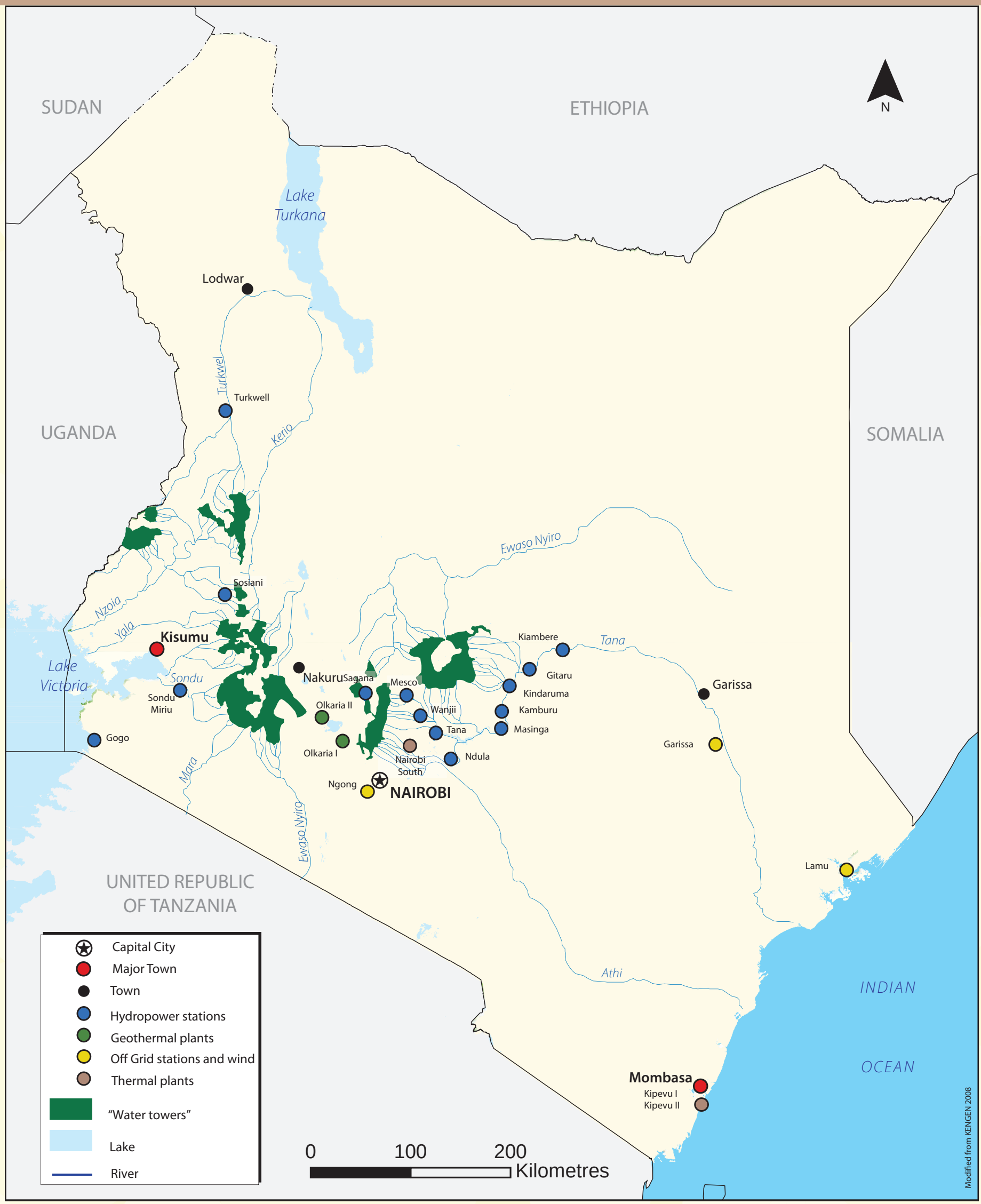


Figure 13: Location of power stations

Conventional Energy: Petroleum

Petroleum fuel is the most important conventional energy source accounting for 23 per cent of total national energy consumption. Kenya imports all its petroleum requirements either in the form of crude oil or finished petroleum products and they account for a significant proportion of national importation costs. Most of the petroleum fuels are consumed in the transport sector and in electricity production. Road tankers, rail, or oil pipelines transport petroleum products from the port of Mombasa to other parts of the country. The oil pipeline network extends to the cities and towns of Nairobi, Nakuru, Eldoret, and Kisumu. Plans are underway to extend the pipeline to Uganda.

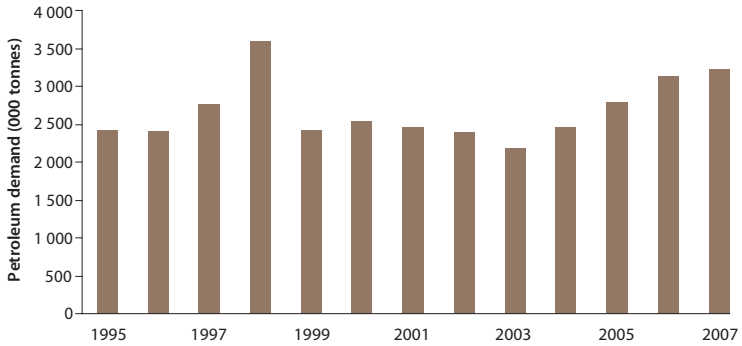


Figure 14: National petroleum energy demand, 1995 – 2007 (Source: CBS 2001)

In recent years, Kenya has geared up petroleum exploration as a major step towards providing the energy needed to attain Vision 2030. To this end, several inland and offshore blocks have been leased to petroleum exploration companies (Figure 16). Adherence to high environmental standards during the exploration and production process is essential, especially since some of these blocks overlap with existing protected areas.

It is important to note that demand for petroleum sometimes increases with drought events and that petroleum consumption is a major source of the greenhouse gases that contribute to climate change. On the other hand, traditional domestic energy sources such as fuelwood and hydropower could be managed on a sustainable basis, while other renewable energy sources, such as solar, geothermal, wind, and biogas, could be developed to increase their contribution to the nation's energy needs.

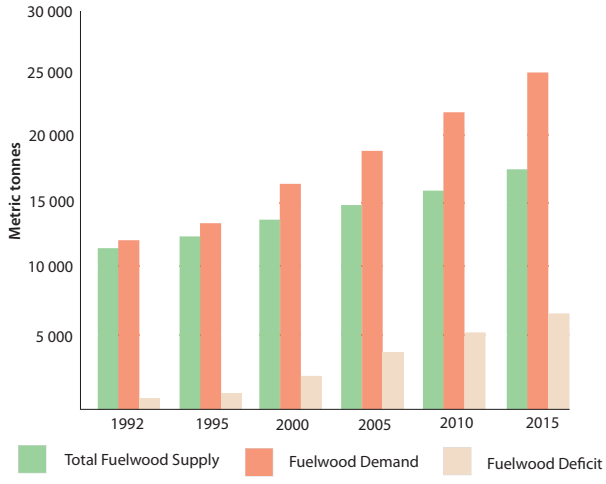


Figure 15: Fuelwood supply, demand, and deficit (Source: MENR 1994)

Traditional Energy: Fuelwood

Fuelwood is the nation's major source of energy, especially for rural people who make up 80 per cent of the total population. Although it constitutes the most significant energy source, the resource base is rapidly shrinking as demand outstrips the sources of local firewood and charcoal (Figure 15). Furthermore, the use of inefficient methods of burning is widespread, including traditional three-stone fireplaces for firewood and earth-mound charcoal kilns. Excessive reliance on fuelwood and the supply/demand imbalance are the cause of much deforestation and forest fragmentation, which in turn accelerates land degradation and threatens water catchments (GoK 2008). In addition to hampering the achievement of Vision 2030's economic goals, the fuelwood crisis undermines progress towards the MDG goal of increasing the land area covered by forest. Another impact of burning fuelwood and charcoal is respiratory illness among women who are exposed to indoor smoke from kitchen fires. There is, therefore, a great need for the adoption of improved efficiency and energy-saving stoves and kilns and for the nation to shift away from a reliance on fuelwood, or excessive demand will increase pressures on already vulnerable forest resources.

Bundle of fuelwood

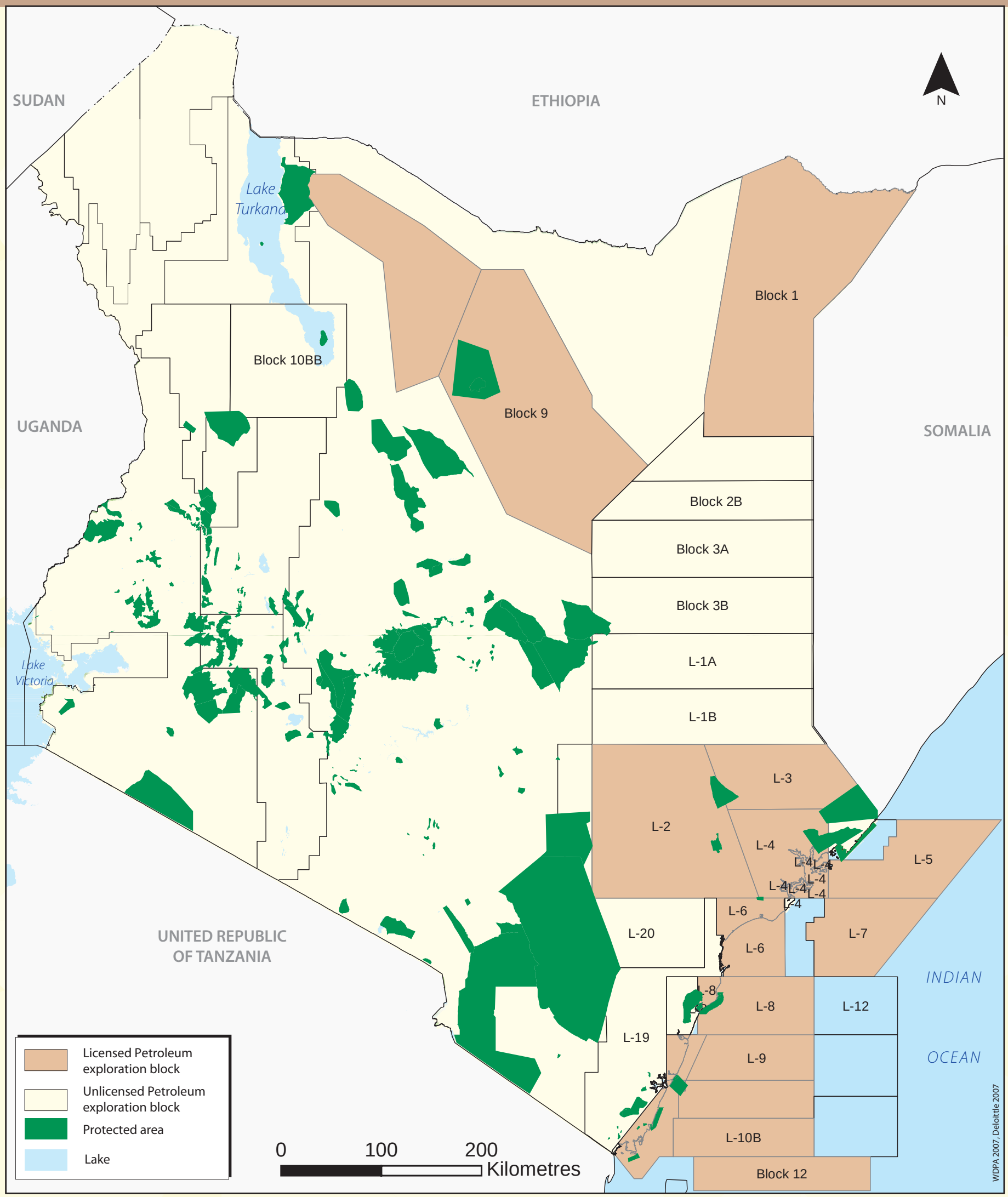


Figure 16: Inland and offshore licensed and unlicensed petroleum exploration blocks and protected areas overlap in various instances

Renewable Energy

Eighty-one per cent of the energy used in Kenya is from renewable sources, including solid biomass (fuelwood) (REN21 2008). Geothermal energy is by far the most developed renewable energy form, accounting for about 11 per cent of all the electricity produced in the country (GoK 2008). It is produced at three sites in the Rift Valley and a new plant is being built in Hell's Gate National Park to increase capacity. Kenya's geothermal potential is very large and it has several advantages—it is generated domestically so doesn't rely on expensive oil imports and it doesn't emit greenhouse gases. Future development, however, must avoid damaging the environment for local people, wildlife, and tourism.

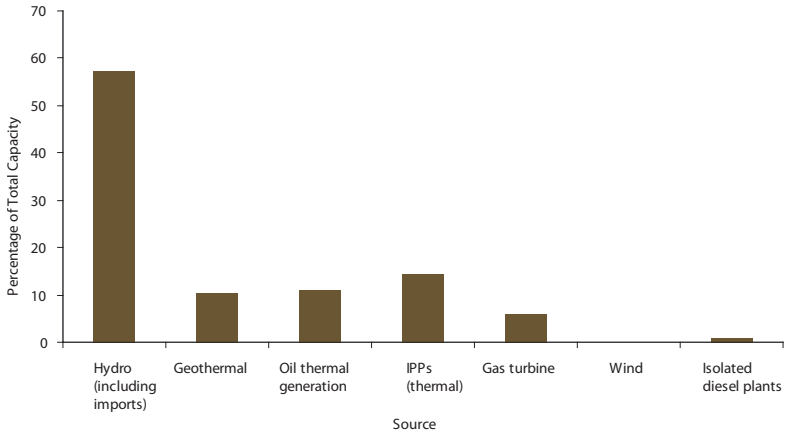


Figure 17: Electricity power generation capacity from various sources, 2000 (Source: GoK 2008)

Steam rises from a geothermal plant

Kenya's electric power generation capacity in the year 2005 was 5.5 billion kWh (EIA 2008). In 2000, hydropower accounted for about 57 per cent of the total. Petroleum based, geothermal, and wind account for 31 per cent, 11 per cent, and less than 0.1 per cent respectively (GoK 2008) (Figure 17).

The water used in hydropower generation comes from dams on major rivers flowing from Kenya's five water towers (page 6). Deforestation, land cover conversion, or any other activity that degrades these water towers will in turn lead to a reduction in the amount of electricity generated hence directly affecting the attainment of Vision 2030.

The exploitation of solar, wind, and biogas energy is still very low in spite of the country's enormous potential for these environmentally sound energy sources and the need for sustainable and affordable energy sources to reduce reliance on fuelwood (GoK 2008). Solar energy is currently under-exploited although it widely regarded as a plausible option to stimulate rural electrification. To date, it is being exploited in Kenya for lighting (photovoltaic), water pumping (mechanical), refrigeration, and water heating (solar water heaters). The solar market is currently estimated to be worth over Ksh. 300 million per year. A solar photovoltaic policy framework and strategy is being developed under the power sector reorganization programme.

Wind energy also remains largely under-developed and under-exploited. A study in 2002 found there is the potential for about 0.6 per cent of total energy to come from community wind energy (GoK 2002). Wind energy applications, especially those related to mechanical functions, have a long history in Kenya. In 1986, there were over 200 working windmills, of which about 100 were in Lamu and Mombasa districts. Local expertise for building windmills, especially for water pumping, is still available in the private sector. The Ministry of Energy created a national wind atlas for Kenya in 2003. It provides useful information to facilitate both public and private sector investment in this important energy sub-sector.

Biogas technology for cooking and lighting gained momentum in the mid-1980s during the German-funded Special Energy Project. Active promotion of biogas resulted in an estimated 1 000 biogas plants being constructed and in use by 1995. Most of these plants are found in areas of high agricultural potential.

Young man selling a solar panel

Flash floods wash out a section of a road in Baringo District

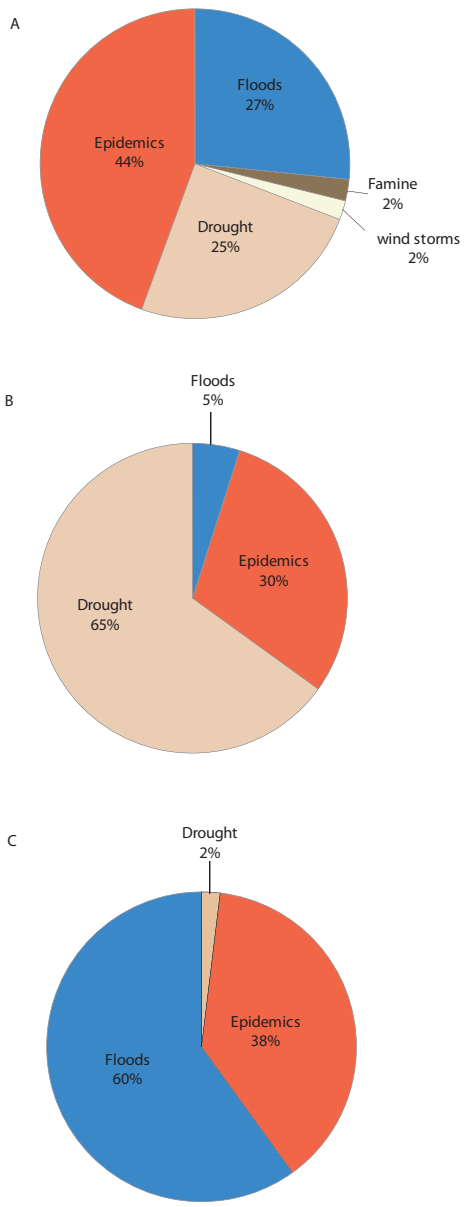


Figure 18: Types of hazards in Kenya (Source: Mutua 2005)

Key: a) Prevalence b) People affected c) People killed or affected adversely (disasters)

Environmental Disasters and Challenges to Vision 2030

Kenya has always been plagued by natural, weather-related disasters that cause diseases, deaths, and suffering throughout the nation. Figure 18 illustrates the prevalence of various types of hazards and the proportion of Kenyans affected by each of them.

Especially prevalent are the twin weather-related hazards of drought (Figure 19) and flooding (Figure 20). As the nation strives to achieve its development goals, including targets under the MDGs and those related to Vision 2030, it needs to effectively plan and manage its environmental, as well as its economic and human resources, to avoid allowing recurring natural phenomenon to turn into human and economic disasters.

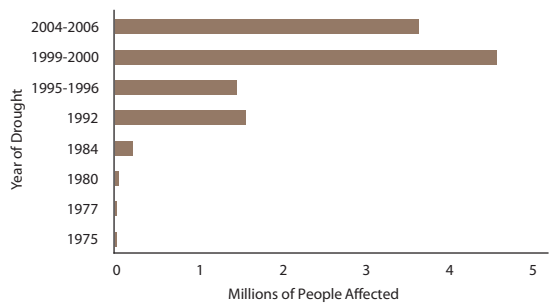


Figure 19: Number of Kenyans (million) affected by drought, 1975-2006 (Source: KMD 2008)

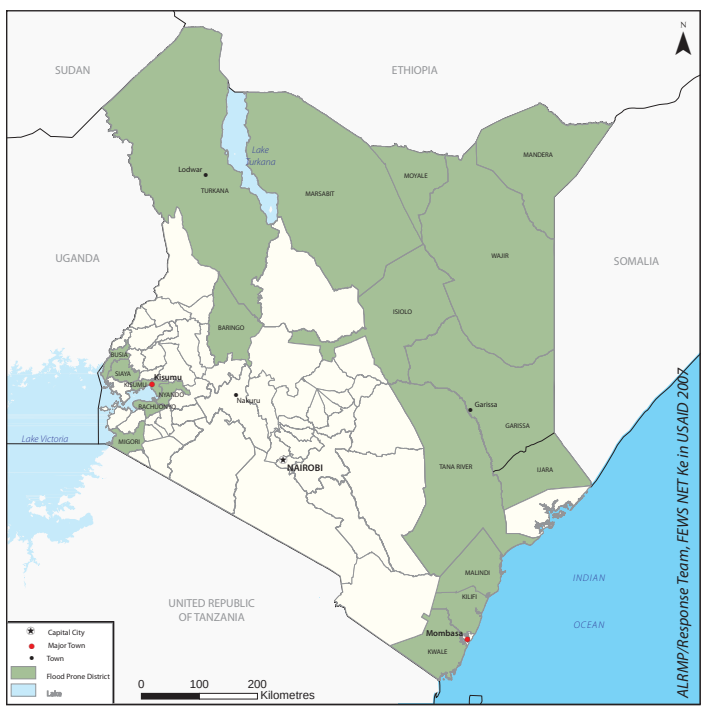


Figure 20: Areas affected by floods

Many areas, especially in the northeast, along the coast, and in western Kenya, are susceptible to floods and the country's rangeland districts generally experience flashfloods during the rainy seasons.

Although these events are natural in origin, the impacts of human-induced climate change are predicted to exacerbate them. It is already evident that the frequency and occurrence of floods in many parts of the country have increased significantly since the 1990s, for example. In addition, environmental changes brought by human activity, such as those highlighted in this Atlas, including deforestation; desertification; coastal modification, such as the removal of mangroves; and agricultural practices in fragile ecosystems, contribute to an increase in the disastrous consequences of what were once purely natural weather hazards. Protecting and restoring these environmental assets will help make Vision 2030's economic and social goals a reality.

DEPHA

Floods in the Tana River District

The Tana River Delta is among Kenya's top three largest and most important freshwater wetland systems. Local people live by the seasons, adapting to the regular floods that keep the area fertile through the year.

Floods in Bundalangi

Budalangi division lies to the north of Lake Victoria near the Kenya-Uganda border's Busia District. Floods are characteristic in the region. Between 1977 and 1984, dykes were built along the river to prevent the worst floods. Large areas of forests upstream from the source near the rivers have been cleared mainly for settlements and farmland. This has led to erosion and inevitable soil slippage and landslides when yearly floods occur. Without recourse to other options, when the dry season returns, survivors go back to their land and rebuild their homes in areas susceptible to recurring flooding disasters. A lasting solution has yet to be found.

DEPHA

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"Achieving MDG 7 is an important precondition for achieving all the other MDGs"

-Achim Steiner

United Nations Under-Secretary General
Executive Director of the United Nations
Environment Programme (UNEP) 2006
(Steiner 2006)

Chapter 2: Millennium Development Goals

This chapter has a special focus: it assesses Kenya's progress towards achieving the targets associated with the Millennium Development Goals. As shown in Chapter 1, environmental goods and services underpin economic and social development; thus maintaining and improving the environment's viability is essential for Kenya to be able to adequately support its growing population and achieve its development plans. In its efforts to achieve Vision 2030, the Government of Kenya is working towards a long-term plan based on the Millennium Development Goals (MDGs). In addition to increasing budgetary allocation for them and tracking and monitoring progress, it has undertaken a number of capacity-building and sensitization activities at the district level. This chapter notes how Kenya has made important strides towards achieving some of the MDG targets, while reversing environmental degradation remains a major challenge.

The Millennium Declaration

The eight Millennium Development Goals (MDGs) (Table 1 on the following page) provide a framework to plan and implement development, and include time-bound targets and indicators by which progress can be measured over the period from 1990 until 2015 when the targets are expected to be met. Each year, the United Nations Secretary-General presents a report to the United Nations General Assembly on progress achieved towards implementing the Declaration, based on the 60 selected indicators and 21 targets aggregated at global and regional levels.

By 2008, it was apparent that no African country was likely to achieve all of its goals by 2015. The international community strengthened partnerships with Africa at the highest level to ensure that its development needs are mainstreamed in the global economy. Numerous environmental, social, and political constraints, however, continuously pose significant challenges to achieving the MDGs in Africa (IISD 2008). Figure 1 shows the proportion of sub-Saharan countries that had attained various levels of seven of the MDGs.

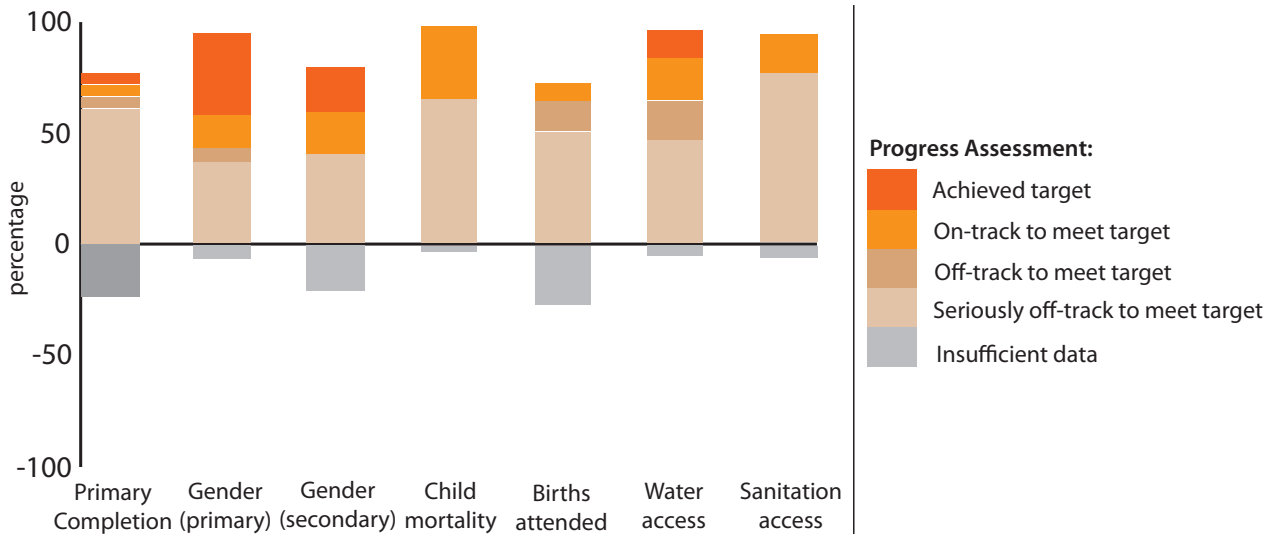

Figure 1: Sub-Saharan Africa's progress towards MDG targets (Source: World Bank 2008)

Painted face and headdress of a Kikuyu tribeswoman

The Kikuyu make up the largest tribal population in Kenya. There are about 5 347 000 Kikuyu people in Kenya, equal to about 22 per cent of Kenya's total population. By tradition, the Kikuyu are farmers; their homelands in the foothills of Mt. Kenya and highlands on either side of the Rift Valley are some of the most intesively farmed areas of the country (Gordon 2005, CIA 1996).

Table 1: The MDGs and their associated targets and indicators

Goals and Targets (from the Millennium Declaration)	*Indicators for monitoring progress*
Goal 1: Eradicate extreme poverty and hunger	
Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	1.1 Proportion of population below $1 (PPP) per day[a] 1.2 Poverty gap ratio 1.3 Share of poorest quintile in national consumption
Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	1.4 Growth rate of GDP per person employed 1.5 Employment-to-population ration 1.6 Proportion of employed people living below $1 (PPP) per day 1.7 Proportion of own-account and contributing family workers in total employment
Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	1.8 Prevalence of underweight children under-five years of age 1.9 Proportion of population below minimum level of dietary energy consumption
Goal 2: Achieve universal primary education	
Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	2.1 Net enrolment ratio in primary education 2.2 Proportion of pupils starting grade 1 who reach grade 5 2.3 Literacy rate of 15-24 year-olds
Goal 3: Promote gender equality and empower women	
Target 3.A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015	3.1 Ratios of girls to boys in primary, secondary and tertiary education 3.2 Share of women in wage employment in the non-agricultural sector 3.3 Proportion of seats held by women in national parliament
Goal 4: Reduce child mortality	
Target 4.A: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	4.1 Under-five mortality rate 4.2 Infant mortality rate 4.3 Proportion of one year-old children immunised against measles
Goal 5: Improve maternal health	
Target 5.A: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio	5.1 Maternal mortality ratio 5.2 Proportion of births attended by skilled health personnel
Target 5.B: Achieve, by 2015, universal access to reproductive health	5.3 Contraceptive prevalence rate 5.4 Adolescent birth rate 5.5 Antenatal care coverage (at least one visit and at least four visits) 5.6 Unmet need for family planning
Goal 6: Combat HIV/AIDS, malaria and other diseases	
Target 6.A: Have halted by 2015 and begun to reverse the spread of HIV/AIDS	6.1 HIV prevalence among population aged 15-24 years 6.2 Condom use at last high-risk sex 6.3 Proportion of population aged 15-24 years with comprehensive correct knowledge of HIV/AIDS 6.4 Ratio of school attendance of orphans to school attendance of non-orphans aged 10-14 years
Target 6.B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all who need it	6.5 Proportion of population with advanced HIV infection with access to antiretroviral drugs
Target 6.C: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	6.6 Incidence and death rates associated with malaria 6.7 Proportion of children under 5 sleeping under insecticide-treated bednets 6.8 Proportion of children under 5 with fever who are treated with appropriate anti-malarial drugs 6.9 Incidence, prevalence and death rates associated with tuberculosis 6.10 Proportion of tuberculosis cases detected and cured under directly observed treatment short course
Goal 7: Ensure environmental sustainability	
Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	7.1 Proportion of land area covered by forest 7.2 CO_2 emissions, total, per capita and per $1 GDP (PPP) 7.3 Consumption of ozone-depleting substances 7.4 Proportion of fish stocks within safe biological limits 7.5 Proportion of total water resources
Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	7.6 Proportion of terrestrial and marine areas protected 7.7 Proportion of species threatened with extinction
Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	7.8 Proportion of population using an improved water source 7.9 Proportion of population using an improved sanitation facility
Target 7.D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	7.10 Proportion of urban population living in slums[b]
Goal 8: Develop a global partnership for development	
Target 8.A: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system Includes a commitment to good governance, development and poverty reduction—both nationally and internationally	Some of the indicators listed below are monitored separately for the least developed countries (LDCs), Africa, landlocked developing countries and small island developing States. ***Official development assistance (ODA)*** 8.1. Net ODA, total and to the least developed countries, as percentage of OECD/DAC donors' gross national income
Target 8.B: Address the special needs of the least developed countries *Includes:* tariff and quota free access for the least developed countries' exports; enhanced programme of debt relief for heavily indebted poor countries (HIPC) and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction	8.2. Proportion of total bilateral, sector-allocable ODA of OECD/DAC donors to basic social services (basic education, primary health care, nutrition, safe water and sanitation) 8.3 Proportion of bilateral official development assistance of OECD/DAC donors that is untied 8.4 ODA received in landlocked developing countries as a proportion of their gross national incomes 8.5 ODA received in small island developing States as a proportion of their gross national incomes ***Market access***
Target 8.C: Address the special needs of landlocked developing countries and small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly)	8.6 Proportion of total developed country imports (by value and excluding arms) from developing countries and least developed countries, admitted free of duty 8.7 Average tariffs imposed by developed countries on agricultural products and textiles and clothing from developing countries 8.8 Agricultural support estimate for OECD countries as a percentage of their gross domestic product 8.9 Proportion of ODA provided to help build trade capacity
Target 8.D: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.	***Debt sustainability*** 8.10 Total number of countries that have reached their HIPC decision points and number that have reached their HIPC completion points (cumulative) 8.11 Debt relief committed under HIPC and MDRI Initiatives 8.12 Debt service as a percentage of exports of goods and services
Target 8.E: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries	8.13 Proportion of population with access to affordable essential drugs on a sustainable basis
Target 8.F: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications	8.14 Telephone lines per 100 population 8.15 Cellular subscribers per 100 population 8.16 Internet users per 100 population

The Millennium Development Goals and targets come from the Millennium Declaration, signed by 189 countries, including 147 heads of State and Government, in September 2000 (http://www.un.org/millennium/declaration/ares552e.htm) and from further agreement by member states at the 2005 World Summit (Resolution adopted by the General Assembly—A/RES/60/1, http://www.un.org/Docs/journal/asp/ws.asp?m=A/RES/60/1). The goals and targets are interrelated and should be seen as a whole. They represent a partnership between the developed countries and the developing countries "to create an environment—at the national and global levels alike—which is conducive to development and the elimination of poverty".

[a] *For monitoring country poverty trends, indicators based on national poverty lines should be used, where available.*

[b] *The actual proportion of people living in slums is measured by a proxy, represented by the urban population living in households with at least one of the four characteristics: (a) lack of access to improved water supply; (b) lack of access to improved sanitation; (c) overcrowding (3 or more person per room); and (d) dwellings made of non-durable material.*

Source: UN 2007b

Table 2: Key links between the environment and the MDGs	
MDG 1: Eradicate poverty and hunger	Poor people often depend on natural resources and ecosystems for income and livelihoods (food, shelter, medicine, water, etc.). The economy of the poorest countries often relies on natural resources exports, such as agricultural commodities and raw materials, and ecotourism.
MDG 2: Universal primary education	Time spent collecting water and fuelwood by children—especially girls, and especially during droughts—can reduce the time at school or prevent school attendance.
MDG 3: Gender equality	Time spent collecting water and fuelwood by women can reduce the time for schooling, undertaking income-generating activities, and participating in community decision-making. Unequal access to land and other natural resources limits possibilities for decision-making and empowerment.
MDG 4: Reduce child mortality	Children are more vulnerable to environment-related health problems because their immune systems are not fully developed and their metabolisms are different from those of adults. Environment-related diseases (diarrhoea, acute respiratory infection, leukaemia, childhood cancer, etc.) are primary causes of child mortality. Increasing the provision of clean, accessible water (MDG 7) can significantly decrease child mortality (MDG 4) and fatal diseases (MDG 6), making it possible for children and women to go to school (MDGs 2 and 3).
MDG 5: Improve maternal health	Exposure to indoor air pollution and carrying heavy loads of water and fuelwood negatively affect women's health, can make women less fit for childbirth, and put them at greater risk of complications during pregnancy.
MDG 6: Combat disease	Most diseases in developing countries are environmental in origin, as specific environmental conditions may contribute to the growth and the spread of illnesses and limit access to treatment facilities and supplies. For example, a range of environmental factors affect malaria, since stagnated water and increasing temperatures associated with climate change create favourable conditions for disease-carrying mosquitoes. Undisturbed forests also harbour fewer malaria vectors, thereby reducing exposure to disease.

(Source: UNDP 2006)

Environmental Links to the MDGs

Environmental resources and conditions have a significant impact on many aspects of poverty and development, and achieving environmental sustainability is fundamental to achieving all of the MDGs. One of the most powerful ways to help achieve the first MDG — eradicate extreme poverty and hunger — is to ensure environmental quality and quantity is maintained in the long term (Table 2).

Lush vegetation in forest understory provides biodiversity

Eager children in school

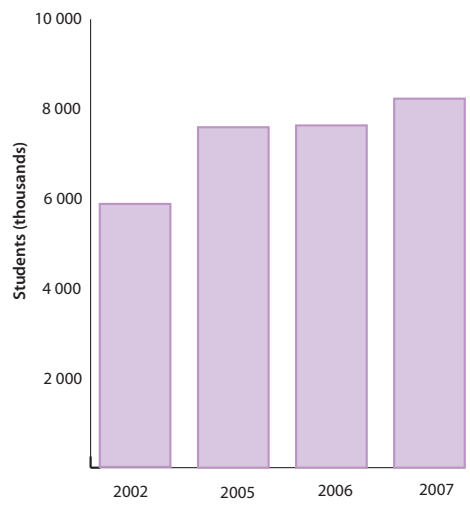

Figure 2: Primary school enrollment, 2002-2007 (Source: KNBS 2008)

Kenya's progress towards achieving the Millennium Development Goals

Kenya has made progress towards achieving a number of the goals. By 2007, the nation had achieved notable headway in the fight against poverty. Although the proportion of the population living below the poverty line increased from 52.3 per cent in 1997 to an estimated 56 per cent between 2000 and 2002, by 2005/06, it had dropped to 45.9 per cent (GoK 2007). Likewise, headway has been made towards the provision of universal primary education (Goal 2), with 90 per cent of girls and 95 per cent of boys enrolled in primary school. Kenya is also making promising advances in combating HIV/AIDS, malaria, and other diseases (Goal 6) (GoK 2007).

Table 4 (pages 46-47) provides an overview of Kenya's progress towards achieving the MDG goals from the 1990s to about 2000. To better evaluate the success of each goal, estimated targets (when quantifiable) are included in parentheses.

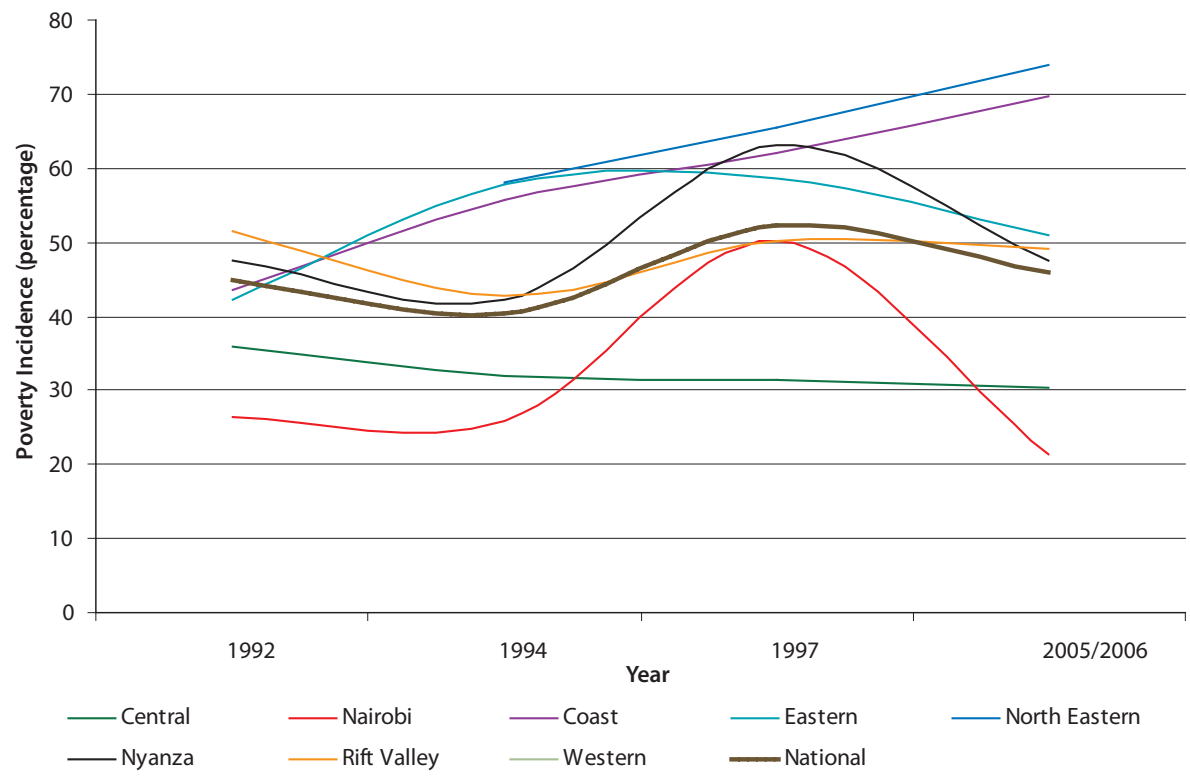

Figure 3: Poverty incidence, 1992-2006

Poverty incidence decreased in all provinces between 1997 and 2005/06 except the Coast and North Eastern Provinces.

(Source: GoK 2007, from Kenya Intregrated Household Budget Survey 2006)

Agricultural fields provide income and food security

Table 3: MDG 7— Ensure Environmental Sustainability	
Target A:	Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources
Target B:	Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss
Target C:	Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation
Target D:	By 2020, achieve a significant improvement in the lives of at least 100 million slum dwellers

Kenya's progress towards MDG 7: Ensure Environmental Sustainability

Kenya's environment has suffered from the impacts of human activities. Deforestation, land degradation, and water pollution are some of the challenges the nation needs to address in order to achieve MDG 7. The nation, however, has increased the proportion of land area protected for biological diversity from 12.1 per cent in 1990 to 12.7 per cent in 2007. A number of social and political factors continue to put pressure on natural resources and compromise the effective implementation of sustainable development strategies in Kenya. They include limited government capacity for environmental management and insufficient institutional and legal frameworks for enforcement and coordination (UNDP 2005).

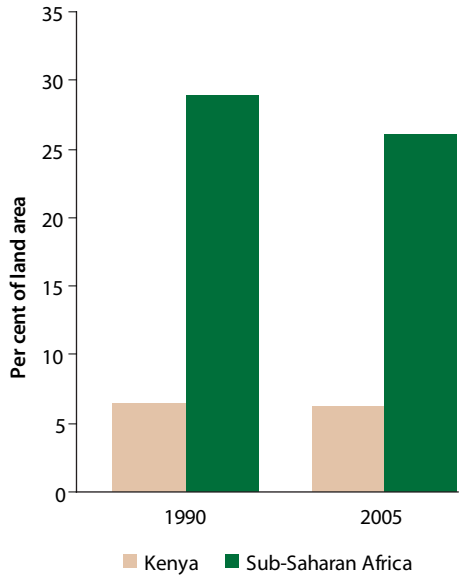

Figure 4: Forest and woodlands (Source: UNStats 2008)

Land area covered by forest

Kenya is one of the least forested countries in sub-Saharan Africa (UN 2008) with forests covering only 37.6 million ha — about three per cent of total land area (UNDP 2007). Between 1990 and 2005, the proportion of forested land in sub-Saharan Africa dropped by three per cent, from 29 per cent to 26 per cent. During the same period, Kenya's proportion of forested land decreased by 0.3 per cent (Figure 4).

Although Kenya's forests cover a small proportion of the total land area, they are home to 50 per cent of the nation's tree species, 40 per cent of large mammals, and 30 per cent of the nation's birds (KFWG 2008). Between 1990 and 2003, 186 000 ha of forest land was converted to other uses (UN 2007a). Biodiversity loss can have irreparable consequences for ecosystem services, food security, and tourism, all of which make significant contributions to Kenya's economy.

Clearing forest land for raising crops to support Kenya's growing population

Table 4: Indicators of Kenya's progress towards the MDGs, 1990s and 2000s.

Goals and indicators	Past[2] (1990s)	Present[3] (target) (2000s)
Goal 1: Eradicate extreme poverty and hunger		
1.1 Population below $1 (PPP) per day, percentage	-	52(1997)
1.2 Poverty gap ratio	-	-
1.3 Share of poorest quintile in national consumption, percentage	3.4	6(1997)
1.4 Growth rate of GDP per person employed, percentage	-4.69	3.02
1.5 Employment-to-population ratio (both sexes), percentage	63.9	63.1
1.6 Proportion of employed people living below $1 (PPP) per day, percentage	47.1	17.4(1997)
1.7 Proportion of own-account and contributing family workers in total employment	-	-
1.8 Prevalence of underweight (moderate and severe), children under 5, percentage	22.3	19.9
1.9 Undernourished population, percentage	39	31(2002) **(19)**
Goal 2: Achieve universal primary education		
2.1 Net enrollment ratio in primary education, percentage	64(1999)	76.2
2.2 Proportion of pupils starting grade 1 who reach last grade of primary, percentage	71.7	83.6 **(100)**
2.3 Literacy rate of 15-24 year-olds (male), percentage	-	79.8(2000)
2.4 Literacy rate of 15-24 year-olds (female), percentage	-	80.7 (2000)
Goal 3: Promote gender equality and empower women		
3.1 Gender Parity Index in primary level enrollment	0.96	0.97 **(1)**
3.2 Gender Parity Index in secondary level enrollment	0.77	0.93 **(1)**
3.3 Gender Parity Index in tertiary level enrollment	0.54(2000)	0.6 **(1)**
3.4 Seats held by women in national parliament, percentage	1.1	7.2
3.5 Share of women in wage employment in the non-agricultural sector	21.4	32.2(1997)
Goal 4: Reduce Child Mortality		
4.1 Under-five mortality rate, per 1 000 live births	97	121 **(32)**
4.2 Infant mortality rate, per 1 000 live births	64	79
4.3 Children 1-year old immunized against measles, percentage	78	77
Goal 5: Improve maternal health		
5.1 Maternal mortality ratio, per 100 000 live births	365[3]	560 **(92)**
5.2 Births attended by skilled health personnel, percentage	45.4	41.6 **(100)**
5.3 Contraceptive use among married women (15-49 yrs. old), percentage	32.7	39.3
5.4 Adolescent birth rate, per 1 000 women	118	116(2001)
5.5 Antenatal care coverage for at least four visits, percentage	-	52.3
5.6 Antenatal care coverage for at least one visit, percentage	94.9	88.1
5.7 Unmet need for family planning (total), percentage	36.4	24.5
Goal 6: Combat HIV/AIDS, malaria and other diseases		
6.1 People living with HIV, percentage	7.7(2001)	4.9
6.2 Condom use at last high-risk sex (female), percentage	14(1998)	25.4
6.3 Condom use at last high-risk (male), percentage	43 (1998)	46.8
6.4 Population 15-24 year-olds who have comprehensive correct knowledge of HIV/AIDS (female), percentage	-	34

[1] 1990-1993 unless otherwise indicated
[2] 2003-2008 unless otherwise indicated
[3] GoK (2008a)

(Source: UNStats 2008)

6.5 Population 15-24 year-olds who have comprehensive correct knowledge of HIV/AIDs (male), percentage	-	47
6.6 Ratio of school attendance of orphans to school attendance of non-orphans	0.94	0.95
6.7 Proportion of population with advanced HIV infection with access to antiretroviral drugs, percentage	27(2006)	38 **(100)**
6.8 Death reate associated with malaria, per 1 000	0.63(2000)5	1.35[4]
6.9 Incidences of malaria, percentage	14(2000) 4	27.7[4]
6.10 Death rate associated with tuberculosis, per 100 000 population	28.5	71.9
6.11 Incidences of tuberculosis, per 100 000 population	116.2	384.5
6.12 Prevalence of tuberculosis, per 100 000 population	132.9(2000)	334.1
6.13 Tuberculosis detection rate under directly observed treatment short course, percentage	56.6(1995)	70
6.14 Tuberculosis treatment success under directly observed treatment short course, percentage	74.7(1995)	82.4
6.15 Proportion of children under 5 sleeping under insecticide-treated bed nets, percentage	2.9(2000)	52[5]
6.16 Proportion of children under 5 with fever who are treated with appropriate anti-malarial drugs, percentage	40.4(1998)	26.5

Goal 7: Ensure environmental sustainability

7.1 Land area covered by forest, percentage	6.5	6.2
7.2 Carbon emissions, total (thousand metric tonnes CO_2)	5 826	10 588
Carbon emissions, per capita (metric tonnes CO_2)	0.2485	0.3054
Carbon emissions, kg CO_2 per $1 GDP (PPP)	-	-
7.3 Consumption of all ozone-depleting substances, ODP metric tonnes	452.3	134.8
7.4 Proportion of fish stocks within safe biological limits	-	-
7.5 Proportion of total water resources used, percentage	6.7	8.9
7.6 Proportion of species threatened with extinction	-	-
7.7 Proportion of terrestrial and marine areas protected to total territorial area, percentage	11.9	12.7
7.8 Proportion of population using an improved drinking water source, percentage total	41	57 **(82**)
7.9 Proportion of population using an improved sanitation facility, percentage total	39	42 **(78)**
7.10 Slum population in urban areas, percentage	70.4	54.8

Goal 8: Develop a global partnership for development

8.1 Average tariffs imposed by developed countries on agricultural products from developing countries	-	-
8.2 Average tariffs imposed by developed countries on clothings from developing countries	-	-
8.3 Average tariffs imposed by developed countries on textiles from developing countries	-	-
8.4 Net ODA as a percentage of OECD/DAC donors' GNI	-	-
8.5 Net ODA to LDCs as a percentage of OECD/DAC donors' GNI	-	-
8.6 ODA that is untied	-	-
8.7 ODA to basic social services as a percentage of sector-allocable ODA	-	-
8.8 ODA received by landlocked developing countries as a proportion of their GNI	-	-
8.9 ODA received by small island developing states as a proportion of their GNI	-	-
8.10 Agricultural support estimate for OECD countries as a percentage of their GDP	-	-
8.11 Debt relief committed under HIPC and MDRI Initiatives	-	-
8.12 Debt service as percentage of exports of goods and services and net income from abroad,	28.6	6.8
8.13 Developed country imports from developing countries, admitted duty free	-	-
8.14 Developed country imports from the LDCs, admitted duty free	-	-
8.15 ODA provided to help build trade capacity	-	-
8.16 Total number of countries that have reached their HIPC decision points and number that have reached their HIPC completion points (cumulative)	-	-
8.17 Population with access to affordable drugs	0.79	0.84
8.18 Telephone lines, per 100 population	0	20.91
8.19 Cellular subscribers, per 100 population	0	7.89
8.20 Internet users, per 100 population		

[4] GoK (2008b)
[5] GoK (2008c)

Reliance on fuelwood: a daunting challenge to stemming deforestation

Fuelwood accounts for over 70 per cent of the total energy consumption in Kenya (GoK 2004). This heavy reliance on wood for fuel and other livelihood needs such as timber, charcoal, building materials, and non-timber forests products, poses a major threat to existing forests. About 67 per cent of the national population depends on firewood for fuel (90 per cent for rural and 10 per cent for urban) with about 47 per cent of the national population depending on charcoal (82 per cent urban and 32 per cent rural) (GoK 2008).

Since 1930, Kenya has lost about 65 per cent of its original standing wood volume; Kenya's growing population threatens the few remaining forested areas and their ecosystem goods and services.

Among the strategies needed to increase forest areas is to reduce over-reliance on fuelwood consumption and increase access to alternative energy sources (GoK 2007) (Chapter 1).

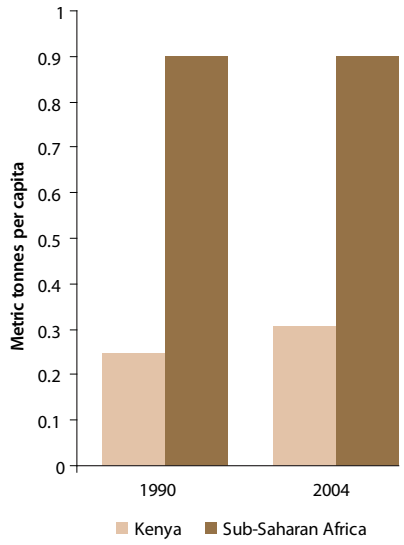

Figure 5: Per capita carbon dioxide emissions (Source: UNStats 2008)

Carbon emissions

Worldwide, carbon dioxide (CO_2) emissions reached 2 900 million metric tonnes in 2004 and they continue to rise, as evident from increasing concentrations of CO_2 in the atmosphere. Per capita CO_2 emissions in sub-Saharan Africa were 0.9 metric tonnes between 1990 and 2004. This is less than one-tenth of the per capita CO_2 emissions in the developed world (UN 2007b). Kenya's per capita emissions are much lower than the sub-Saharan average (Figure 5), although there was a slight increase from 1990 to 2004 (UN 2008). Nevertheless, carbon pollution, resulting mainly from industries and the increasing number of motor vehicles on Kenyan roads, is one of the leading environmental health problems in the country affecting both rural and urban populations (GoK 2007).

Exhaust pipe spewing out carbon emissions which contribute to climate change

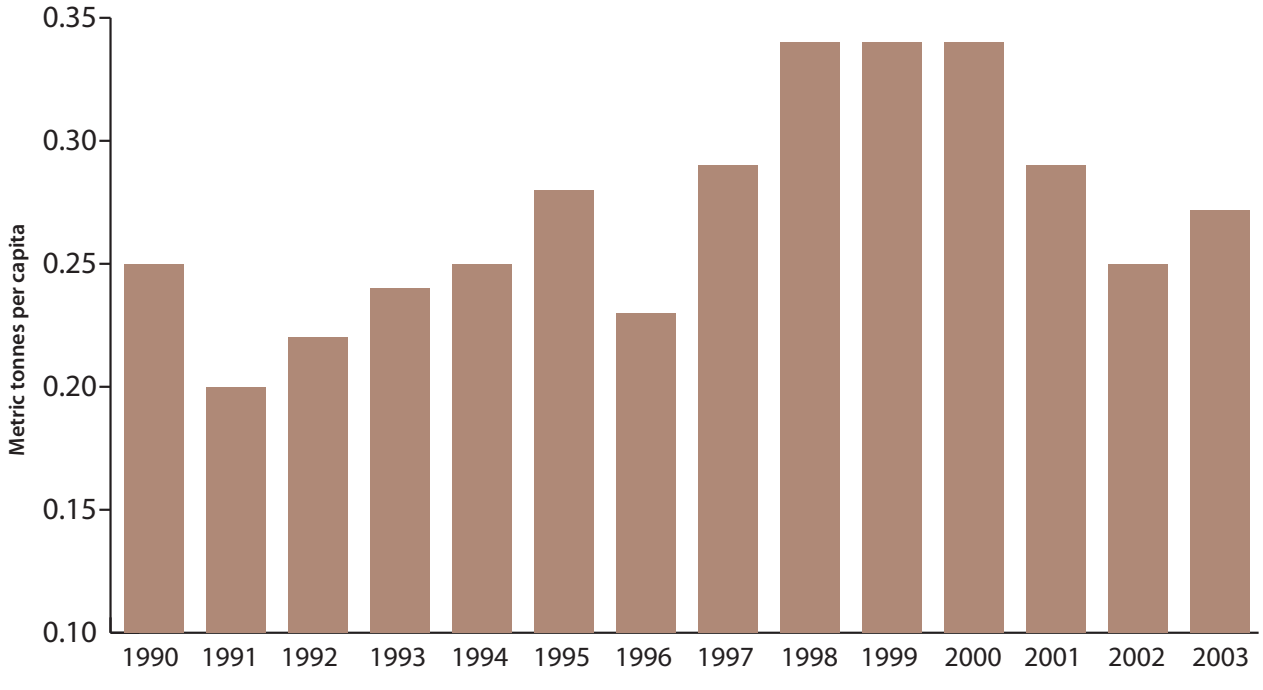

Figure 6: Changes in per capita carbon dioxide emissions in Kenya, 1990-2003 (UNStats 2008)

A crab blends in with its environment

The proportion of the total area set aside as terrestrial and marine protected areas

Kenya has 348 designated protected areas, representing 75 238 km^2 or 12.7 per cent of the nation's total territorial area (UNDP 2005). These include five Biosphere Reserves and three World Heritage Sites (Thaxton 2007).

Over 6 500 plant species are found in Kenya of which 260 are endemic. The nation also has more than 1 000 bird species and over 350 species of mammals, ranking it second highest among African countries in species richness for these animal groups (GoK 2007).

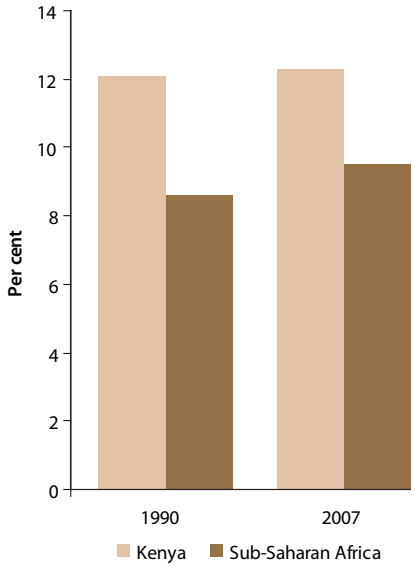

Figure 7: Protected area ratio to total territorial area (Source: UNStats 2008)

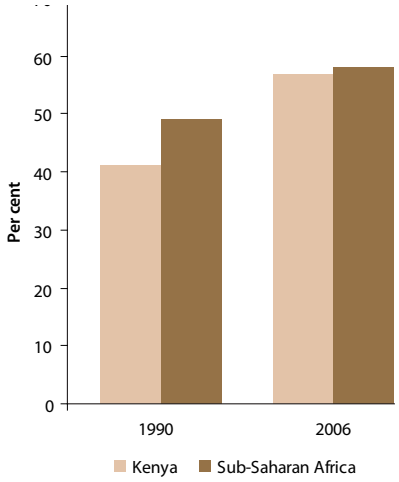

Figure 8: Proportion of the population using improved drinking water sources (Source: UNStats 2008)

In 2006, approximately 57 per cent of Kenyan households used water from sources considered safe.

The proportion of the population using an improved drinking water source

Overall, Kenya has made progress since 1990 in providing its growing population access to clean drinking water—more progress than sub-Saharian Africa in general. In Kenya's urban areas, however, access had declined during that time. Much effort is still needed to reach the 2015 target of halving the number of Kenyans without access to clean drinking water.

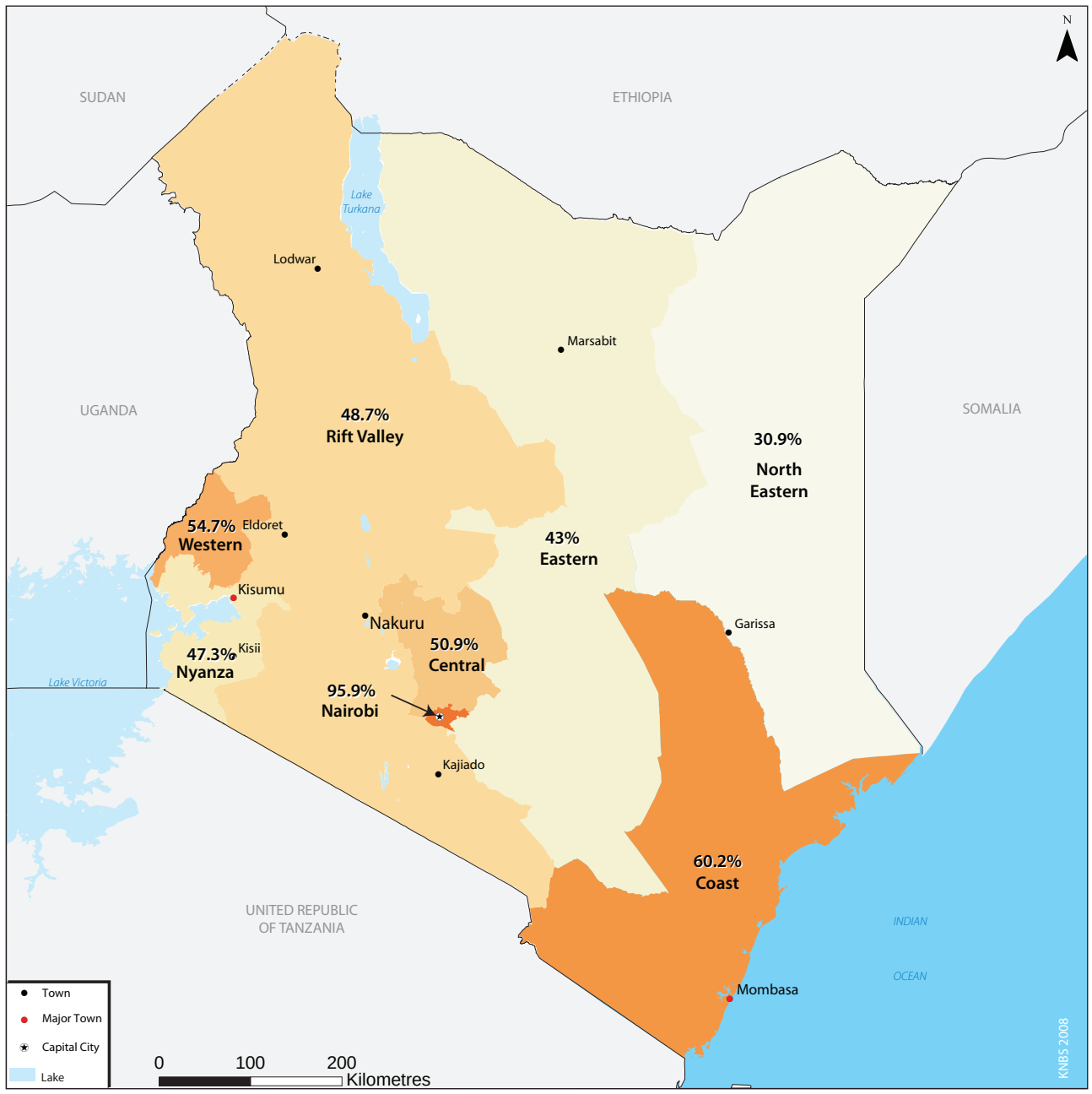

Figure 9: Percentage of households (urban and rural) with access to safe water, 2005-2006

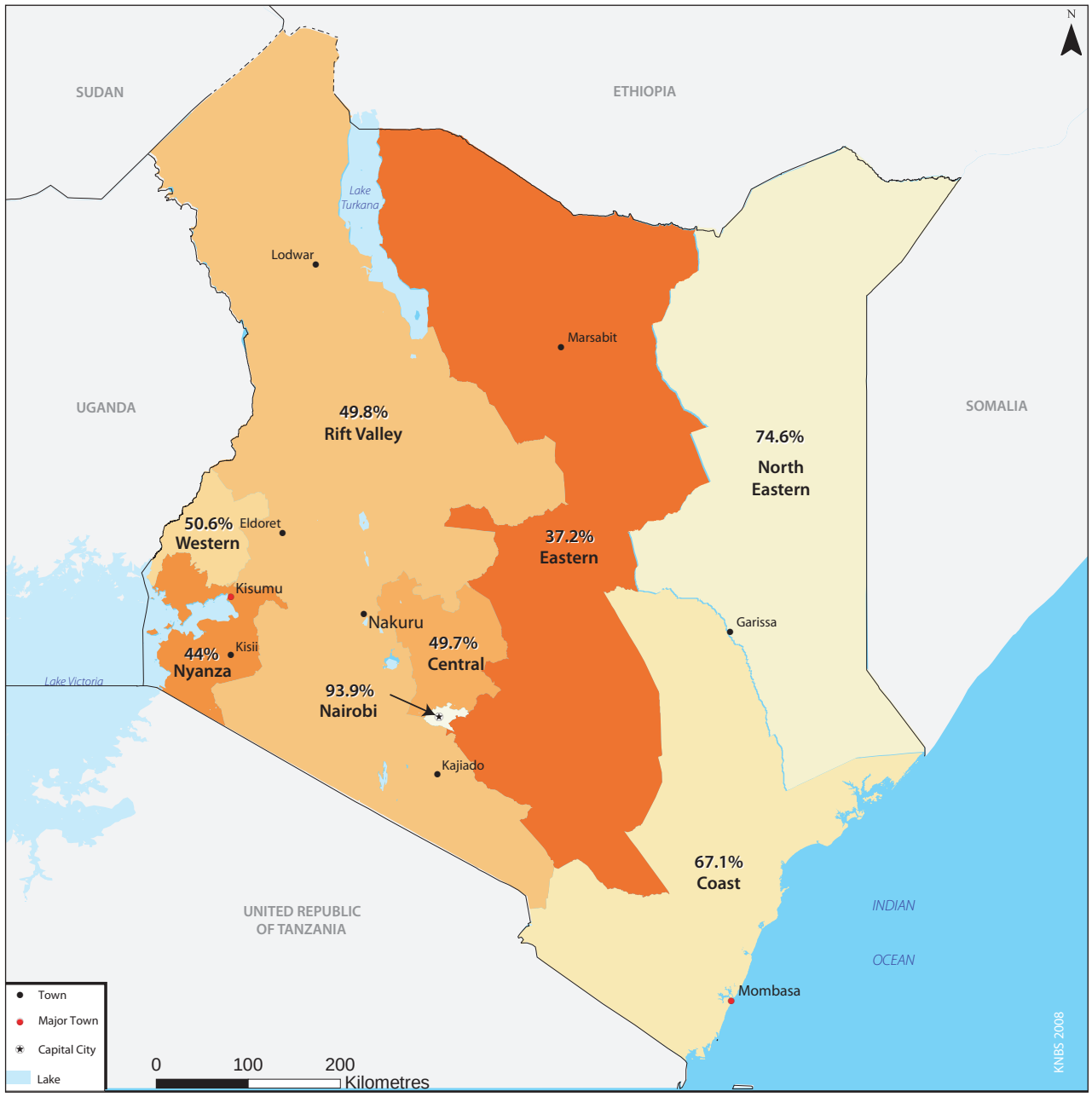

Figure 10: Percentage of households (urban and rural) with access to an improved water source

Safe drinking water pump at a local school

Increasing accessible water supplies tackles several MDGs at once

Kenya is below the international water scarcity threshold (1 000 m^3 per person per year) with only 935 m^3 available per person per year (FAO 2007), and population growth is forecast to reduce this figure to 359 m^3 by 2020 (UN-Water 2006).

Kenya's water resources are unevenly distributed. Many of its arid regions receive only 250 mm or less of rain per year. Highly stressed water systems include Lakes Victoria, Nakuru, and Naivasha, as well as the Nzoia, Nyando, Turkwel, Kerio, Athi, Voi, Tana, and Ewaso Nyiro rivers. In addition, salinity levels in many water bodies, such as Lake Turkana, are too high for human use of the water. In arid regions, when they occur, rains come mainly in violent storms causing erosion and leaching nutrients from the soil.

Women have the main responsibility for managing their household's needs for water, sanitation, and health. In a number of regions, women and girls spend many hours a day fetching water. In the Samburu District of central Kenya, for example, some women walk more than nine kilometres daily to find water (Aguirre 2007). With the increased frequency of droughts, women's trekking distances for water are increasing. The time spent obtaining water is time that could otherwise be devoted to schooling, child-care, or to income-generating activities. In addition, women are confronted with personal security risks while away from home and they endure immense physical burdens, since 20 litres of water can weight about 20 kg (UNDP 2008) (Table 2).

Increasing the provision of clean, accessible water to communities can significantly decrease child mortality and fatal diseases and make it possible for children and women to go to school. Access to clean water is therefore crucial in attaining most of the MDG targets.

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According to the Kenya Integrated Household Budget Survey, only 49 per cent of Kenya's rural population has access to clean water compared to 83 per cent in urban areas (GoK 2007). This disparity also exists between districts and regions (Figure 10). For example, access to safe water varies from a high of 96 per cent in Nairobi to as low as 14 per cent in Mwingi District (GoK 2007).

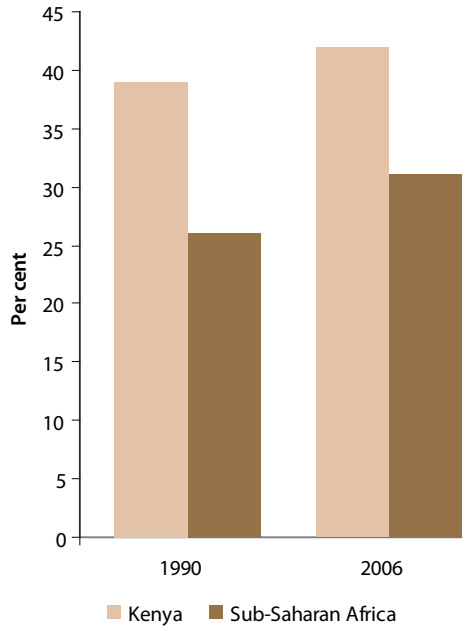


Figure 11: Proportion of total population using improved sanitation facilities (Source: UNStats 2008)

The proportion of the population using an improved sanitation facility

An estimated 1 600 million people will need access to improved sanitation over the period 2005-2015 to meet the MDG targets (UNEP 2008). Yet if trends since 1990 continue, the world is likely to miss the target by almost 600 million people. In Africa, only northern Africa is on track to halve the proportion of people without basic sanitation by 2015, whereas sub-Saharan Africa is set to achieve only half of the 2015 objective, with a small increase from 26 to 31 per cent between 1990 and 2006. To date, only 19 per cent of the Kenyan population living in urban areas has access to proper sanitation facilities (UnStats 2005). If this trend continues, Kenya is likely to miss the target.

Access to improved sanitation varies from region to region with the Western and Central provinces enjoying better sanitation coverage at 96.2 per cent and 99.7 per cent, respectively. The North Eastern

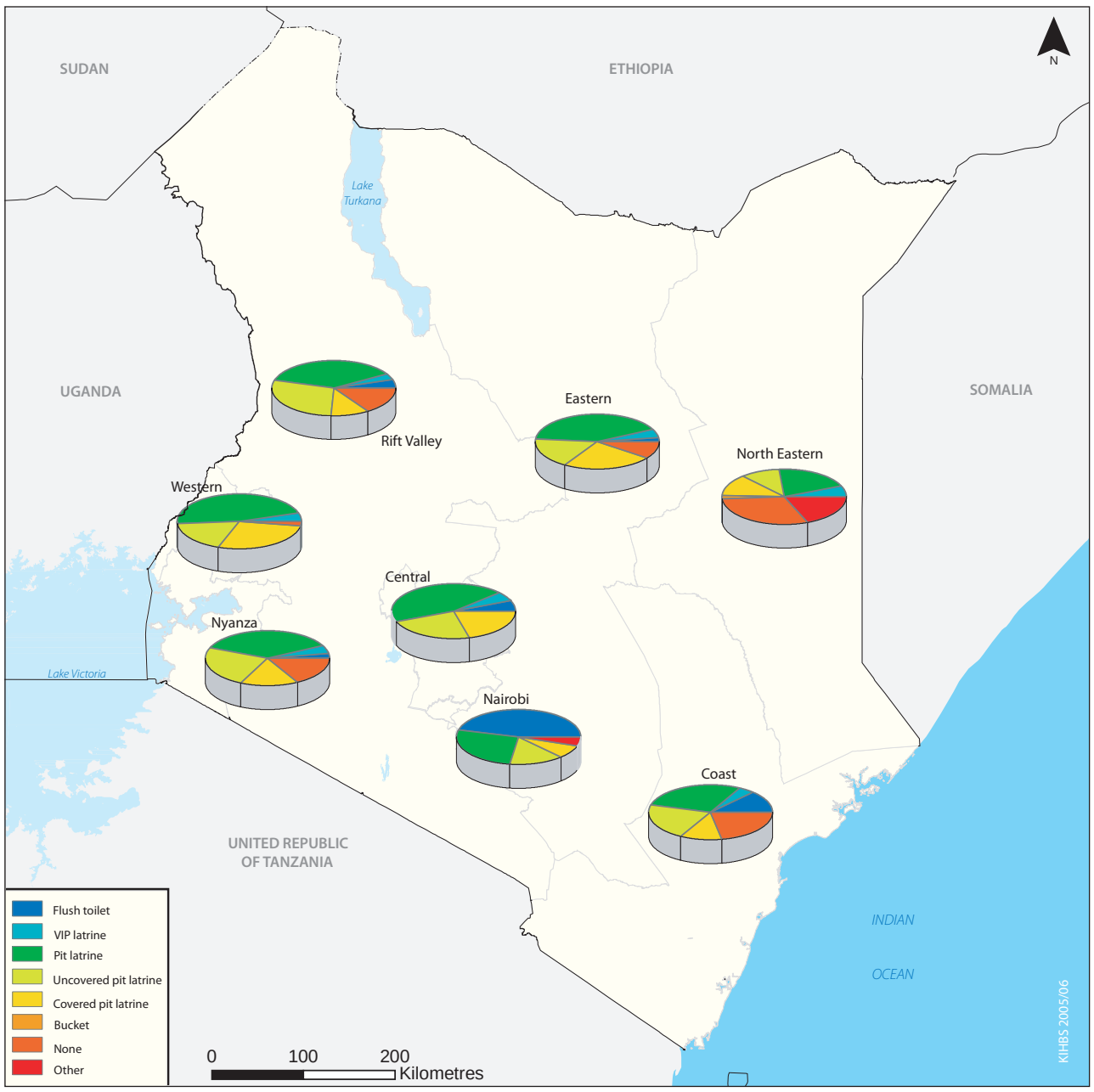


Figure 12: Percentage of households using main types of toilet facilities

Harvesting energy from human waste

In one part of the Kibera slums, a network of public latrines has been built featuring a facility that converts human waste to energy, which in turn is used for lighting and heating water. The human waste is put in an airtight biodigester from which methane gas is captured and filtered into an upper tank. During this process, solid waste is also treated and filtered through reed beds before being collected and sold as fertilizer. This is an excellent example in which simple technologies are applied in slum areas not only to improve sanitation, but also raise incomes and provide sustainable energy. (*Source: Houreld 2008)*

Province has the lowest access with only 36.7 per cent. Nationwide, Samburu and Turkana Districts are the most underserved with only 11.6 per cent and 17.7 per cent, respectively (GoK 2007). Pit latrines, whether improved or not, are the most widely used toilet facilities (Figure 12, page 51) and most sewerage collection treatment and disposal systems were constructed 20 to 40 years ago. Over the last 30 years, there has been inadequate funding to rehabilitate, upgrade, and expand water supplies and sewerage facilities (UNDG 2005).

A sewage treatment facility improves the health and well-being of Kenya's people

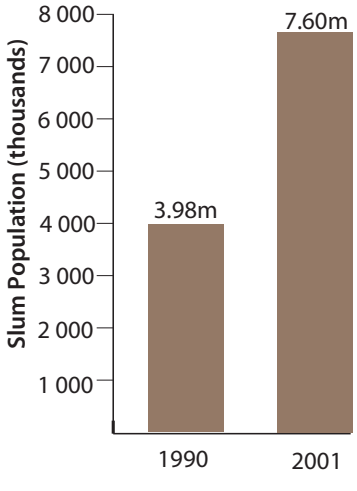
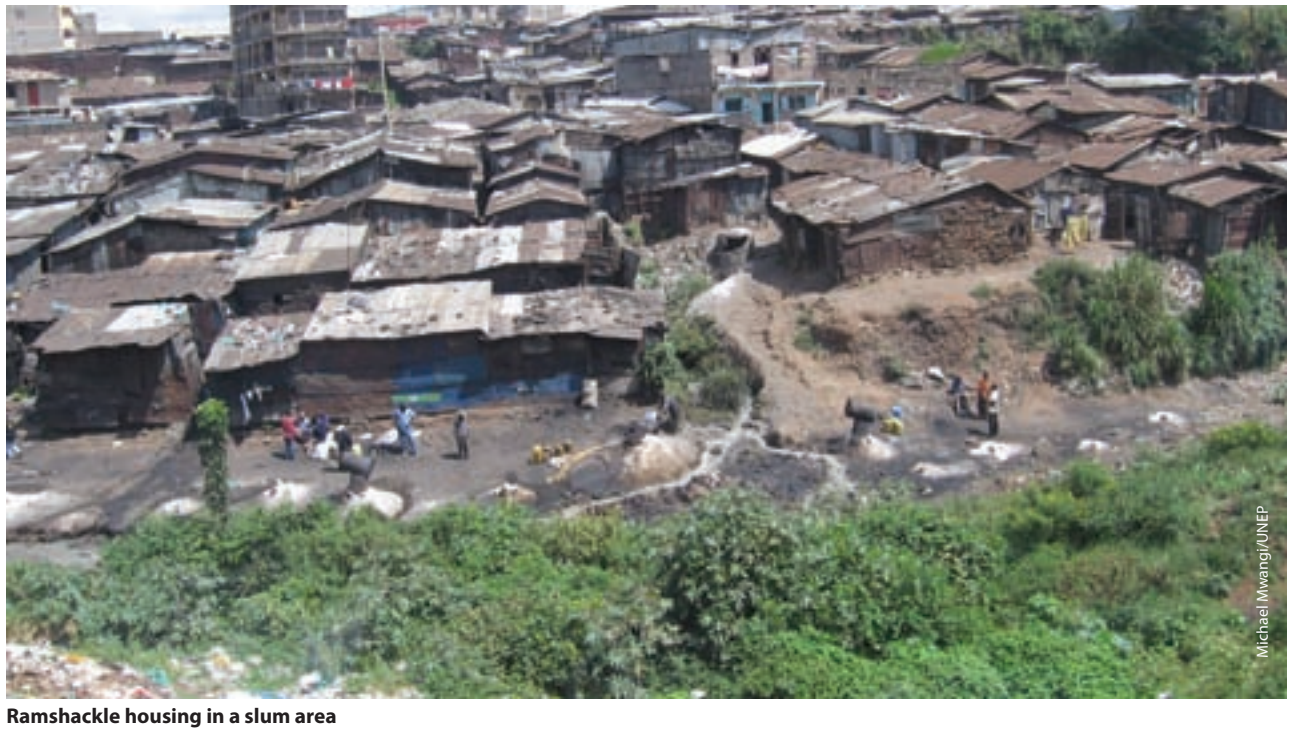


Figure 13: Slum population growth (Source: KNBS 2008)



Ramshackle housing in a slum area

The proportion of slum populations in urban areas

By the end of 2008, half the world's population will live in cities and towns and by 2050, 70 per cent of people will live in urban areas. Both urban migration and rapid population growth continue to expand the number of urban dwellers, which will rise from 3 200 million people in 2008 to nearly 5 000 million by 2030, with most of the growth taking place in Africa and Asia (UNEP 2008).

In 2005, one in three urban dwellers lived in slum conditions. This means they lacked at least one of the basic conditions of decent housing: adequate

Figure 14: Proportion of households with access to secure tenure (Source: UNStats 2008)

Aerial view of the Kibera slum

Youth in the Kibera slum make solar panels

Kenya has one of the largest and most dynamic solar markets in the developing world. Some ten major companies import photovoltaic solar panels and there are an estimated 1 000-2 000 solar technicians. More than 200 000 systems have been sold in Kenya since the mid-1980s, three quarters of them to private households (ILO 2008).

The Kibera Community Youth Programme (KCYB) operates in one of the largest slums in sub-Saharan Africa. It provides employment for local youth in an assembly line making small and affordable solar panels. These panels power radios and charge mobile phones in Kibera, but their use has also spread to all parts of Kenya. Numerous groups from neighbouring countries have requested similar projects (Herro 2007).

sanitation, improved water supply, durable housing, or adequate living space. Sub-Saharan Africa remains one of the regions where the lack of adequate shelter among urban populations is most acute (UN 2007b). In Kenya there has been a decline in the proportion of urban people living in slums (a decrease of 15.6 per cent since 1990), although the actual number of slum dwellers only decreased by 88 059 during this time. In 2005, four million Kenyans still lived in slums (UNStats 2008). The annual urban population growth rate reached 3.2 per cent between 2000 and 2005, compared to 1.9 per cent in rural areas. Even with a decline in the growth rate of slum dwellers, rapid urban expansion makes it a challenge to improve living conditions quickly enough to meet the MDG target.

Slum upgrade project conducted by the government

The Environment and Poverty

Developing countries, such as Kenya, are still heavily reliant on revenues from exported natural resources such as agricultural commodities. For example, in the 1990s, 53 per cent of Kenya's export earnings were derived from agricultural products such as coffee, sugar, and flowers (Nyangito n.d.). Agriculture presently accounts for 26 per cent of Kenya's GDP (NEE 2008).

The distribution of poverty across Kenya varies from one province to another. Each province offers a unique blend of environmental, geographical, and infrastructure characteristics, which in turn influence poverty levels. Certain environmental factors can contribute to poverty alleviation (Figure 15).

Poor households rely heavily on expenditure-saving, labour intensive activities for their subsistence and survival, such as collecting water and fuelwood or grazing animals on common lands. Common property resources or open access lands are important sources of livelihoods for the poor, providing them with a variety of goods, which can include food, water, fuel, fodder, bamboo, resin, gum, oils, construction materials, honey, medicinal plants, and spices, among others.

Many poor households depend on their local environments for food security. Generally, food security depends on food availability and stability, accessibility, and use. Poor soils and low agricultural productivity, lack of control over land management, and competition from other users are some of the conditions that threaten household food security. Food security is closely related to the achievement of a number of other MDGs: for example, poor nutrition is implicated in more than half of all child deaths worldwide (Jolly 2001), showing the gains to be made by addressing food security in targeting goal 4, which calls for reducing child mortality.

Over 36 per cent of all the rural poor Kenyans live on marginal lands or areas that are particularly vulnerable to environmental degradation, such as floodplains, coastal areas, and degraded hillsides. Depending on such lands for food can render poor people vulnerable to periodic hunger. Environmental hazards and extreme events, such as droughts, floods, forest fires, and landslides, are more damaging in marginal and degraded ecosystems and the poor living there are least able to cope with their impacts. For all these reasons, achieving the first MDG—eradicating extreme poverty and hunger—requires renewed efforts towards achieving MDG 7, through the sustainable management of land, water, biodiversity resources, and the adequate provision of urban sanitation, potable water, and waste management.

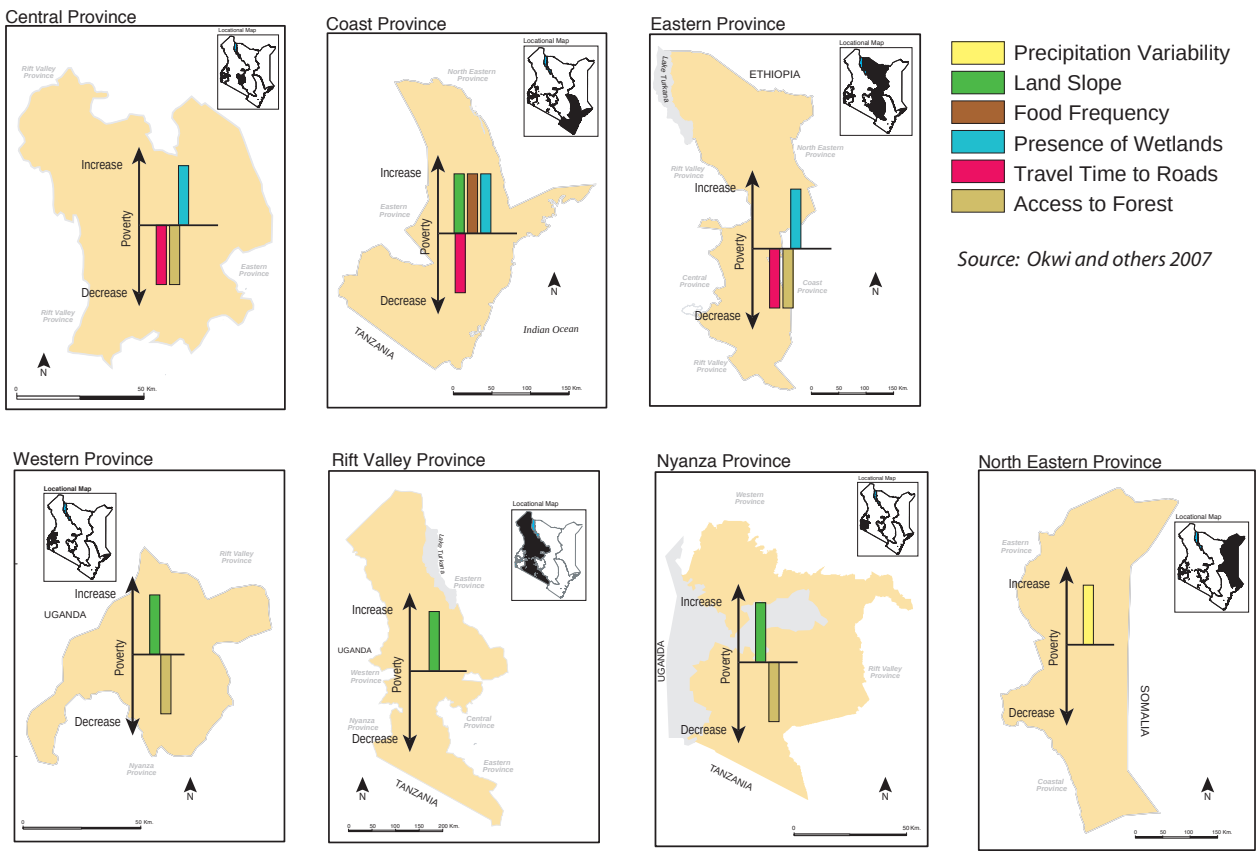


Figure 15: The effect of six environmental factors on poverty, by province.

Studying the correlation of environmental factors with poverty can aid in designing poverty alleviation projects.

Severe impact of drought on livestock and livelihoods

Climate Change and the MDGs

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC 2008).

"The poorest countries and most vulnerable citizens will suffer the earliest and most damaging setbacks of climate change, even though they have contributed least to the problem" (UNDP 2008)

According to UNDP, the mean annual temperature in Kenya has increased by 1.0°C since 1960 representing an average rate of 0.21°C per decade. It is projected to increase by 1.0 to 2.8°C by the 2060s and by the year 2100, temperatures in Kenya could increase by about 4°C causing variability of rainfall by up to 20 per cent (Kabubo-Mariara 2007).

Given that a large portion of Kenya is semi-arid with high temperatures and low precipitation, frequent droughts, water scarcity, and unpredictable climate variability will have the largest impacts on people living in these regions. The agricultural sector, which relies on predictable rainfall and temperatures, will suffer the most since it directly or indirectly supports 80 per cent of the population and agro-based industries support much of Kenya's economy (Kabubo-Mariara 2007). Kenya's high dependence on natural resources, its poverty levels and low capacity to adapt, and the existence of other significant environmental stress make it highly vulnerable to the impacts of climate change.

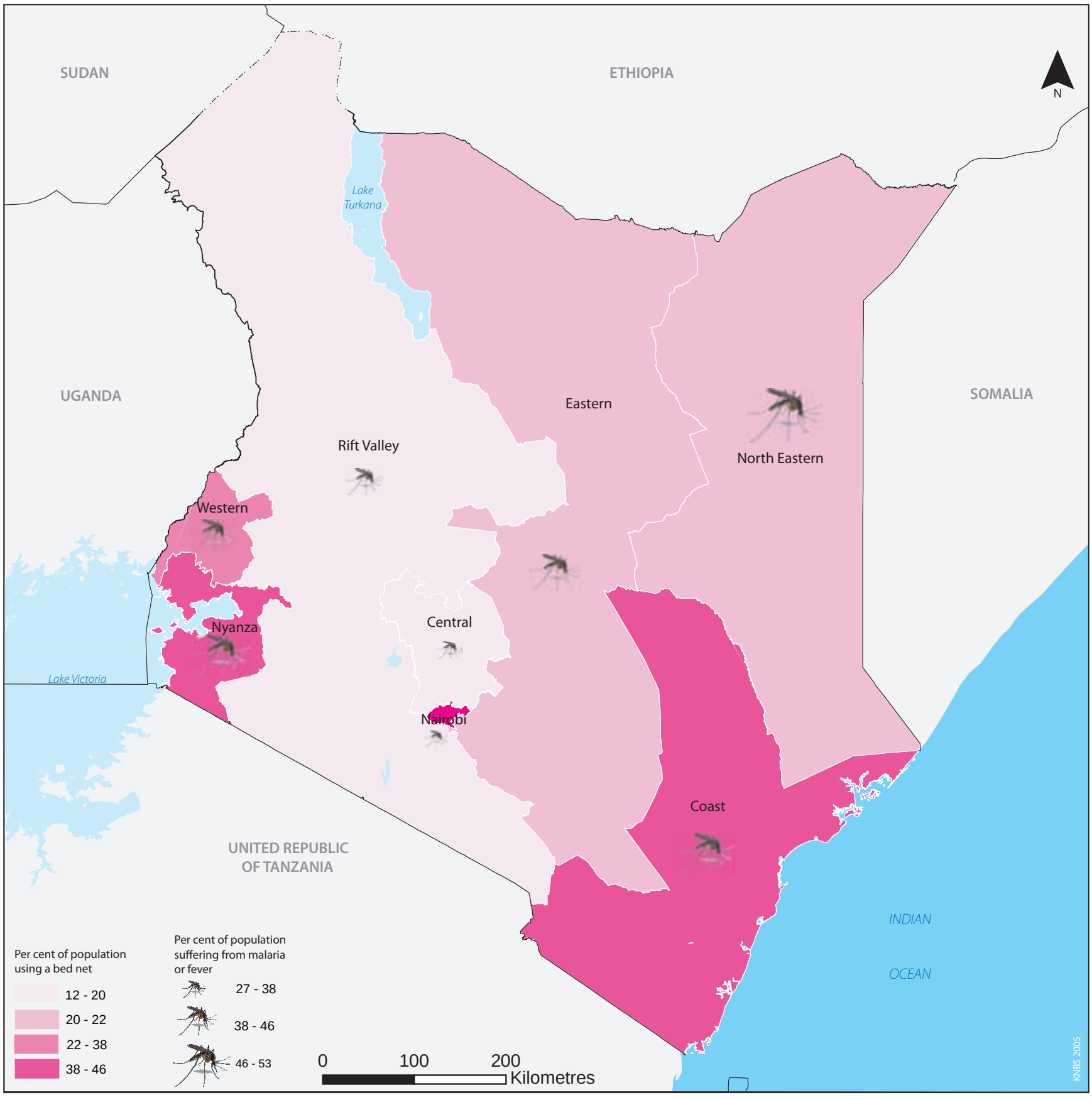
The impacts of climate change are linked with the achievement of key national development objectives and the MDGs including: poverty, food insecurity, health threats, environmental degradation, and loss of natural resources. Thus, the MDG's development objectives will be constrained by climate change impacts unless the capacity to adapt is strengthened.

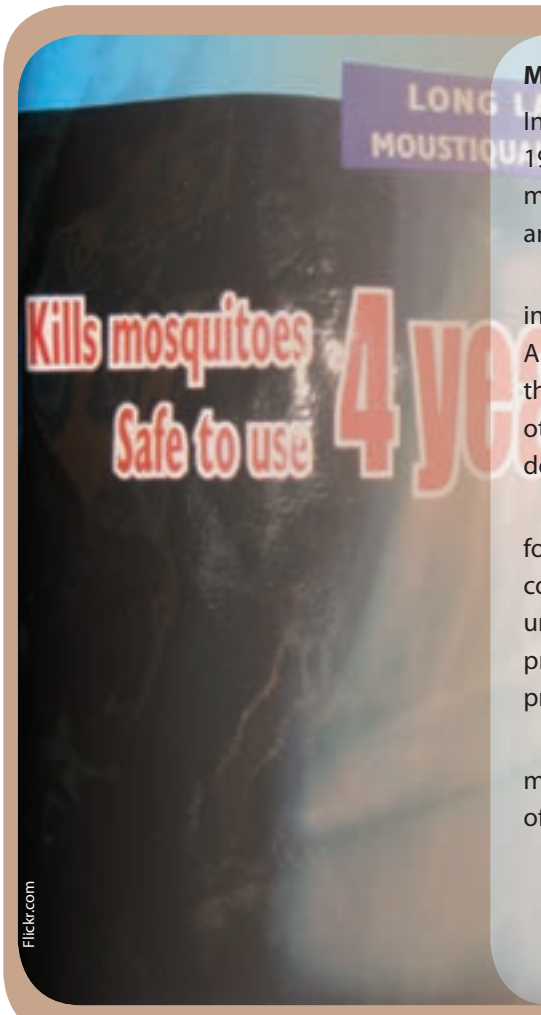
Credit constraints, poverty, and a lack of information, however, remain significant obstacles to adopting both short- and long-term adaptation measures. There is a critical need for governments to support climate change adaptation strategies, including monitoring climate change and disseminating information to farmers. Farmers will need to improve management approaches, including crop diversification; water harvesting, recycling, and conservation; and the irrigation and shading and sheltering of crops (Kabubo-Mariara 2007). The following section looks at the ways in which climate change is likely to affect incidences of droughts and floods, health, food security, natural disaster, and land degradation, which are key to the achievement of the MDGs in Kenya.

Climate Change and Human Health

Human health is likely to be affected by various climate change-related health factors, including the altered distribution of some infectious diseases and disease vectors (IPCC 2008). Projected trends in climate change-related exposures will increase malnutrition and consequent disorders; increase the number of people suffering from death, disease, and injury from heat waves, floods, storms, fires and droughts; and continue to change the range of some infectious disease vectors. The burden of diarrhoeal diseases will increase and the geographical range of malaria will expand in some places and contract in others (Confalonieri and others 2007).

Figure 16: The proportion of households using bed nets and the proportion suffering from malaria





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Malaria and the environment

In Kenya, malaria is estimated to cause one of every four childhood deaths (World Bank 2008). Since 1988, there has been an increase in the number of malaria outbreaks in the Kenyan highlands, where malaria was previously rare. Many studies on malaria vectors have linked environmental degradation and human activities with the increased counts of malaria infections.

For example, research shows that the survival rate of Anopheles gambiae (the vector of malaria) in the Kenyan highlands is higher in deforested areas than in forested ones (Afrane and others 2006). A study in Kisii District shows that where there is high vegetation density and older natural habitats there is a greater diversity of mosquito predators and a lower density of mosquitoes (Carlson and others 2004). Also, extensive lakeshore areas in Kenya have been deforested for fuel and agriculture, destroying habitats of mosquito predators (Sulaiman 2007).

Given this relationship between vector development and environmental conditions, increasing forest protection, especially in the Kenyan highlands where the vectors are controlled by vegetation cover as well as by humidity and temperature, could help prevent malaria epidemics by providing unsuitable environments for malaria vector development. In addition to helping prevent malaria, protected forest cover contributes to carbon sequestration and biodiversity, reduces soil erosion, and protects water resources.

Moreover, the increased frequency of floods and droughts are likely to increase the incidence of malaria by creating stagnant pools suitable for mosquito proliferation. Therefore, addressing the issue of climate change worldwide will in turn help reduce the risk of increased malaria rates in Kenya.

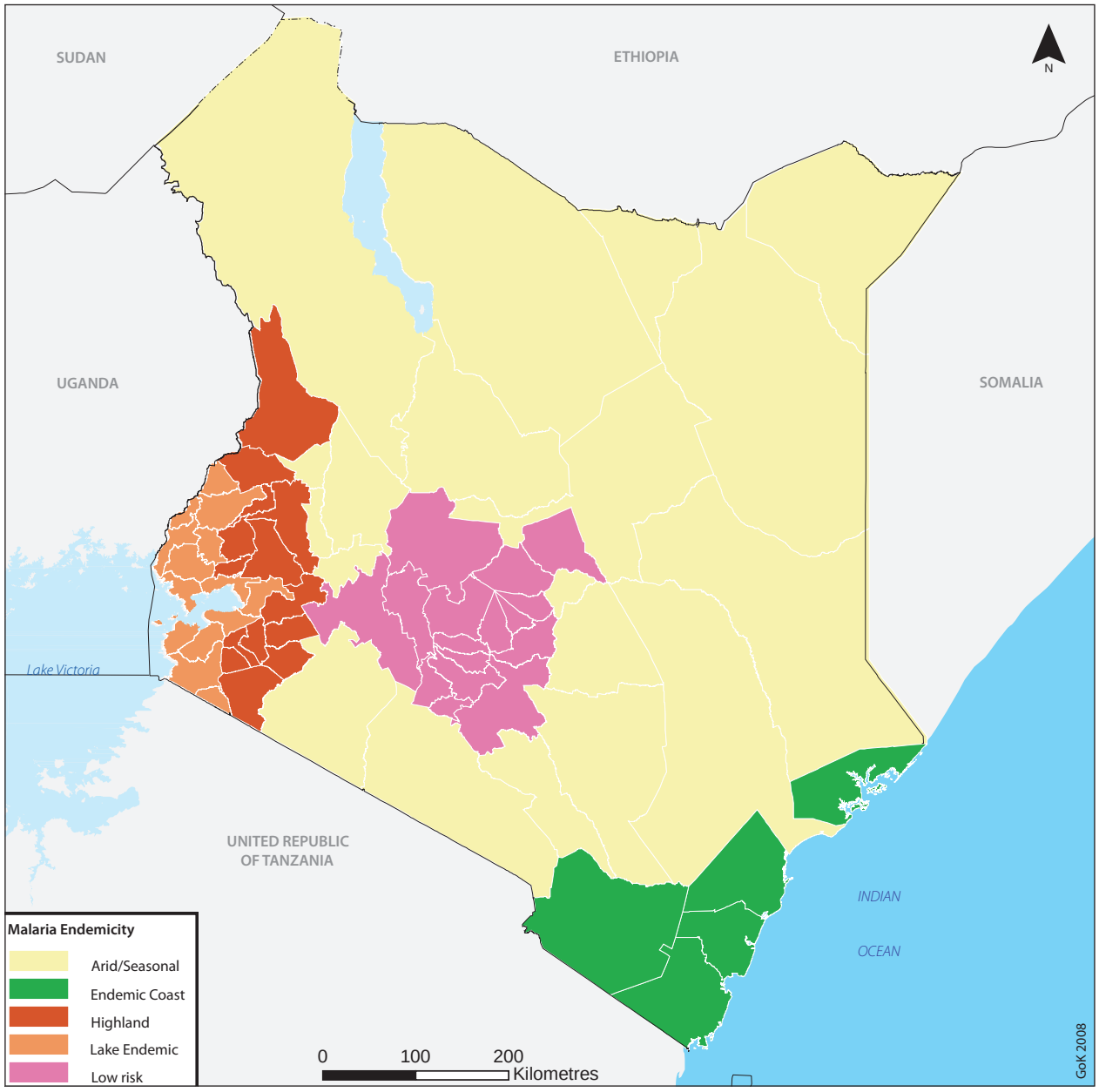


Figure 17: The geographical spread of malaria

Malaria outbreaks follow changing climatic factors due to human and natural alterations of the environment.

Nation Media Group

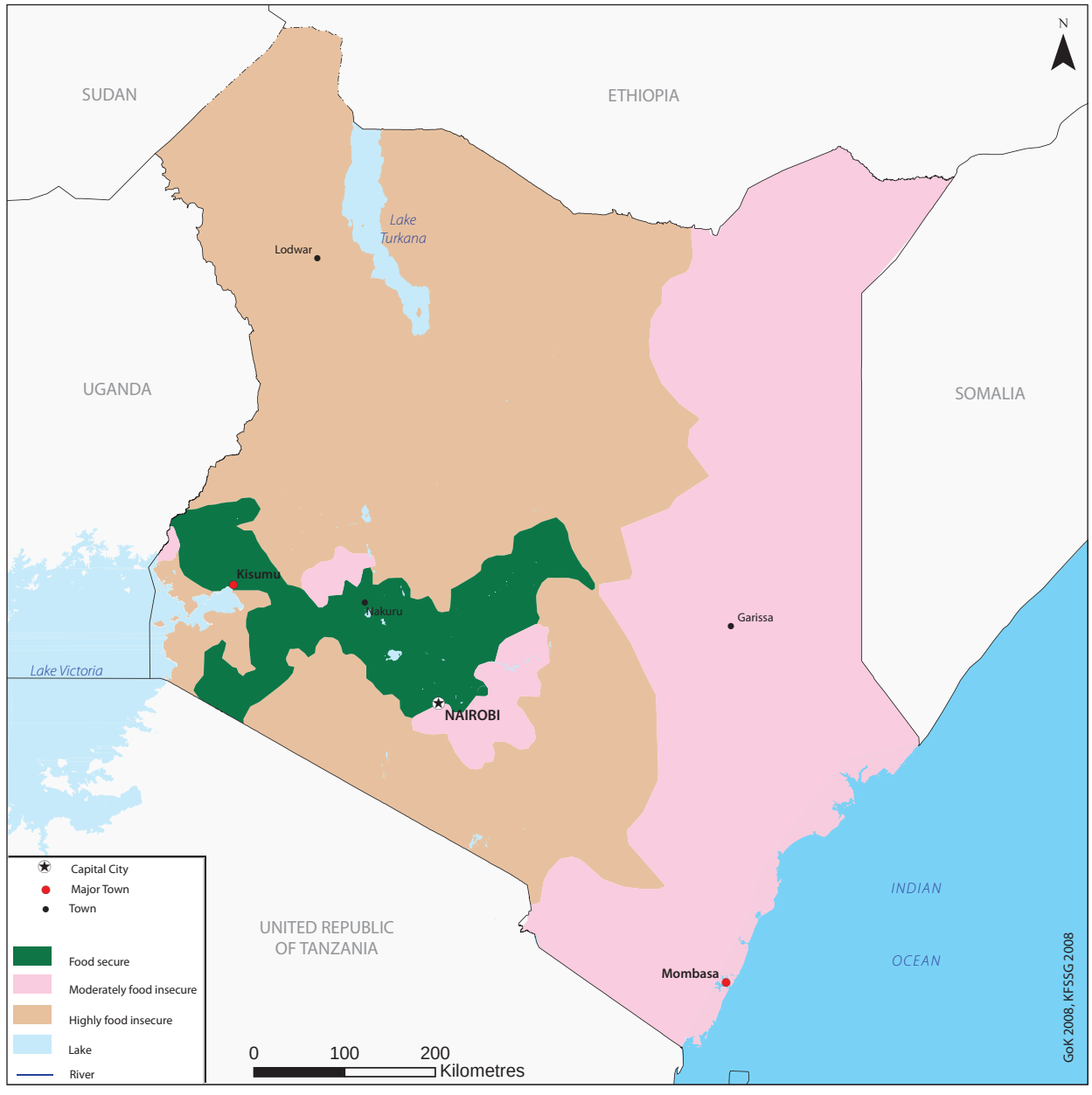
Maize is an important crop for food security in Kenya

Climate Change and Food Security

Some 57.6 million ha in Kenya are devoted to agriculture. Of this, only 9.4 million ha or about 17 per cent of the total land area is classified as having high to medium potential for farming (DRSRS 2008, FAO 2000). The arid and semi-arid lands (ASALs) cover over 48.0 million ha, accounting for about 83 per cent of the total land area. In the ASALs, about 9 million ha can support some form of agriculture while 15 million ha are just adequate for livestock keeping. The rest, amounting to 24 million ha, is dry and only suitable for nomadic pastoralism. Productivity in lands of high to medium potential is declining in the face of growing demands for food and other agricultural products. Soil erosion, loss of soil fertility, flooding, and biodiversity loss are increasing in all areas (Survey of Kenya 2003).

Changing environmental factors related in part to climate change have already had an impact on household food security for the many Kenyans who would benefit from reliable forecasts, increased water availability, and improved soil fertility to sustain their livelihoods.

Figure 18: Food security distribution



Life in the desert. Note the use of woody vegetation for constructing shelter

In some places, climate change has been implicated in decreased water resources, which has had a cascading effect: increased trekking distances and water costs; more competition for declining water supplies; failed crops; increased food prices; earlier livestock migrations; weaker livestock, predisposing them to disease; and food insecurity as families are left without milk and animal products (KFSSG 2008). Its effects on agriculture will be more pronounced in medium and low potential zones than in zones of high agricultural potential (Kabubo-Mariara 2007).

Climate Change and Floods and Droughts

Climate change is a likely factor in the increased intensity of El Niño events, resulting in more severe and frequent floods and droughts. El Niños occur when a large area of the central and eastern equatorial Pacific becomes warmer than normal. Recent research indicates that El Niños have been more intense since 1900 than at any time in the last 130 000 years (WHO n.d.).

In Kenya, droughts tend to occur every three years and last for one to two years, depending on the climate zone.There has been an increased frequency of floods and droughts in Kenya over the past 10 years: 1996-1997; 1999-2001; and 2003-2006. These droughts decimated livestock populations and crop harvests, and because they recurred so soon, households lacked sufficient time to recover during intervening years (USAID 2008).

Floods are also a major concern for Kenya's food security. Lakeshore and coastal districts are vulnerable to recurrent floods that lead to loss of life and crops, displacement of households, and destruction of homes.

The impacts of drought on livestock and livelihoods

Climate change is threatening the livelihoods of thousands of Kenyans. One of the hardest hit communities is the Maasai in the Magadi area of southern Kenya. Up to 80 per cent of the Maasai in this region have lost their cattle due to increasingly frequent drought, thought to be a result of climate change. Water is becoming harder to find and in many places grass has stopped growing, leaving no food for cattle, the main source of food and income in this community of around 4 000. While some attempts have been made to supply them with water, experts say the effects of global warming are outstripping these efforts (IRIN 2008).


Christian Lambrechts/UNEP

The impact of higher temperatures on tea production in Kenya

Kenya's principal cash crops are tea, horticultural produce, and coffee. In 2005 horticulture accounted for 23 per cent and tea for 22 per cent of the country's total export earnings. Kenya is the world's fourth-largest tea producer and second-biggest exporter. The tea industry directly or indirectly employs three million Kenyans or about eight per cent of the population. A changing climate is likely to affect harvests, livelihoods, and the economy (See chapter 1, page 9, for a map of Kenya's tea growing areas and their relationship to the country's five water towers).

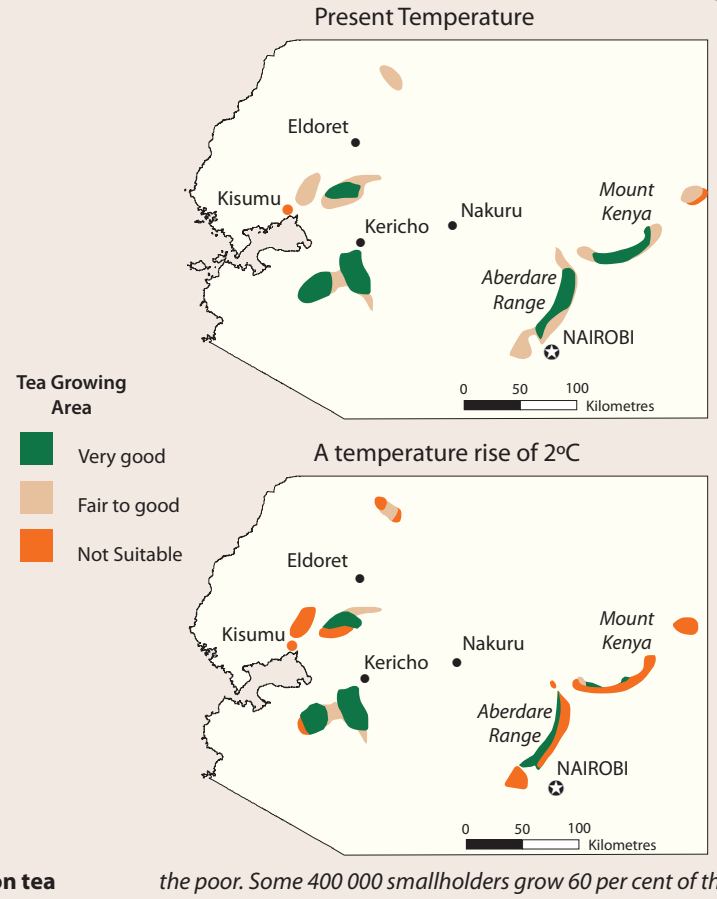


Figure 19: The effect of a temperature rise on tea growing areas

If temperatures rise by 2°C, large areas of Kenya currently suited to growing tea would become unsuitable, with enormous impacts on the Kenyan economy and especially on the poor. Some 400 000 smallholders grow 60 per cent of the country's tea, with large estates growing the rest. While large tea estates can likely afford extra irrigation and other inputs to cope with the effects of climate change, smallholders face difficult challenges in adapting.

Source: WGCCD 2005

Climate Change and Land Degradation

Floods and droughts can trigger or exacerbate the processes of land degradation, such as desertification, erosion, and landslides, affecting the amount and quality of land available for agricultural activities. Resource depletion and poverty lead to further land degradation and unsustainable land use.

The increased frequency of extreme weather events (such as floods and droughts) has adversely affected Kenya's agricultural sector, especially in areas of highest farming potential and in the arid and semi-arid lowlands (ASALs) (Kabubo-Mariara 2007). When nutrient-rich land for farming is lost, food insecurity

Young goat herder. Goats provide needed milk and meat for villagers, but overgrazing may lead to land degredation


The World Bank Group

Eroded land

deepens. In addition, when vegetation re-growth in pastoral and marginal agricultural areas is limited, in times of high rainfall the run-off cannot accumulate as effectively for water-storage purposes (USAID 2008). Finally, faced with degrading lands, farmers may move their activities into natural habitats such as forests at the expense of floral and faunal diversity.

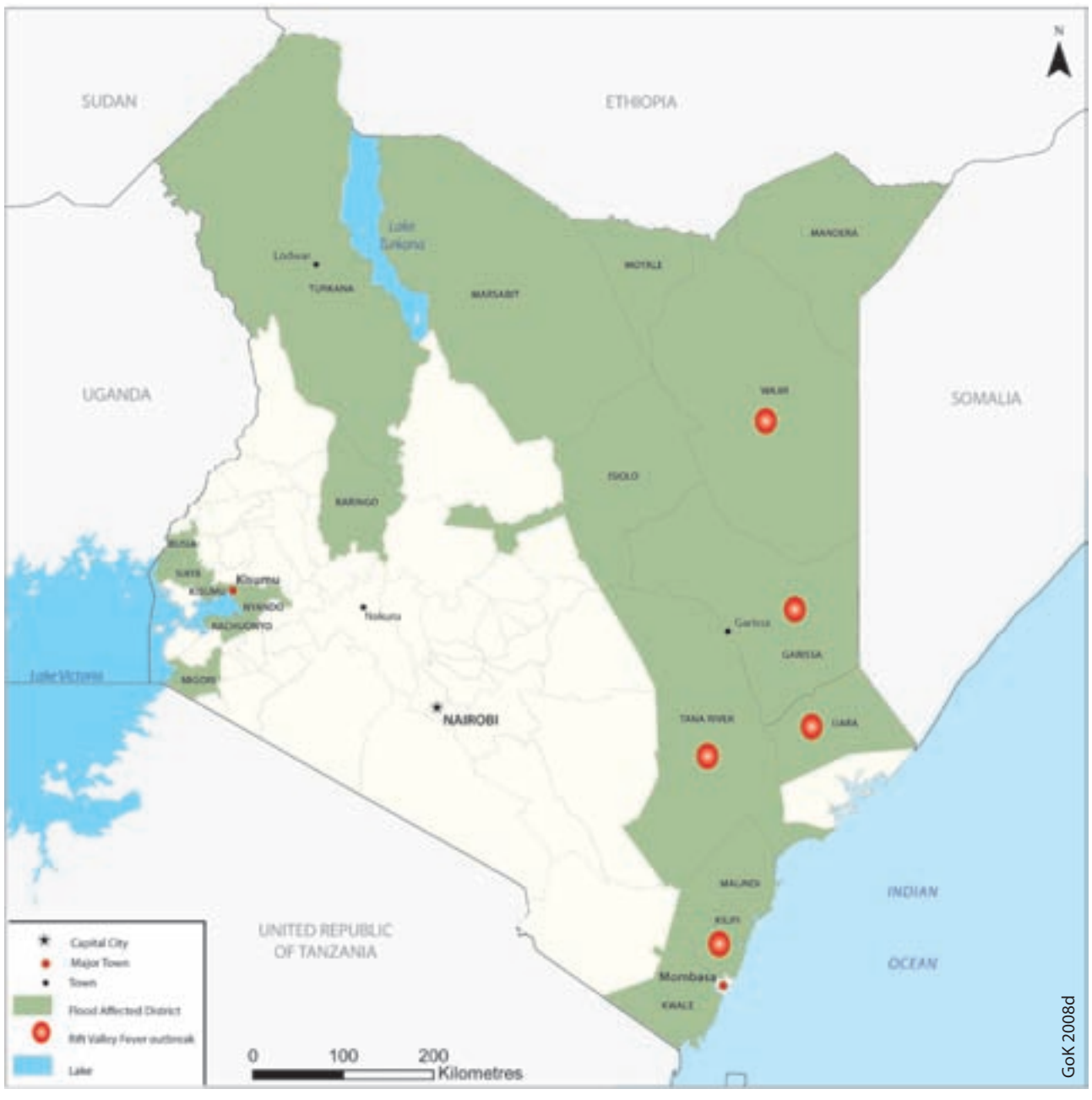


Figure 20: Regions of Rift Valley Fever outbreaks are located wihin flood affected areas

Achieving the MDGs

Case Study: Kenya's Sauri Millennium Village Project

In July 2004, Sauri, Kenya was selected to be the first Millennium Research Village. Sauri is a town of about 5 000 people located in Siaya District, Nyanza Province.

The Millennium Villages Project is a United Nations initiative to empower 12 impoverished rural communities in 10 African countries to achieve the Millennium Development Goals within a ten-year time frame. The villages represent each of Africa's 12 principal agro-ecological zones and farming systems. People in the selected villages work with a wide range of experts, scientists, and local development professionals in agriculture, nutrition, health, education, energy, water, communications, and the environment. Some of the projects include rainwater harvesting and improved springs; improved sanitation through the construction of pit latrines; distribution of treated mosquito nets and a malaria prevention communication campaign; planting indigenous tree species around springs; and establishing community tree nurseries. While the projects benefit from the knowledge and skills of international experts and large financial inputs, the Sauri project is providing valuable lessons on population, health, and environment integration (Mutuo 2007, Millennium Promise 2008).

Notable project achievements include the following:

- In 2004, 85 per cent of the population was experiencing food insecurity; improvements in agricultural production helped reduce food insecurity to 18 per cent by 2007.
- Maize production in Sauri has more than tripled — from 1.9 tonnes/ha to 6.2 tonnes/ha, with the help of inputs such as fertilizer and improved seed.
- A school-feeding program has been implemented in all 28 primary schools across the Sauri cluster and is now providing lunch to 17 514 students. By offering nutritious, locally produced food, the program has directly led to increased school attendance and better academic performance.
- Out of the district's 385 primary schools, Bar Sauri Primary School is now one of the top academic performers, jumping from a rank of 195th to the top 10.
- Malaria prevalence in Sauri is down from 55 per cent to 13 per cent due to the distribution of insecticide-treated bed nets and improved clinics that can now facilitate malaria diagnosis and treatment.

Climate Change and Pests

Climate change will affect the nature and distribution of agriculture pests, diseases, and weeds, with impacts on livestock and human health and in turn, on livelihoods, food security, and the economy. Temperature increases may extend the geographic range of some insect pests, for example, with the tsetse fly distribution and human disease vectors most affected. The spread of the highly virulent peste de petits ruminants (PPR) disease, which has a livestock mortality rate of 50 to 80 per cent, would exacerbate insecure food supplies (KFSSG 2008).

Excessive rainfall promotes the reproduction of the Rift Valley Fever (RVF) mosquito and severe infection outbreaks have typically followed El Niño events (WHO 2008). RVF outbreaks in the past have worsened food insecurity among eastern pastoralists already suffering from severe drought and floods (USAID 2006). Figure 20 shows the geographical distribution of Rift Valley Fever outbreaks and flooded areas in Kenya during such an outbreak at the end of 2006.

Mosquitoes can spread highly virulent diseases such as Rift Valley Fever and malaria

Gerald Yuvallos/Flickr.com

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Christian Lambrechts/UNEP

William Warby/Flickr.com

"It is generally realized that the protection, management and development of … shared ecosystems … require a regional approach…"

-UNEP and GEF 2008

Chapter 3: Transboundary Issues

The plants, animals, micro-organisms, waters, weather systems, and other elements that constitute the environment — including people — do not remain within jurisdictional boundaries. More often than not, they cross the political boundaries between nations. When this occurs, the environmental issues of mutual concern that arise from the shared natural area, resource, system, or migratory species are called "transboundary".

Transboundary issues present unique challenges for a number of reasons. Conflicts can arise when an environmental problem caused in one nation spills over into another. On the other hand, neighbouring countries often face similar problems related to both the causes of environmental change in a shared natural area and to the impacts on people and livelihoods. Cooperative environmental management and policy-making to address issues of mutual concern are complicated, however, since laws and regulations usually differ on either side of a border and there are many institutional players with different agendas and mandates.

Transboundary Environmental Issues

Kenya shares borders with five other East African countries: Ethiopia, Sudan, Uganda, United Republic of Tanzania, and Somalia. Inevitably, many of its ecosystems and natural resources are transboundary.

This chapter presents examples of four transboundary environmental issues of importance to Kenya and her neighbours:

- Transboundary protected ecosystems;
- Transboundary water resources;
- Transboundary movement of people;
- Transboundary movement of pests and disease.

The Tanzania (on left) and Kenya (on right) border on the northeast slopes of Mt. Kilimanjaro

D.J. Campbell/Michigan State University

Sun Setting on Lake Victoria

Lake Victoria, shared by Kenya, Tanzania, and Uganda, is the second largest freshwater lake in the world. Its basin supports a large population and nurtures a rich fauna and flora

Transboundary Protected Areas

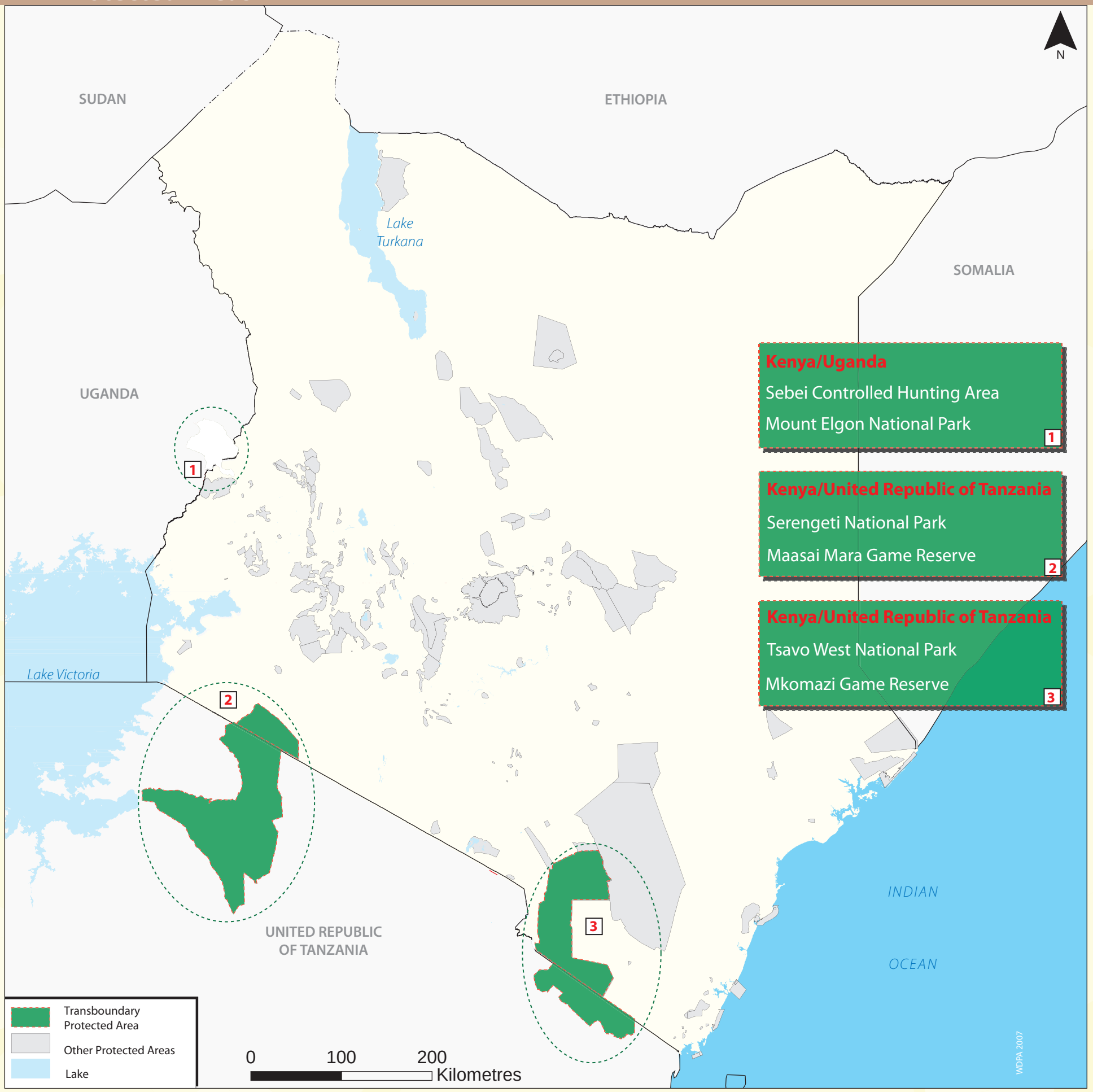


Figure 1: Kenya's transboundary protected areas

Wildebeest take chances crossing the Mara River during their annual migration

Transboundary Protected Ecosystems

Kenya has a total of 348 protected areas, which cover about 75 237.9 km^2 (12.7 per cent of the country's land area) (WDPA 2007). Kenya shares one main protected area with Uganda (Mount Elgon National Park) and two with Tanzania (the Maasai Mara, and Tsavo West) (Figure 1).

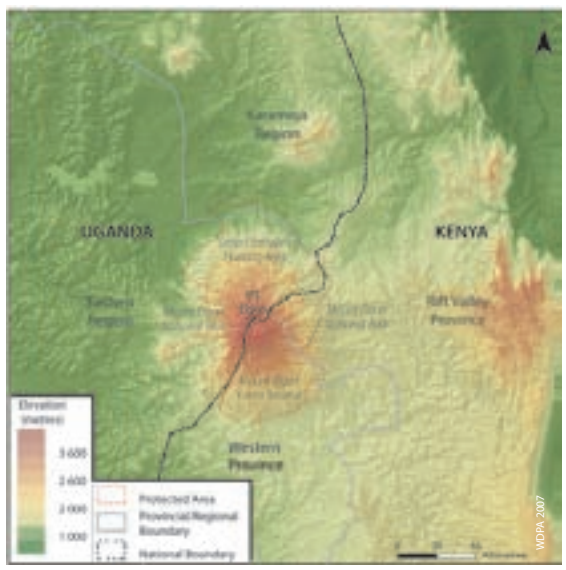


Figure 2: Mount Elgon National Park has a total protected area of 1 279 km^2, 1 110 km^2 in Uganda and 169 km^2 in Kenya

Mount Elgon National Park

Mt. Elgon is an isolated mountain ecosystem that sits on the border between Uganda and Kenya about 140 km northeast of Lake Victoria. Both countries have separately designated Mt. Elgon National Parks in their respective portions of the area.

The mountain is a 4 321 m high extinct volcano, Kenya's second-highest mountain (after Mount Kenya), and the fourth highest mountain in Africa. It is an important watershed with extensive forests on its lower slopes and is home to globally renowned biodiversity resources. The region has fertile, usually well-drained, deep and workable soils. Combined with a favourable climate, it has significant agricultural potential. Wildlife includes elephants and buffaloes, small antelopes, forest monkeys, and over 300 species of birds.

The surrounding area is very densely populated, with up to 600 people per km^2 in some places. The population is largely made up of subsistence farmers who value the region's agricultural productivity and use its natural products and forest resources to help sustain themselves. Local populations use the protected area not only to gather non-timber forest products, but also to cut timber, graze livestock, clear land for farming, and poach wildlife. These activities, however, pose threats to the mountain's biodiversity.

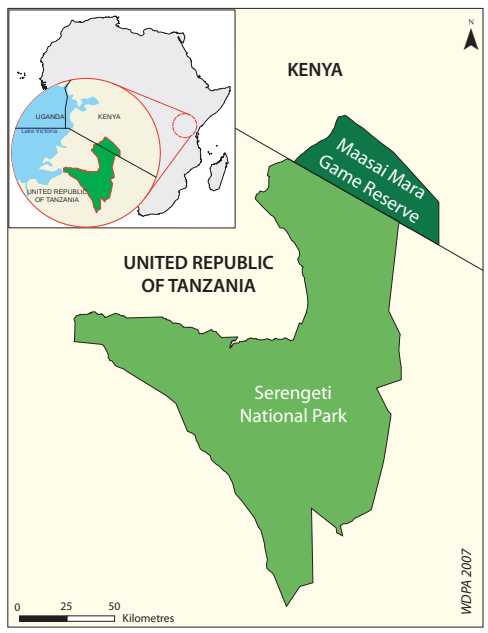


Figure 3: Location of Maasai Mara Game Reserve and Serengeti National Park

Maasai Mara Game Reserve and Serengeti National Park

Kenya and the United Republic of Tanzania share one of the greatest regions of migrating wildlife in the world, known as the Maasai Mara Game Reserve in Kenya and the Serengeti National Park in the United Republic of Tanzania.

This transboundary savannah ecosystem is under protection to safeguard its diverse fauna and flora, including the vast herds of seasonally migrating wildebeest (*Connochaetes taurinus*). Each April and May, more than one million wildebeest,

400 000 Thomson gazelles (*Eudorcxas thomsoni*) and over 200 000 zebras migrate out of Tanzania's Ndutu Plain to Kenya's Maasai-Mara Game Reserve. These migrating herds create one of nature's most spectacular phenomena and make the Maasai Mara Game Reserve and Serengeti National Park major attractions for international tourists with resultant revenues supporting the economies of both countries.

The Mara River, the only perennial river in the transboundary ecosystem, is often the only source of water for grazing animals during the dry season. Increasing water demands from agriculture, industries, and growing human populations are likely to reduce its availability for migratory species. During the short-term 1993 drought, nearly 400 000 wildebeest and uncounted other species died due to water shortages in the river (WWF 2006).

In January 2006, seasonal rains were late and there was widespread drought in East Africa. It partially disrupted the migration of more than 1.5 million wildebeest, zebras, and other herbivores as they made their way from the Maasai Mara to the Serengeti (Ngowi 2006). The severity of the drought is illustrated in the satellite images below, where Lake Eyasi and Lake Manyara were almost completely dried out in 2006.

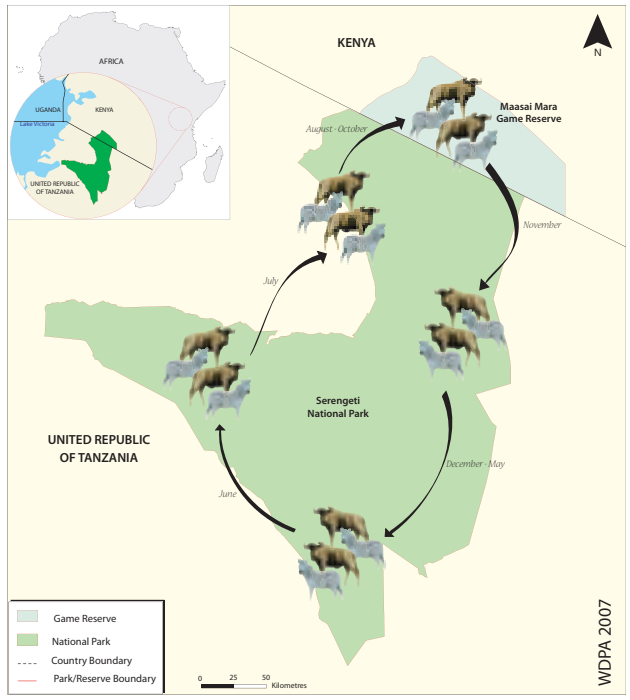


Figure 4: Wildebeest migration pattern

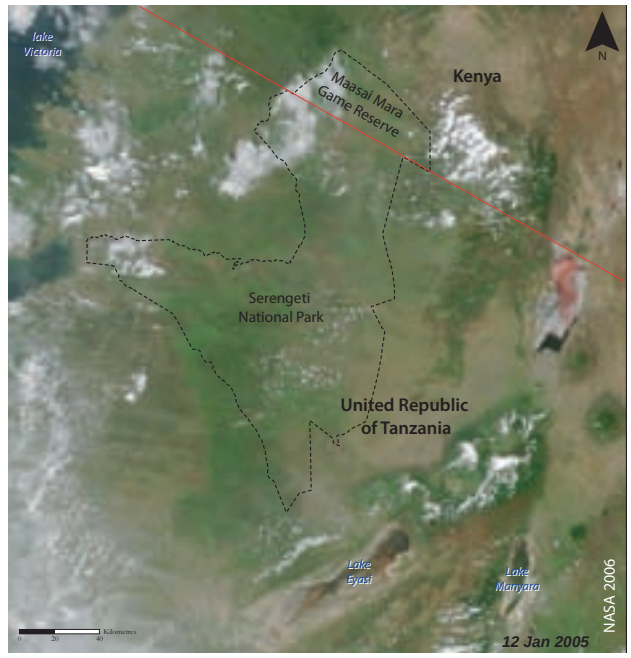
Every year, herds of wildebeest, zebra, and other herbivores migrate in a clockwise fashion along a migratory route between the Serengeti National Park in the United Republic of Tanzania and the Maasai Mara Game Reserve in Kenya.

Tsavo West National Park and Mkomazi Game Reserve

The Tsavo National Park is divided into Tsavo East and Tsavo West by the main Mombasa-Nairobi road. The former is larger and more arid and the latter is more rugged, with numerous outcrops and rocky hills. Gazetted in 1948, Tsavo National Park is the largest of Kenya's parks. The entire Tsavo ecosystem also includes the South Kitui National Reserve and Chyulu Hills National Park, making it one of the largest coherent conservation areas in Africa (Woodley 2008).

Tsavo West Park covers 7 065 km^2, which represents about 30 per cent of Kenya's total area under parks. It contains diverse wildlife and their habitats and a scenic mountainous landscape (KWS 2007). Tsavo West joins Tanzania's Mkomazi Game Reserve (MGR), which lies in north-eastern Tanzania between the coast and Mount Kilimanjaro, and forms the southern limit of the Tsavo ecosystem. The springs at the foot of Mount Kilimanjaro, especially the Mzima Springs, feed the Tsavo River that flows through Tsavo West (USGS 2008). Large herds of elephant, oryx, and zebra migrate between the parks in the wet season.

The border with Tanzania bisects the 30 km^2 Lake Jipe, at the south-west corner of Tsavo West. It is a transboundary water body of global and local significance for a number of reasons: it is a Ramsar Wetland of International Importance; it is an essential permanent water reservoir for wildlife in the two National Parks; it supports thriving fishing and water transport businesses; and it is the only place in the world where the Oreochromis jipe fish, now on the verge of extinction, lives. The Lake has been drying up, however, threatening people's livelihoods and the health and survival of dependent wildlife. It lost about half of its water mass between 1996 and 2006 and siltation and salinity levels rose dramatically. Its water catchment continues to be degraded by farmlands and water diversions from the River Lumi, and it suffers from the proliferation of the typha weed, which at one point covered 65 to 80 per cent of the lake. Both countries have initiated projects to address the problems and by late 2008, they appeared to be succeeding. A more concerted effort may be needed to completely restore the lake (ASNS 2008, Mwakio 2008, SGP 2006, SGP 2006a).



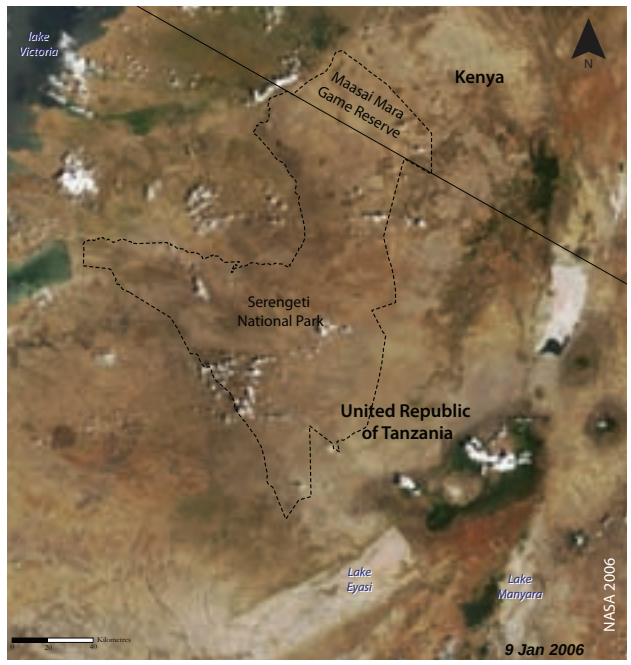


Figure 5: Serengeti drought

A pair of images comparing green vegetation in 2005 to the parched, brown landscape in 2006.

Water birds eagerly await the return of fishermen

Transboundary Water Resources

Transboundary rivers and water catchments all over the world are increasing sources of potential conflict due to difficulties in the shared management of declining water resources. In some places, water pollution also exacerbates cooperative management efforts. Worldwide, there are 263 international transboundary river basins, with 59 of these in Africa and five in Kenya (UNU 2006).

Lake Victoria Basin

Lake Victoria Basin (LVB), (Figure 6), is located in the upper reaches of the Nile River Basin. The basin is shared by Kenya, Uganda, the United Republic of Tanzania, Rwanda, and Burundi, and occupies about 251 000 km^2, while the Lake itself covers 69 000 km^2. Six per cent of the Lake's surface area lies within Kenya, while the ratio in Uganda and Tanzania is 45 per cent and 49 per cent respectively (Osumo 2001). Lake Victoria is the world's second-largest freshwater lake and the largest lake in Africa. It is fed by waters from the Kagera, Mara, Simiyu, Gurumeti, Yala, Nyando, Migori, and Sondu–Miriu rivers, which account for 20 per cent of the Lake's water, while the remaining 80 per cent is from direct rainfall (Awange and others 2008).

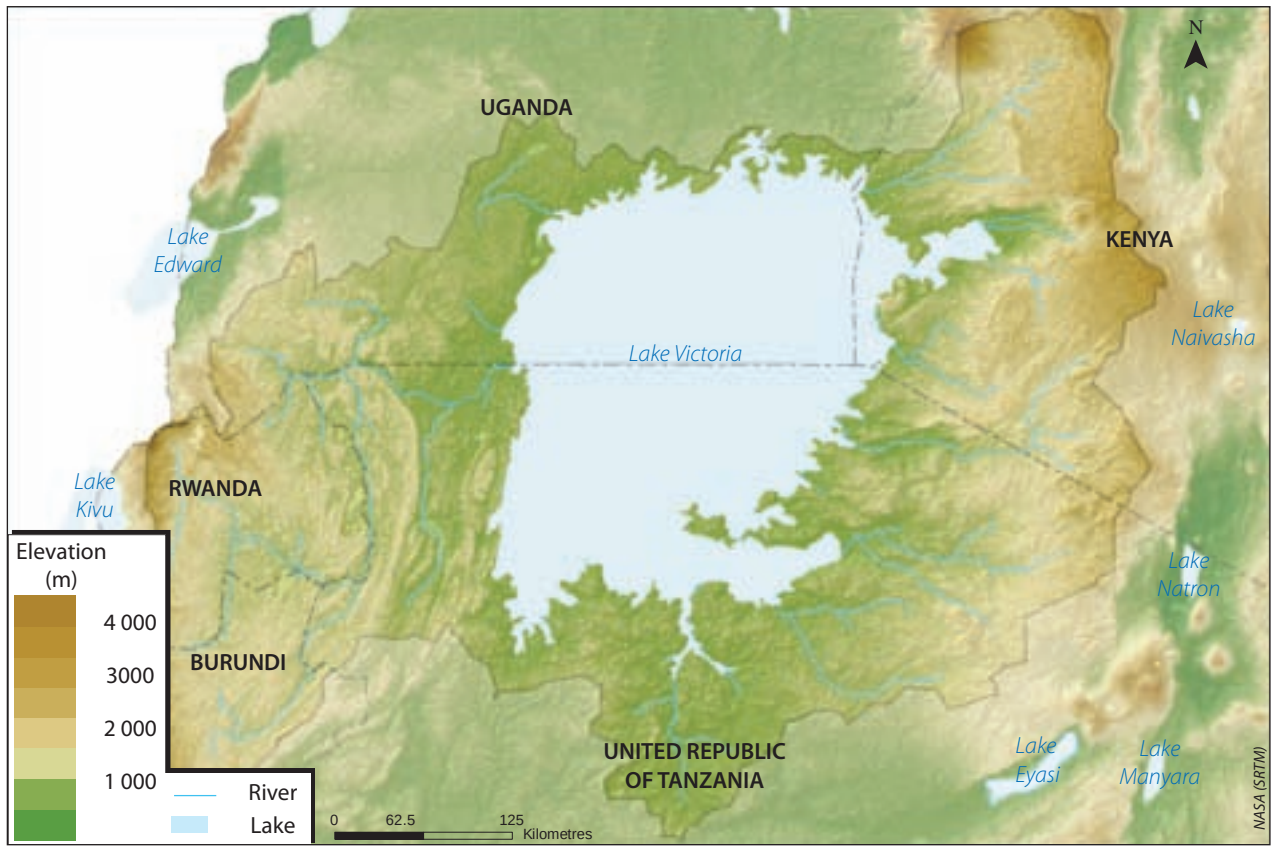


Figure 6: Lake Victoria Basin and the five countries that share it

Fish is a common source of protein in the diets of communities living around Lake Victoria

The People

The Lake Victoria Basin enjoys favourable conditions for agriculture, fishing, and other economic activities. These attractions have led it to become the site of one of the world's densest rural populations. The population's average annual growth is three per cent, and increasing numbers and densities of people are exerting ever greater pressures on the region's natural resources (Figure 7) (UNEP 2006).

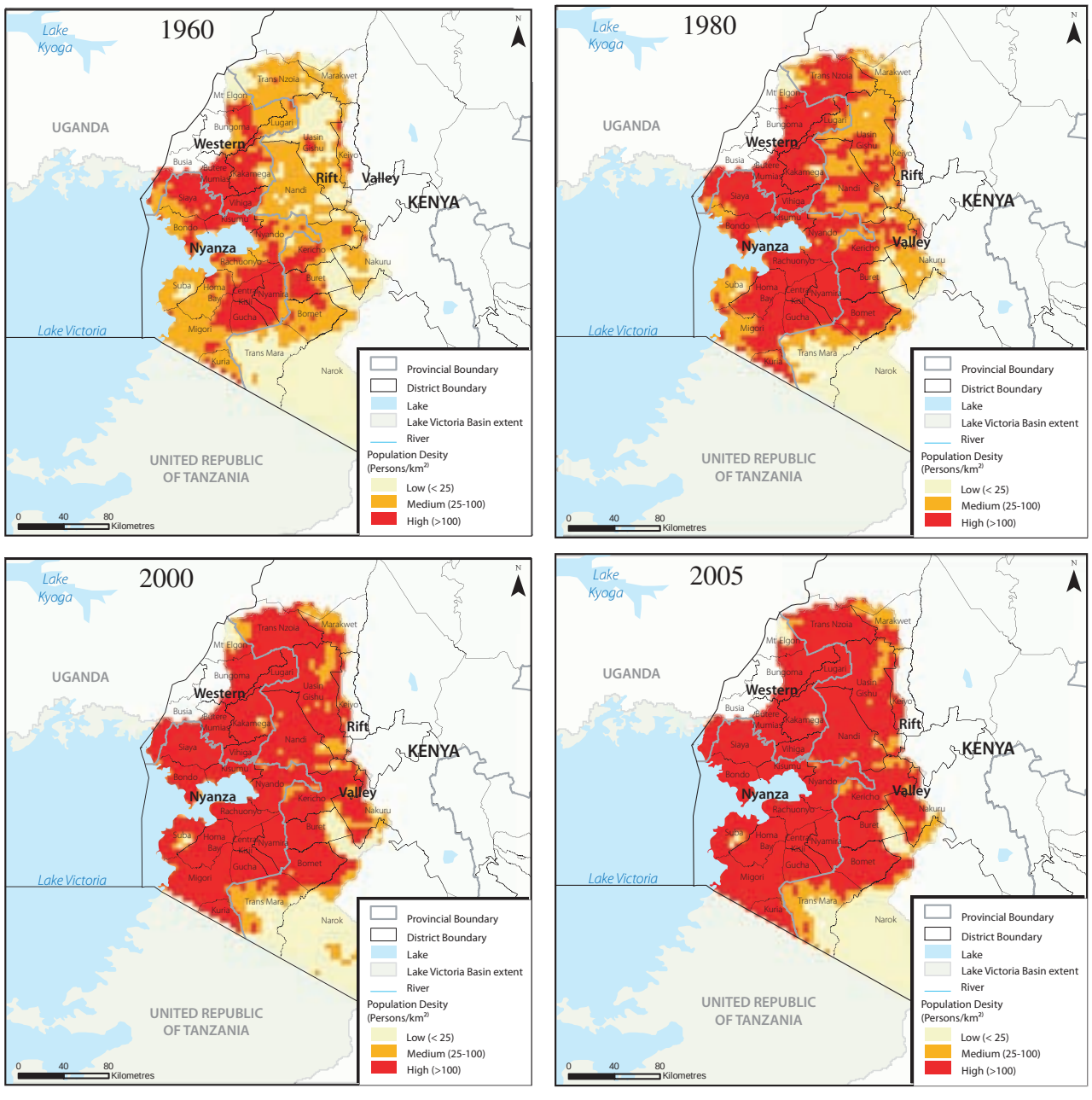


Figure 7: Population density change within the Kenyan portion of Lake Victoria Basin, 1960-2005 (Source: UNEP/GRID Sioux Falls, UNEP 2006)

Increased population density since 1960 exerts greater pressures on the region's resources

Gully erosion within Nyando river basin

Environmental Factors

Natural Resources

The Basin provides livelihoods for about a third of the combined population of the three countries that share the lake's waters. In 1996, subsistence agriculture, pastoralism, and agro-pastoralism supported about 21 million people in the Basin and provided average yearly incomes in the range of US $90 to 270 (World Bank 1996), with agriculture and fishing being the most important economic activities.

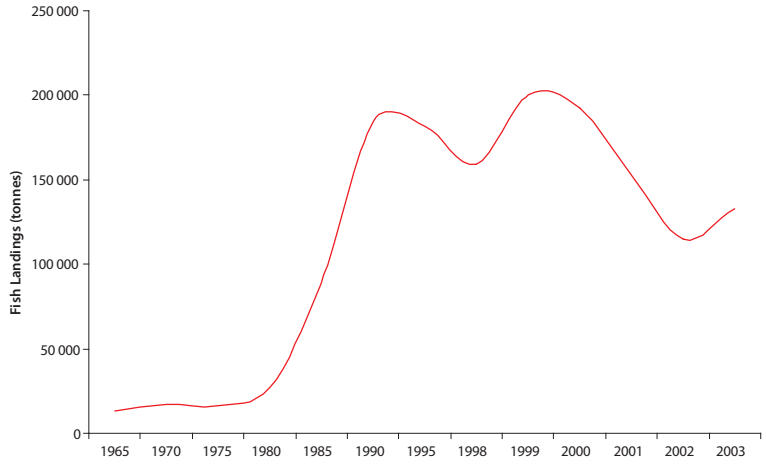


Figure 8: Fish landings in Lake Victoria were generally low until the early to mid-1980s, when populations of Nile Perch exploded (Source: UNEP 2006)

The fishing industry benefited from the introduction of Nile Perch and the expansion of export markets to Europe and Asia, transforming fishing from a subsistence activity to a competitive commercial industry that contributes about 0.5 per cent to Kenya's GDP (Bwathondi and others 2001, URT 2002).

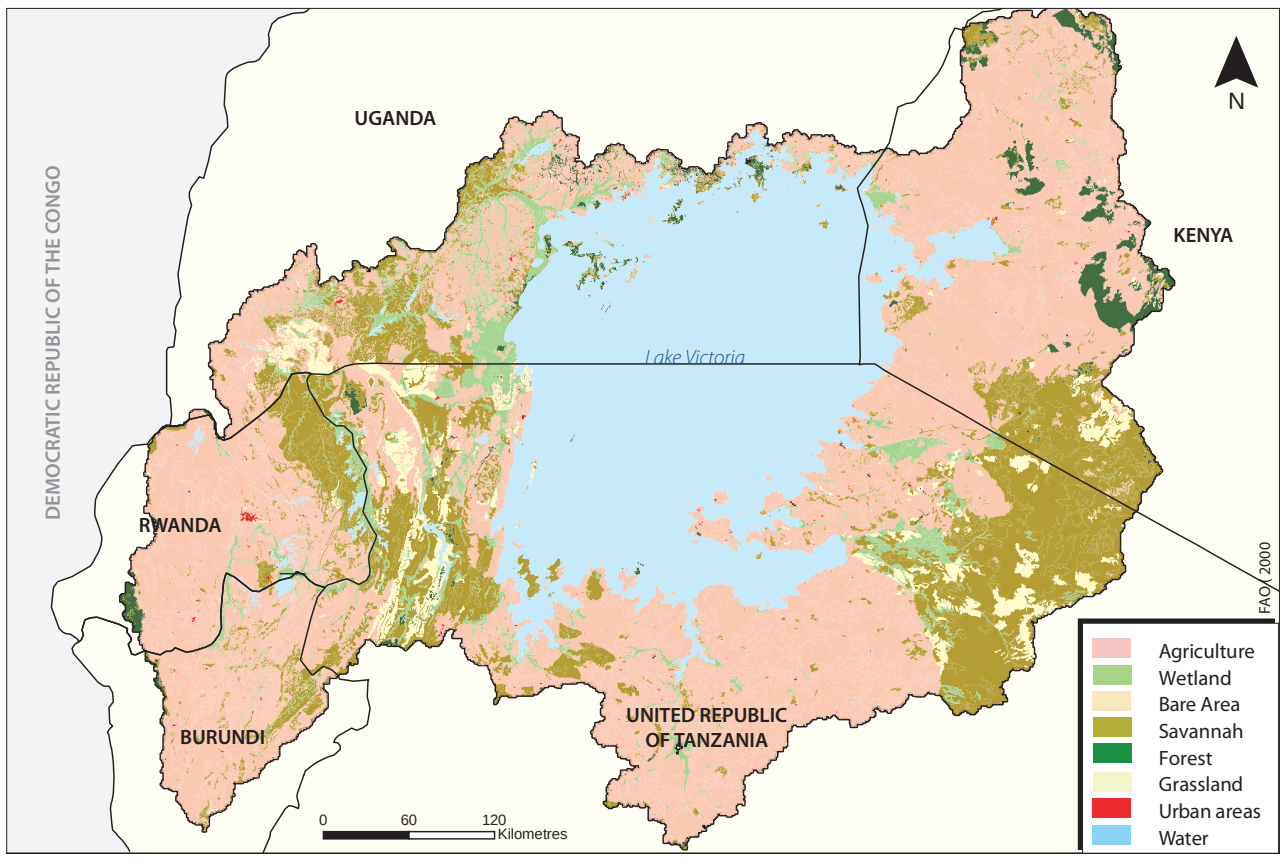


Figure 9: Land cover map of the Lake Victoria Basin

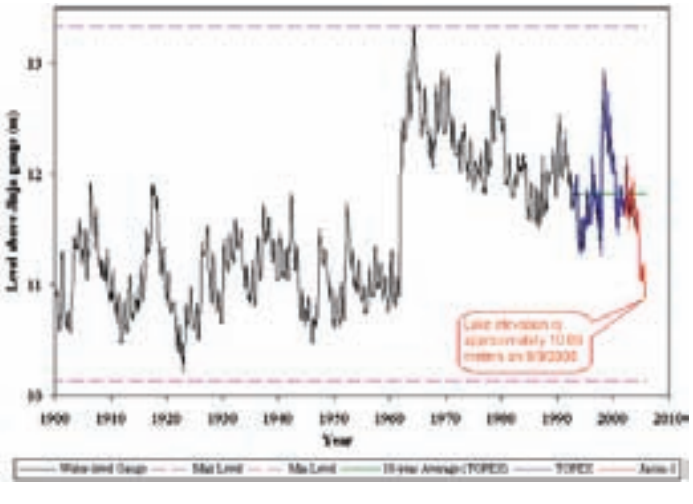


Figure 10: Historical water levels in Lake Victoria (Source: USDA FAS 2008)

Water levels in Lake Victoria were unusually high from the mid-1960s until December 2005. Since then water levels dropped roughly a metre.

Water level fluctuations

In the 105-year history of accurate measurements on Lake Victoria, water levels have fluctuated widely (Figure 10). Low water levels are a threat to the population that relies on the lake for water, food, and energy.

Soil erosion near Maasai Mara National Reserve

Soil erosion

Increased population pressures around the Lake have reduced vegetation cover and exposed soils to water erosion, which is extensive in many parts of the Lake Victoria Basin; about 45 per cent of the land is prone to water erosion (UNESCO 2006). Since 1963, 3.2 million tonnes of soil (or the equivalent to one million truckloads) have washed into Lake Victoria (WAC 2008). Erosion has led to the siltation of dams and increased the risk of river and estuary flooding. For example, erosion-related processes have led to periodic flash floods on the Budalangi and Kano plains (UNEP 2006). In Kenya each year, the value of soil lost due to erosion is three to four times as high as the annual income from tourism (WAC 2008).

Water quality

Changes in the Lake's water quality have been dramatic: before the 1960s, Lake Victoria's waters were clean and filled with life. Today, they are murky, foul-smelling, and choked with algae (UNEP 2006). One of the major causes has been the increased influx of untreated municipal waste-water and sewage. Table 1 gives the number of urban centres with sewered and unsewered urban populations in the basin. These effluents reduce oxygen while building up nitrogen and phosphorous loads in the receiving waters.

Table 1: Number of sewered and unsewered urban populations in Lake Victoria basin

Country	Total population (1 000 people)	Sewered, urban population (per 1 000)	Unsewered, urban population (per 1 000)	Number of towns
Kenya	10 200	390	630	18
Uganda	5 600	210	870	9
United Republic of Tanzania	5 200	27	340	4
Rwanda	5 900	-	400	5
Burundi	2 800	-	140	4
Total	29 700	627	2 380	40

Source: Scheren and others 2000

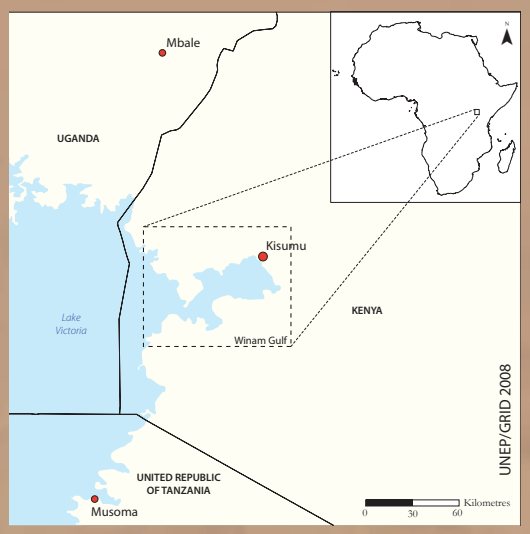


Figure 11: Location of Winam Gulf

Winam Gulf

Winam Gulf, a large arm of Lake Victoria that extends east into Kenya, faces numerous water quality problems. These include siltation, sedimentation, toxic contamination, and eutrophication (UNEP 2008).

Winam Gulf is relatively shallow, with an average depth of about six metres. Rapid population growth, urbanization, and farming practices have led to increased nutrients flowing into the Gulf, while soil erosion in parts of the lake's catchment has increased siltation and sedimentation in certain areas (Winam Gulf's satellite images in Chapter 4).

Invasive species

Water hyacinth (*Eichhornia crassipes*) invaded Lake Victoria in the 1990s, and Winam Gulf became one of the most severely affected regions. The plant's growth creates dense mats of vegetation that restrict oxygen exchange across the interface between the air and water. Dying organic matter also uses oxygen, which leads to the deterioration in water quality and can cause fish mortality. Biodiversity levels usually decline. In addition, the mass of plants can block waterways and harbours and damage generating turbines, creating important economic losses (Osumo 2001).

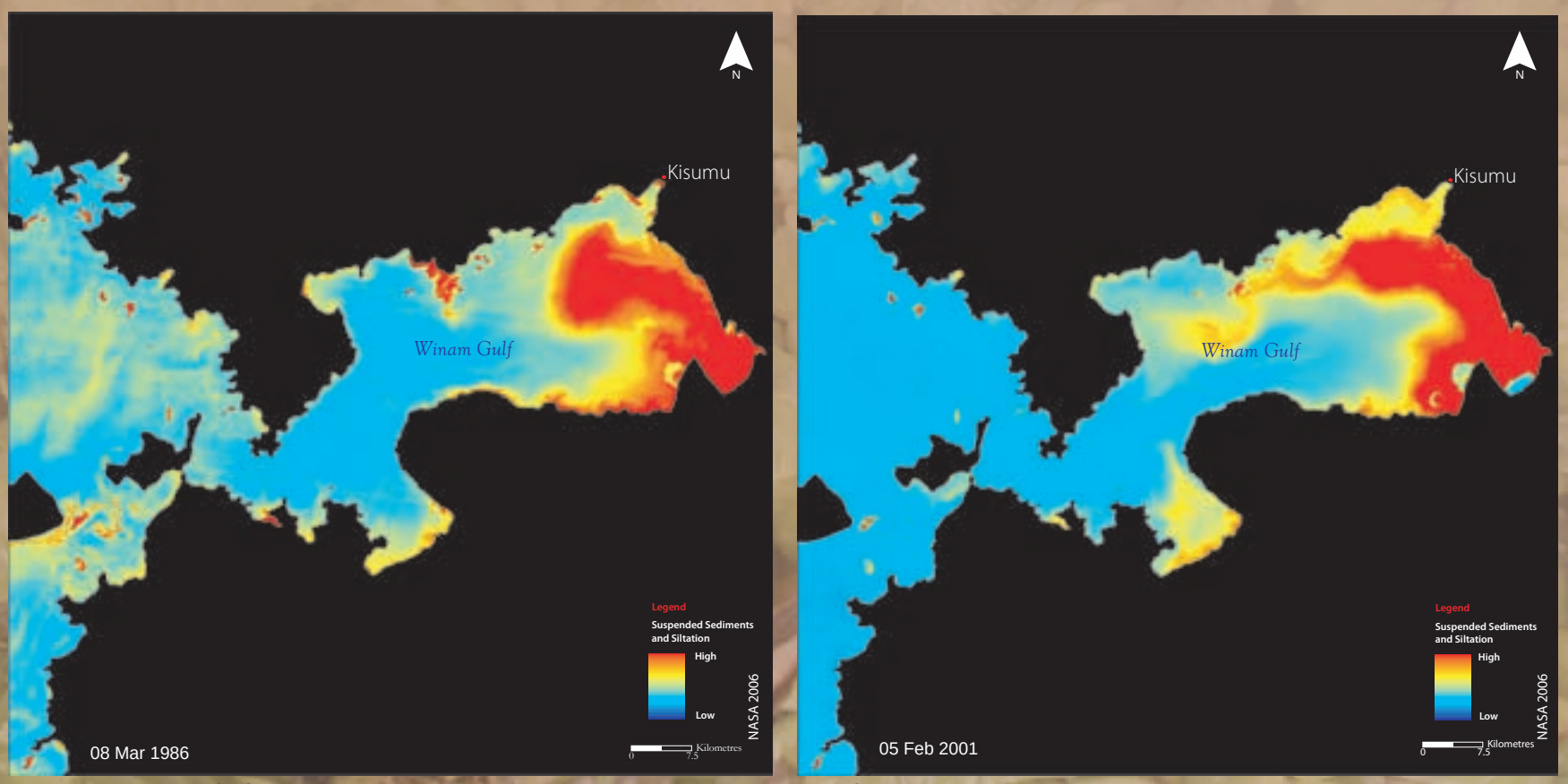


Figure 12: Winam Gulf affected by increased siltation and suspended sediments, 1986 (left) and 2001 (right). Highly affected areas appear in red while least affected areas are blue (Source: UNEP 2008)

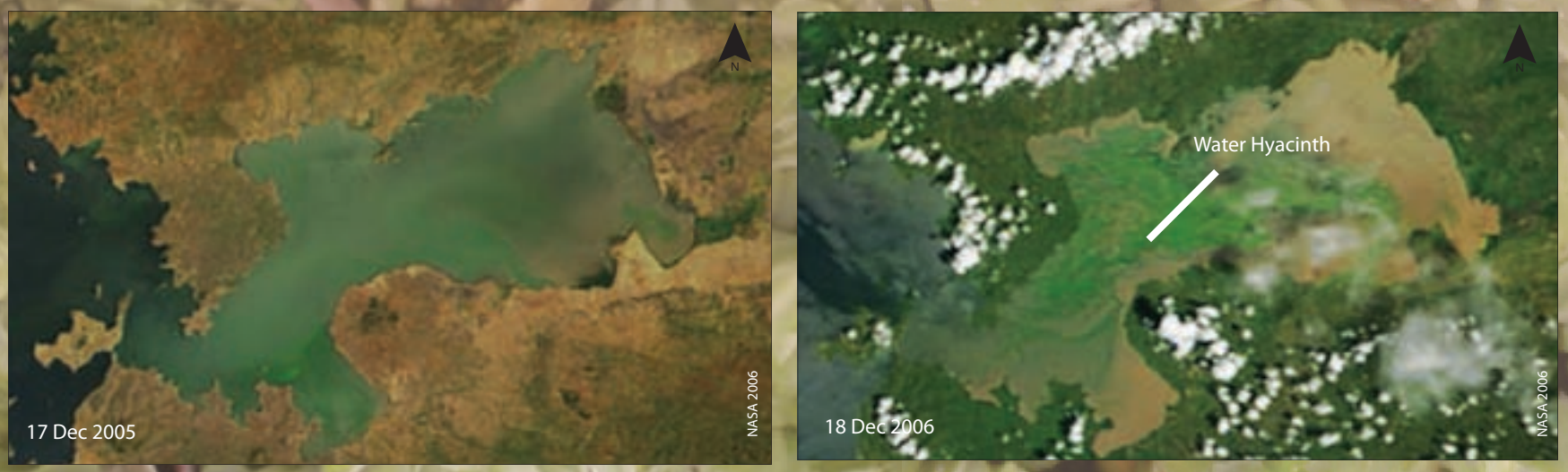


Figure 13: Winam Gulf affected by water hyacinth. The unusually heavy rains of 2006 flooded the inflowing rivers and raised water levels in the Gulf which allowed water hyacinth to reinvade the Gulf (Source: UNEP 2008)

Mara River Basin

(Part of Lake Victoria Basin)

The Mara is an international river shared between Kenya and Tanzania. Its basin is about 13 750 km^2, of which about 65 per cent is located in Kenya and 35 per cent in Tanzania. The Mara River runs through the Maasai Mara Game Reserve on the Kenyan side and the Serengeti National Park on the Tanzanian side, both of global conservation significance and of great economic importance. It flows into Lake Victoria, the source of the Nile.

Figure 14: Mara River Basin

The basin extends across the Maasai Mara Game Reserve and the Serengeti National Park

Local communities and other stakeholders in the Mara River Basin are increasingly facing water shortages as well as problems with poor water quality and environmental degradation. This limits attempts to alleviate poverty and improve health care, food security, economic development, and protection of natural resources.

Main competing interests for water resources include the large-scale irrigation plantations on the Kenyan side, the Maasai Mara and Serengeti wildlife protected areas, small-scale farmers and pastoralists on both sides of the basin, the mining industry in Tanzania, small-scale fishing activities, and urban and rural domestic water supplies. Further problems are caused by the loss of forest cover in the upper catchments and along rivers, unsustainable agricultural practices (including irrigation), pollution threats from urban settlements, and mining (WWF 2006).

Village women collecting water. Water in these arid regions is scarce and people have to use what they can find

The Juba-Shebelle Basin

The Juba-Shebelle basin occupies about one-third of the land areas of Ethiopia, Kenya, and Somalia, and covers about 2.7 per cent of the African continent. About one quarter of the Basin is located in Kenya (Figure 15). The Basin is fed by the Shebelle and Juba Rivers. Over 90 per cent of the Shebelle River's discharge originates in the Ethiopian highlands, where runoff varies a great deal from year to year. Although its basin is smaller than the Shebelle's, Ethiopia's Juba River is one of East Africa's most important because geological conditions create a much larger discharge (FAO 1997).

Figure 15: Juba-Shebelle Basin

The basin extends across the Ethiopian, Kenyan, and Somalian borders

Lesser Flamingoes

The Lesser Flamingo (Phoenicopterus minor) feed on spirulina, the source of the bird's pink colour. Millions of flamingoes visit the lake to breed, safe from predators that are not adapted to the lake's alkalinity.

Table 2: Contribution of Kenya to the hydrology of the Juba-Shebelle basin (Source: USGS-Hydro1k n.d.)

Country	Total area of the country (km^2)	Area of the country within the basin (km^2)	Total area of basin (%)	Total area of country (%)	Average annual rainfall in the basin area (mm)		
					min.	max.	mean
Kenya	580 370	210 226	25.9	36.2	205	1 795	395
Basin		810 427	100.0		205	1795	435

Figure 16: Lake Natron Basin

The Natron Basin

Lake Natron is a Rift Valley soda lake that is shared by Kenya and Tanzania (Figure 16). The Lake has an average width of 15 km and is very shallow, with a maximum depth of only 0.5 to 2 m (Ramsar 2008). Its main source of perennial water is the Ewaso Nyiro River, which emanates from the Mau Escarpment in Kenya and flows southwards along the eastern edge of the Nguruman Hills. Major rivers from Kenya's Loita Hills also provide seasonal inflows, which also come from the Loliondo Mountains in the north-west, the Gol Mountains in the west, and the Ngorongoro Highlands to the south and minor streams from Mount Gelai in the south-east (Ramsar 2008).

Rift Valley lakes such as the Natron and Turkana have chemical compositions that reflect their volcanic origins. The valley floor is mainly alkaline lavas, so rainwater and springs carry sodium carbonate into Lake Natron. Since the lake has no drainage outlet, sodium accumulates in the water and creates an unusual environment hostile to most organisms. This makes Lake Natron the world's most caustic water body, and gives it unique flora and fauna, such as salt-tolerant microorganisms and the Lesser Flamingo. The lake is the only breeding area for the 2.5 million Lesser Flamingoes that live in the valley.

Figure 17: Lake Natron's colour

Salt-tolerant microorganisms such as the blue-algae spirulina thrive in Lake Natron, giving a red tint to the lake's water.

Environmental issues

The lake faces some major environmental threats from both local and distant sources. Lake Natron's headwaters are in the Mau forest, hundreds of kilometres away, but deforestation there poses a serious threat to the lake's salinity balance. Other potential threats are planned development projects, including a proposed hydroelectric power plant on the Ewaso Nyiro River in Kenya and the possible building of a soda ash plant on its shores. The latter would extract sodium carbonate from the lake's waters to make washing powder for export. It would involve the construction of housing for over 1 000 workers and a coal-fired power station to provide the plant's energy.

Water from the Ewaso Nyiro River flows into Lake Natron. Land degradation upstream may contribute to siltation downstream

Figure 18: Lake Turkana Basin

Lake Turkana Basin

Lake Turkana is another Great Rift Valley lake, located in the arid northwestern part of Kenya and the southwestern portions of Ethiopia. The Basin covers 209 157 km^2 (WRI 2002) and includes the following lakes: Lake Abaya Hayk', Lake Ch'amo Hayk', and Lake Ch'ew Bahir in Ethiopia and Lake Turkana, Lake Baringo, and Lake Bogoria in Kenya.

The lake itself is 250 km long with a mean width of 30 km and a surface area of about 6 750 km^2. The average depth is 35 m while the maximum depth is 115 m (UNEP 2004). Lake Turkana is the Rift Valley's largest closed-basin lake, and loses water mainly by evaporation. More than 90 per cent of its intake comes from the River Omo, which enters the lake from the north.

A volcanic cone rises from Lake Turkana

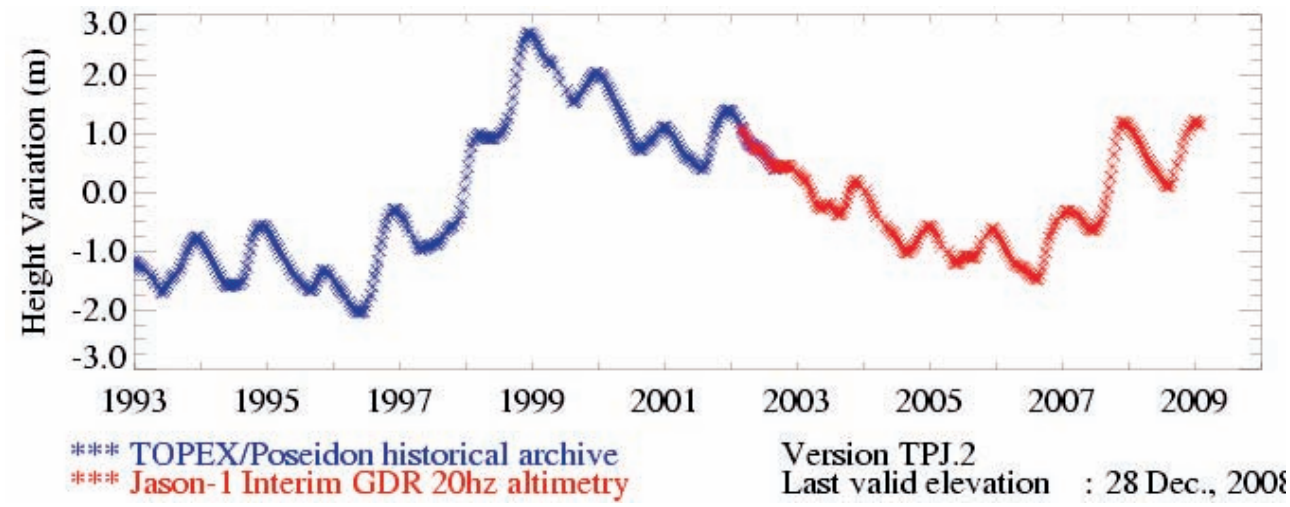


Figure 19: Lake Turkana's relative lake height variations (Source: USDA 2008)

Environmental management

There are no specific laws governing the use of Lake Turkana or its river waters. Major political and management concerns in the Basin include insecurity because of conflicts within the bordering countries including ethnic conflicts over grazing grounds, chronic water scarcity, and drought-related food insecurity. The new Kenya Water Act and Kenya's subscription to the Desertification and Ramsar Conventions promote the management and protection of the Lake's water resources (UNEP 2004).

Villagers assemble for a photograph

The people

The Lake Turkana area is known as "the cradle of mankind" because early hominids have been found in the region, including remains of various Australopithecus species, *Homo habilis*, *Homo erectus*, and *Homo sapiens* (Finke 2001).

Today, Turkana pastoralists live in the west (Turkana District, Kenya) and Gava pastoralists in the east (Marsabit District, Kenya) of the Lake, respectively. They are mostly nomadic, but some are fishermen. The total population of the catchment area is about 15.2 million out of which 12.3 million live in the Ethiopian portion (UNEP 2004).

Figure 20: Location of Lotagipi Swamp

Lotagipi Swamp

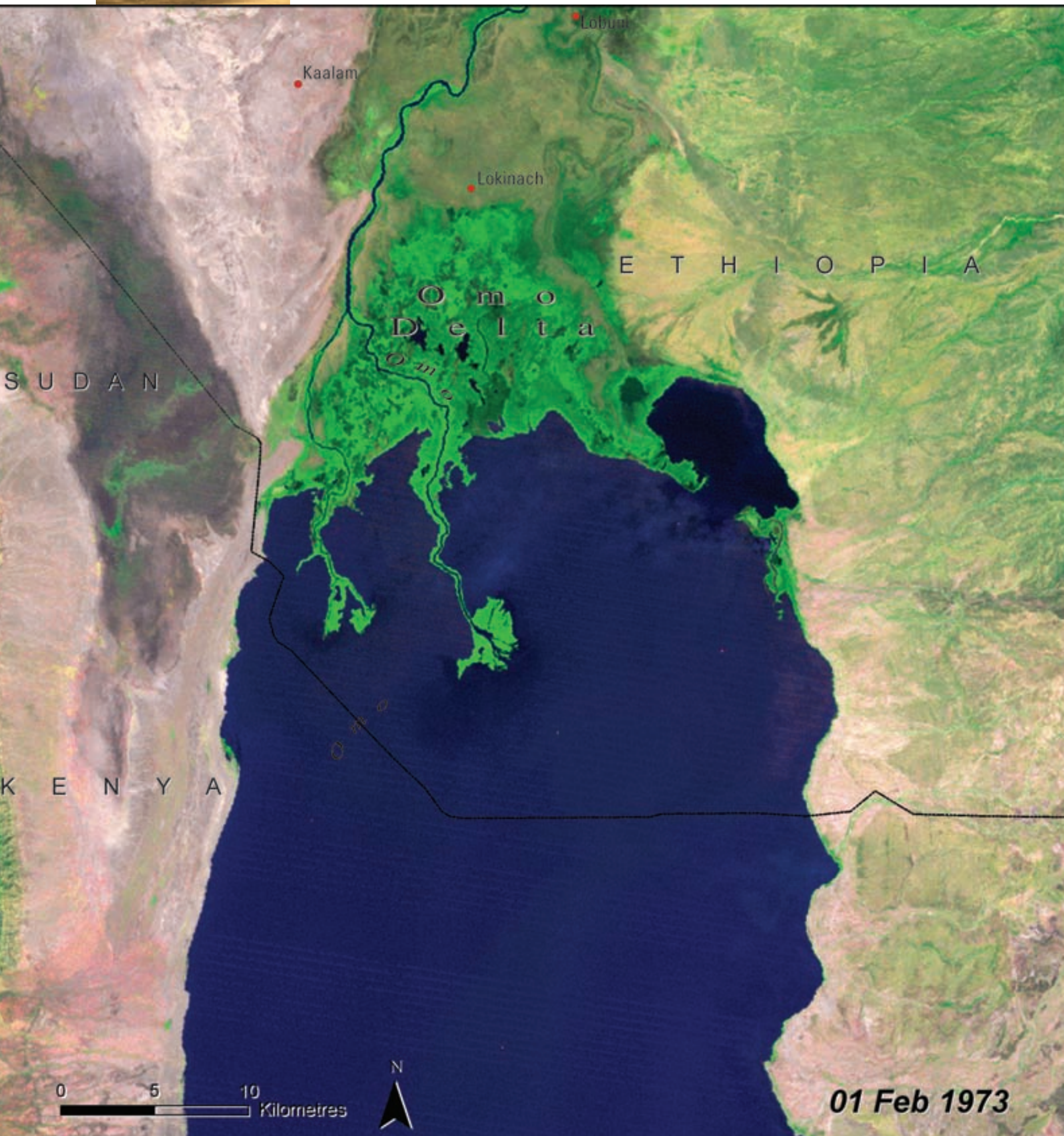
Lotagipi Swamp is located 90 km west of Lake Turkana in a floodplain that straddles the Kenya-Sudan border. The wetland is 120 km long, 85 km of which extends into Kenya. At its widest northern end, it is 125 km wide. A large permanent swamp zone resides where the Tarach and Narengor Rivers traverse the lake along the lowest part of the plain. During the rainy season, the wetland is flooded and water levels can exceed one metre in the small lake that forms temporarily. The region is little utilized by people except for some hunting and it has no protected status (UNDP 2006).

Turkana women take up agriculture as opposed to pastoralism

The Omo Delta: Expanding Land

The Omo Delta is located at the north end of Lake Turkana, a large closed-basin lake located primarily in Kenya. The Omo River provides the majority of the lake's water. The 1973 image shows the delta entirely within the boundaries of Ethiopia. By the time the 2005 - 2006 image was acquired the southern most point of the delta was roughly 12 km to the south and had crossed the Ethiopia-Kenya border.

While the relative contribution of several causes is uncertain, reduced lake levels and an increase in sediment inflow are believed to be the primary causes. Decreased rainfall, increased upstream diversion



of water and increased evaporation due to higher temperatures all likely contribute to the lower lake levels. Soil disturbance for agriculture has increased erosion and increased the inflow of sediment to the lake. The fact that the delta now falls in two countries has complicated its management.

The increasing area of the delta has provided new land for the 20 000 Dassanech people — traditional inhabitants of the delta. Primarily pastoralists the Dassanech also grow millet, maize, and beans on the delta. In the fall of 2006 severe flooding killed around 100 Dassanech and destroyed houses, crops, and infrastructure.

A nomadic pastoralist in northern Kenya

Transboundary Movement of People

Kenya's relative political stability has made it a safe haven for refugees fleeing conflicts in neighbouring countries, including Uganda, Rwanda, Burundi, Ethiopia, Somalia, and Sudan. It has also been a transit area for refugees resettling in other countries or being repatriated (Okoth 2003).

The United Nations Refugee Agency estimates the total number of refugees at the end of 2000 at 206 220 and in 2007 alone, it reported that there were 25 000 new arrivals (UNHCR 2002, UNHCR 2007).

Somalia has been the source of the majority of refugees to Kenya. An estimated 420 000 refugees entered the country at the height of the 1992 Somalia crisis; by the end of 2002, the number had fallen to about 230 000 (Okoth 2003). During 2006 and 2007, a new influx of Somali refugees fled escalating violence and sought refuge in Kenya. By the end of 2008, more than 65 000 Somali refugees had entered the country that year, up from 19 000 in 2007 (Simpson 2008).

The majority of refugees end up in camps in semi-arid and geographically remote areas of Kenya, such as Dadaab and Kakuma (Okoth 2003). In 1991, the Dadaab camps were built to shelter 90 000 people; by 2008, some 250 000 refugees lived there (Simpson 2008). As shown in the satellite images, the impacts on the environment have been great.

Sun Xaiogang/Center for African Studies, Kyoto University, Japan

In addition to the influx of refugees, transboundary movement of people in Kenya has included the traditional migratory patterns of pastoralist peoples. Pastoralist livelihood systems require high mobility levels to access water and grazing, and historically they occurred without regard for political boundaries. There have been some low intensity conflicts on the Ugandan border with Kenya, however, where this pastoralist economy is eroding with the trend toward private land and resource ownership and restrictions on movement and grazing rights. This has led to increased competition for natural resources such as land and water in this fragile arid and semi-arid region. Conflicts have been exacerbated by economic and social marginalization by governments and growing population pressures (Mwaura 2005).

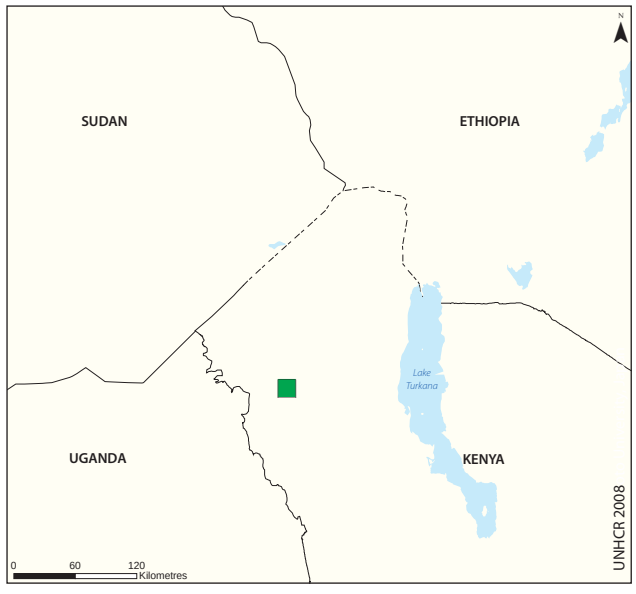


Figure 21: Location of Kakuma Refugee Camp

Kakuma Refugee Camp

Kakuma refugee camp, established in 1992, is one of the oldest and largest refugee camps in the world with refugees from Sudan, Somalia, Ethiopia, Burundi, Congo, Eritrea, and Uganda. It is located in Turkana District, in the northwestern region of Kenya. The camp, covering 25 km^2, has led to severe land degradation in the surrounding areas because of overgrazing and meeting firewood needs (Ohta 2002).

Dadaab Refugee Camp: People Pressures

Ifo, Dagahaley, and Hagadera refugee camps are located in Dadaab town in the North Eastern Province of Kenya, near the border with Somalia. The camps date back to 1991 when civil wars erupted on a large scale in Somalia. The conflicts, along with prolonged drought, forced more than 400 000 people from Somalia to flee to Kenya and another 500 000 to other neighbouring countries (UNEP 2008).

The 1986 image shows a fairly intact landscape dominated by shrub vegetation characteristic of the semiarid area. In the 2007 image, the Ifo, Dagahaley, and Hagadera refugee camps stand out distinctly, revealing the impact of a high concentration of people on the environment. Shrublands have been reduced largely to bare spots with sparse and stunted shrubs and grasses, while riverine vegetation has also suffered loss and degradation.


NORTHEASTERN
PROVINCE
Dadaab
Hagadera
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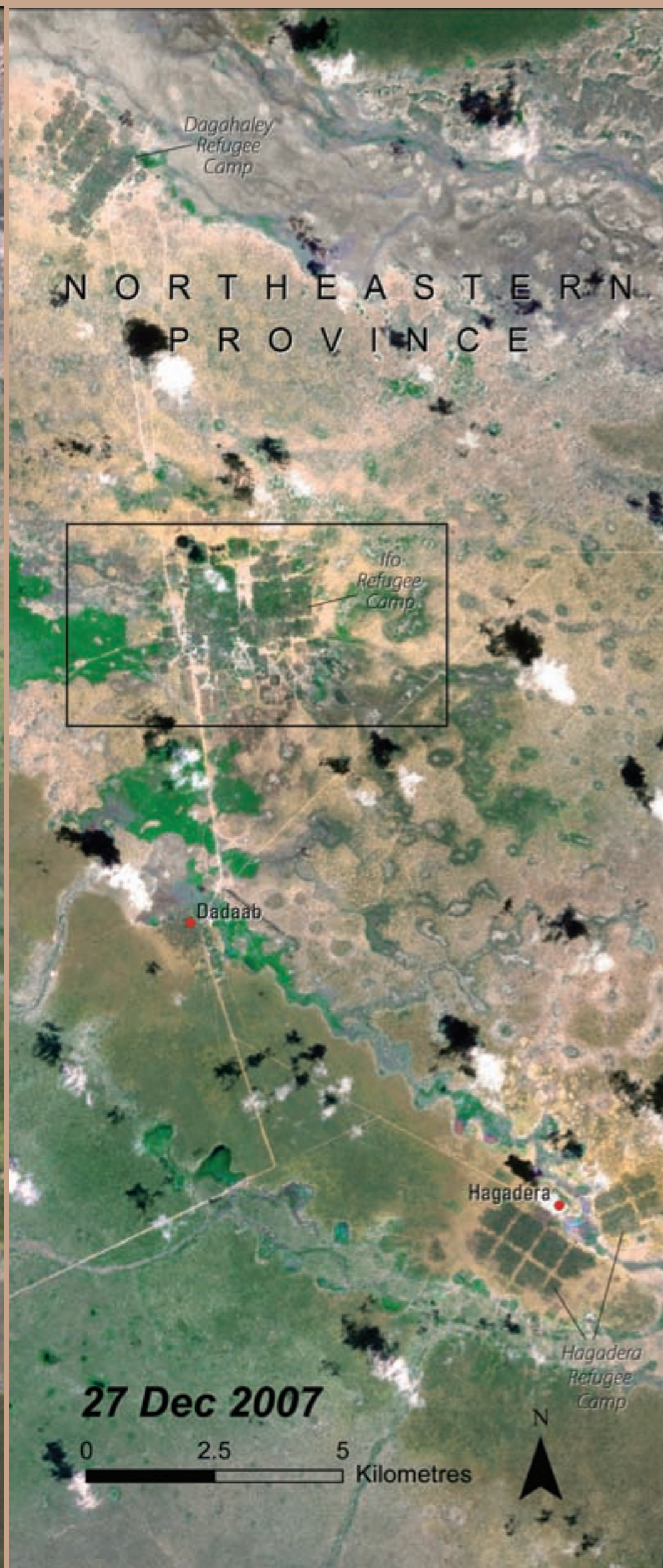
Dagahaley
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NORTHEASTERN
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Farms

Transboundary Movement of Pests and Diseases

Pest infestations

Pest infestations, such as plagues of desert locusts, the Africa Armyworm, and Red-billed Quelea birds, though periodic, are serious transboundary issues.

Desert Locusts

Desert Locusts (*Schistocerca gregaria*) have threatened crop production in Africa for centuries. This voracious insect can affect the livelihoods of at least one-tenth of the world's human population (FAO 2007).

Kenya's latest infestation occurred in November 2007 and was the first time in more than 45 years that Desert Locust swarms have invaded northeast Kenya (FAO 2007a). They came from Yemen, moved across Somalia and Ethiopia where they laid eggs, and finally infested northeastern Kenya where they ravaged pasture and crops in the arid area that is already a victim of frequent droughts (KPEN 2007).

Desert Locust

Armyworms

The African armyworm (S*podoptera exempta)* is a night-flying migrant moth. In early May 2008, Armyworms destroyed at least 30 000 hectares of maize around the Mount Kenya region. Still moving at that time, they threatened the entire country's food security (AFP 2008). Source populations originate from moth outbreaks in southern and central Tanzania, which then migrate to northern Tanzania and Kenya (ABC n.d.). With the onset of the main rainy season in 2008, Armyworm moths from infestations in Tanzania were likely to migrate north into Kenya (SIFO 2006).

African armyworm

Red-billed quelea

In addition to desert locusts, the Red-billed quelea (*Quelea quelea*) is considered one of the biggest threats to food security in Africa. A single flock can include millions of birds and a nesting colony can extend over hundreds of kilometres. Kenyan laws protect the birds in parks and forests, but when they invade farms, they are considered a pest. The expansion of agricultural lands with large areas of cereal crops has allowed the Red-billed quelea to flourish.

Red-billed quelea

Infectious Diseases

Infectious diseases are important transboundary issues since humans and livestock can be infected with diseases originating from neighboring nations. For example, Yellow Fever is a viral disease transmitted by mosquitoes. Although outbreaks of Yellow Fever have never been recorded in Kenya, in the early 1990s, deaths associated with Yellow Fever occurred in the country (TMB 2004).

The transmission of diseases from migrating wildlife to livestock is a common transboundary problem. One such threat in Kenya is the Highly Pathogenic Avian Influenza (HPAI). Each year, about 270 species of birds migrate into Kenya. They stop at water points where they can freely associate with local birds, which in turn encounter domestic poultry destined for human consumption. Infected migrating birds can thus bring diseases across borders (FAO 2005). As a result, there are the stringent sanitary standards for international trade in animals and animal products. The presence of transboundary diseases and the limits on their trade can greatly reduce Kenya's export of wildlife, livestock, and their products.

Immunisations help prevent the spread of disease

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Andries Oudshoorn/Flickr.com

"However it is viewed, the hotspots concept can be used to identify situations that, if left unattended, could prove harmful, both to the environment and to those dependent on it"

-FAO 2003

Chapter 4: Environmental Hotspots

This chapter is the heart of the Atlas. It is a visually stunning series of satellite photos that in a glance shows readers the extent to which human activities have wrought changes on Kenya's landscapes. It relies heavily on the interpretation of environmental change by comparing two satellite photos of the same place at different times, sometimes as much as thirty years apart. The images are displayed side-by-side, allowing viewers to engage in the well-known "spot the difference" puzzle. Readers are aided by short descriptions of each site and pointers that note specific salient changes.

The focus is on "environmental hotspots," a generic term used here to describe those lands and waters that are experiencing the most evident and dramatic change. This is the first publication that systematically uses satellite imagery to identify environmental change in Kenya and a number of caveats are in order. First, it was beyond the scope and resources of the researchers to scan images of Kenya's entire area over a 30-year period to identify change; second, some important environmental change is too subtle to be evident on such images; and third, the nature, cause, and consequences of some apparent change remains unknown until research is conducted on the ground.

Thus, this chapter is not a comprehensive rendering of all kinds of alterations actually taking place in Kenya's ecosystems. Rather, it shows the results of a survey of images to illustrate the major changes already noted in the scientific literature. The paired images have been organized into the following series of case studies, each of which includes an introduction to the issue: Land use and land use change; Water; Forests; Land degradation; and Biodiversity.

An arid ecosystem is home to a variety of flora and fauna

A Cheetah in the Scenic Landscape of the Maasai Mara Game Reserve

Cheetahs have disappeared from many areas in their African range because of habitat loss, lack of prey, disease, and high cub mortality. Based on past estimates of cheetah numbers in Kenya's protected areas, it is thought that less than 1 000 remain in the country, although it is likely that most cheetahs live outside such areas.

Land Use and Land Use Change

This section depicts the extent and distribution of various land uses in Kenya and describes how they have been changing over the past several decades. It provides context for the following pairs of satellite images that show some environmental changes taking place in specific areas of the country. This introduction portrays change in agricultural and pastoral land areas in particular; environmental change in forested regions is described in another section further on and has been discussed in the part of Chapter 1 that looks at Kenya's five "water towers". Urban land use change is discussed elsewhere in this Atlas. Although urban areas occupy only 0.1 per cent of the land, their impacts can be far-reaching, as noted in Chapter 5.

Land Use and Land Use Change

Kenya's land area is about 582 646 km^2, of which 2.2 per cent is surface water. Generally, Kenya's land use is largely pastoral in semi-humid and semi-arid zones and agricultural in the moist and humid zones. A huge proportion of Kenya's land area is mainly arid or semi-arid lands, called ASALs, accounting for over 80 per cent of the total area (GoK 2004). About 17 to 20 per cent of the land has medium to high potential for agriculture; these lands are termed High to Medium Potential Lands (HMPLs). Together, forests, woodlands, national reserves, and game parks cover ten per cent of the land (Survey of Kenya 2003, NLPS 2007, WRI and others 2007). Figure 1 shows the proportions devoted to various land uses and land covers, which correspond to those shown on the map (Figure 2).

Croplands

Agricultural activity supports about 80 per cent of Kenyans and contributes, directly and indirectly, about 53 per cent of the nation's Gross Domestic Product. Agroecosystems cover about 19 per cent of the land, and HMPLs support about 75 per cent of the country's population (WRI and others 2007). Only about eight per cent of the total land area is arable, however, and Kenya has a lower average population-to-cropland ratio than sub-Saharan Africa in general, with an estimated 160 ha of land for every thousand people compared to 280 ha, respectively (IFPRI 2007).

Most Kenyan farming is exclusively rainfed, so occurs where annual and seasonal rainfall patterns are reliable. About 90 per cent of croplands are in areas with high agricultural potential in central and western Kenya where they are dominated by a mix of dairy cattle, food, and cash crops, including wheat, tea, sugarcane, irrigated rice, and maize. Agropastoral activities involving some cropping mixed with livestock

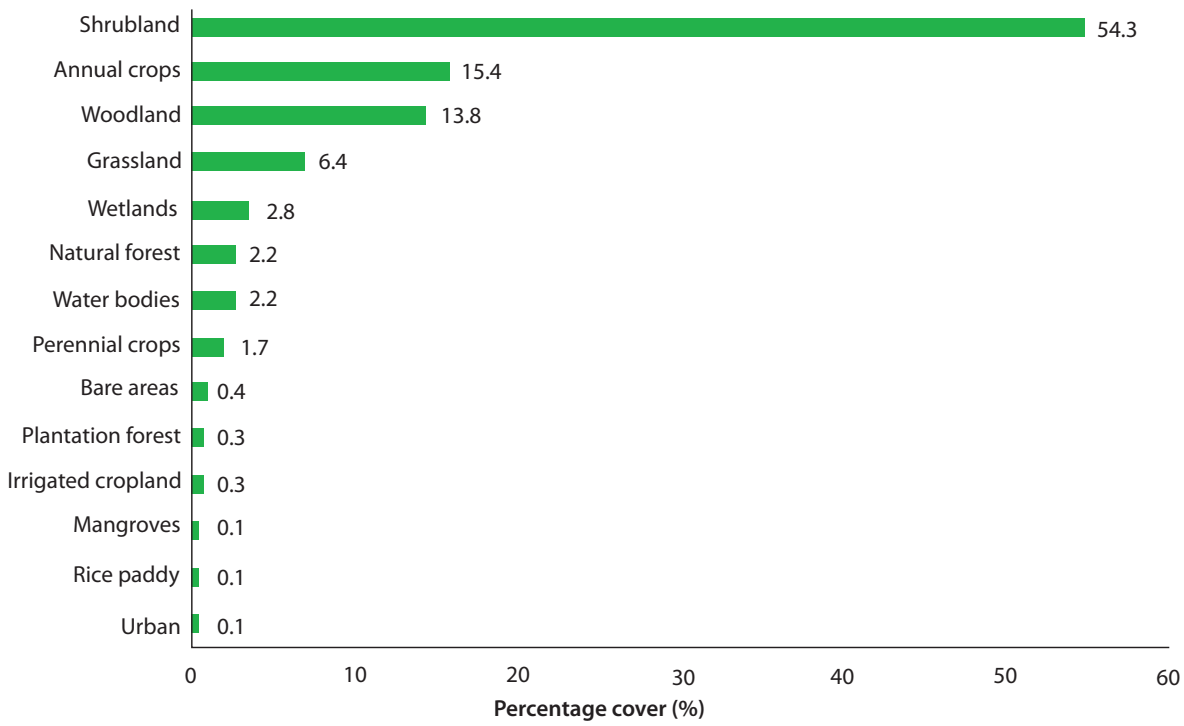


Figure 1: Land use and land cover types (Source: FAO 2000)

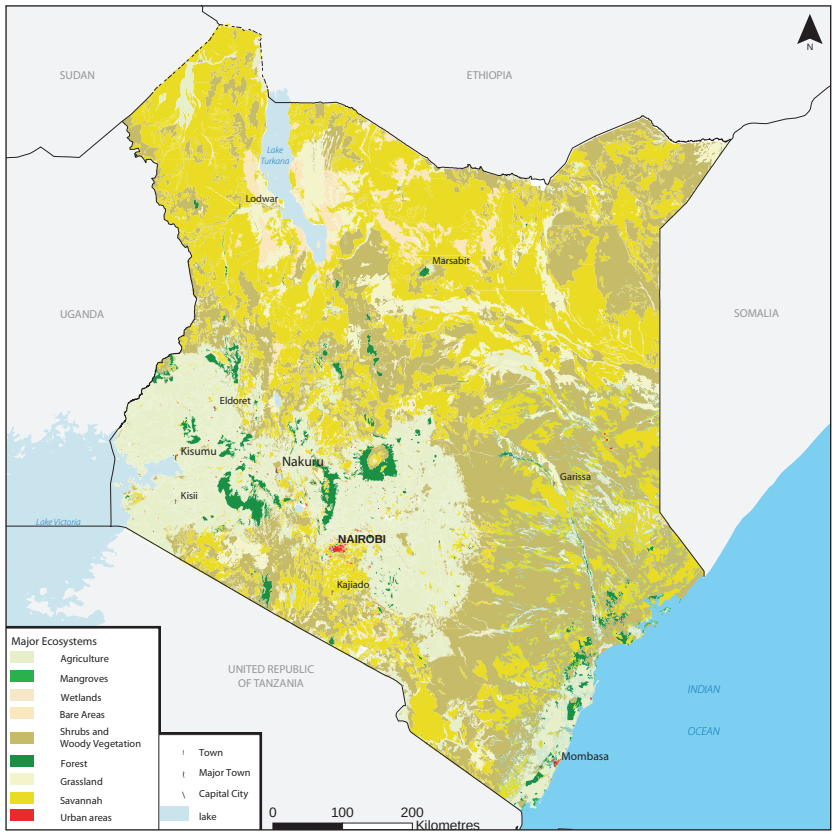


Figure 2: Map of land uses and land cover types (Source: FAO 2000)

raising take places where rainfall is scant or erratic (WRI and others 2007).

The total average area under cultivation at a national level continues to increase, as crops are introduced in degazetted forest lands, some humid rangelands are converted to farmland, and land under fruits and vegetables increases. Crops are grown on a significant proportion of marginal land with low or variable rainfall and it is likely that more such lands are being converted to crops even though there is high risk of failure (WRI and others 2007).

Amounts of land in the agriculturally productive highlands and the productivity of these lands are declining due to growing populations; an increase in competing land uses including forestry, wildlife conservation, and urban development; poorly planned settlements; new cultivation methods and cropping systems; the sub-division of land; and the introduction of irrigation schemes and sedentary farming and livestock management (Figure 2).

Land division is an ongoing problem in the HMPLs, where they often suffer from continuous fragmentation into sizes too small to be profitable. Social impacts include the exclusion of women in land ownership and decision-making (NLPS 2007). As a result of these changes, all areas are experiencing land degradation, which is examined in another section of this chapter.

Pastoral lands

Kenya's arid and semi-arid lands (ASALs) cover as much as 80 per cent or more of its total area and are comprised of savanna and grassland ecosystems, and bushland and woodland ecosystems (WRI and others 2007). They are characterized by a patchwork of grasses, trees, and shrubs and support about 70 per cent of the national livestock herd and are home to about 10 million people (or about 34 per cent of the population) (GoK 2004).

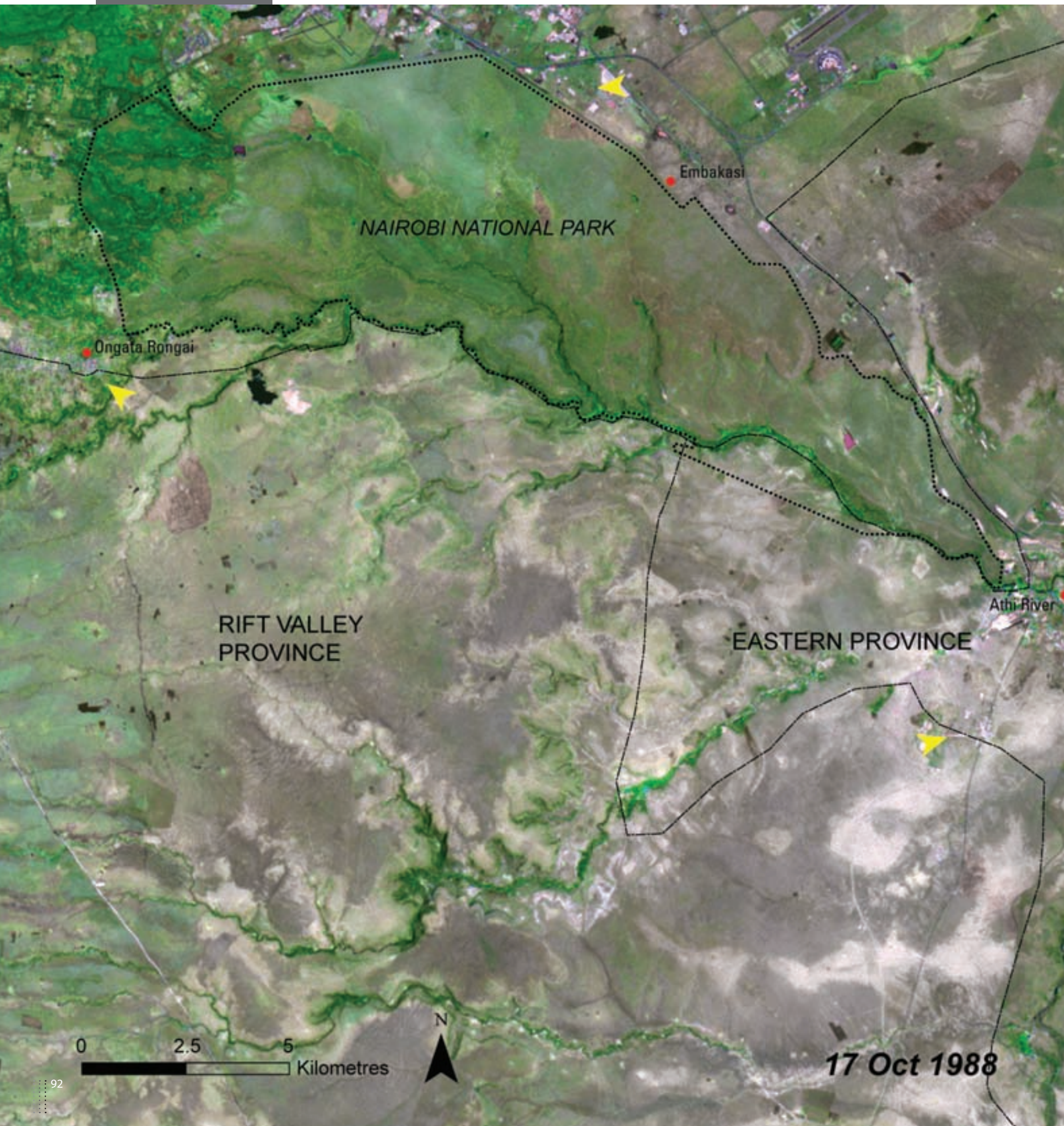
Pastoralists and agropastoralists own about half the country's cattle and small ruminant herd and all of its camel population. Kenya's pastoralist systems hold a significant amount and variety of the country's human and natural capital, including languages, indigenous knowledge, cultures, and uniquely adapted breeds (GoK 2004). They also contain most of Kenya's national parks and game reserves and so are key contributors to the tourism industry.

Land use has been changing in the ASALs as traditional land rights are increasingly ignored and growing human and livestock populations degrade pasture and water resources. Access to grazing land has diminished as more lands are appropriated for crops, the development of new water sources, conservation areas, and uses by the state (GoK 2004, WRI and others 2007). In addition, ASALs are subject to recurring drought, which exacerbates land degradation and threatens the lives and livelihoods of over 3.5 million pastoralists (UNEP 2008).

Nairobi National Park

Barriers to Wildlife

Founded in 1946, Nairobi National Park covers 117 km^2 and is the world's only Game Park located within a major city. The park's highland dry forest and savannah grasslands host a diverse range of wildlife species. About 100 species of mammals, including four of the "big five" (lion, leopard, buffalo, rhino) reside in the park. Other animals commonly observed include cheetah, Serval cats, hyenas, crocodiles, wildebeest, zebra, baboons, and snakes. With over 400 bird species, the park is classified as an Important Bird Area (IBA). For hundreds of years, Nairobi National Park was the terminus of migratory wildlife moving in search of water and breeding grounds. Animals dispersed to the Park from Kilimambogo/Oldonyo sabuk in the north, Amboseli in the south, Narok in the south west, and Machakos in the east. Between the 1950s and 1960s,



however, farmers and settlers gradually took over the land at the base of the Ngong Hills in the west. South of the Park, group ranches sprung up by the 1970s and private land ownership was adopted in the 1980s and 90s, thus blocking migratory corridors for wildlife.

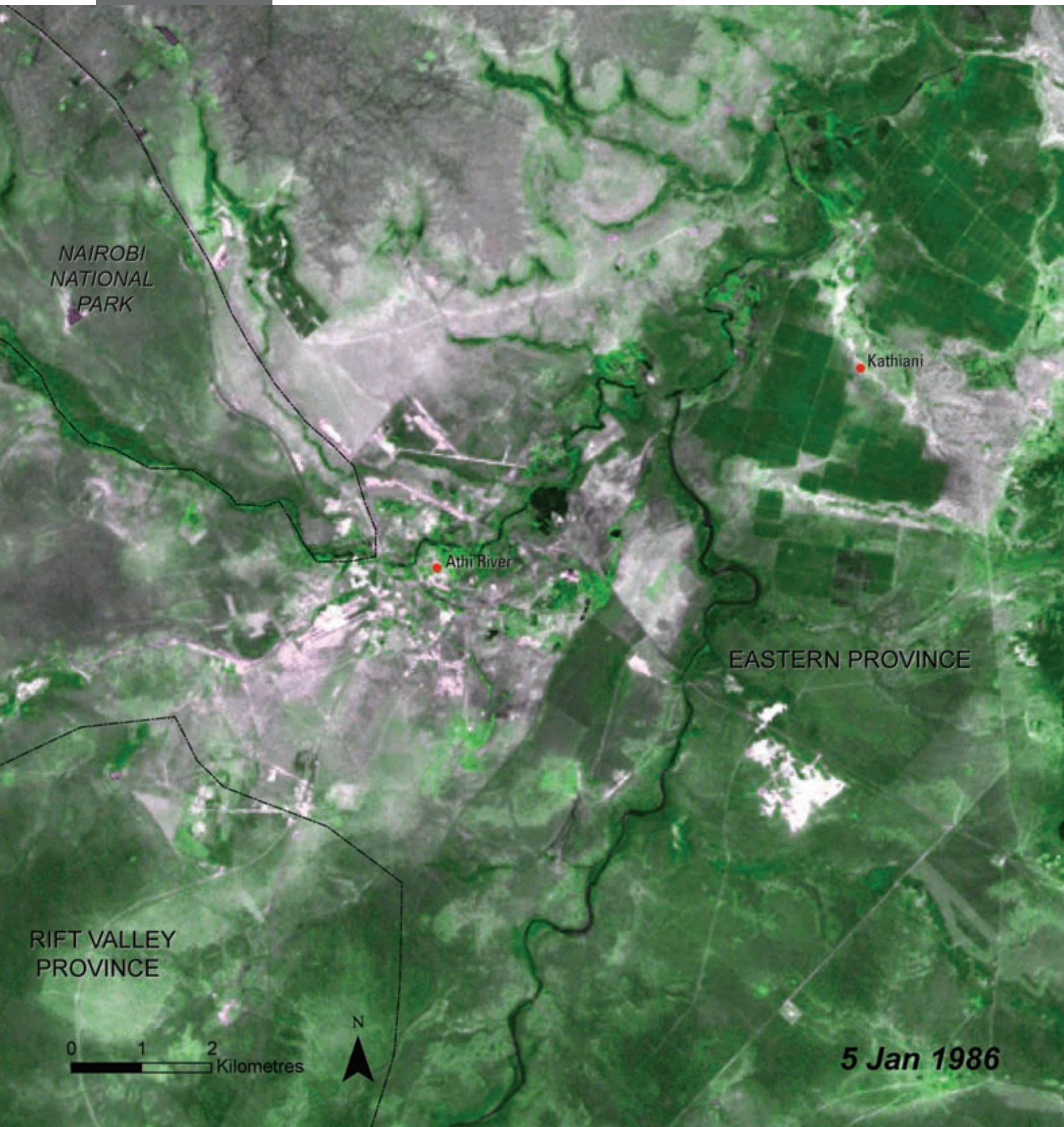
Among Kenya's Parks, Nairobi National Park ranks fifth in visitor numbers and income generation. It receives more than 100 000 visitors a year, which generates about Ksh. 45 million. The Park's main challenges include a burgeoning human population, which grew from 80 000 to 410 000 from 1969 to 1999, and increasing settlements south of the park. This has led to human-wildlife conflict, pollution of streams, poaching for game meat, livestock invasion by wild animals, and the introduction of invasive species.

Mlolongo Township

Urban Sprawl

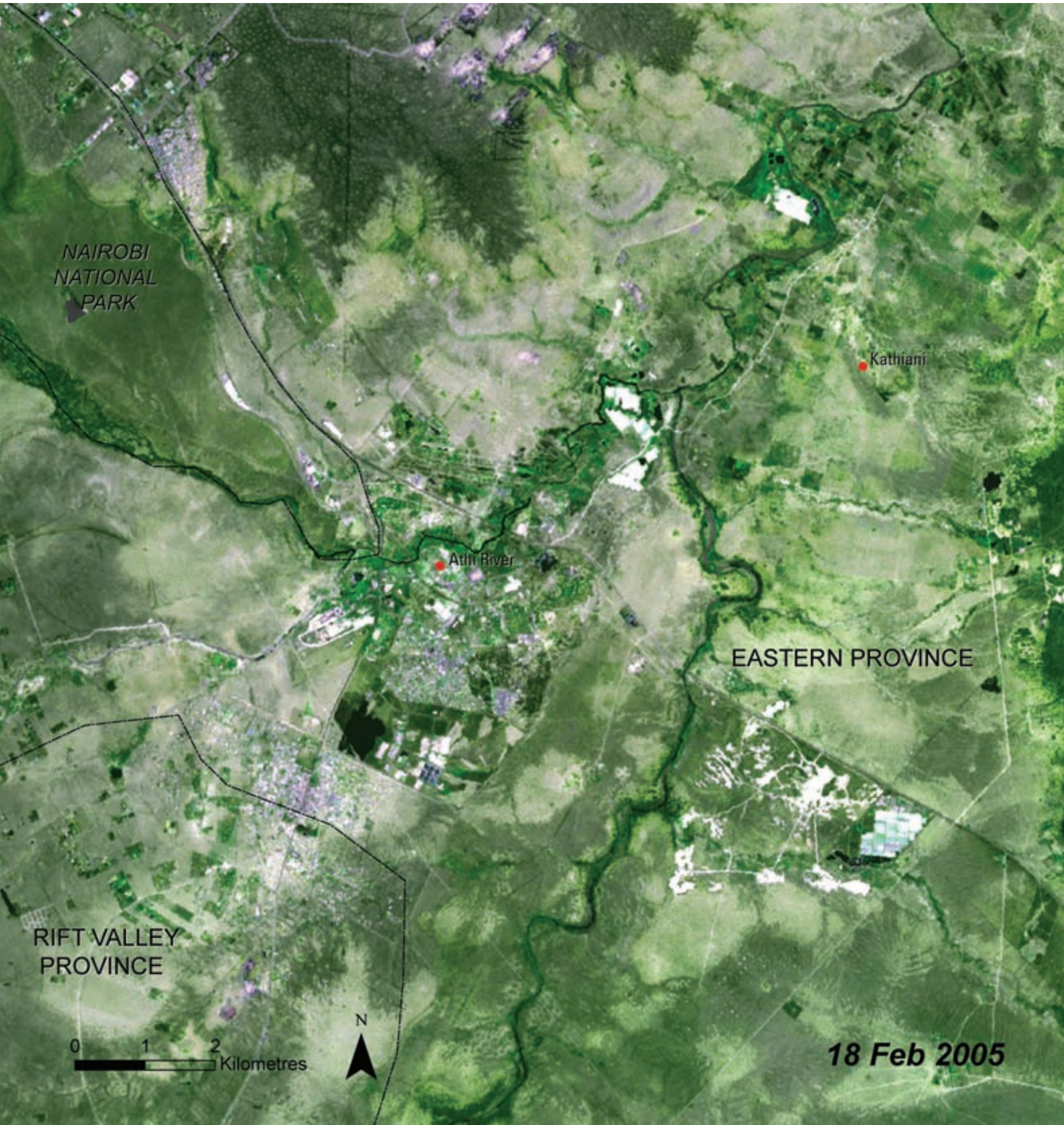
Mlolongo Township is situated along the Nairobi-Mombasa highway about 15 km southeast of Nairobi (1°23'38"S, 36°56'28"E). It is strategically positioned, with Nairobi's industrial area eight kilometres to the north, the Kitengala urban sprawl six kilometres to the south, and the densely populated Athi river mining area five kilometres to the southeast.

Mlolongo is the Swahili word for "queuing". It earned this name because trucks form long queues for the weighbridge here while they rest and wait for goods to be inspected. By the mid 1980s, sand traders from Machakos district some 30



km further east had found Mlolongo a suitable place for trading. By the 1990s, Mlolongo was booming and the town's trade was fast expanding.

From a small long-distance truck stopover, Mlolongo grew rapidly until its present population of over 12 000 people. The township has recently been included in Nairobi's metropolitan plan, which will improve its infrastructure development and the provision of urban services that are currently lacking.



Lake Naivasha
Greenhouse Footprints

Unlike other lakes in Kenya's Eastern Rift Valley, Lake Naivasha is a freshwater lake, receiving most of its inflow from the Aberdare Mountains to its east. Naivasha has a history of fluctuating depths and surface area due to its shallow depth and rainfall variability in its catchment. It is a valuable freshwater resource for human uses and for a diverse population of waterbirds and large mammals, including hippopotamuses. The lake supports a range of economic activities including commercial flower growing, fishing, and a geothermal power plant.

In recent years, pressure on the Lake has increased as population and human activities have intensified throughout its catchment. Several of these changes can be seen in the differences between the 1973 and 2008 satellite images. The

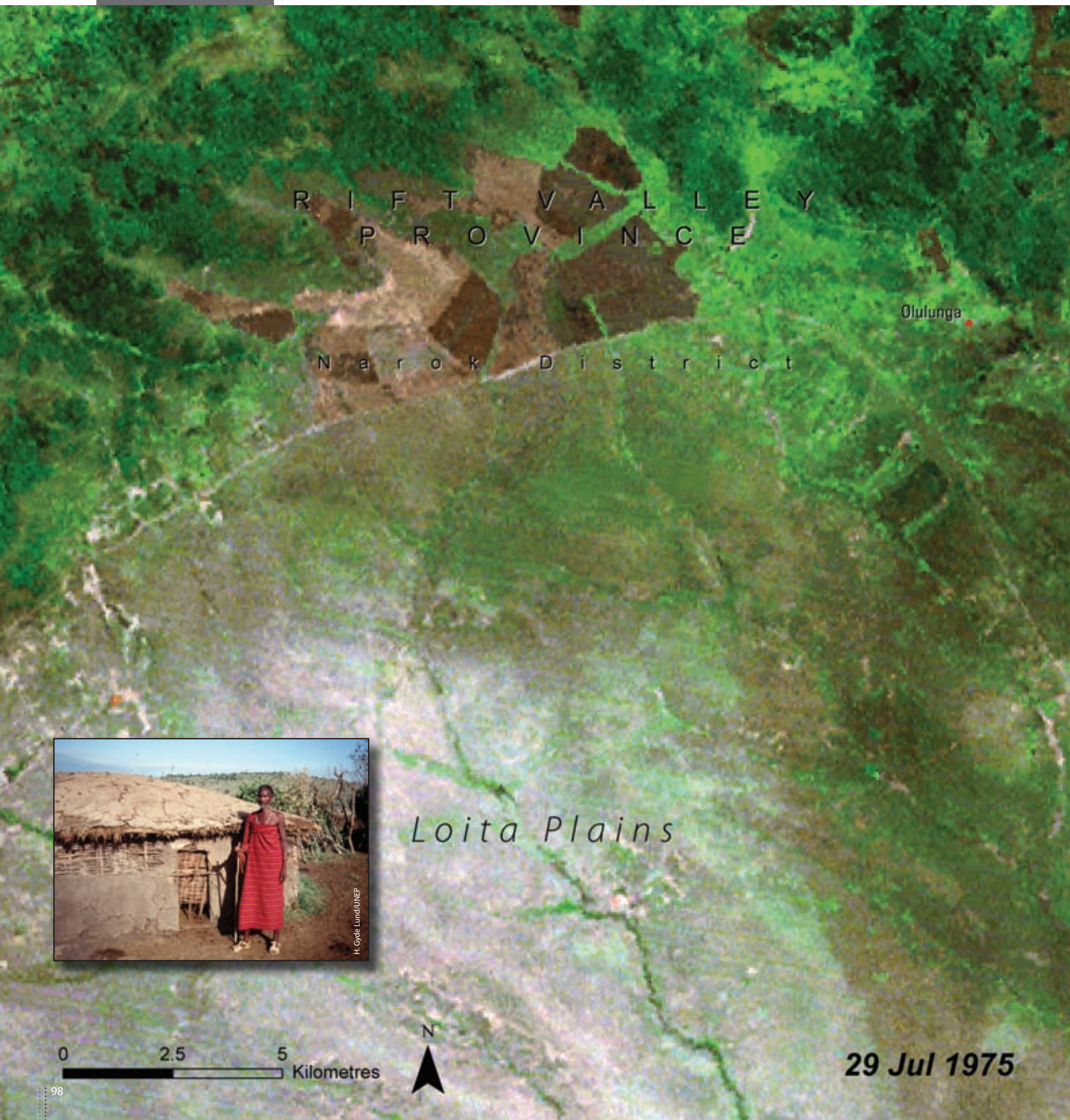
footprints of Naivasha town and Karagita have grown considerably, reflecting the increased population throughout the catchment, now well above 600 000. Many commercial greenhouse flower farms have been built since the early 1980s. These are visible surrounding the lake as bright white and light blue squares of greenhouse roofs. The boundary of the Eburru Forest also retreats noticeably between the two images.

Designated a Ramsar Wetland of International Importance, efforts are being made to sustainably manage the lake. Nevertheless, water abstraction for agriculture; watershed deforestation; diversion of inflow from Malewa and Gilgil Rivers; nutrient, sediment, and chemical runoff into the lake; and invasive species are just some of the many concerns bearing on Naivasha's future.

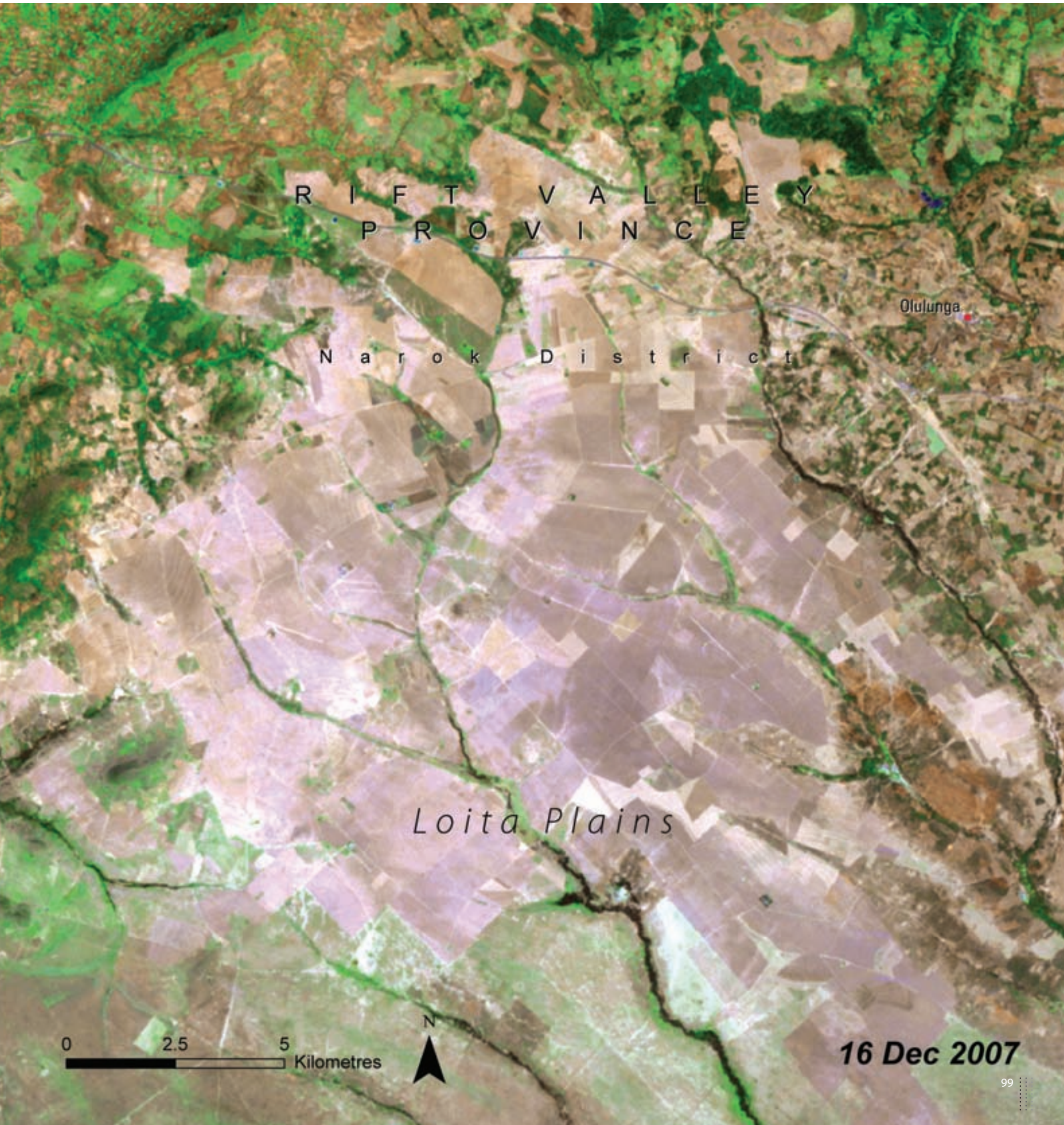
Loita Plains

Grasslands Lost to Farms

The Loita Plains, northeast of world famous Maasai Mara National Reserve, are an important part of the larger Serengeti-Mara Ecosystem. They are core breeding and calving grounds and wet-season grazing land for the wildebeest, whose annual migration is the primary tourism feature of the Maasai Mara Reserve. The natural landscape here is tall grass savanna with some scattered acacia and dwarf shrubs. The primary human inhabitants of the Loita Plains are the Maasai, who have traditionally been nomadic pastoralists. Responding to the limited, unpredictable, and seasonal rains on these grasslands, the Maasai, like the wildebeest, traditionally migrated through the year to where the grasses provided adequate food for their cattle. Over the past several decades, changes in land use in the Narok District have caused



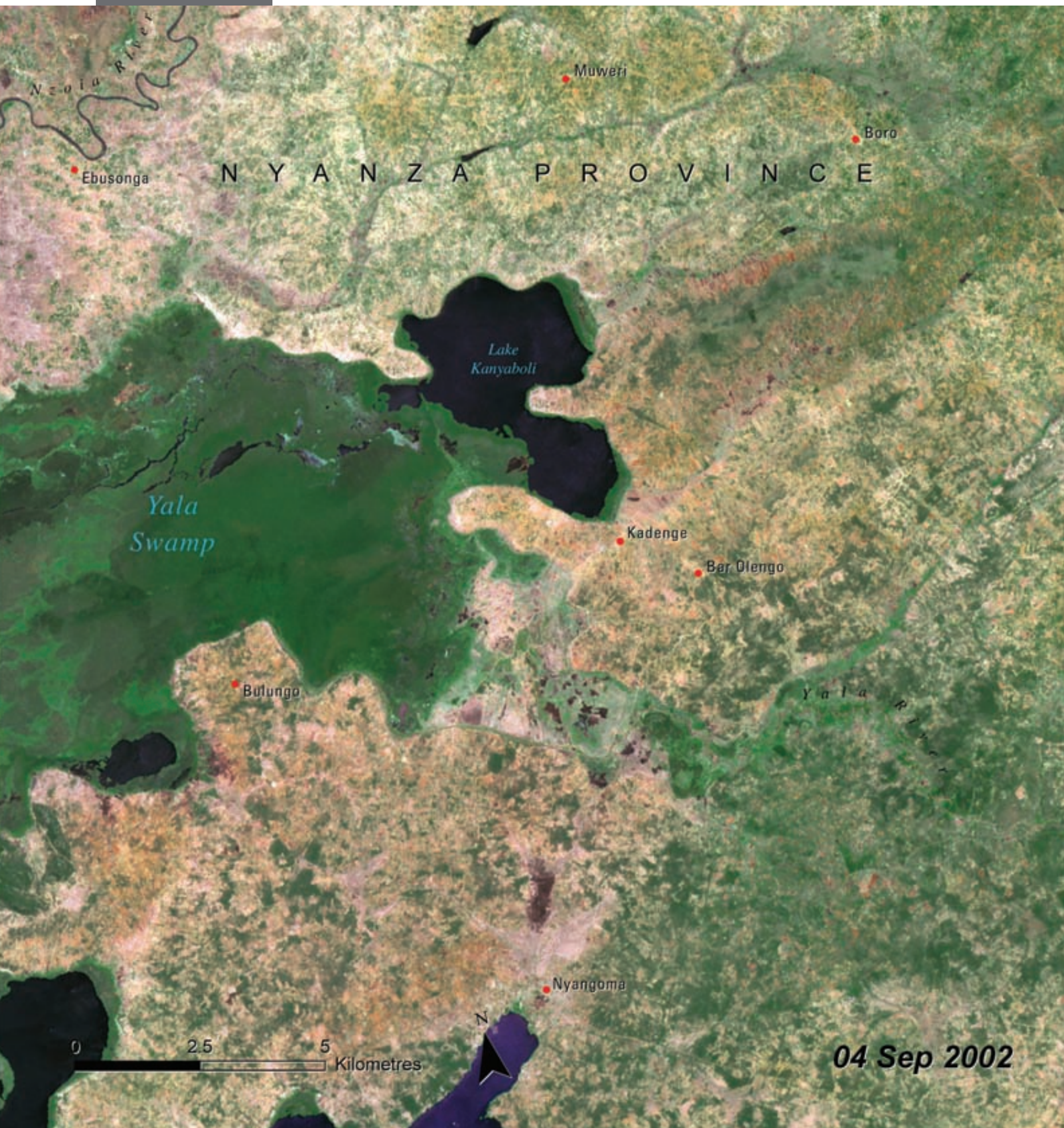
changes in ways of life for both the Maasai and the wildebeest. While most Maasai in both Tanzania and in Kenya have taken up cultivation in recent decades, land tenure restrictions in Tanzania have tended to prevent widespread development of mechanized cultivation. In Kenya, however, large mechanized wheat farms in the area surrounding Maasai Mara expanded roughly 1 000 per cent between 1975 and 1995, most of them on the Loita Plains. This has reduced the available natural grasslands in this important wildebeest habitat. The Maasai Mara is perhaps the most famous of Kenya's tourist attractions and the annual migration of the wildebeest and other large mammals is one of the Mara's most compelling features. Management of competing land uses for this vast grassland will require a careful balance if its value is to be preserved for future generations.



Yala Swamp

Irrigation Drains a Wetland

Yala Swamp, Kenya's third largest wetland, is formed on the deltaic sediments of the Nzoia and Yala Rivers where they enter the northeastern corner of Lake Victoria. The majority of the swamp's surface area is covered with emergent wetland vegetation, including papyrus, phragmites, and typha. The wetland is vital habitat for many bird and fish species including several fish species that have disappeared from the main body of Lake Victoria, displaced by the introduction of the Nile Perch. The swamp also serves as a filter to the waters entering Lake Victoria, limiting sediments, nutrients, and pollutants from the Nzoia and Yala River catchments.

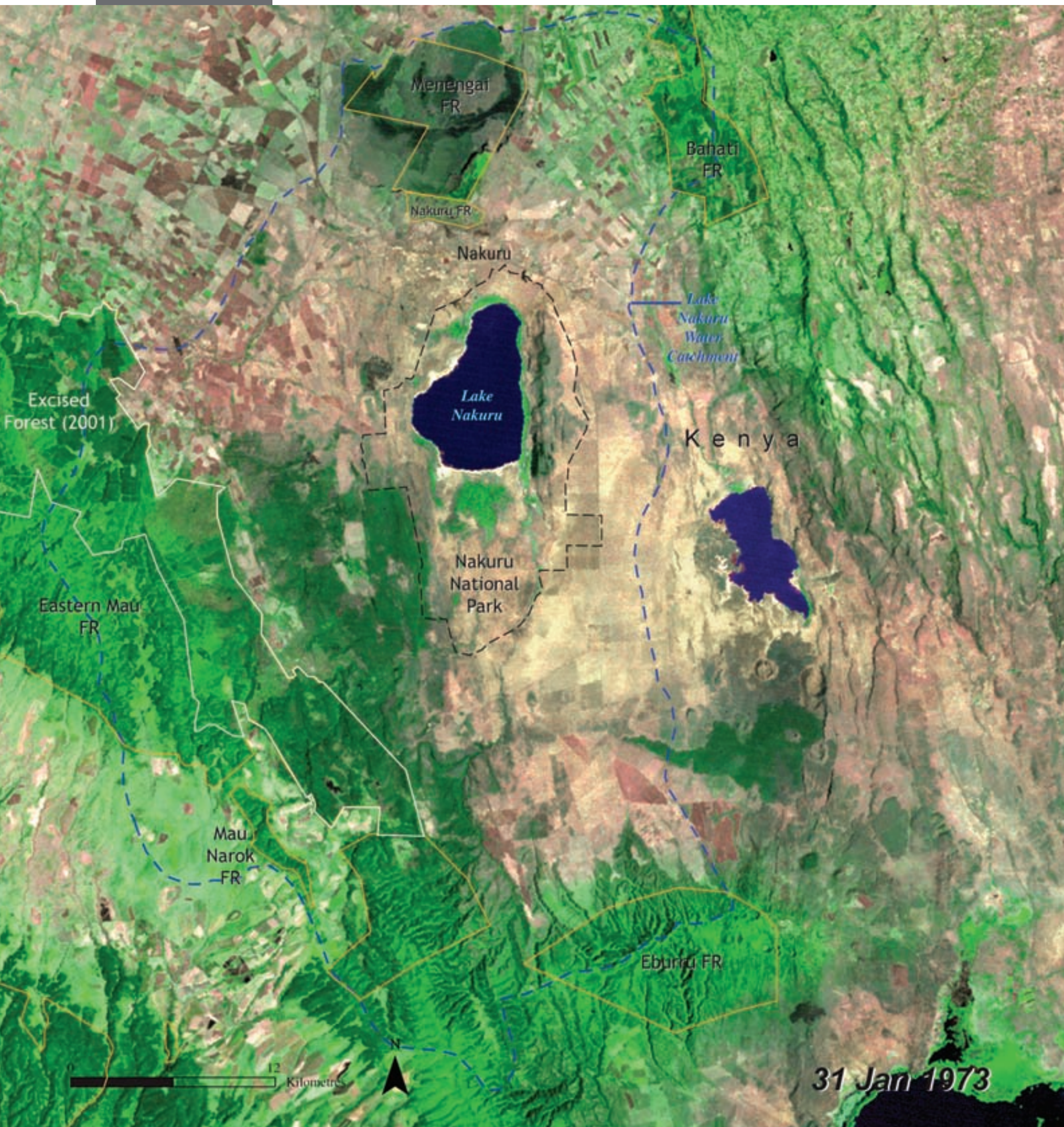


Drainage of the swamp has been ongoing since the mid-1960s, with a significant portion of the swamp's original 17 500 ha now converted to agriculture. In 2002, 10 000 ha were leased to a foreign company for a large-scale irrigated rice project. The project built a dam on the Yala River, drained a large area of swamp, and flooded public land, disrupting the lives of many and displacing some from their homes. The company has proposed a further expansion of its activities, which would require the draining and development of an additional 9 200 ha of Yala Swamp extending from its current location to the north boundary of Yala Swamp. Development of this area has pitted the Kenyan government and private investors against conservationists and local citizens. The large commercial rice project development can be seen at the centre of the two satellite images.

Lake Nakuru
Degrading Watershed

Lake Nakuru, in Kenya's Eastern Rift Valley, falls entirely within Lake Nakuru National Park, the second most visited protected area in Kenya. Its primary water source, the River Njoro, originates on the eastern escarpment of the Mau Forest Complex. With no outlet, Lake Nakuru has highly saline and alkaline water.

It hosts the world's largest concentration of flamingoes, as well as many of the animal species that make Kenya a highly-valued tourism destination, including lions, leopards, rhinoceros, and water buffaloes. In its total area of 188 km^2, there are over 450 bird species and 56 mammal species. Recognized as a Wetland of International Importance, Lake Nakuru was declared a Ramsar Site in 1990.



Loss of natural vegetation, particularly forests, in Nakuru's watershed threatens the Lake's water quality and water balance. Between 1986 and 2003 alone, roughly one-fifth of the forested area in the upper reaches of the River Njoro catchment was lost. Another analysis found that just less than half of the dense vegetation cover in the Lake Nakuru basin was lost between 1973 and 2003. These images show the land-cover degradation in the Lake's catchment between 1973 and 2006. In 2001, the Government of Kenya announced its intention to excise 353 km^2 of forest in the eastern Mau Forest Reserve (the white boundary in the 2006 image). As a result, most of the forest cover in the upper catchment of River Njoro will disappear.

Menengai FR
Bahati FR
Nakuru FR
Nakuru
Lake Nakuru Water Catchment
Excised Forest (2001)
Lake Nakuru
Kenya
Nakuru National Park
Eastern Mau FR
Mau Narok FR
Eburru FR
N
0
12
Kilometres
27 Jan 2006

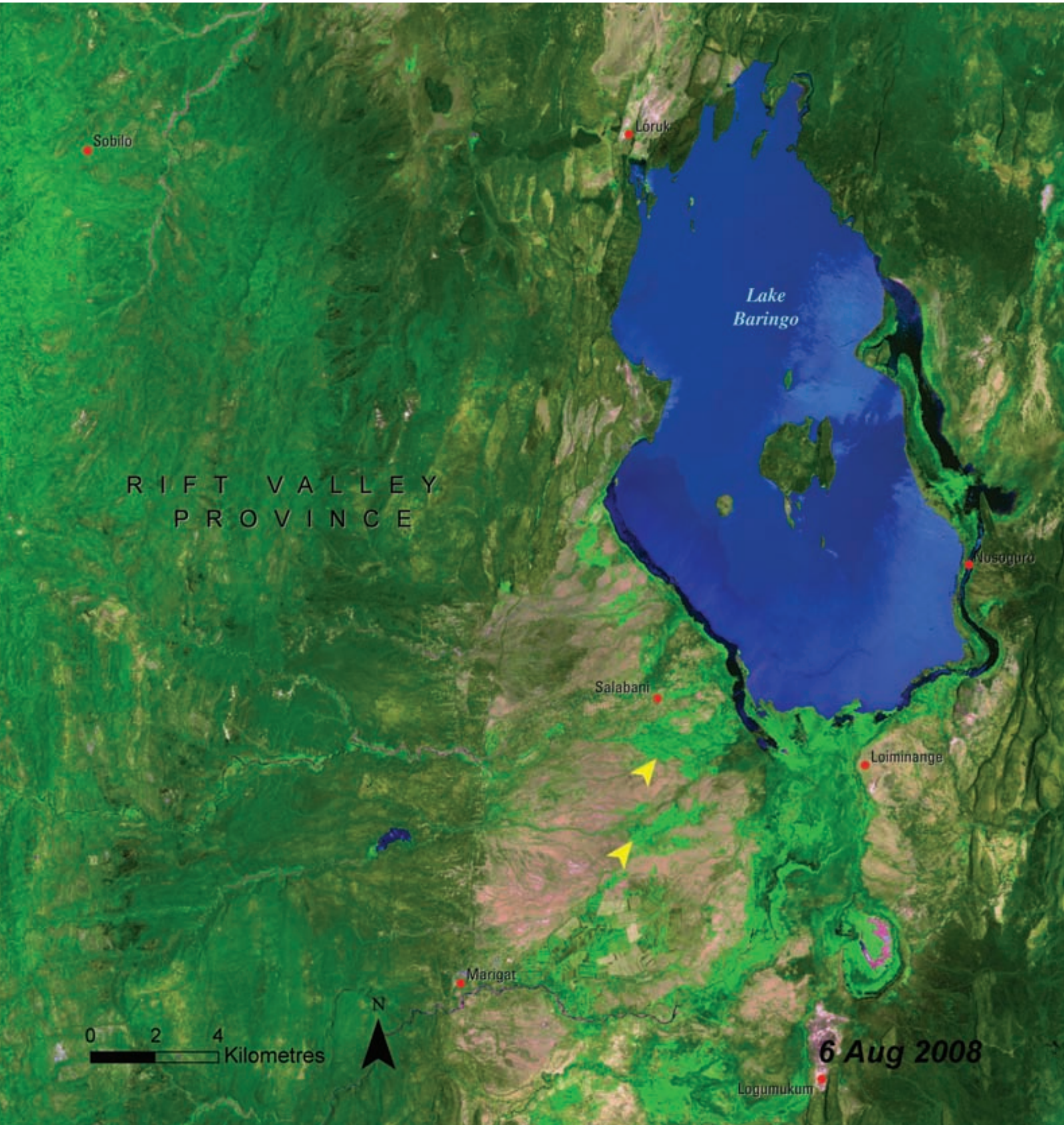
Lake Baringo
Introduced Species

Prosopis, a perennial deciduous thorny shrub or small tree native to the Americas, was introduced in the Baringo District in central Kenya in the 1980s by the Kenyan government, with financial backing from the Food and Agricultural Organization of the United Nations (FAO). It was intended to ensure self-sufficiency in wood products, make the environment habitable, and safeguard existing natural vegetation from over exploitation by rising human populations.

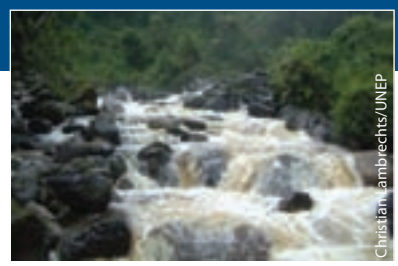
Some parts of the world where it has been introduced have benefitted from the new shrub but it has become invasive in the Lake Baringo area and has been of little use. Prosopis distribution in Baringo District is generally limited to Mairigat Division but has spread rapidly causing problems to traditional pastoral livelihoods by blocking pathways, altering river

courses, taking over farmlands, and suppressing other fodder species. In addition, when goats eat the pods from the bushes the high sugar content damages their teeth. The worst hit locations include Salabani, Ngambo, and Lobo.

There has been an effort to manage Prosopis in Baringo with assistance from FAO. The project, which has adopted a participatory approach, is testing for viable methods of utilizing and controlling the species. Initial results from this small-scale project have shown that with the appropriate support, local communities can manage large infestations, although strict follow-up programmes are needed to check any future re-invasion.



Water



This section and the paired images that follow illustrate the changes and threats to Kenya's fragile water sources. Kenya's natural endowment of freshwater is already highly limited; the annual renewable fresh water supplies represent 647 m^3 per capita, which is significantly below the 1 000 m^3 per capita the United Nations classifies as chronically water-scarce (UNEP 2008). Population growth alone will continue to reduce per capita water availability in the future so that by 2020, it is expected to be only 359 m^3 per capita (UNESCO 2006, WRI and others 2007).

Rainfall

Kenya's water supplies are fed by rainfall, which is highly spatially variable, ranging from less than 200 mm a year in the northern arid and semi-arid lands to 1 800 mm in the western region (Figure 1). It exceeds 1 250 mm a year in only three per cent of the country's area, but these regions feed Kenya's major rivers. Rainfall is also erratic and varies greatly throughout the year. There are two distinct rainy seasons east of the Rift Valley: the "long rains" come from March to May and the "short rains" from October to December. Major droughts and floods occur regularly. Since 98 per cent of Kenya's crops are rainfed, high rainfall variability is a significant risk factor for most farmers. Rainfall variability will likely increase with climate change, further straining the natural resource base of Kenya's economy and its citizens' livelihoods (Survey of Kenya 2003, WRI and others 2007).

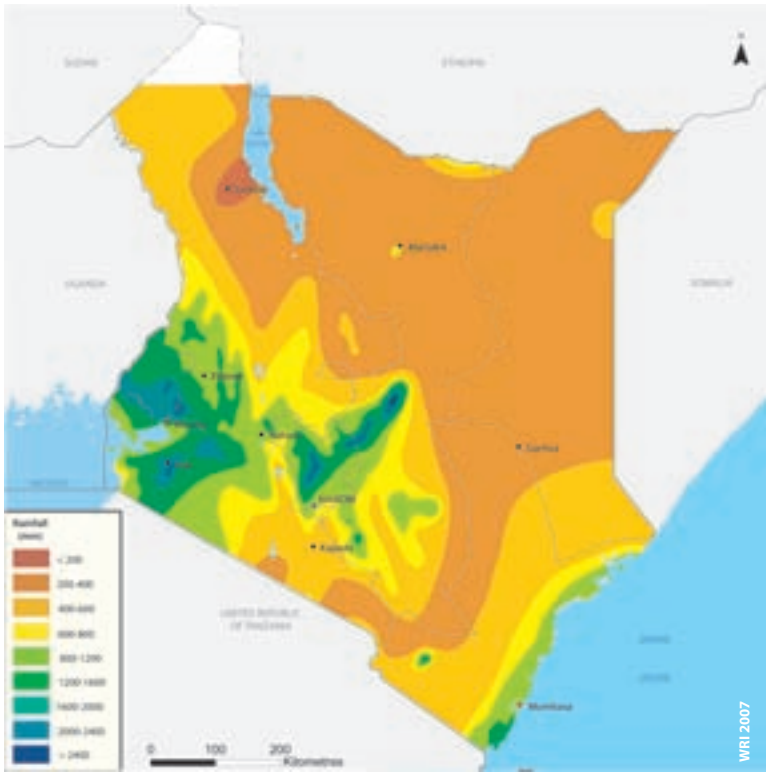


Figure 1: Average annual rainfall distribution

Water resources

Surface waters cover about two percent of Kenya and supply 20.2 billion m^3 of the country's estimated 30.7 billion m^3 of renewable water per year. The rest, about 14 per cent of total water resources, comes from groundwater and transboundary rivers (NEMA 2004).

The majority of Kenya's lakes are in the Great East African Rift Valley and include closed and open-basin systems. Most of the lakes are saline with the exception of Victoria, Naivasha, and Baringo. As shown in Chapter 1 and Figure 2, surface waters are fed by five "water towers" representing the country's major drainage areas in the highland's forested catchments (WRI and others 2007).

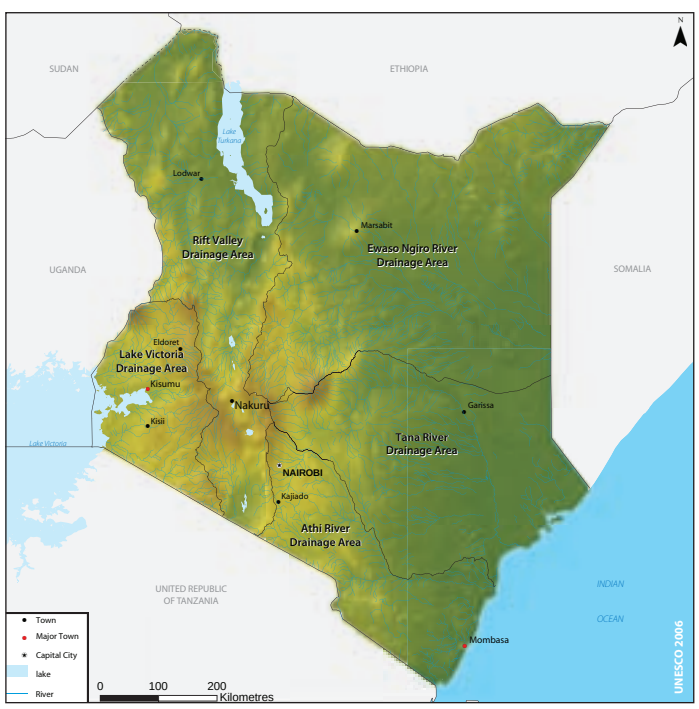


Figure 2: Kenya's surface drainage systems

Kenya's water resources include its important wetlands, which cover about 3 to 4 per cent of the land and include coral reefs, marine inshore waters, mangroves, deltas, creeks, lake shores, rivers, marshes, ponds, dams, and mountain bogs. Many communities rely on wetlands for food, medicinal plants, firewood, and many other materials. Wetlands also provide ecosystem services such as filtering and storing water, protecting coastlines from erosion, and as wildlife habitats (Ramsar 2001, FAO 2006).

Water demand and use

Agriculture uses just over three-quarters of the surface water withdrawn for human uses while

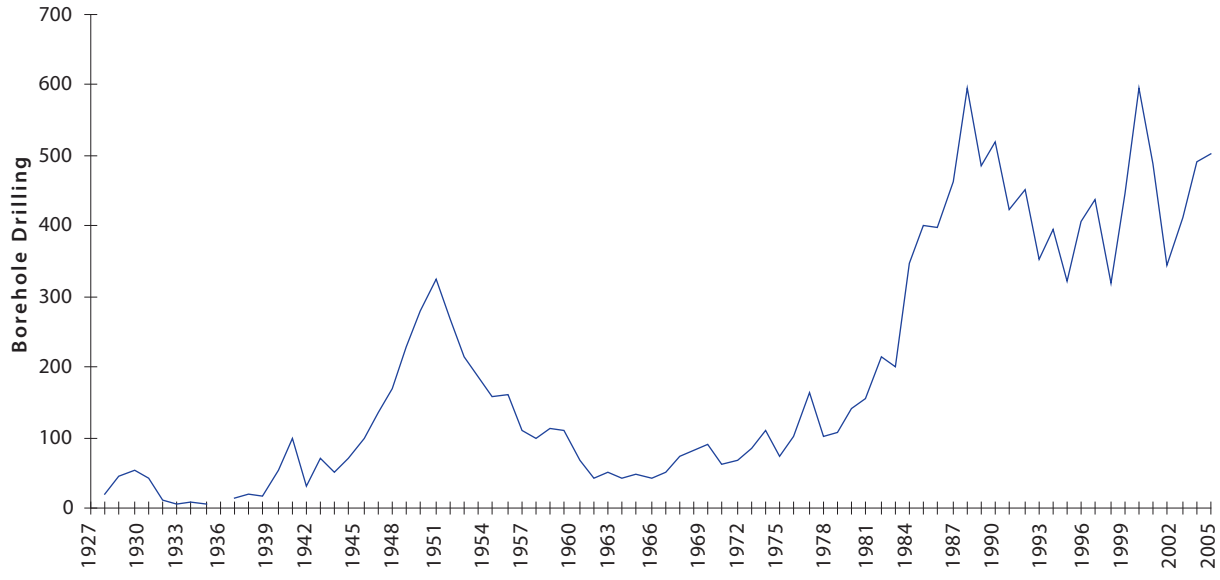


Figure 3: Borehole drilling 1927-2005 (Source: GoK 2008)

domestic and industrial withdrawals account for 17.2 and 3.7 per cent, respectively (FAO 2006). At the same time as water availability has been decreasing and rainfall variability rises with climate change, demand for water has also been growing. Total water withdrawal is estimated to be over 2.7 km^3 but water demand is projected to increase withdrawals to 5.8 km^3 by the year 2010 (FAO 2006).

Only two per cent of Kenya's croplands are irrigated, compared to the sub-Saharan average of 2.7 per cent, and only 19 per cent of land with irrigation potential is presently equipped with irrigation systems (WRI and others 2007). There are some 9 000 boreholes throughout the country to withdraw groundwater. Figure 3 shows the increased rate at which they were sunk, especially since the 1980s. Given the age of many of them, most require rehabilitation (FAO 2006).

Environmental challenges

Kenya's 1992 National Development Plan noted that 33 sub-basins without perennial river flow had an apparent water shortage and predicted that of 164 sub-basins with perennial river flows, 90 will suffer from surface water deficit by 2010 (FAO 2006). Population pressures and the increased pace and scale of human activities in watersheds are straining water supplies. As shown in Chapter 1, encroachment into the forested areas that make up Kenya's five "water towers" is seriously degrading the catchment areas as trees are felled for fuel, new farming areas, settlements, and pastures. In addition sediment loads are increasing due largely to poor land use practices in the catchments. Every year, the Rivers Tana and Sabaki deposit several million tonnes of sediment. Sedimentation seriously degrades various coastal resources and reduces the life of reservoirs (Twong'o and Sikoyo 2002).

Both surface and groundwaters receive urban pollution from wastewaters and sewage and chemicals from agricultural runoff. As well, declining and degraded water supplies have led to conflicts among different users, such as between pastoralists and farmers, upstream and downstream users, humans and wildlife, among others. Invasive species are another environmental problem associated with human impacts on water resources in Kenya. Some lakes, especially Victoria and Naivasha, have been subject to the invasive water hyacinth, which has choked off large parts of their surfaces, while the introduction of the Nile Perch in Lake Victoria has affected species composition.

Population pressures and increased human activity in and around wetlands are transforming them for commercial uses including agriculture, salt-panning, and fish farming, among others, and they are being compromised by pollution from agricultural runoff, industries, and municipal effluents that renders their waters unhealthy for humans and livestock (Macharia 2004, Ramsar 2001). The following satellite images provide examples of how some of the environmental changes described above are affecting the country's water sources.

Seven Forks Dams

Silting of Reservoirs

The River Tana, Kenya's longest river, originates in the elevated forest regions of Mount Kenya and the Aberdare Mountains. Masinga Dam built in 1980-1981, and the four reservoirs below it are known as the Seven Forks Dams. Masinga was designed to control the Tana's flow to maximize the hydroelectric output of the other dams. The Seven Forks Dams provide the bulk of Kenya's hydroelectric power.

The Project's design estimated that three million metric tonnes of sediment would accumulate behind the dams per year. Thus, their life span was expected to be roughly 500 years. By 1988, however, the siltation rate was 10 million metric tonnes per year—a rate that will drastically reduce the dam's life.

Increased agricultural activity and deforestation, particularly in the upper elevations where rainfall is much heavier, have been blamed for this increase in sediment. Deforestation has increased the erosive capacity of rainwater throughout the catchment, especially in the Thiba and Tana catchment basins.

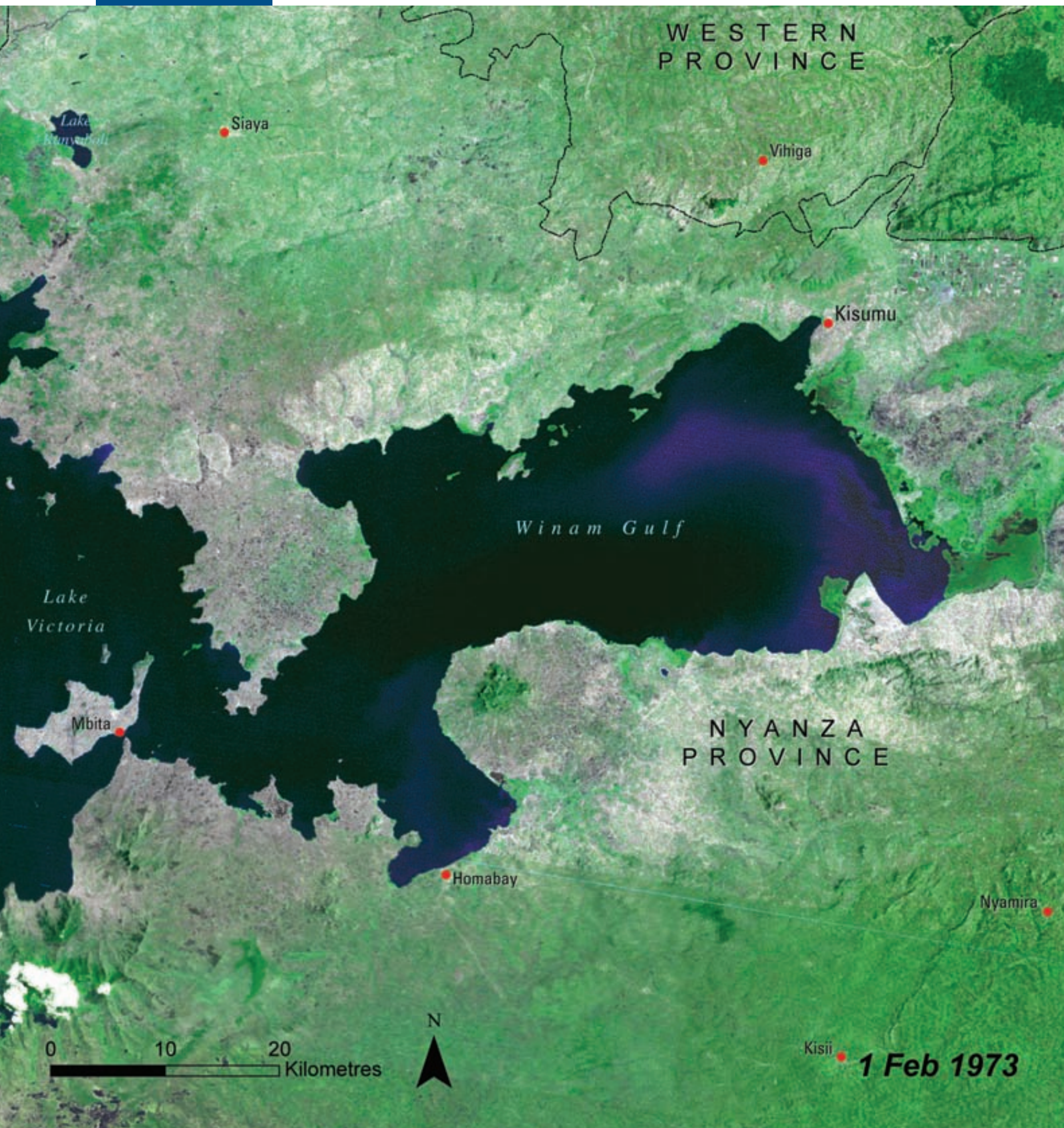
The satellite images from 1987 and 2005 both show suspended sediments in the waters of some of the Seven Fork's reservoirs. In the 2005 images, the light-colourerd areas in the eastern half of Masinga indicate light reflected by suspended sediments in the water. In spite of issues with the Project's long term viability, the Project has continued to expand. The recently built Kiambere Dam can be seen at the right edge of the 2005 image.

Winam Gulf

Silt and Sewage

With a surface area of 68 870 km^2, Lake Victoria is Africa's largest lake and the world's second-largest freshwater lake. Its waters are shared by three East African countries — Kenya, Tanzania, and Uganda. The lake has experienced myriad environmental problems including invasive species, declining water quality, fluctuating water levels, and direct discharge of wastes into the water system.

The Winam Gulf is the protruding arm of Lake Victoria into Kenya. The gulf is about 100 km west to east and 50 km north to south with an average water depth of about six metres. Among the environmental challenges Winam Gulf faces are sedimentation, waste contamination, and agricultural runoff. Poor land-management practices, including



deforestation in the Nandi Hills, have resulted in excessive sediment flowing into the lake. A comparison of Landsat images from 1973 and 2001 shows a significant increase in suspended sediment in the gulf. The lighter cyan color in the 2001 image is light reflected from siltation and sedimentation.

A massive increase in human population has led to increased solid waste and sewage. Lacking proper waste-management systems, much of this finds its way into the Gulf. Also, because of increased agriculture, agro-chemicals are transported through streams into the Gulf. These pollutants cause algal blooms that deplete the dissolved oxygen in the Gulf, threatening the fish population.

Lake Olbollosat

Disappearing Lake

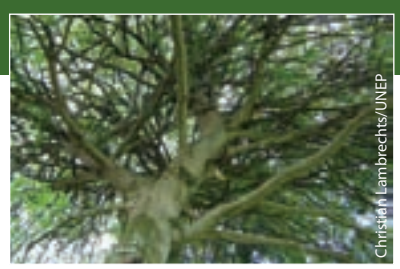
Lake Olbollosat, the only lake in Kenya's Central Province, lies in Great Rift Valley to the northwest of the Aberdare Mountains. The Lake covers over 40 km^2, of which only a small part is open water. Its catchment is the Ewaso Nyiro North Basin, which covers over 200 000 km^2 and is the country's largest drainage basin. It is also an internal basin, which along with a high evaporation rate, gives the Lake its elevated salinity level.

The lake and its catchment area provide a variety of important habitats including open water, floating marshes and swamps, open grasslands and riverine forests along the rivers, and springs that feed the lake. The lake is earmarked for

designation as a Ramsar Wetland of International Importance because of the wealth of biodiversity it supports, particularly its migratory bird species.

A rapidly growing population threatens this valuable habitat. Impacts include catchment degradation, siltation, overgrazing, encroachment on riparian land, agricultural pollution, and excessive water abstraction. Lake Olbollasat's water volume has fluctuated over the years. While Lake Olbollasat has periodically dried up and then come back to life in the past, environmentalists are concerned that the increasing number of pressures may mean that if it dries up again, it could be the end of Lake Olbollasat.

Forests


Christien Lambrechts/UNEP

Although forests cover only about three per cent of Kenya's land area, they are essential ecosystems, providing fuel, timber, food, medicinal plants and other forest products, wildlife habitat, tourist attractions, water catchments, carbon storage, and a myriad of additional goods and services as well as cultural and spiritual values. As underscored in Chapter 1, about 10 per cent of the population lives within five km of Kenya's indigenous closed-canopy forests and derive direct benefits from them, and in some areas, as much as 70 per cent of the income in households adjacent to forests comes from forest activities (KFWG 2008). Kenya's coastal forests are important for their role in protecting shores from degradation, especially erosion, and its mangroves are particularly significant for the role they play in trapping sediment, filtering water, recycling nutrients, and as habitat for valuable fish species. The closed canopy forests are habitat for a disproportionately large percentage of the country's wildlife and other biodiversity. It is estimated that they harbour 40 per cent of large mammals, 30 per cent of birds, and 35 per cent of the nation's butterflies. About half of Kenya's threatened mammals and birds are found in its forests (Survey of Kenya 2003).

Kenya's forests are so important that Chapter 1 devoted a large section to the country's five "water towers", whose forests capture and store water that flows into rivers delivering this precious resource to people and ecosystems as far away as the coast and all its borders with neighbouring countries. These catchments produce crucial waters that generate hydro electricity, feed irrigation schemes for small landholders and large plantations, and sustain wildlife in the country's famous wilderness parks (Survey of Kenya 2003). This section gives an additional brief overview of Kenya's forest resources to provide context for the following paired images depicting environmental change in the nation's forested "hotspots".

Kenya's forest stocks

Kenya's different forest types are classified according to climatic conditions: coastal forests, dry-zone forests, montane forests, and the western rain forests. According to the Kenya Indigenous Forests Conservation Programme (KIFCON), Kenya has about 1.24 million ha of closed-canopy indigenous forests. The Kenya Forest Service manages most of these as gazetted forest reserves while the Kenya Wildlife Service (KWS) manages other closed-canopy forests gazetted as National Parks and National Reserves (KFWG 2008). In total, gazetted reserves cover about 1.64 ha or two per cent of the land area (Figure 1) (Wass, 1995, World Bank/GoK 2000, UNEP 2006).

The Forestry Department's inventory states that 165 000 ha are under plantations but this figure does not account for them all. The Ministry of Local Government holds some 100 000 ha of forest as Trust Land on behalf of local people; these forests are generally poorly managed (KFWG 2008). Kenya's total forest area also includes woodlands, bushlands, and wooded grasslands, which in fact contain most of the country's woody biomass (WRI and others 2007). The densest forests occur in the moist highlands where the human population and agricultural production are also concentrated. In the extensive semi-arid region, forests are mainly found on isolated hills and in discontinuous narrow bands along riverbeds. Coastal forests exist in

Uneven forest canopy

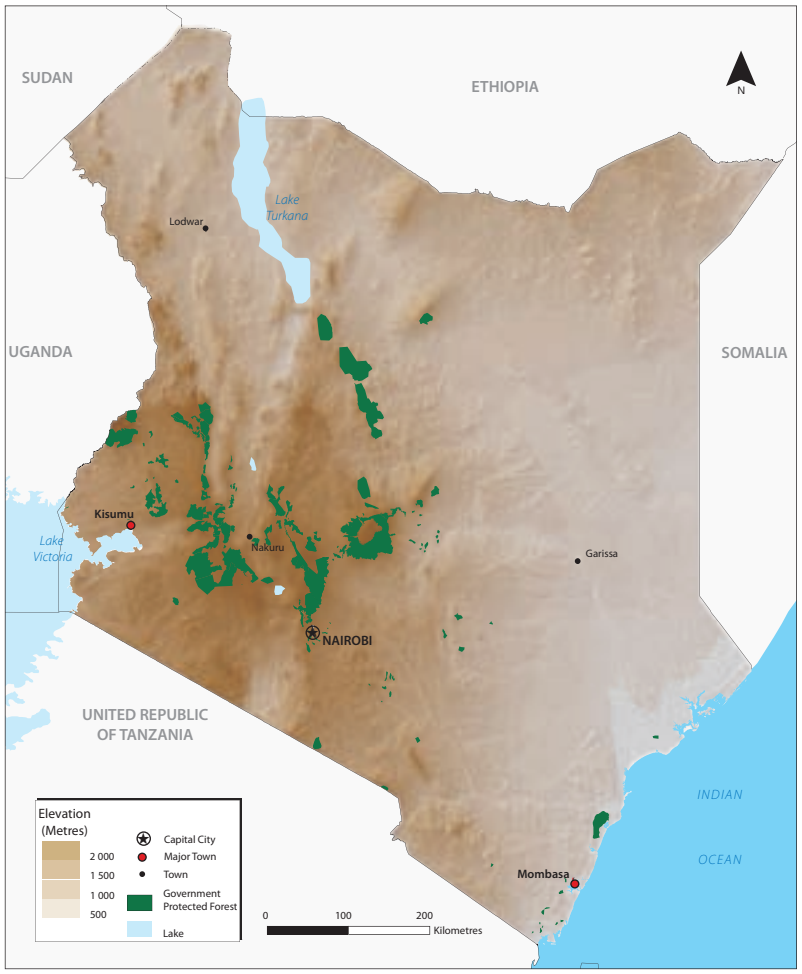


Figure 1: Gazetted forests (Source: KFS 2007)

isolated blocks comprising about 83 800 ha and mangroves along the coast cover about 53 000 ha (Twong'o and Sikoyo 2002).

Human use of the forests

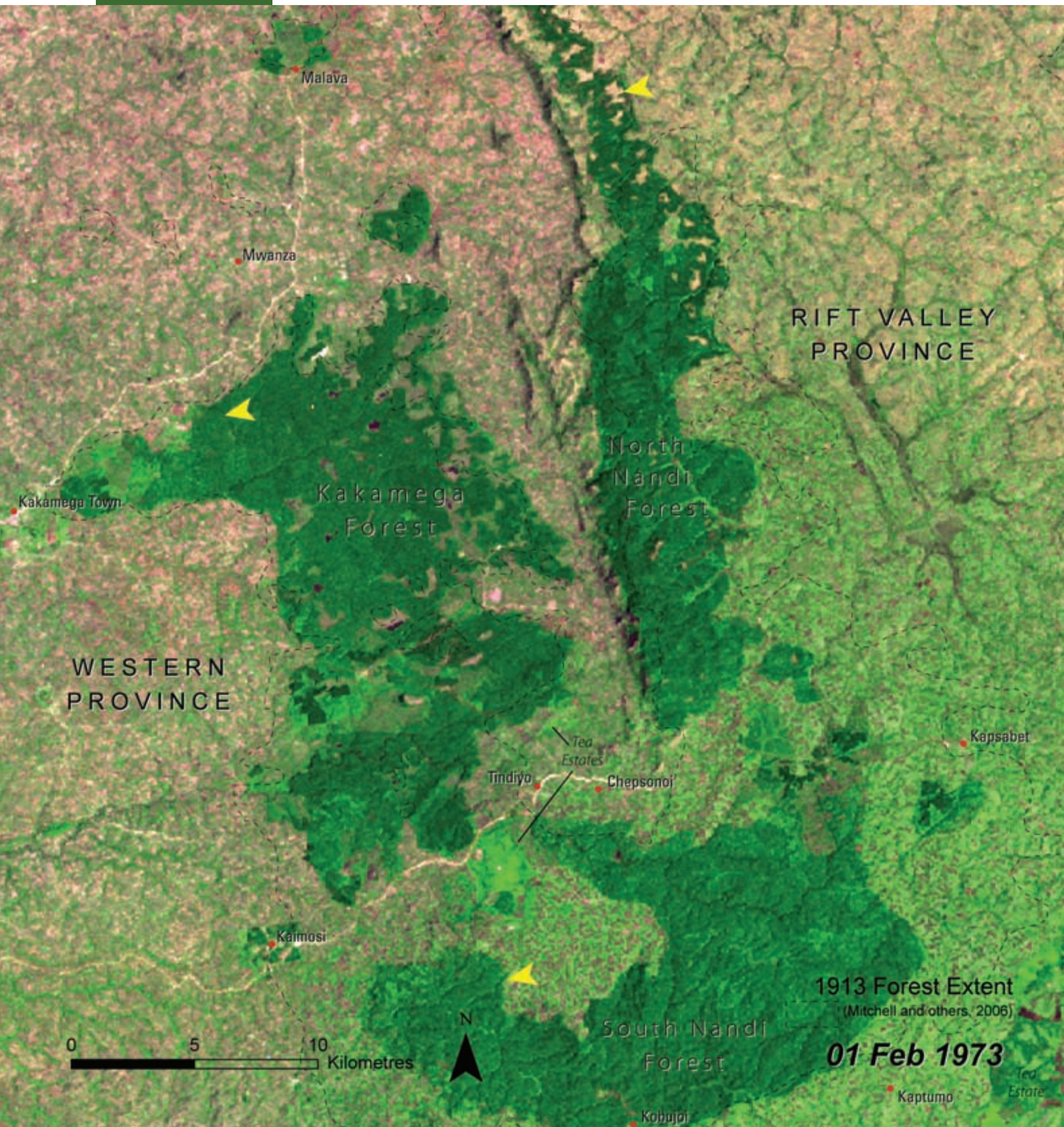
Kenya's forests and woodlands have been subject to intense human activity and with its growing population and economic expansion, they continue to be threatened by encroachment for agriculture, pastures, woodfuel, and timber. As shown in Chapter 1, firewood and charcoal from forests and woodlands account for about 70 per cent of national energy, while plantations provide wood for timber and poles; these needs continue to grow (KFWG 2008, WRI and others 2007). Forests have also been lost to land conversion by burning, which emits large amounts of greenhouse gases (Ogola n.d.) and parts of protected areas have been degazetted or excised, as mentioned in Chapter 1. Coastal forests have been subject to overharvesting for timber and other products, large-scale conversion to ports, settlements, tourist infrastructure, aquaculture, rice farms, and salt pans. Untreated wastes, agricultural chemicals, and industrial pollution from upstream waters also threaten them as does siltation as a result of upstream dams (Twong'o and Sikoyo 2002, WWF 2006). Among Kenya's most endangered forests are the Kakamega Forest, the Mau Forest Complex, and Karura Forest (UNEP and DRSRS 2004).

During the 1990s, forests suffered severe losses, with as much as 93 000 ha cut during the decade (FAO 2001). In total, between 1990 and 2005, Kenya lost five per cent of its remaining forest cover, or around 186 000 ha of which 38 000 ha were indigenous forests (UNEP 2006). It is thought that since pre-agricultural times, about 70 per cent of Kenya's mangroves have been lost (Twong'o and Sikoyo 2002). The result of forest loss has been fragmentation, land degradation and the loss of precious topsoil, the loss of wildlife habitat and consequent declines in biodiversity (Peltorinne 2004). This severe deforestation and degradation led to serious plantation activity beginning in 2003, and in 2004, felling of valuable natural hardwood was banned. Deforestation rates of indigenous forest since 2005 decreased by 5.1 per cent (UNEP 2006).

Kakamega Forest

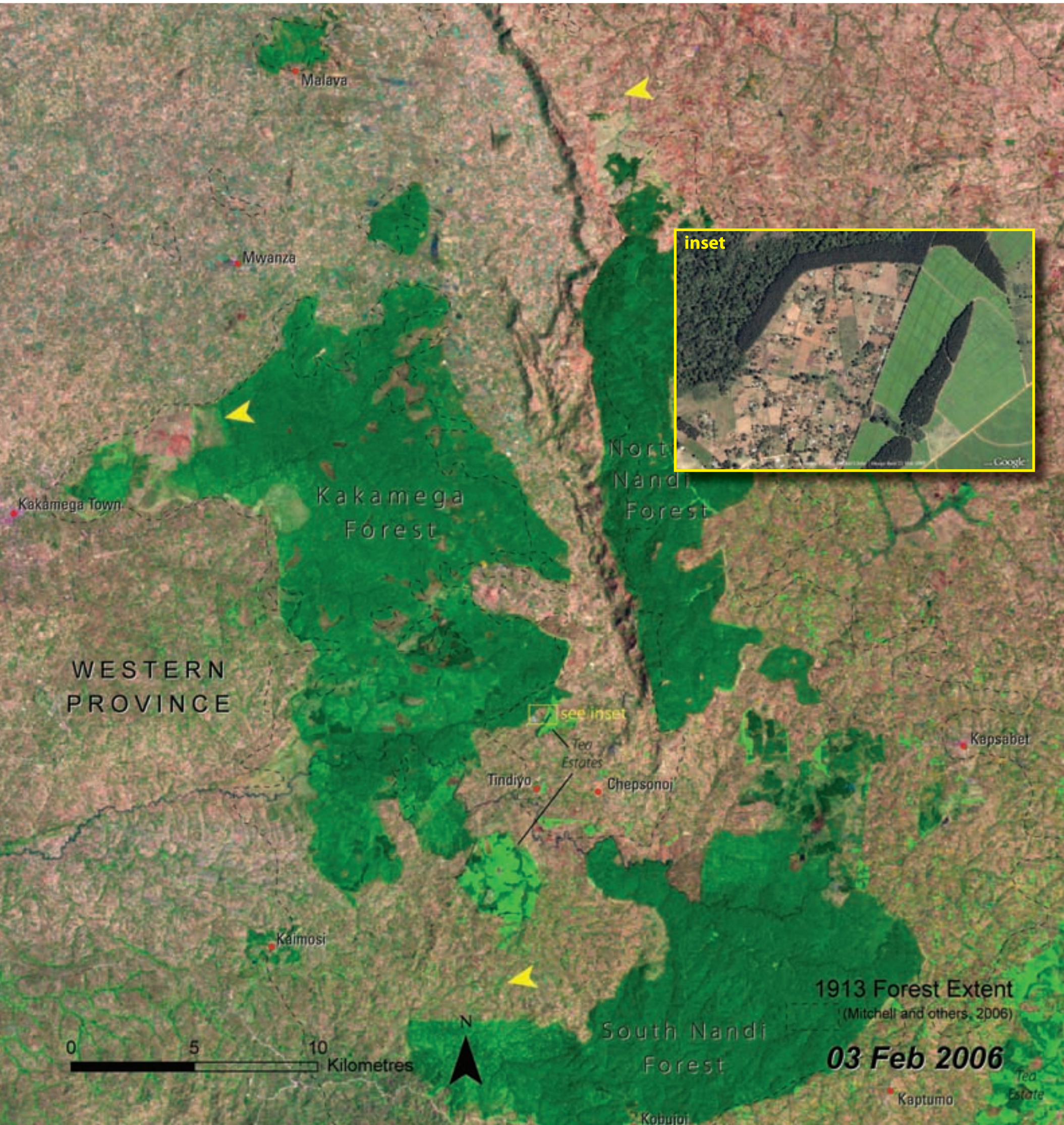
Kenya's Only Tropical Rain Forest

Kakamega Forest is Kenya's only area of tropical rain forest and the eastern-most remnant of the Guineo-Congolian tropical rain forests. It receives among the highest average precipitation of any area in Kenya, ranging from 1 500 mm to 2 300 mm. It was contiguous with the North and South Nandi Forests as recently as 1913; both these forests are slightly more elevated and have more montane forest species than does Kakamega. Kakamega Forest contains a wealth of biodiversity including several globally and regionally threatened bird species. Kakamega, North Nandi, and South Nandi are all designated Important Bird Areas. The Kakamega area is also home to among the densest rural populations in the world, with between 400 and 1 300 people per km^2. This population has put heavy pressure on the forest (yellow



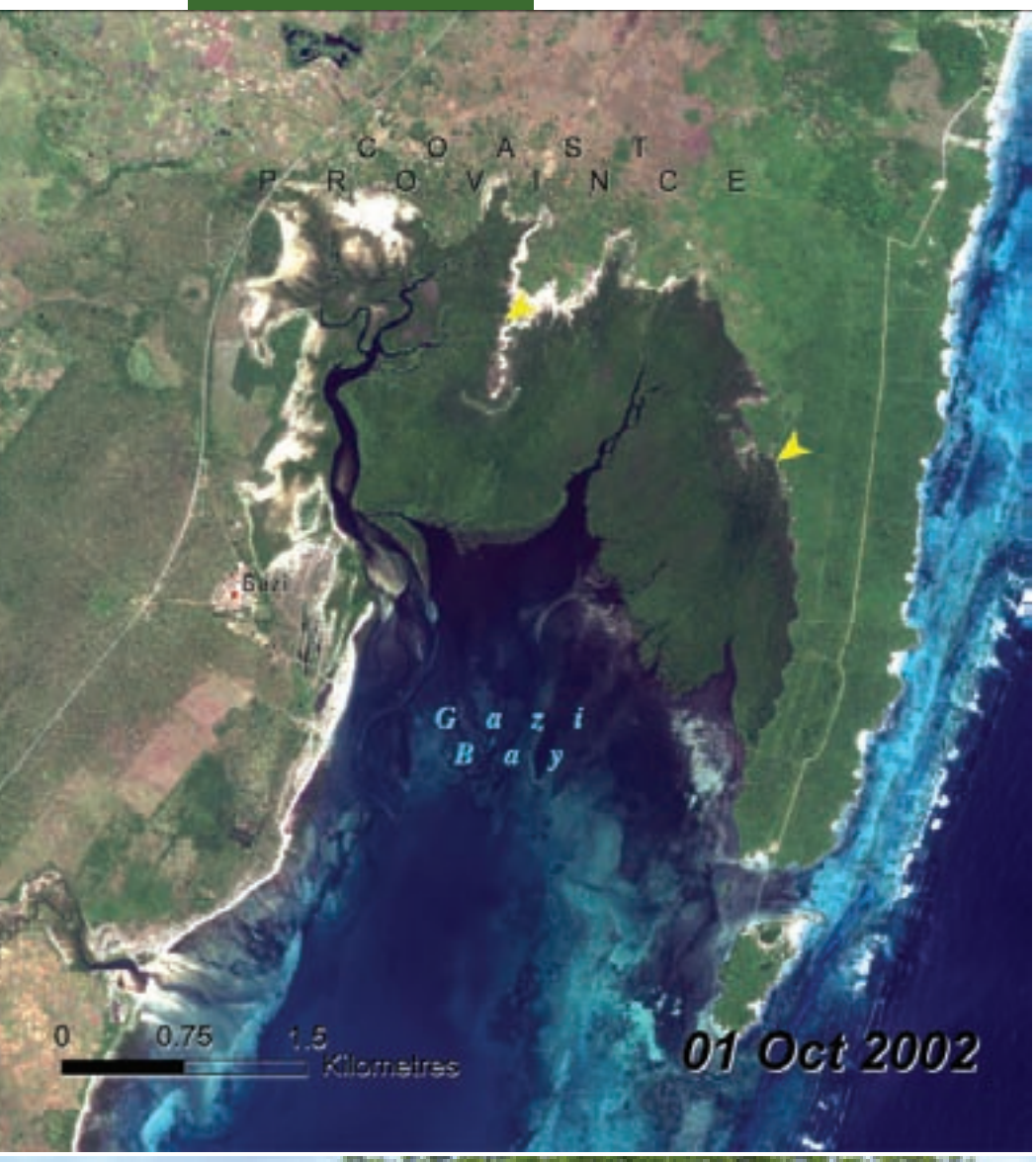
arrows), converting land for tree plantations, tea estates, selective logging, charcoal production, cattle, and shamba agriculture. It is estimated that the forested area of the Kakamega, North Nandi, and South Nandi blocks has been reduced to roughly 34 per cent of its 1913 extent (not counting forest plantations). A core of "near natural and old secondary forest" remains but is surrounded by secondary forests, plantation forests, grassland, bushland, and tea plantations.

Kenya's natural endowments, including Kakamega and the Nandi Forests, are central attractions for tourism and crucial to the livelihoods of its people. Intense pressure through continued encroachment poses a very real threat to the future of Kakamega Forest.



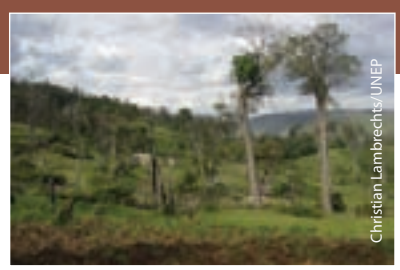
Ngomeni
Disappearing Mangroves

Mangroves are salt-tolerant species of trees and shrubs found in the inter-tidal environments of the tropics and sub-tropics. There are approximately 54 000 ha of mangroves along Kenya's 450 km-long coastline, primarily in protected bays, river estuaries, and on the lee side of islands. The majority of Kenya's mangroves are concentrated in the Lamu (June 2008 image) and Tana River districts, with concentrations also at Mombasa, Kilifi, Gazi Bay (October 2002 image), and Funzi Bay. Kenya's mangroves are nursery areas for many marine species, including edible crabs and small pelagic fish. In addition, they provide habitat for a variety of bird, vertebrate, and invertebrate species. Mangroves also provide timber products such as firewood, building poles, and charcoal, and non-timber products like honey, crabs, fish, and medicinal plants.



Kenya's mangroves are threatened by overexploitation of wood products and conversion to salt-panning, agriculture, and other land uses. Some estimates suggest that about half of the mangroves in Kenya have been lost over the past 50 years. The images from June 1975 and January 2000 show the loss of roughly 10 000 ha of mangroves to salt-panning operations between Ngomeni and Karawa (yellow arrows). Many of Kenya's remaining mangroves have been seriously degraded by over exploitation of wood products, particularly in the area around Lamu. Researchers have been studying reforestation of mangroves in the Gazi Bay area with the hope of being able to restore some of Kenya's lost mangroves.

Land Degradation


Christian Lambrechts/UNEP

As the land use section earlier in this chapter shows, demands on the land for economic development and pressures from a burgeoning population are leading to unprecedented land use change. In turn, unsustainable land use is driving land degradation. The result is a loss of land productivity with impacts on livelihoods and the economy. This section describes land degradation trends in Kenya as an introduction to the following pairs of satellite images that show this degradation on the ground.

Symptoms of land degradation and desertification

Land degradation is defined as the long-term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover unaided (Bai and others 2008). Land degradation occurs slowly and cumulatively and has long lasting impacts on rural people who become increasing vulnerable (Muchena 2008). The UN Convention to Combat Desertification (CCD), of which Kenya is a signatory, recognizes land degradation as a global development and environment issue. Desertification is the most severe form of land degradation. The CCD defines desertification as land degradation in arid, semi-arid, and dry sub-humid areas (also referred to as drylands) resulting from various factors, including climatic variations and human activities.

Table 1: Degrees of desertification potential, 1997

Degree of Desertification	Area (in %)
None to slight	13.0
Moderate	64.0
Severe	21.0
Very severe	1.7

Source: Macharia 2004

Pressures that lead to land degradation

Unsustainable human activities that take place in already fragile areas and that are aggravated by natural disturbance such as drought or flooding lead to land degradation and desertification. Kenya's 2002 National Action Programme on desertification reported the following: "The existing ecological conditions in drylands are harsh and fragile. These conditions are exacerbated by frequent drought and the influx of people from the high potential areas into the drylands. Overgrazing and subdivision of land into uneconomic land parcel sizes have further worsened them. Under

Deforestation and a heavy rainfall often lead to erosion and soil loss


Christian Lambrechts/UNEP

Table 2: Degraded areas 1981-2003

Degrading area (km^2)	Per cent of territory	Per cent of globally degrading areas	Total NPP Loss (tonne C/23yr)	Per cent of total population	Number of affected people
104 994	18.02	0.294	6 612 571	35.59	11 803 311

Source: Bai and others 2008

these circumstances, drylands are getting more and more vulnerable to desertification in Kenya" (GoK 2002). The land use section of this chapter shows how population growth is contributing to the influx of more people into arid and semi-arid land (ASAL), land is being fragmented into uneconomical parcels, marginal lands are increasingly being cultivated, pastures are being overgrazed, and forests encroached upon. All these conspire to degrade the land (Muchena 2008, KLA n.d.).

Land degradation is increasing

Studies in 1997 showed that 64 per cent of Kenya's land area was potentially subject to moderate desertification and about 23 per cent were vulnerable to severe to very severe desertification (Table 1). In the northern rangelands, 12.3 per cent suffered from severe land degradation, 52 per cent to moderate land degradation, and 33 per cent faced slight vulnerability to degradation. The latter study identified degradation in ASALs as a potential precursor to widespread desertification (KLA n.d.). In the early 2000s, approximately 30 per cent of Kenya was affected by very severe to severe land degradation (UNEP 2002) and an estimated 12 million people, or a third of the Kenya's population, depended directly on land that is being degraded (Bai and others 2008). The droughts of 1970-2000 accelerated soil degradation and reduced per-capita food production (GoK 2002).

More recent studies extrapolating on local findings of spatial and temporal patterns of land degradation estimate it is increasing in severity and extent in many areas and that over 20 per cent of all cultivated areas, 30 per cent of forests, and 10 per cent of grasslands are subject to degradation (Muchena 2008). A 2006 pilot study found that potential areas of land degradation, defined as places where both net primary productivity and rain-use efficiency (the ratio of net primary productivity to precipitation) were declining, occupied 17 per cent of the country and 30 per cent of its cropland. The expansion of cropping into marginal lands accounts for much of this degradation. It identified the drylands around Lake Turkana and marginal cropland in Eastern Province as the areas of sharpest decline (Bai and Dent 2006). One measure of land degradation is the loss of net primary productivity (NPP), although such losses do not always indicate land degradation (Bai and others 2008). A 2008 study that used remote sensing to identify degrading areas based on loss of NPP between 1981 and 2003 found that 18 per cent of Kenya's total land area was degraded (Table 2).

The consequences

The impacts of land degradation and desertification include a reduction in crop and pasture productivity and fuelwood and non-timber forest products, which are closely linked to poverty and food insecurity. The damage to soil, loss of habitat, water shortages, and siltation reduce biodiversity and ecosystem services and have economic consequences (KLA n.d.).

Land degradation manifests itself in many forms; among them are soil erosion, increased sediment loading of water bodies (such as Lake Olbollosat, the Winam Gulf, and Lake Baringo, all of which feature in satellite images in this Atlas), loss of soil fertility, salinity, reduced ground cover, and the reduced carrying capacity of pastures (as in Amboseli National Park, for example).

Lake Elmentaita

Flamingoes Leave Habitat

Lake Elmentaita lies at the bottom of the Central Kenyan Rift Valley, at 1 786 m above sea level. Zebra, gazelle, eland, and families of warthog graze its salty shores. Approximately 10 000 years ago, Elmentaita was part of a much larger lake that included modern-day Lake Nakuru. Changes in climate conditions since then have reduced the lake's size to its present extent.

Ornithologists have recorded as many as 40 000 flamingoes at Lake Elmentaita. The vast flocks of flamingoes feed on the algae that thrive in its shallow alkaline waters. One of the great spectacles of Africa, these vast flocks of flamingoes are threatened by silt from farms surrounding the lake that inhibits the growth of the blue-green spirulina algae on which the flamingoes feed.

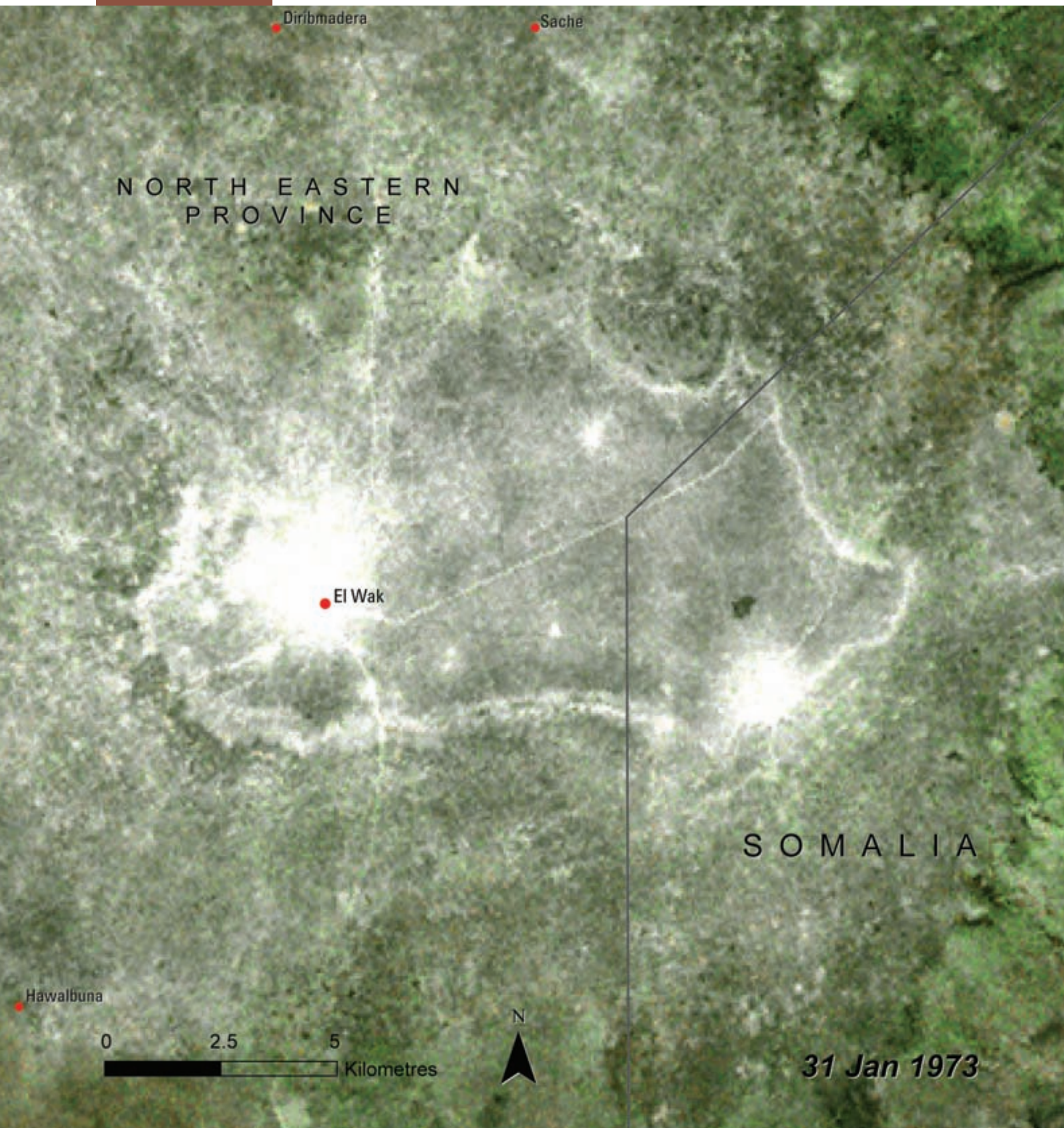
In addition, a record of the lake's water levels since 1958 shows a steady decline. Lake Elmentaita's level has fluctuated dramatically in the past, and changes to the ecosystem caused by rising or falling water levels have dispersed many of the flamingoes and pelicans to other lakes in the Rift Valley. Since the 1970s, the shallow alkaline lake has gradually shrunk from 18.5 km^2 to less than 14.3 km^2 and it could vanish entirely in the future. Changes in the watershed, especially the dramatic increase in farmland, are thought to be the cause of the recent rapid changes in water levels. Much of the watershed's forests have also been removed or degraded.

El Wak

Boreholes and Overgrazing

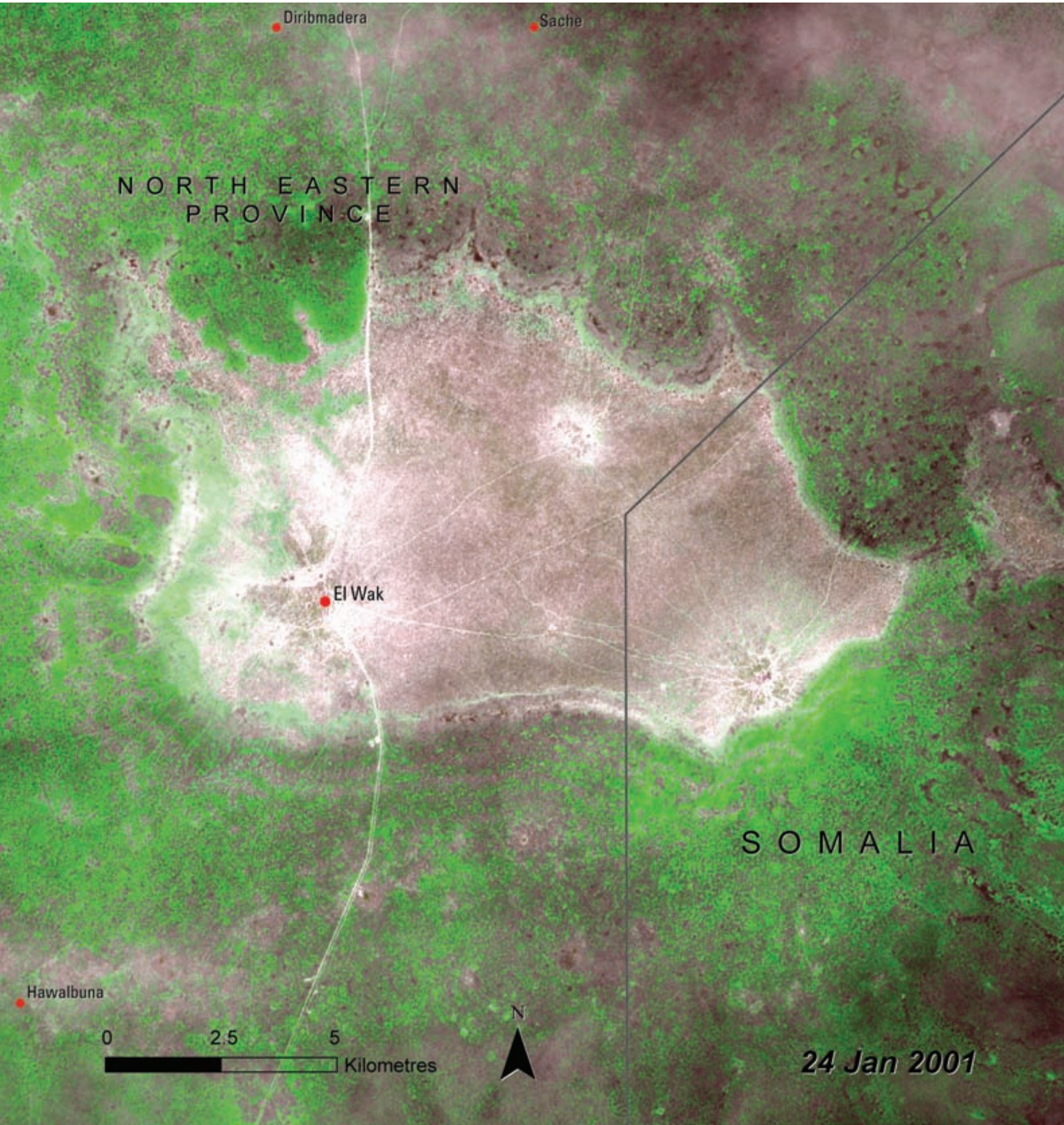
El Wak is located in the Mandera District of Kenya's North Eastern Province. It is in arid lands with very low potential for rangelands, given its average annual rainfall of about 250 mm and temperatures as high as 35° C to 40°C. In addition to these harsh conditions, North Eastern Province is rated the poorest province in Kenya with 74 per cent of the population living below the poverty line and 50 per cent of the population under the age of 15, giving it among the highest dependency ratios in Kenya.

Nomadic pastoralism has traditionally been the backbone of the economy in North Eastern Province, with herds moving across large expanses of rangeland to access adequate food and water. The area sees frequent droughts usually



accompanied by livestock diseases. Recent droughts and the resulting reduction in herd size have reduced the viability of a purely pastoral livelihood.

The government, non-governmental organizations, and multi-lateral donor organizations have created boreholes, wells, and earthen dams to provide water in the most arid districts. Boreholes surrounding El Wak have attracted permanent settlements and increased livestock populations causing serious land degradation. The satellite images from 1973 and 2001 show this increase in the intervening 33 years. This degradation poses a new threat to local people's livelihoods as the land's capacity to support rangeland surrounding the borehole decreases.



Laikipia District

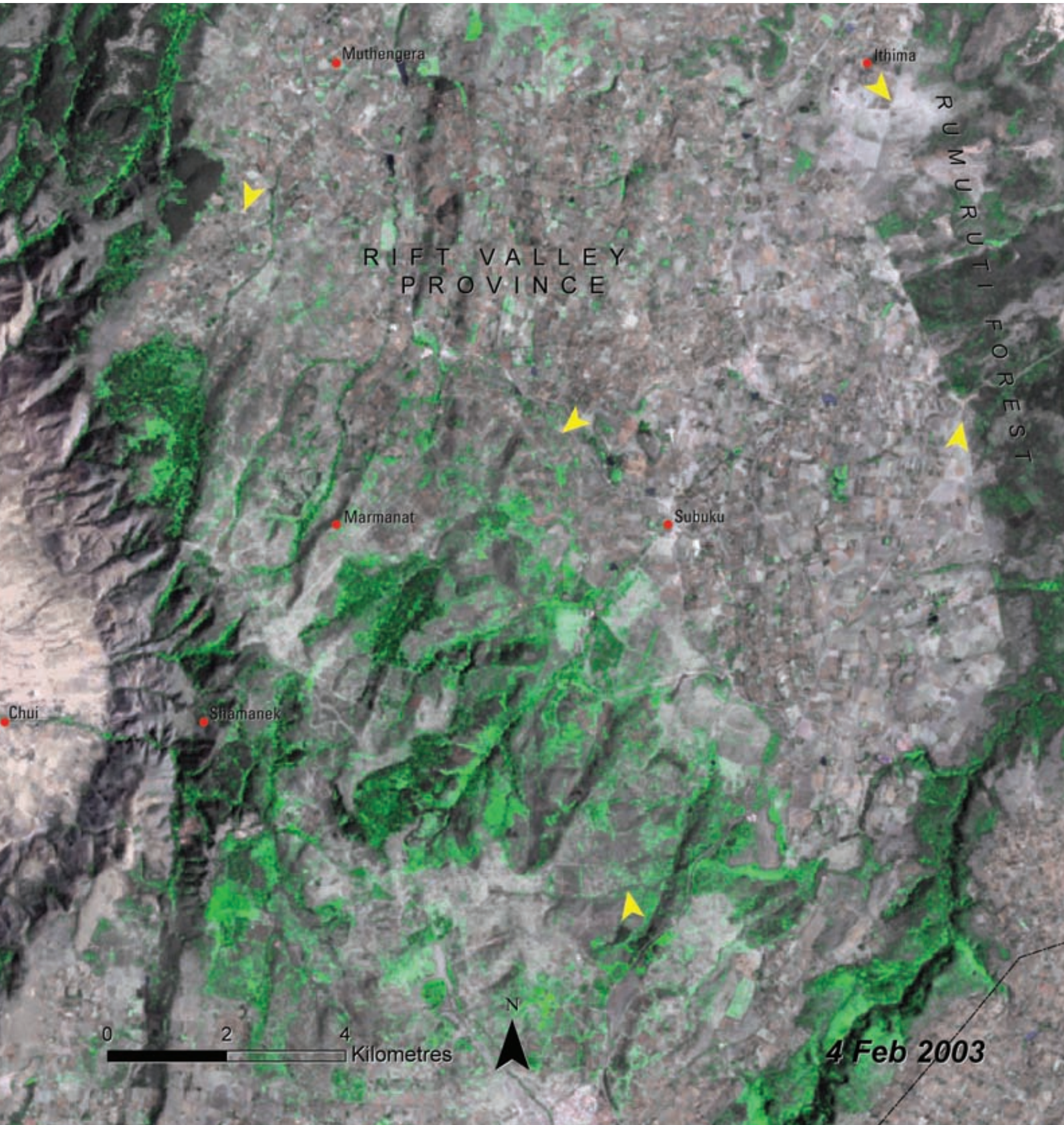
Land Division and Population Growth

Rainfall across the Laikipia Plateau ranges from around 900 mm near the Mt. Kenya and Aberdares Massifs in the south to less than 500 mm in the more arid areas to the north. This savanna landscape is traversed by the Ewaso Nyiro River, a vital water source particularly to the drier north. The Plateau supports among the highest wildlife populations in Kenya including all of the native large carnivore species and an impressive diversity of large mammals in spite of the fact that only a small fraction of the district is formally protected.

In the early 20th century, the plateau was home to the pastoral Maasai communities. By following the rains and utilizing the vast expanse of grazing land to support their cattle, the Maasai were able to support themselves sustainably.

During the colonial era, most of the plateau was converted to large commercial ranches pressing the Maasai into the northeast corner of the plateau. The population of Laikipia District has grown rapidly since the 1960s with an annual growth reaching over seven per cent between 1967 and 1979. Much of this growth was in the arable southwestern corner.

In the central plateau, the large, sparsely populated ranches enjoy the luxury of balancing their use of the land to match the land's regenerative capacity. In the District's southwest and northeast corners, however, pressures from growing populations are forcing the land's viability. The impact of increasing numbers of people and small farms between 1986 and 2003 can be seen the satellite images of the southwest corner of Laikipia Plateau.

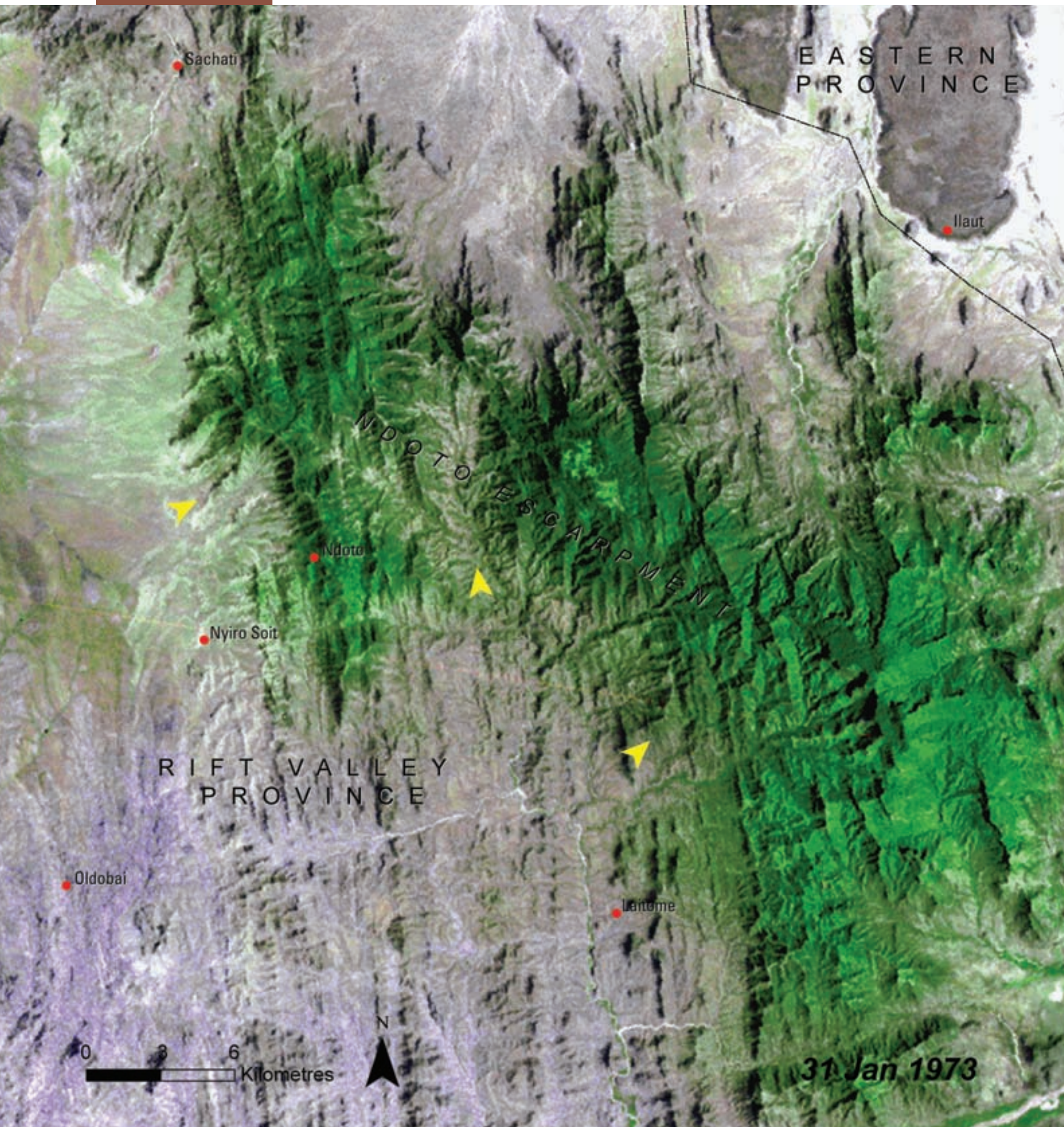


Samburu District

Increasing Livestock

Samburu District, in the Rift Valley Province, stretches north from the Ewaso Nyiro River to the south of Lake Turkana. It is an expansive, predominantly pastoral area. Among the major physical and ecological features in Samburu District are Mount Kulal, the Samburu National Reserve, the Buffalo Springs National Reserve, and the Loriki Forest.

The semi-nomadic pastoralist Samburu people, the main ethnic group in the district, keep cattle, sheep, goats, and camels. Traditionally, the Samburu have been able to co-exist in relative balance with the area's wildlife, which includes elephants, lions, giraffes, ostriches, cheetahs, and leopards. As the population in Samburu has grown, some of these



pastoralists have adopted increasingly settled, western lifestyles, including some farming. Nevertheless, a predominantly pastoral approach to cattle-raising has been maintained.

The cattle population has grown along with the human population. This puts increasing pressure on this fragile arid environment. In particular, the increasing livestock population has led to localized areas of land degradation where cattle are concentrated during the dry season. Loss of forest and vegetation cover is evident in the changes between these two images from 1973 and 2000.

Khuvasale and Murang'a
Landslides

Scores of lives have been lost to landslides in Kenya in recent decades. In addition, productive farmland, personal property, roads, railways and bridges have been destroyed. It is estimated that millions of Kenyan shillings of property damage have been caused by landslides in the past decade alone. Most of these landslides occur in the southwestern quarter of the country where steep slopes and heavy rainfall create dangerous conditions during the rainy season. Unfortunately, these areas also have dense populations which settle in these areas because of their high agricultural potential. While these disasters are prompted by periods of heavy rainfall their likelihood is often increased by human

A landslide in Gatara, on the eastern slopes of the Aberdares, destroyed homes and 1 000s of tea bushes

A section of Massii-Makueni high were a major bridge was destroyed by a late 1990s landslide

activities such as removal of vegetation, altered drainage, overgrazing and cultivation on steep slopes. Removal of trees and other natural vegetation changes drainage and infiltration patterns and destabilizes soils on slopes.

The Murang'a District on the eastern footslopes of the Aberdare Range has high rainfall, intense population and intense farming. The area's soils are prone to landslides, exacerbated by the removal of forests and shrubs for farming (Feb 2003 image). Between 1960 and 1980 the district experienced 40 landslides. In Kakamega North District, following a night of very heavy rain in August 2007 two landslides occurred at Khuvasale village. The disaster killed seven people and left at least 39 injured. The village is located along the Nandi Escarpment (Feb. 2005 image) in an area of intense small scale agriculture and heavy rains.

People work to unearth those buried by the Khuvasale landslide in August 2007

The Khuvasale landslide, August 2007

Biodiversity

As it is everywhere on the planet, biodiversity, or the diversity of species, genes, and ecosystems, is declining in Kenya. Of all African countries, Kenya ranks second highest in bird and mammal species richness. It also has high levels of species endemism, or species that live nowhere else on earth. The loss of Kenya's rich variety of wildlife species diminishes the planet's store of living things; it is also an enormous threat to the nation's tourism industry, a mainstay of its economy, and it undermines the livelihoods of those reliant on local resources for their livelihoods. This section, which complements a brief discussion of biodiversity in Chapter 1, introduces the following satellite images that vividly illustrate how human activities are threatening the ecosystems that provide habitat for the country's rich biodiversity.

Kenya's landscapes are immensely diverse, so the organisms they harbour are also rich in variability. Kenya is home to some 35 000 known species of flora and fauna (Thaxton 2007). Kenya's grasslands contain a unique assembly of megafauna, and as shown in Chapter 1, the nation's closed canopy forests, which hold about half of Kenya's tree species, provide habitat for about 40 per cent of its larger mammals, 30 per cent of birds, and 35 per cent of its butterflies (KFWG 2008). The coastal forests, western plateau forests, and the northern end of the Eastern Arc Mountains (Taita Hills) are the most diverse forest regions (Peltorinne 2004). Kenya's marine and coastal areas also contain a large diversity of species, with about 456 species of fin fish, 169 coral species, 9 species of mangroves, 11 species of seagrasses, 344 mammal species, 5 species of reptiles, as well as uncounted numbers of phytoplankton, zooplankton, and other species (GoK 1998).

Habitat loss and fragmentation

Globally, habitat loss is the greatest threat to biodiversity. Kenya's increasing population, poverty, and the drive for economic growth are the underlying pressures that contribute to habitat loss and fragmentation. Land degradation, described earlier in this chapter, also threatens biodiversity. To some degree, all forest areas in Kenya are fragmented, while parts of grass- and shrub-lands are highly degraded (Duraiappah and Roy 2007). Gaps in vegetation cover caused by fragmentation can isolate populations of certain species and lead to their demise (Peltorinne 2004), while land and water degradation render habitats unhealthy thus threatening species survival.

Invasive alien species

Invasive species are the second greatest threat to biodiversity. Kenya has been subject to the invasion of at least 34 alien species, with negative impacts on biodiversity, agriculture, and human development as such species compete with native ones or invade new areas. They include eleven arthropods, ten microorganisms, nine plant species, and four vertebrates. Notable examples include the larger grain borer (*Prostephanus truncatus*), the water hyacinth (*Eichhornia crassipes*), and Prosopis spp. Few of these species are under control, although Kenya has initiated measures to mitigate their impacts (Chagema and Kuria 2003).

Threatened species

As already mentioned in Chapter 1, Kenya's threatened species include 33 species of mammals, 28 breeding bird species, 5 species of reptiles, 4 of amphibians, 29 of fish, 16 molluscs species, 11 species of other invertebrates, and 103 plant species.

Biodiversity hotspots

Biodiversity hotspots (as opposed to Kenya's generic "environmental hotspots" highlighted in this chapter), are internationally recognized as the richest and most threatened reservoirs of plant and animal life on earth. Each of the world's 34 places identified as biodiversity hotspots contain at least 1 500 species of vascular plants (>0.5 percent of the world's total) as endemics and has lost at least 70 per cent of its original habitat.

There are eight such spots in Africa, two of which partially occur in Kenya: the mountains of the Eastern Afromontane hotspot; and the Coastal Forests of Eastern Africa (CI 2007).

The former consists of mountainous areas scattered along Africa's eastern edge. The main part of this hotspot is the Eastern Arc Mountains and Southern Rift, which stretches from southeastern Kenya to southern Tanzania and Malawi. In the Eastern Arc Mountains, represented in Kenya by Mount Kenya and Mount Elgon, vegetation types include upper montane, montane, submontane, and lowland forests. Afroalpine vegetation, which grows above 3 400 m, is characterized by giant senecios (*Dendrosenecio spp.*), giant lobelias *(Lobelia spp.*), and Helichrysum scrub (CI 2007).

The Coastal Forests of Eastern Africa hotspot is made up of tiny and fragmented forest remnants, but they contain extraordinary biodiversity, with more than 1 750 endemic plant species and 28 endemic plant genera. Kenya's portion is a relatively narrow (up to 40 km) coastal strip and a 120 km extension along the Tana River (Burgess and others 2004). The Tana River is home to the Tana River red colobus and the Tana River mangabey, two critically threatened and endemic primates (pictured in Chapter 1 of this Atlas). Kenya's Kiunga Marine National Reserve in this hotspot supports the world's largest breeding colony of roseate terns (WWF 2008). The Kwale-Usambara subcentre of endemism, on the Kenya-Tanzania border, is an exceptionally important part of the hotspot. The Kenyan and Tanzanian coastal forests are the origin of the 40 000 cultivated varieties of African violet, which form the basis of a US$100 million global trade in house plants. Subsistence and commercial agricultural expansion is the biggest threat to these already fragile ecosystems (CI 2007).

Important Bird Areas

Internationally Important Bird Areas (IBAs) have also been identified as places where biodiversity needs urgent protection. IBAs do one (or more) of three things: hold significant numbers of one or more globally threatened species; are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species; and have exceptionally large numbers of migratory or congregatory species (BirdLife International 2008).

In 2004, there were 60 IBAs in Kenya, many of which are already protected areas, including Arabuko Sokoke Forest Reserve, a refuge for six globally threatened bird species, and Lake Nakuru National Park, with its immense numbers of flamingoes and other waterbirds. Other IBAs are not yet protected, including densely populated valleys where Kenya's endemic Hinde's Babbler survives. The most significant threats to IBAs are overgrazing and illegal grazing, which seriously threaten the conservation status of 57 per cent of them, while more than half are under serious threat from illegal selective logging and vegetation destruction. The most severely threatened sites include Yala Swamp, Busia Grasslands, Mukurwe-ini Valleys and Mau-Narok/Molo Grasslands (Otieno and others 2004).

Protected areas

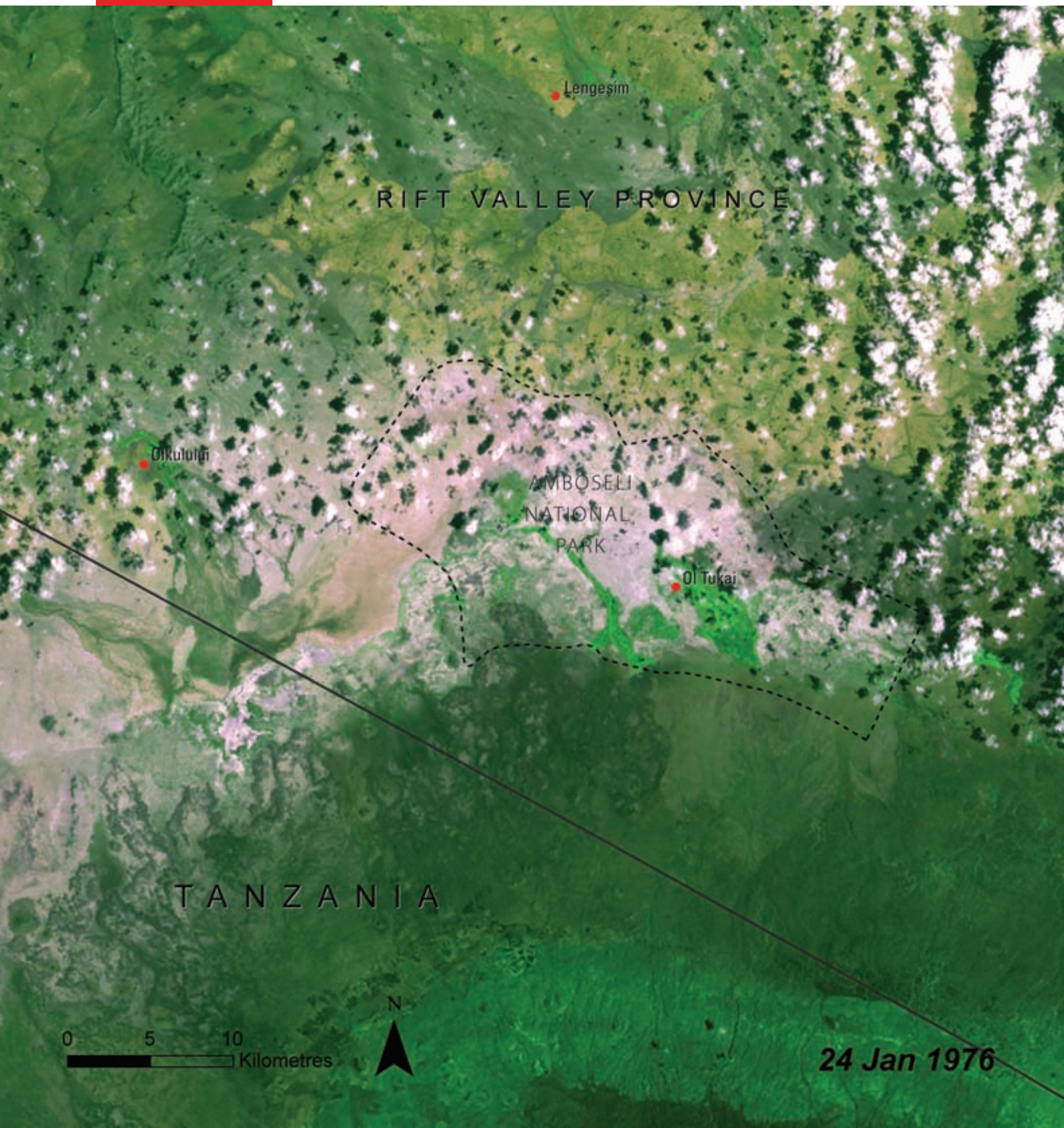
One of the key methods governments take to protect biodiversity is the setting aside of national parks, wildlife refuges, and other types of legally protected areas. As shown in Chapter 2, in 2007, Kenya had 348 designated protected areas, representing 75 238 km^2 or 12.7 per cent of Kenya's territory. Of these protected areas, 14 are internationally recognized.

Christian Lambrechts/UNEP

Amboseli Reserve

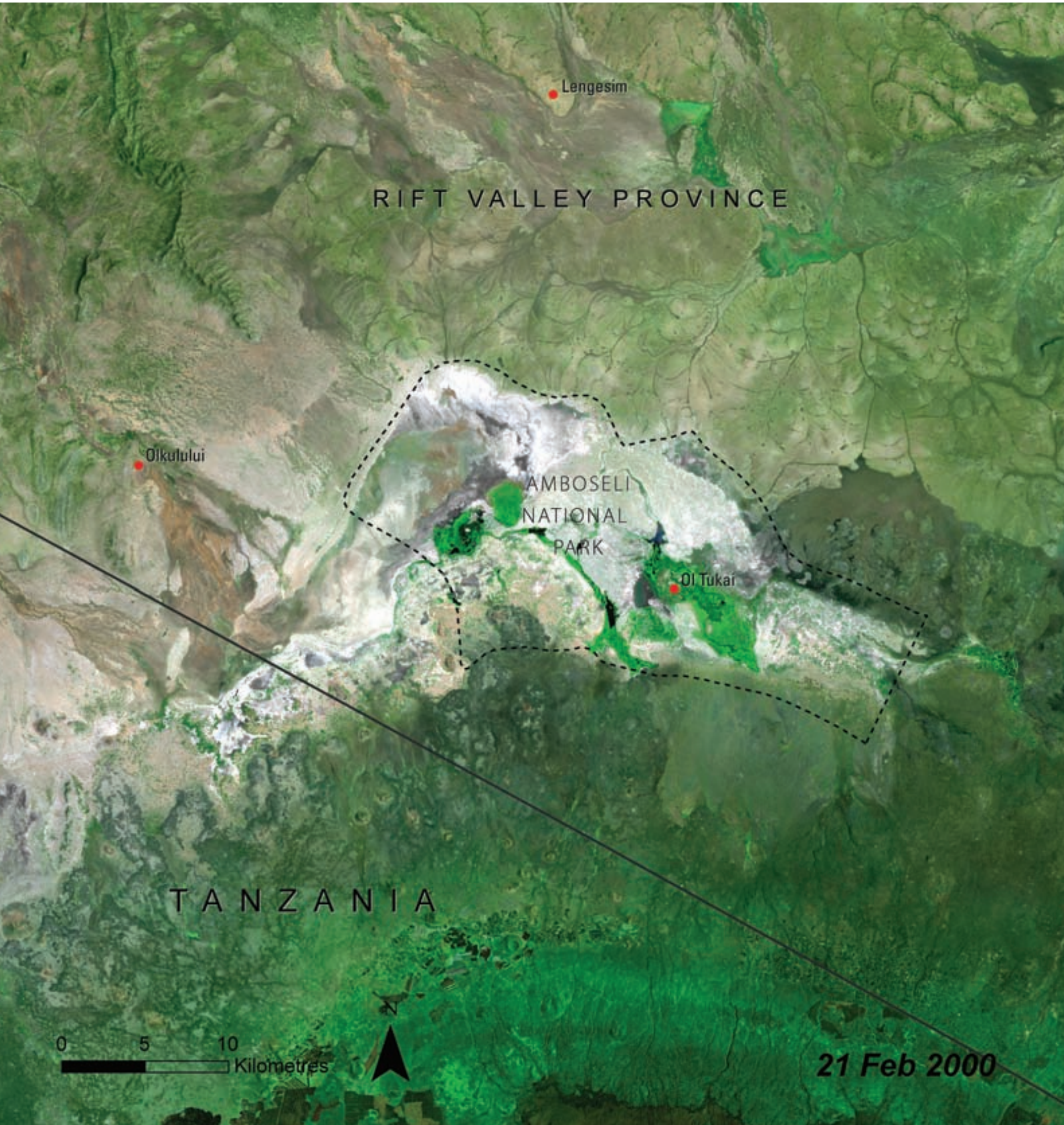
Fragmented Forests

Amboseli National Park and Biosphere Reserve on Kenya's Tanzania border lies at the foot of majestic Mt. Kilimanjaro. Its unique arid environment, with a system of swamps fed by water from the forests of Kilimanjaro, supports a remarkable variety of wildlife. Amboseli's population of elephants has grown to 1 400 since the 1980s. While the last of the park's rhinos were killed in the early 1990s, they are survived by stable populations of hippos, buffaloes, and giraffe. The large array of other wildlife includes characteristic savanna species such as zebra, wildebeest, gazelle, oryx, impala, dik-dik, lions, and hyenas and roughly 400 bird species. The park is small and relies on 4 000 km^2 of surrounding "dispersal areas" to provide migration corridors and increase the feeding and breeding grounds for Amboseli's wildlife. These vital areas are



declining as population, farming, cattle, and other human activities increase in areas surrounding the park. Fencing of some swamp areas to prevent elephants from destroying crops displaces the elephants and other wildlife species from their traditional grazing areas, blocks their dispersion, and denies them access to water.

Fragmentation of the environment is also a concern for traditional livelihoods in the area. The area's Maasai population traditionally used mobility and the ecological variety of the area to cope with rainfall variability, moving to alternative pasture when necessary. Fragmentation and private land ownership are changing these patterns toward intensive grazing and in many cases, overgrazing and land degradation.

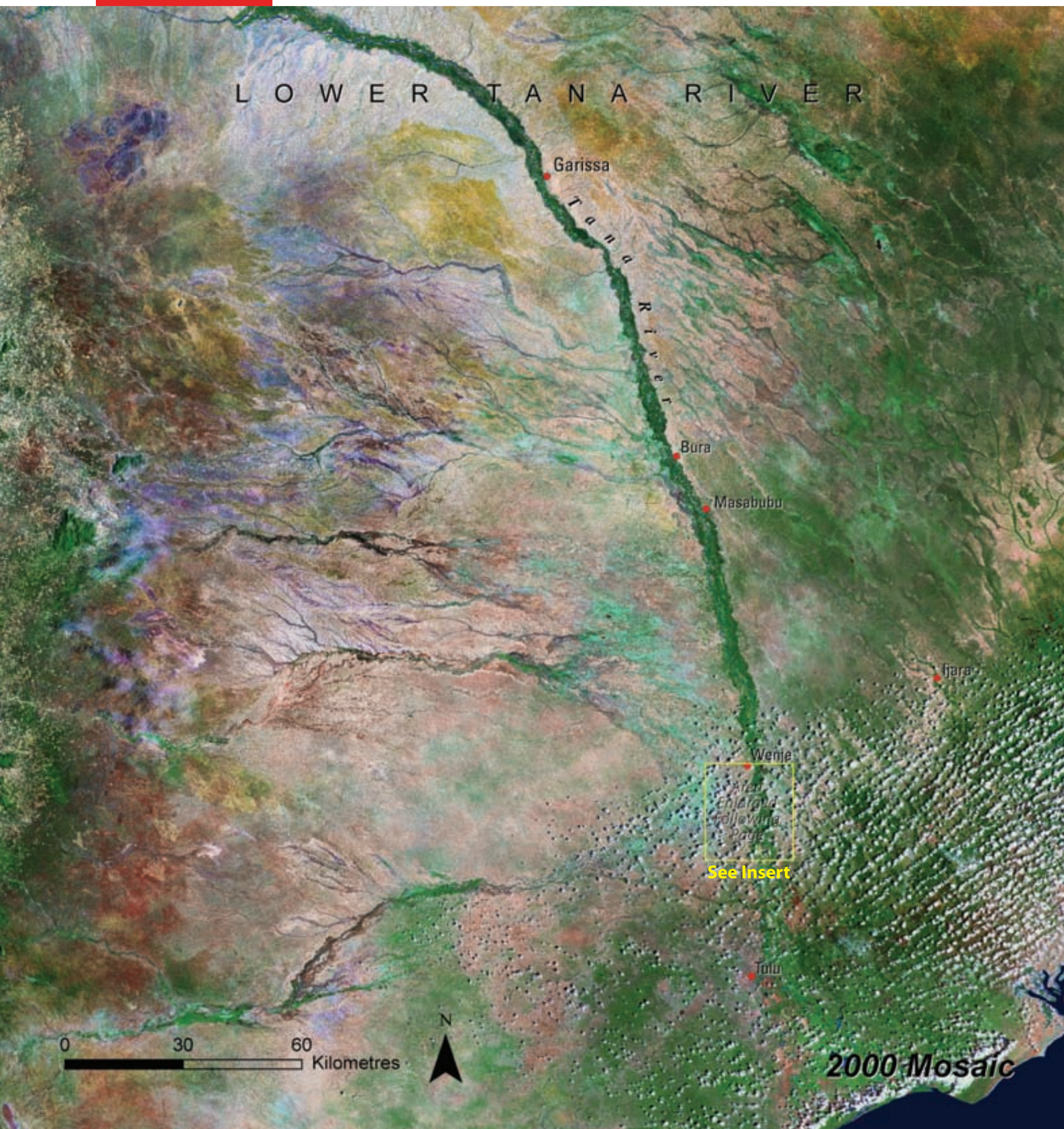


Tana River Primate Reserve

Forest Loss

The Tana River Primate Reserve, located on the river's lower reaches in the Tana River District, Coast Province, was established in 1976 to protect two endangered primate species endemic to the area—the Tana River red colobus and the crested mangabey. The riverine forests that line the lower Tana River is the sole habitat of both species and they are in decline. These forests are remnants of rainforests that covered Eastern Africa during periods of moister climate roughly 8 000 and 28 500 years ago.

Under the current drier climate, the extent of the forests is limited by the depth of the water table, which declines rapidly with distance from the river. What remains of the forests is being lost to shifting cultivation, irrigation dykes,



flooding, and other human activities, as well as natural changes in the river course. Since the 1980s, a further one-third of the forests in the area surrounding the Tana River Primate Reserve were lost. The loss has been slightly less within the reserve than outside.

The 2000 era image of the area of the Lower Tana River shows the limited extent and isolated nature of these forests. The loss of forest area and the fragmentation of the remaining forest put the endangered red colobus and crested manabey at greater risk of extinction. The total population of the Tana River red colobus is estimated to be at 1 300 individuals and their average group size is declining.

Wenje
LOWER TANA RIVER
Highway 88
Tana River National Primate Reserve
0 2.5 5 Kilometres
N
05 Jan - 15 Feb 2007

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Nairobi *from* Space

Nairobi and its Environment

In addition to being Kenya's capital, Nairobi is its largest and most populous city, with about eight per cent of the nation's citizens, and it accounts for about half of Kenya's economic activity. A high rate of natural growth and the influx of rural migrants are exploding the city's population. Huge areas occupied by informal settlements and slums, ubiquitous traffic jams, and a lack of adequate city planning challenge its ability to address environmental problems such as air and water pollution. Given its importance and its impact on all aspects of Kenya's development, this chapter focuses on environmental change in Nairobi.

Ngong River / Tom Maruko / Flickr.com

Nairobi's rivers are increasingly choked with uncollected garbage and human waste from slums and overflowing sewers. The growing population places increasing burdens on the rivers from its waste production, inappropriate waste treatment, and a lack of comprehensive environment policies.

Flickr.com

With at least 700 000 inhabitants, the Kibera slum in Nairobi is Kenya's biggest informal settlement. Slum dwellers often have inadequate access to safe water supplies and sanitation and are subject to severe disease outbreaks.

Nairobi Dam / UNEP

Nairobi consumes about 350 000 m^3 of water a day. Despite the fact that production exceeds demand, only about 42 per cent of households in Nairobi have proper water connections (MWI/WSP 2005). Moreover, 50 per cent in volume is lost due to leakages and illegal connections (UNEP/DRSRS undated). Nairobi Dam is now polluted and infested with water hyacinth.


Tom Makuko / Flickr.com

Nairobi generates 1 530 tonnes of solid waste a day, of which 68 per cent comes from domestic sources. The city collects about 40 per cent of the waste, while the private sector collects about 20 per cent and the balance is left uncollected (CCN 2007).


Neeks / Flickr.com

Compared to other urban centres in Kenya, Nairobi has the greatest concentration of industrial and vehicle air pollutants. Car congestion is an increasing problem and traffic-related costs are estimated at 50 million Ksh a day through increased fuel consumption, mechanical damage, and pollution (Moody 2007).


Flickr.com

Nairobi is a major contributor to Kenya's economy. It generates about half of the nation's GDP, employs 25 per cent of Kenyans and almost half of the country's urban workers (CCN 2007).


Flickr.com

Nairobi is nicknamed the "Safari Capital of the World" due to the high number of tourists visiting the region each year. Its airport, the largest in East and Central Africa, handled close to 4.4 million passengers in 2006.


Flickr.com

Located only seven kilometres from the city centre, Nairobi National Park serves as an important recreational area and provides essential ecosystem services. With 100 000 visitors annually, it is also an important contributor to Kenya's tourism economy.

Eugene Apindi/UNEP

"Cities can achieve more sustainable land use if municipalities combine urban planning and development with environmental management"

-Anna Tibaijuka

Executive Director UN-HABITAT
Director General UNON 2007
(Tibaijuka 2007)

Chapter 5: Nairobi and its Environment

Nairobi's name comes from the Maasai phrase "enkare nairobi" which means "a place of cool waters". It originated as the headquarters of the Kenya Uganda Railway, established when the railhead reached Nairobi in June 1899. The city grew into British East Africa's commercial and business hub and by 1907 became the capital of Kenya (Mitullah 2003, Rakodi 1997).

Nairobi, A Burgeoning City

Nairobi occupies an area of about 700 km^2 at the south-eastern end of Kenya's agricultural heartland. At 1 600 to 1 850 m above sea level, it enjoys tolerable temperatures year round (CBS 2001, Mitullah 2003). The western part of the city is the highest, with a rugged topography, while the eastern side is lower and generally flat. The Nairobi, Ngong, and Mathare rivers traverse numerous neighbourhoods and the indigenous Karura forest still spreads over parts of northern Nairobi. The Ngong hills are close by in the west, Mount Kenya rises further away in the north, and Mount Kilimanjaro emerges from the plains in Tanzania to the south-east. Minor earthquakes and tremors occasionally shake the city since Nairobi sits next to the Rift Valley, which is still being created as tectonic plates move apart.

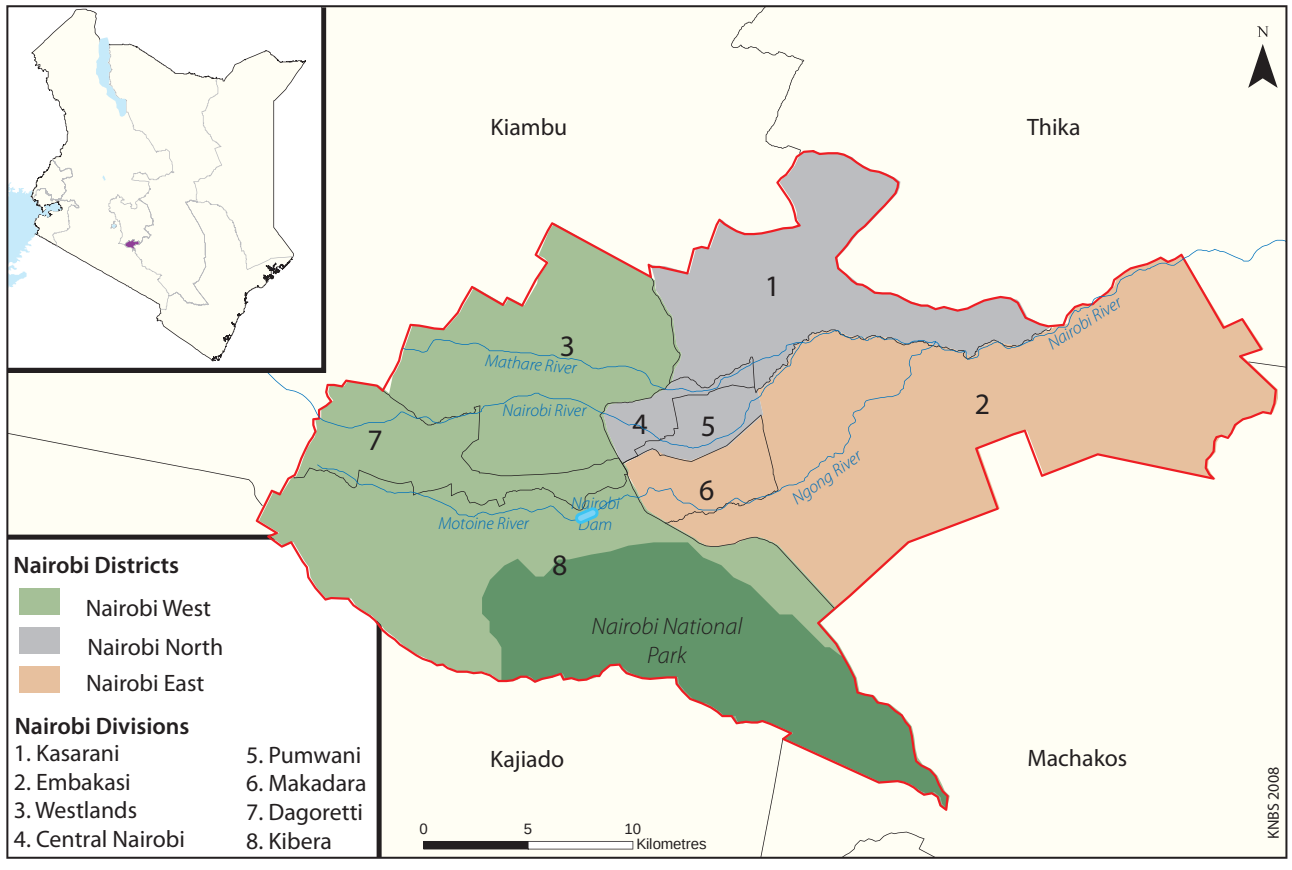


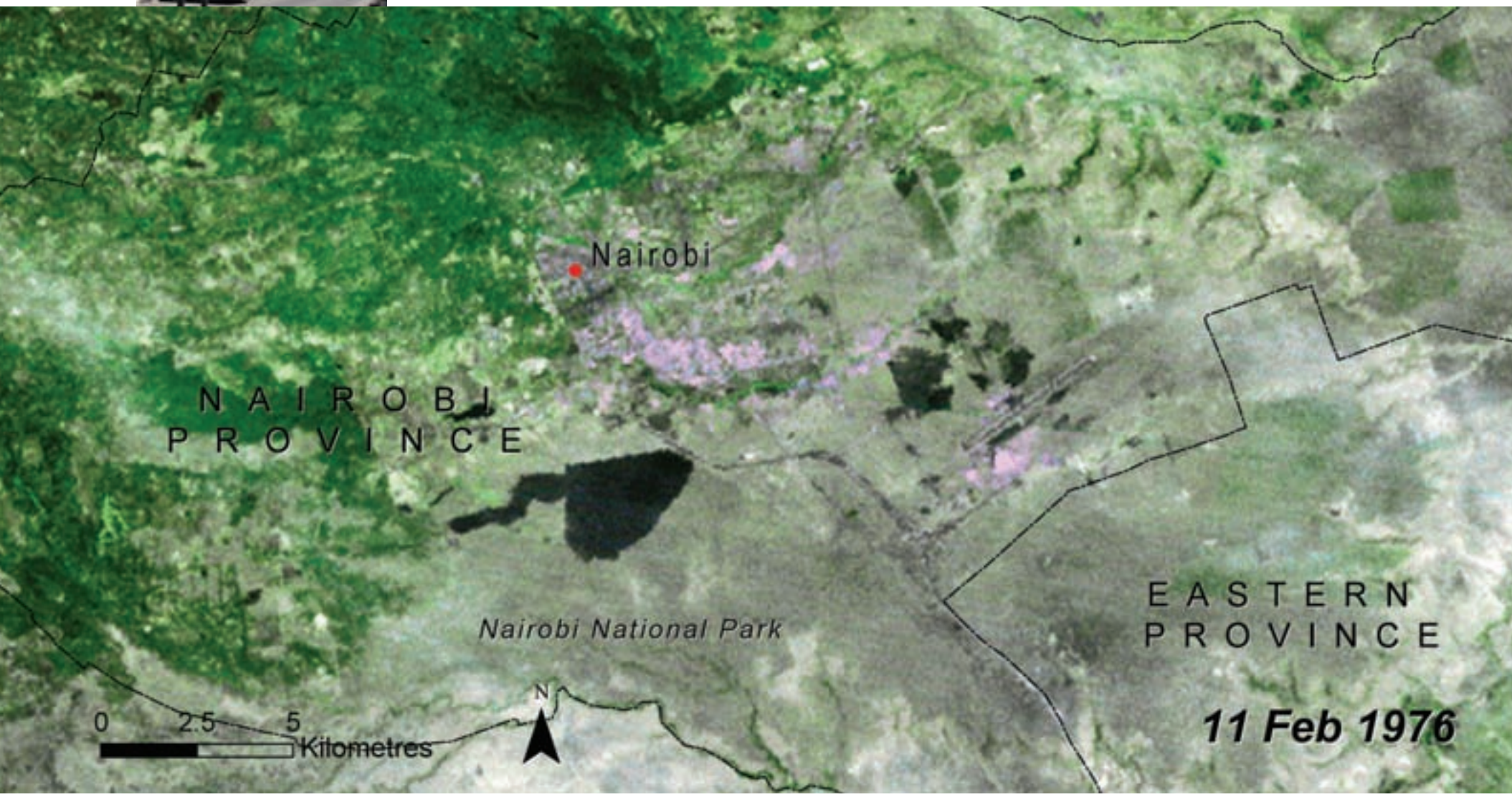
Figure 1: Nairobi's three districts and eight divisions

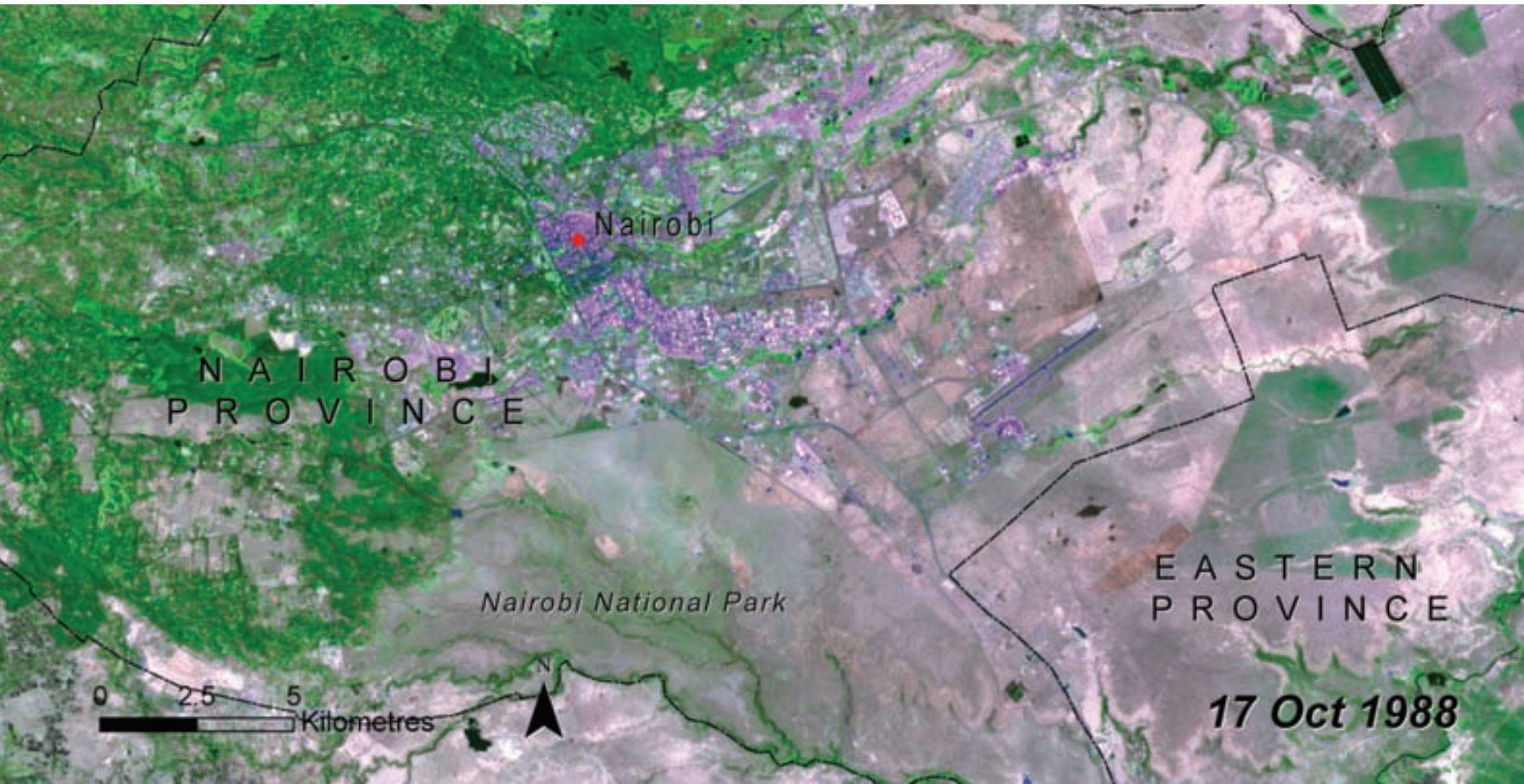
Kenyatta International Conference Centre

The Kenyatta International Conference Centre, located in the heart of Nairobi's Central Business District, has a 33-story tower and a large amphitheater built in the shape of a traditional African hut.

Nairobi

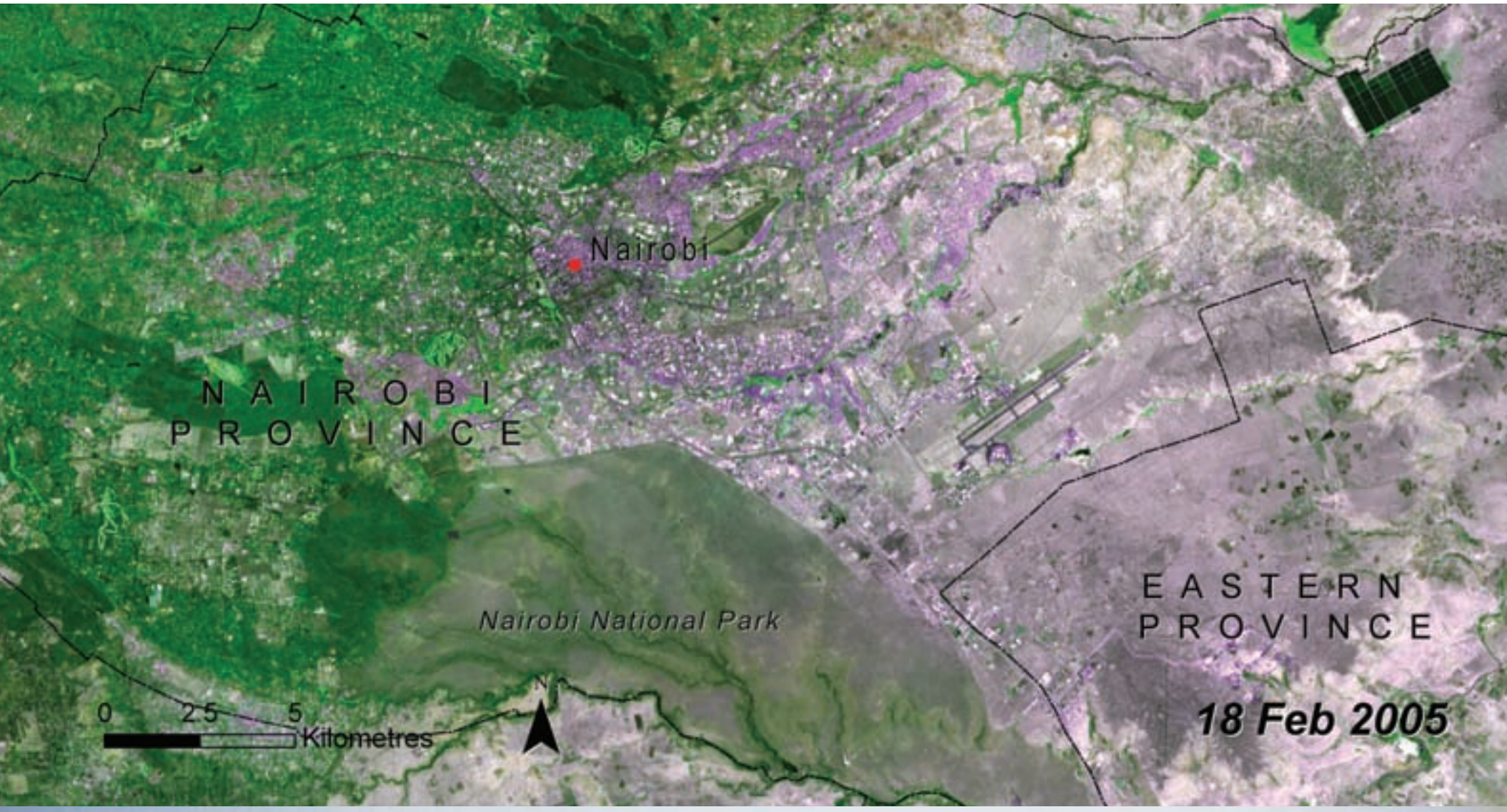
Following its founding in 1902, Nairobi took roughly 40 years to exceed a population of 100 000 people. By independence, 20 years later it had reached around 350 000 people (Olima 2001). Rapidly increasing population has been ongoing since, surpassing one million in the 1980s, two million in the 1990s and now approaching three million residents. While the annual rate of growth has at times exceeded ten per cent, it has more recently decreased to below four per cent per year — still very high by global standards. Nairobi is projected to top 3.8 million by 2015. The footprint of the city's growth can be defined in at least two ways — the official boundaries and the actual changes in settlement, which can be seen in





this series of satellite images. The light purple of the intense urban settlement can be seen steadily growing between 1976 and 2005.

Much of Nairobi's urban footprint is unplanned settlement driven by rapid population growth and urban poverty, among other things. Sprawling informal settlements handicap the city's delivery of social services and negatively impact the quality of life. Informal settlements date to the city's earliest days when European settlers appropriated large tracts of land displacing the local African population with no provision for their resettlement. In the early 1990s, it was determined that over half of the city's population was living in unplanned settlements.



Typical street scene in Nairobi

Population growth: a major driver of environmental change

In 1901, there were only 8 000 people living in Nairobi. By 1948, the number had grown to 118 000 and by 1962, the city had a population of 343 500 people. By the 2009 census, the city's population will be about 3.1 million and in 2015 it is projected to be 3.8 million (Rakodi 1997, CBS 2001). Nairobi's early growth was fuelled by rural migrants and an explosion of growth took place between 1979 and 1989 when 772 624 newcomers came to the city (NEMA 2003). The forces motivating rural-urban migration to Nairobi include better economic prospects, opportunities for higher education and higher wage employment, and the attraction of Nairobi as a market for goods and services.

Nairobi is currently home to nearly three million people and represents about a quarter of Kenya's urban population. A growing economy and swelling population numbers from both in-migration and natural growth are continually increasing the city's size. A significant number of commuters from satellite towns such as Thika, Naivasha, Ngong, and Machakos come into Nairobi daily to work or bring goods and supplies. Daily commuters from such satellite towns contribute an estimated additional half-million people to the city's population.

Nairobi's large and growing population is one of the main forces driving the city's overwhelming environmental challenges. Ongoing rural to urban migration, high natural birth rates, and poor or inappropriate city planning conspire to continue degrading the city's water and air quality. In turn, environmental degradation has impacts on human health and the economy. For the country to achieve the MDGs, progress must be made in Nairobi, as Kenya's capital city and its largest urban centre. An important target is stabilizing the fertility rate at 2.1 by 2010, as recommended by the Population Policy for Sustainable Development (CBS 2004).

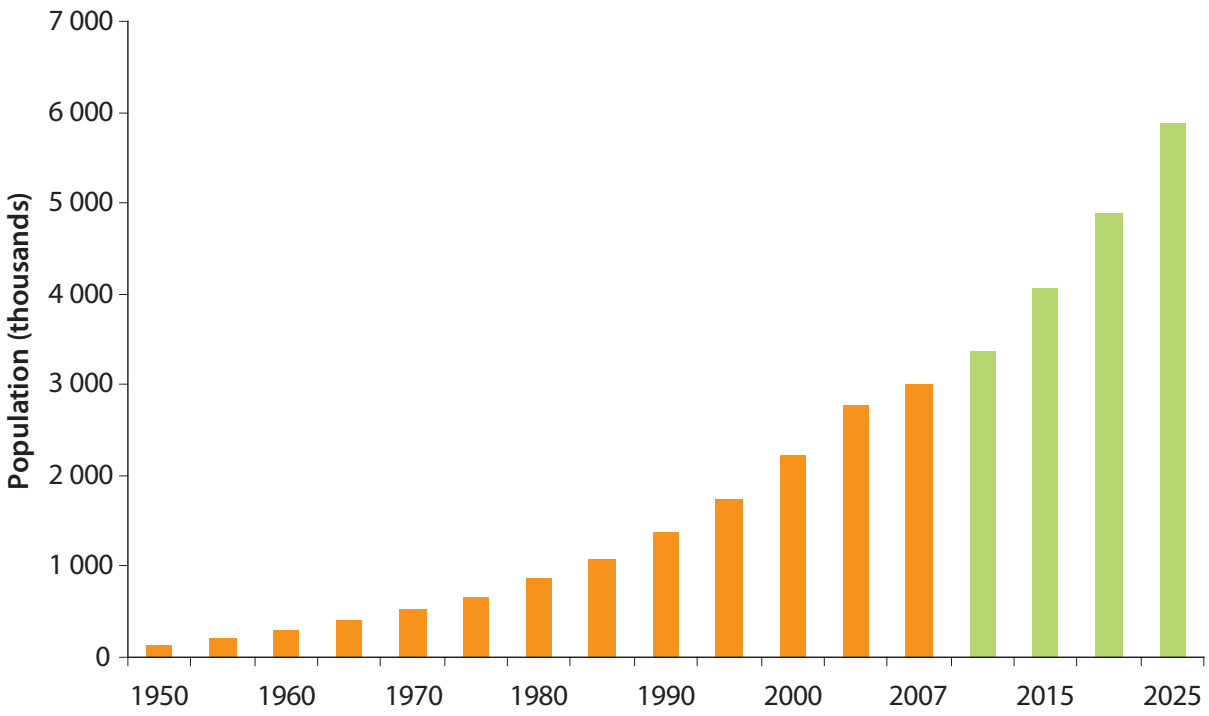


Figure 2: Nairobi's historical and projected population , 1950-2025 (Source: KNBS 2008)

Robin Hutton/Flickr.com

Giraffe strolls in Nairobi National Park with the skyline of the capitol city in the background

Major Environmental Issues

As Nairobi's settlements sprawl outwards, they take over forested and agricultural land, fragmenting and degrading remaining natural areas. In addition, rapid population growth has outstripped the city's ability to deliver adequate services such as education, health care, safe water, sanitation, and waste removal. It has also led to an explosion in the number of cars and other vehicles, leading to ubiquitous traffic jams and high levels of air pollution. As it continues to grow, Nairobi faces the challenge of planning for sustainable urban development that provides adequate housing and services at the same time as it protects air and water quality and the natural environment within and around the city.

The major environmental issues faced by the city and its residents and looked at in this section of the Atlas include rapid urbanization, informal settlements, air and water pollution, water supply and sanitation, and solid-waste management.

Rapid urbanization

Nairobi once had a reputation as a healthy place to live and was called the "Green City in the Sun". Its landscape was characterized by natural forests, labyrinthine riverine ecosystems, and wetlands. The area boasted abundant wildlife in forest groves, marshy wetlands, the Kitengela Corridor, and the Athi-Kapiti plains.

Nairobi's physical expansion has come at the expense of the natural environment. Urban sprawl and the construction of roads and other city infrastructure has led to the loss of forests and other natural areas, such as mixed rangeland and bushlands. As a result, the forest cover receded and was replaced by coffee plantations. Later, the demand for food for the growing population led to the transformation of the city's outskirts to other agricultural uses, which in turn were threatened by further urban growth.

Park entrance sign to Nairobi National Park

Protected green spaces

Nairobi has managed to retain a number of green spaces within and close to the city, which provide its residents with shady recreation areas and visitors with a glimpse of Kenya's renowned wildlife and characteristic vegetation. They also help to maintain biodiversity, filter pollutants from the air, and act as minor water catchments within and on the outskirts of the city.

Although these green spaces have been protected, much of the natural vegetation surrounding Nairobi was lost as the city's boundaries were extended numerous times to accommodate the growing population

Table 1: Characteristics and biodiversity of key protected areas in Nairobi (Source: KWS 2006, JICA 2005)

Name	Managing Authority	Area (ha)	Common Species	
			Plants	Animals
Nairobi National Park; Established 1946	Kenya Wildlife Service (KWS)	11.0 640.0	Olea africana, Croton dichogamus calodendrum, Themeda, Cyprus, Digitaria, Cynodon, Acacia xanthophloea, Euphobia candelabrum, Apodytes dimidiata, Canthium schimperanum, Elaeodendron buchananii, newtonia sp, Ficus eriocarpa, Aspilia mossambicensis, Thus natalensis, Euphobia brevitorta, Drimia calcarata, Murdannia clarkeana and Crassula sp.	Giraffes, lions, gazelles, buffaloes, hartebeest, wild pigs, wildebeest, warthogs, crocodiles, hippos, and about 400 species of birds
Karura Forest; (Gazetted 1932)	Forest Department	1 063.0	Olea europeae var. africana, Croton megalocarpus, Warburgia ugandansis, Brachyleana huillensis and Uvaridendron anisatum	Monkeys, bush baby, bush bucks, bush pigs, porcupines, duikers, genets, dikdik, epauletted bat, Africa civet
Ng'ong Forest	Forest Department and KWS	638.4	Eucalyptus, Pine, Cyprus, Croton and Cordia species	Over 120 species of birds, over 35 mammals such as leopards, monkeys, reptiles, insects, and amphibians
Ololua Forest	Nairobi City Council and The National Museums of Kenya	667.0	Olea africana, Eleodendron buchananii, Akokanthera schimperi, Brancylaena species, Croton megalocarpus, Carisa edual and Rhus natalensis. Others include aloe, Acaca species	Olive baboons, monkeys, yellow baboons, porcupines, bush baby, bush bucks, bush pig, dikdik, epauletted bat, duikers, African civet, and genets, grey wagtail, Eurasian cuckoo, willow warbler
The Nairobi Arboretum	Forest Department; Established 1907	25.0	Several collections of plant species	Chameleon, skunks, butterflies, dragonflies, ants, bees and beetles, Ayres's hawk eagle
Nairobi City Park	Nairobi City Council	60.0	Olea europeae var. africana, Croton megalocarpus and Warburgla ugandansis	Hundreds of bird species, butterflies and baboons

View of the downtown Nairobi

and the associated need for more land. As the city expanded after its founding, much of the new settlement was unplanned. By 1993, informal settlements housed about 55 per cent of the city's population (Matrix Development Consultants 1993).

Although it covers only 0.1 per cent of Kenya's total surface area, Nairobi has about eight per cent of the country's total population. The city's overall population density is 3 079 people per square kilometre, but this varies significantly from extremely high in the Central and Kibera divisions to very low in the upmarket residential area of Muthaiga in Westlands division. The poorest 60 per cent of Nairobi residents live on only 8.7 per cent of the city's land base, mostly in informal settlements (ITC 2004).

Nairobi National Park is only seven kilometres from the city centre. It is the only protected area in the world with such a variety of animals and birds so close to a capital city. As the city expanded, so has this precious wildlife habitat been increasingly exposed to urban air pollution and threatened by incursions on its land base.

The Park covers an area of 117 km^2 and it is a dry season refuge for wildlife migrating from the Maasai-Amboseli ecosystem and dispersing over the Athi-Kapiti plains and the Kitengela corridor. It is said that at one time, elephants from Amboseli passed through these corridors to the Aberdares and Mt. Kenya areas. Human land use changes have long since erased these corridors, however. Today, Nairobi National Park is the country's most successful Rhino Sanctuary.

Nairobi National Park is still a huge and protected expanse of green space close to the city that serves a vital role in recreation and conservation education for young Kenyans. It also provides critical ecosystem services such as purifying the air and sequestering carbon and plays a major economic role as one of the most commercially viable conservation areas in Kenya. In 2005, the park attracted close to 100 000 visitors (CBS 2006). (See the sections on Nairobi National Park in Chapters 1 and 4 also.)

Scene from a slum area in Nairobi

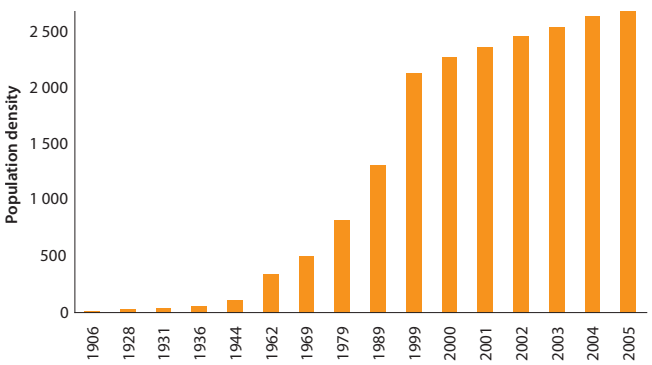


Figure 3: Nairobi's population density, 1906-2005 (Source: CBS 2001)

Informal settlements

Nairobi's rapid growth increased the demand for land and led to land speculation, forcing the poor to settle in fragile and unsavoury areas where they face hardships due to a lack of proper housing and public services and where they are vulnerable to environmental change. Urban poverty, lack of employment opportunities, and inadequate urban planning also conspired in the gradual growth of informal settlements in Nairobi since the city's founding. By 1995, there were a total of 134 informal settlements with 77 589 structures. These settlements had a combined population of 1 886 166 (CCN 2007).

People living in Nairobi's informal settlements, particularly the slums, usually find themselves in the city's most fragile areas, such as flood plains, steep slopes, river valleys, or adjacent to sewers or dump

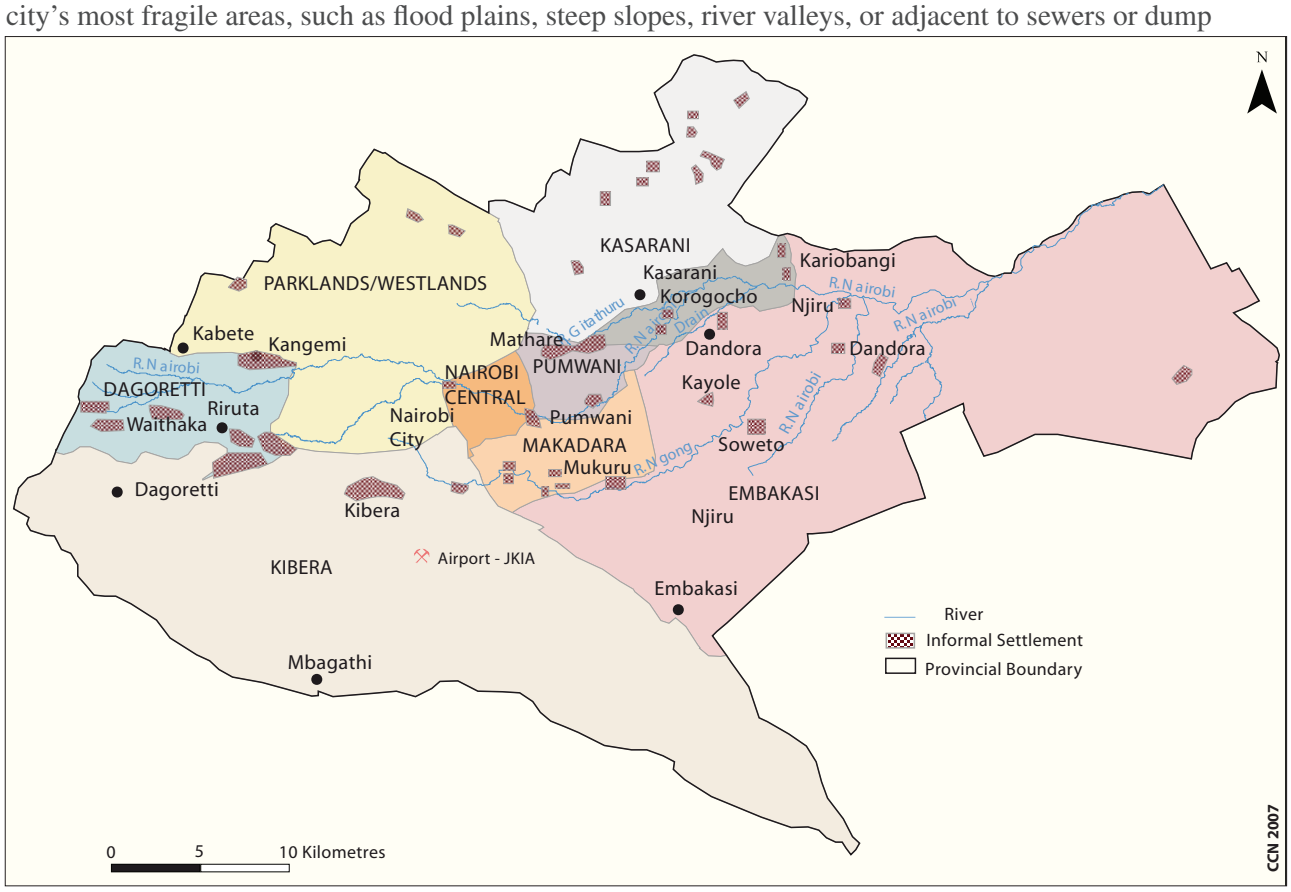


Figure 4: Location of slums in Nairobi

The Dandora Dumping site

sites. The Dandora Municipal Dumping site, which receives most of the city's solid waste, is only about eight kilometres from Nairobi's centre and is surrounded by a low-income residential area. This situation exposes slum residents to floods, land-slides, and health risks from contaminants. In addition, they live in overcrowded conditions with poor sanitation, inadequate and unsafe water, make-shift shelters, and unstable social networks. They also face a high degree of tenure insecurity since most of these settlements are illegal, exposing them to the constant threat of harassment and eviction.

In an attempt to reduce some of the problems of informal settlements, slum upgrading and site and service schemes have been encouraged. The Government of Kenya has established the Slum Upgrading and Low Cost Housing and Infrastructure Trust Fund to serve as a depository for funds mobilized for the Slum Upgrading Programme.

Heavy traffic contributes to air pollution

Air pollution

The main sources of atmospheric pollution are vehicles, industries, emissions from the use of charcoal and firewood, and other municipal sources such as the open burning of waste. The increasing number of cars in the city intensifies traffic and pollution problems. Vehicles emit significant levels of air pollutants, including greenhouse gases and the precursors of smog. Charcoal burning, a very prevalent energy source in the city, emits methane (CH_4) and carbon monoxide (CO) and sends tiny particulates into the air.

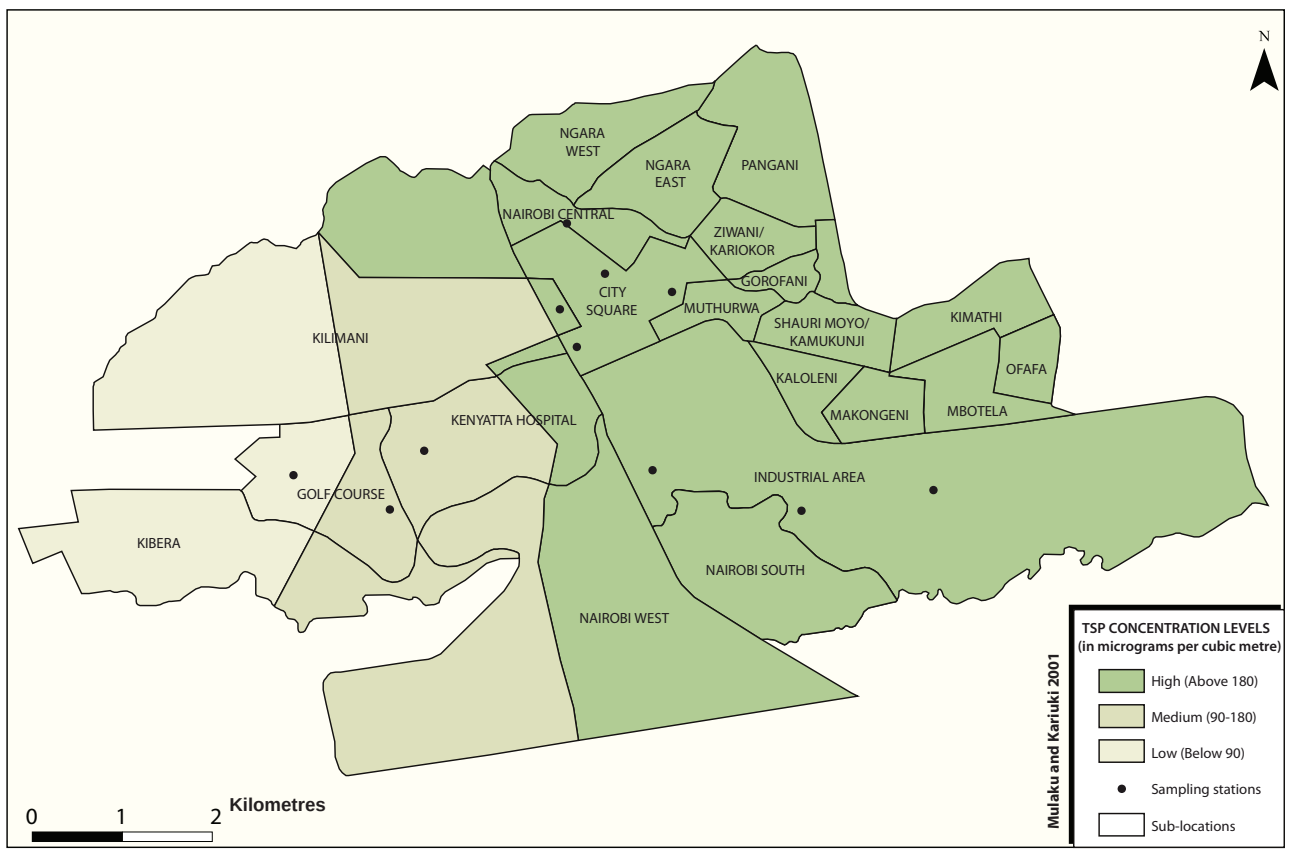


Figure 5: Average total suspended particulates (TPS) over a section of Nairobi

Air pollution adversely affects human health and the environment. Particulates (Figure 5) are associated with respiratory and eye diseases such as asthma, lung cancer, and conjunctivitis, especially in the young and elderly who are more vulnerable. Air pollution is also a major contributor to effects such as acid rain, which has been responsible for much damage to soil, fish resources, and vegetation, often very far from the emission sources.

Water pollution

Ndakaini, Ruiru, and Susumua dams are the principal sources of water for Nairobi. These dams are all on rivers emanating from the Aberdare Forest (one of Kenya's five "water towers"). Several factors compromise the city's water quality, ranging from natural phenomena such as the high fluoride content in groundwater, to anthropogenic factors such as poor wastewater treatment and environmental degradation both within the city and in the surrounding countryside.

The city's wastewater management has not kept up with increasing demands from the growing population and is inadequate to treat the amount of industrial and municipal effluent entering the Nairobi River and other surface waters. Nairobi has changed from a "place of cool waters" to one in which the water is no longer potable or fit for many other useful purposes. A number of factories in Nairobi's industrial area discharge waste directly into the Ngong River, making it the most polluted river in Kenya. Industrial waste effluents include petro-chemicals and metals from micro-enterprises and "Jua-kali". As well, oil and grease from the busy roads run off into adjacent waters.

The Nairobi River also receives improperly treated effluents from the Dandora Sewage Treatment Plant and several drainage channels that gather storm water from Nairobi City. Domestic garbage from informal settlements that have no public waste collection services also finds itself into the river as does sewage from pit latrines and other on-site sewerage-disposal methods. Sanitation facilities are very basic in many informal settlements, consisting of earth drains, communal water points, pit latrines shared by many people, and no systematic solid-waste disposal.

In addition to locally generated water pollution, the city receives effluents that enter the rivers from human activities further afield. The Nairobi River Basin consists of three major rivers (Nairobi, Ngong, and Mathare) whose catchments are found within the Kikuyu and Limuru Hills. Figures 7 and 8 highlight major points of organic, solid waste, and heavy metal pollutants within the basin.

Improperly treated sewerage and uncollected garbage have contributed to a vicious cycle of water pollution, water-borne diseases, poverty, and environmental degradation. Water pollution carries environmental and health risks to communities within Nairobi, especially the poor who may use untreated

Trash and garbage wash down the Nairobi River polluting the water here and downstream

Figure 6: Wet season pollution hotspots

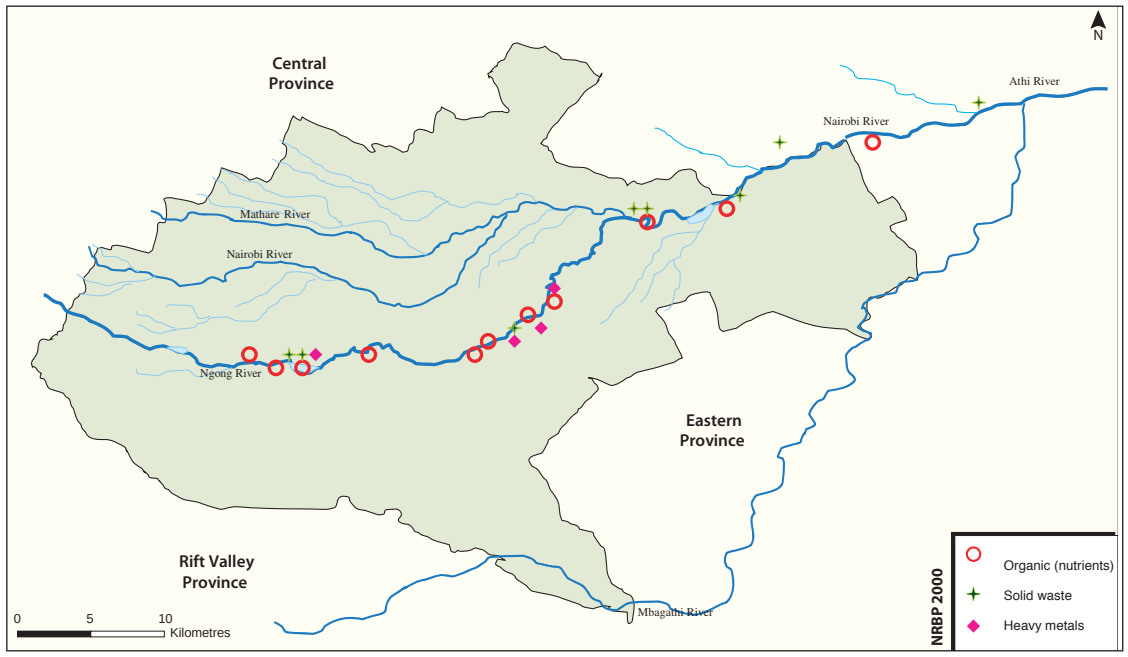
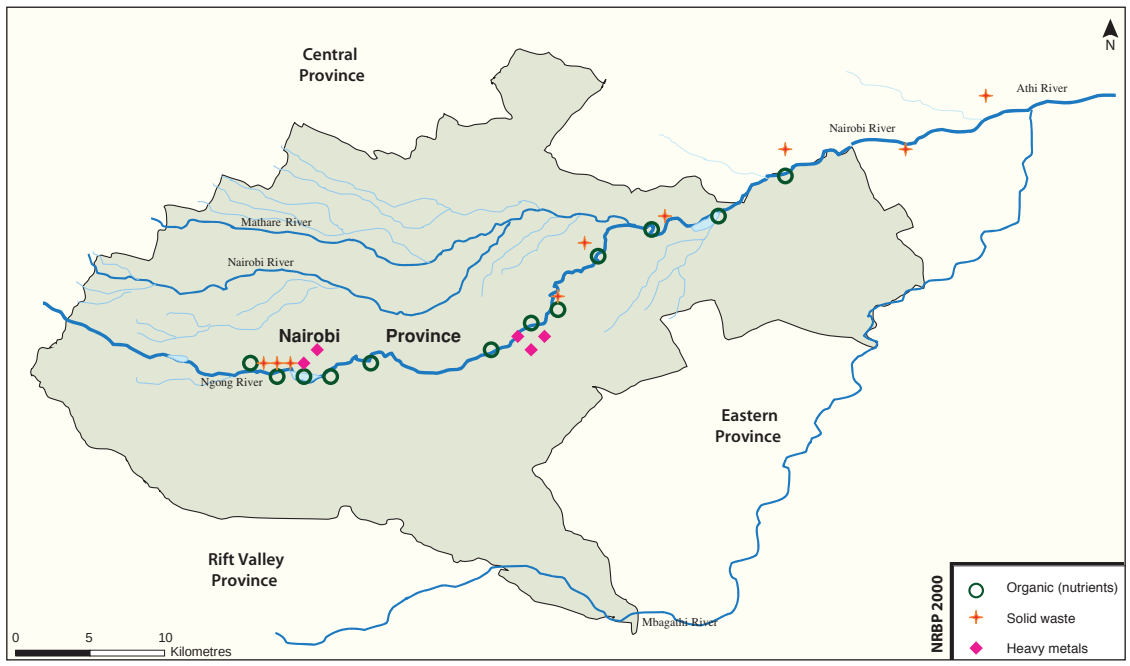


Figure 7: Dry season pollution hotspots



water in their homes and to irrigate their gardens. Farmers along the Nairobi River and its tributaries commonly use polluted waters and raw sewage for irrigation, exposing both farm workers and customers who consume the food crops to potential health problems such as diarrhoeal disease and helminthic infections. Almost half of the vegetables consumed in the city of Nairobi are grown on the banks of polluted rivers. All these impacts affect human health and productivity and challenge Kenya's ability to reach targets under the Millennium Development Goals (as discussed in Chapter 2).

To reduce the sources of water pollution in the Nairobi River and address some of the impacts on both people and the riverine ecosystem, the Nairobi River Basin Programme (NRBP) was initiated in 1999. It is a multi-stakeholder effort with the vision of a restored riverine ecosystem with clean water for the capital city and a healthier environment for the people of Nairobi. Its goal is to rehabilitate, restore, and manage the Nairobi River ecosystem to improve livelihoods, especially for the poor, enhance biodiversity, and provide a sustainable water supply for domestic, industrial, recreational, and emergency uses. NRBP identified five key goals to improve the water quality and environment in the Nairobi River Basin:

- Develop environmental management and planning systems;
- Rehabilitate and restore the Nairobi Dam;
- Develop and implement water quantity and quality measuring protocols;
- Enhance service delivery, environmental conservation, and sustainable use of resources; and
- Sustain public awareness of, and participation in, environmental issues directly affecting the Nairobi River Basin (UNEP 2008).

The City Council of Nairobi improving access to better sanitation facilities by constructing more facilities within common areas

Sanitation

Nairobi faces an enormous challenge in providing adequate public sanitation facilities, sewage disposal, and refuse collection, a problem that is compounded as the population increases. Improperly treated sewerage and uncollected garbage have contributed to a vicious cycle of water pollution, water-borne diseases, poverty, and environmental degradation.

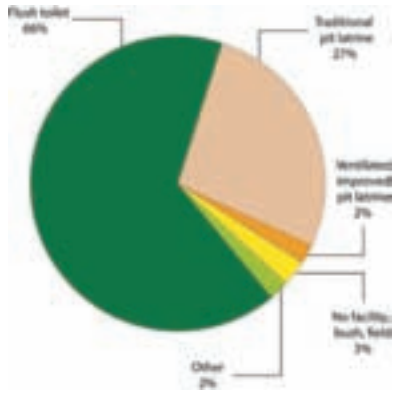


Figure 8: Sanitation facilities used by Nairobi residents (Source: CCN 2007)

Solid waste management

Waste management is a growing problem in Nairobi. Increasing urbanization, rural-urban migration, rising standards of living, and rapid development associated with population growth have resulted in increased solid waste generation by industrial, domestic, and other activities. This increase has not been accompanied by an equivalent growth in the capacity to address the problem. In 1992, from 800 to 1 000 tonnes of solid waste was generated in Nairobi every day, of which less than ten per cent was collected; by 2002, the amount had grown to 1 530 tonnes per day of which 40 per cent was either uncollected, or disposed of by burning or illegal dumping (Syagga 1992, CCN 2007). The proper management of waste has thus become one of the most pressing and challenging environmental problems in the city.

Waste in Nairobi comes from a variety of household, service, and industrial processes in the following proportions: domestic sources: 68 per cent; industrial: 14 per cent; roads: 8 per cent; hospitals: 2 per cent; markets: 1 per cent; and 7 per cent from other sources (NEMA 2003). Food waste, plastic, and paper are the most dominant forms of solid waste in Nairobi (Figure 9). One of the most ubiquitous forms of visible waste is the plastic bag. By 2007, over two million plastic bags were being handed out every year in Nairobi alone. Once released in the environment, they choke wildlife, pollute the soil, and serve as breeding grounds for mosquitoes. In the footsteps of several other African countries, as of 1 January 2008, Kenya imposed a national ban on the importation and distribution of plastic bags less than 30 microns in thickness (NEMA 2008).

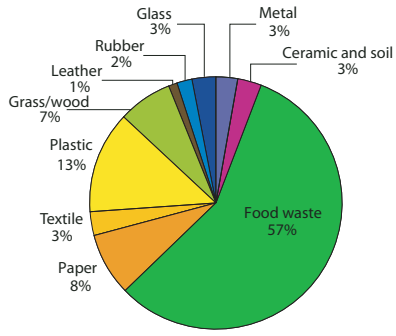


Figure 9: Characteristics of solid waste generated in Nairobi (Source: CCN 2007)

Planning for the Future

In 2007, a state of the environment report for the city was prepared (*City of Nairobi Environment Outlook*) that provided a baseline to assess progress in addressing the city's environmental problems and provided stimulus to the local government to mainstream environmental issues in all development and city planning activities.

In 2008, the Government of Kenya produced the Nairobi Metropolitan Development Plan. Under this development plan, the boundaries of the city (Nairobi Metropolitan Area) will be expanded to include adjoining towns and municipalities (Figure 10).

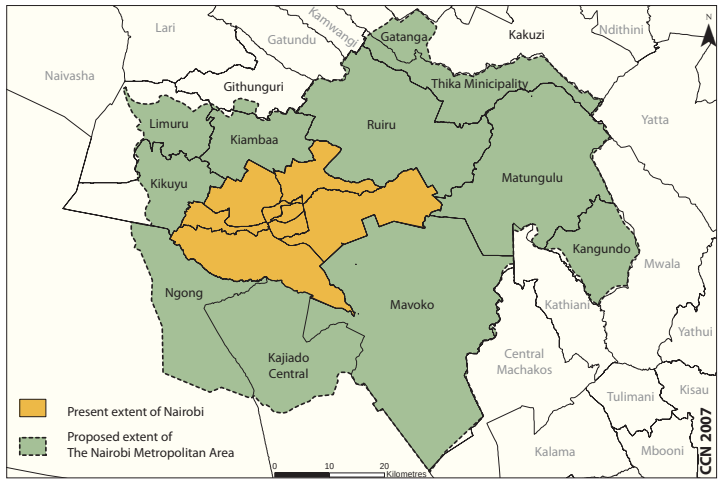


Figure 10: Present and proposed extent of the Nairobi Metropolitan Area

The plan's other goals include the following:

- Develop integrated road, bus, and rail infrastructure for the Metropolitan Area to provide an efficient mass transport system;
- Replace informal settlements with affordable low cost housing;
- Develop and enforce planning and zoning regulations;
- Prepare a spatial plan for the Metropolitan Area;
- Develop efficient water supply and waste management infrastructure;
- Promote, develop, and invest in sufficient public utilities, public services, and world-class infrastructure for transforming Nairobi into a global competitive city for investment and tourism;
- Identify and implement strategic projects and programmes requiring support by the Government;
- Promote the Nairobi Metropolitan Area as a regional and global services centre for financial, information and communication technology, health, education, business, tourism and other services; and
- Develop a sustainable funding framework for the development of identified urban and metropolitan areas.

Given that environmental degradation in Nairobi has such an important impact on such a large number of people as well as on the country's economy and its international reputation, Kenya needs to move quickly and decisively on this plan.

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Acronyms

ALRMP	Arid Lands Resource Management Project
ARTS	ASRC Research & Technology Solutions
ASAL	Arid and Semi-Arid Land
AWF	African Wildlife Foundation
CBS	Central Bureau of Statistics
CCD	Convention to Combat Desertification
CCN	City Council of Nairobi
CH_4	methane
CI	Conservation International
CITES	Convention on International Trade in Endangered Species
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DEWA	Division of Early Warning and Assessment
DEPHA	Data Exchange Platform For The Horn of Africa
DRSRS	Department of Resource Surveys and Remote Sensing
EIA	Energy Information Administration, United States Department of Energy
ENSO	El Niño/Southern Oscillation
FAO	Food and Agriculture Organization
FAS	Foreign Agricultural Service
FEWS NET	Famine Early Warning System Network
FR	Forest Reserve
GDP	Gross Domestic Product
GoK	The Government of Kenya
GRID	Global Resource Information Database
ha	hectares
IBA	Important Bird Areas
ILO	International Labour Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISSD	International Institute for Sustainable Development
ITC	International Institute for Geo-Information Science and Earth Observation
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
KENGEN	Kenya Electricity Generating Company
KFS	Kenya Forest Services
KFWG	Kenya Forests Working Group
kg	kilograms
KIFCON	Kenya Indigenous Forests Conservation Programme
KLA	Kenya Land Alliance
km	kilometres
km^2	square kilometres
km^3	cubic kilometres
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
Ksh.	Kenyan Shilling
kWh	kilowatts per hour
KWS	Kenya Wildlife Service
m	metres
m^2	square metre
m^3	cubic metre
MDGs	Millennium Development Goals
MENR	Ministry of Environment and Natural Resources
mm	millimetres
MW	Megawatts
NEE	National Economies Encyclopedia
NASA	National Aeronautics and Space Administration
NEMA	National Environment Management Authority
NPP	Net Primary Productivity
NRBP	Nairobi River Basin Programme
ODA	Official development assistance
OECD	Organisation for Economic Cooperation and Development
PPP	Public-private partnerships
RCMRD	Regional Centre for Mapping of Resources for Development
SGT	Stinger Ghaffarian Technologies
SoK	Survey of Kenya
t	tonnes
UMD	University of Maryland
UN	United Nations
UNDG	United Nations Development Group
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
UNPD	United Nations Population Division
UNStats	United Nations Statistics Division
UNU	United Nations University
URT	United Republic of Tanzania
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VIP	Ventilated Improved Pit
WCMC	World Conservation Monitoring Centre
WGCCD	Working Group on Climate Change and Development
WCPA	World Commission for Protected Areas
WHO	World Health Organization
WRI	World Resources Institute
WWF	World Wildlife Fund
yr	year

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Acknowledgements

The Government of Kenya and UNEP thank the following contributors:

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