As the age-old adages say, "A picture is worth a thousand words" and "Seeing is believing", this stunning 400-page "Africa: Atlas of our Changing Environment" is a unique and powerful publication which brings to light stories of environmental change at more than 100 locations spread across every country in Africa. There are more than 300 satellite images, 300 ground photographs and 150 maps, along with informative graphs and charts that give a vivid visual portrayal of Africa and its changing environment. Using current and historical satellite images, the Atlas provides scientific evidence of the impact that natural and human activities have had on the continent's environment over the past several decades. The observations and measurements of environmental change illustrated in this Atlas help gauge the extent of progress made by African countries towards reaching the United Nation's Millennium Development Goals. More importantly, this book contributes to the knowledge and understanding that are essential for adaptation and remediation. This UNEP publication should be of immense value to all those who want to know more about Africa and who care about the future of this continent.

UNEP

AFRICA ATLAS OF OUR CHANGING ENVIRONMENT

AFRICA

Atlas of Our Changing Environment

AMCEN

UNEP

AFRICA

ATLAS OF OUR CHANGING ENVIRONMENT

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AFRICA

ATLAS OF OUR CHANGING ENVIRONMENT

A Rwandan dance troupe

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The Changing Earth Surface

NASA

Preface

Africa is the second-largest continent on Earth after Asia and currently considered among the most strategic regions in terms of global development opportunities. With about 30 million square kilometres including adjacent islands and the Sahara, the world's largest desert, Africa covers over 20 per cent of Earth's total land area. Africa is also the second most populous continent after Asia. With over 965 million people it accounts for about one-seventh of the world's human population. The vast landscape of Africa contains a host of natural wonders and rich resources such as coltan and platinum, which are currently considered the most strategic minerals.

Its grasslands, wetlands, mountains, deserts, rainforests and marine areas are home to thousands of species of plants and animals. It is also a land of unparalleled natural beauty and its rainforests are an important storehouse of carbon. Its vast mineral and natural resources provide immense opportunities for economic growth, development and human well-being. The high economic growth of over 4.6 per cent witnessed in the region since 2004 is largely underpinned by the region's environmental resources—oil exploration, improved agricultural performance, and tourism.

Africa is also a land of increasing population and rapidly changing land-use patterns—changes that have profound local, regional and global environmental significance. Sustaining a reasonably high economic growth rate to match the human population growth rate coupled with ensuring the environmental and natural resources integrity is one of the key challenges being addressed by the New Partnership for Africa's Development (NEPAD) through its action plan on the environment (Action Plan). The African Ministerial Conference on the Environment (AMCEN) which is the apex body on the environment is responsible for, inter alia, guiding regional institutions and member states in implementing the Action Plan. It is also responsible for creating an enabling environment for cooperation in cross-border natural resources management and sharing best practices among the countries.

To achieve this in a region which is undergoing rapid changes in its economic development and ecosystems, demands for a dynamic and credible information base. AMCEN is, therefore, very proud to launch the Africa: Atlas of Our Changing Environment, which is an evidence-based complementary publication of our flagship publication, the Africa Environment Outlook (AEO). The AEO report series continue to provide significant input to the AMCEN agenda and inform policy both at the regional and national levels.

AMCEN is indeed pleased to note that with the support of UNEP, all African countries were given opportunity to participate in production of the Atlas by identifying sites for analysis and reviewing the brief country profiles. As we reflect on each country's progress towards achieving the Millennium Development Goal (MDG) 7 as presented in this Atlas, let us renew our political commitment to accelerate our efforts and ensure Africa's path to sustainable development.

I would like to congratulate all the experts, AEO collaborating centres and development partners whose contribution has made this landmark publication possible. It is my sincere hope that what is documented in this report will inspire every reader into action. I wish you an enjoyable reading.

S.E. Monsieur André Okombi Salissa
President of the African Ministerial Conference on the Environment
Minister of Tourism and Environment of Congo

Overlooking fields in Morocco

Flickr.com

Foreword

Africa is made up of a stunning mosaic of forests and woodlands, mountains, deserts, coastal lands and freshwater ecosystems upon which hundreds of millions of people depend. However, environmental change threatens the people and natural resources of this vast continent.

Africa: Atlas of Our Changing Environment provides compelling evidence of the extent and severity of such dramatic change over the past 30 years on the region's environment due to both natural processes and human activities. The Atlas is the first major publication to depict environmental change in all of Africa's countries using satellite imagery. By telling a vivid, visual story of the dramatic impacts on the continent's landscapes, the Atlas is a resource for remedial action at local, national, and regional levels.

One of the Atlas's most striking features is its site-specific, side-by-side display of historical and current remote-sensing imagery. "Before and after" satellite images show different kinds of environmental change: forest conversions and the loss or degradation of habitats; urban growth; altered hydrology (dams, shrinking lakes, river diversions, and drained wetlands); degraded coastal areas; mining developments; dryland modification; and the impacts of climate change. While it's generally a challenge to present visually the impacts of climate change and land degradation in Africa due to the often long intervals between cause-and-effect involving these two issues, the Atlas powerfully tells the story of climate change and its impacts through paired satellite images. Vignettes from people's lives provide personal accounts, describing how environmental change has affected them, how they have adapted to it, and also helped to slow further deterioration or restore environmental quality.

The *Africa: Atlas of Our Changing Environment* is an immense resource for all who have an interest in the regional environment. It among others:

- Introduces Africa in the global context, providing a general description of the region's geography, plants and animals, and its people. Highlights transboundary environmental change across national borders and frontiers, highlighting the effects of such change on people and the environment itself. It emphasizes the need for international cooperation to manage shared water bodies, ecosystems, and protected areas; cross-border pollution; and environmental issues related to conflict.
- Spotlights briefly each country in Africa, describing how each is faring in terms of achieving the targets set under Goal 7 of the United Nations' Millennium Development Goals (MDGs): "Ensure Environmental Sustainability". The incorporation of the MDG Goal 7 targets, and observations on the progress African countries have made towards achieving them, is yet another unique feature of this Atlas.
- Summarizes the magnitude of the challenges that Africa faces that will become even more taxing in light of climate change and its potential impacts on Africa and its people.

The Atlas also examines geographic and ecological issues of relevance at the national level. It presents each country's unique features, and highlights some of the major environmental trends and challenges of each. It displays paired satellite images, focusing on specific sites in each African nation where environmental change is visually evident. Each "change pair" of images is accompanied by a short write-up, drawing on scientific literature. The result is a concise, accessible presentation of a case study of environmental change.

It is important to note that different sites highlighted in this Atlas are only a window through which we can understand that environmental change is a widespread phenomenon throughout Africa.

The *Africa: Atlas of Our Changing Environment* brings compelling visual and scientific evidence of environmental change derived from the Earth observation sciences to a broader audience; builds awareness about our rapidly changing environment; and will help us make better decisions together to ensure our mutual future on this ever-more crowded globe—our planet Earth.

It is the work of many partners of UNEP. I would like to express the gratitude of the United Nations to our partners in Africa as the well as the United States government whose support through agencies not only made the satellite data and analyses available, but also is committed to building capacity in Africa to strengthen efforts to analyse environmental change and inform effective policy responses.

UNEP

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

Reader's Overview

"I reflect on my childhood experience when I would visit a stream next to our home to fetch water for my mother. I would drink water straight from the stream. Playing among the arrowroot leaves I tried in vain to pick up the strands of frogs' eggs, believing they were beads. But every time I put my little fingers under them they would break. Later, I saw thousands of tadpoles: black, energetic and wriggling through the clear water against the background of the brown earth. This is the world I inherited from my parents. Today, over 50 years later, the stream has dried up, women walk long distances for water, which is not always clean, and children will never know what they have lost. The challenge is to restore the home of the tadpoles and give back to our children a world of beauty and wonder."

Excerpt from Nobel Peace Prize Acceptance Speech By Wangari Maathai

10 December 2004

Africa: Atlas of Our Changing Environment is the first publication to use satellite photos to depict environmental change in each and every African country during the last thirty years. Through a rich array of satellite images, graphs, maps, and photographs, this Atlas presents a powerful testament to the adverse changes taking place on the African landscape as a result of intensified natural and human impacts. The remarkable developments in earth observation technology and its application during the last three decades have provided important tools for environmental monitoring. Earth-observing sensor systems on aircraft and spacecraft provide data streams for analysing environmental issues at varying spatial and temporal scales. The power of earth observations technologies to produce thousands of current and historical satellite images has illuminated the stories of environmental change, and has made this publication possible.

Africa: An Introduction to the Continent

There are 53 countries and one "non-self governing territory" (Western Sahara) in Africa. Ecologically, Africa is home to eight major biomes—large and distinct biotic communities with characteristic assemblages of flora and fauna. Chapter One of the Atlas vividly illustrates Africa's geographical attributes, presenting a physical setting in which readers may visualize the changes human actions are etching on the landscape. Maps, images and informative text reveal that Africa is endowed with rich natural resources that provide the basis for its peoples' livelihoods. Among the varied environmental features readers can see are rain forests, wetlands, mangroves, coral reefs, and coastal deltas. These ecosystems provide a rich and diverse array of potential sources of food and materials. In addition, Africa holds approximately 30 per cent of the earth's minerals including 40 per cent of the gold, 60 per cent of the cobalt and 90 per cent of its platinum. In recent years, oil production has been the main contributor towards Africa's economic growth. There are also grazing and agricultural lands that can support farming economies, as evidenced by the 56.6 per cent of Africa's labour force engaged in agriculture.

On the other hand, in many areas the environments from which most people in Africa must eke a living are harsh and the climate challenging. Africa is the world's hottest continent with deserts and drylands covering some 60 per cent of the entire land surface. Only ten per cent of farm soils are prime agricultural land, and more than one-quarter per cent of the land has moderate to low potential for sustainable agriculture. Rainfall variability is high, ranging from near 0 mm/year in parts of the Sahara to 9 500 mm/year near Mount Cameroon. Droughts and famine are ever present, and tens of millions of Africans have suffered the consequences every season. Droughts not only

Giant's Castle, Ukhalamba-Drakensberg Park, South Africa directly cause food insecurity, triggering migration in some cases, but also negatively impact economic performance.

Water

Africa's water resources are continuously affected by persistent droughts and changes in land use. At the same time, a growing population is increasing the demand on already limited water supplies, particularly in areas which suffer from water shortages. Currently, it is estimated that over 300 million people in Africa face water scarcity conditions. About 75 per cent of the African population relies on groundwater as the major source of drinking water, particularly in northern and southern Africa. However, groundwater represents only about 15 per cent of the continent's total renewable water resources.

Land

Land in Africa is becoming increasingly degraded. Erosion and/or chemical and physical damage has degraded about 65 per cent of agricultural lands. This has forced farmers in many places to either cultivate marginal and unproductive soils, further degrading the land, or to migrate to cities and slums. Some areas in Africa are said to be losing over 50 metric tonnes of soil per hectare per year. Thirty-one per cent of the region's pasture lands and 19 per cent of its forests and woodlands are also classified as degraded. Forests account for over 20 per cent of Africa's 30 million km^2 of land area, but are being destroyed and degraded by logging and conversion to plantations, agriculture, roads, and settlements. As a region, Africa is losing more than four million hectares of forest every year—twice the world's average deforestation rate.

Biodiversity

Africa's rich biological diversity—one of the region's most stunning attributes—is in jeopardy due to a confluence of habitat destruction, poaching, and increasing populations. Africa contains over 3 000 protected areas including 198 Marine Protected Areas, 50 Biosphere Reserves, and 80 Wetlands of International Importance. Eight of the world's 34 international biodiversity hotspots are in Africa. Despite their recognized status, these areas remain under threat by civil unrest and encroachment, as well as the introduction of alien species. Resolution of such predicaments has been undermined by administrative problems including lack of funding and inadequate staffing or training.

Changing Conditions

The Atlas paints a vivid picture of the rapid, and in some cases dramatic, transformations taking place on the lands and waters that sustain Africa's people. These include land degradation and desertification, water stress, declining biodiversity, deforestation, increasing dust storms, rising pollution and rapid urbanisation.

Moreover, climate change is likely to intensify these conditions and alter the environment even further. Although Africa emits only four per cent of total global carbon dioxide emissions, its inhabitants are projected to suffer disproportionately from the consequences of global climate change. Given its economic constraints, Africa's capacity to adapt to climate change is relatively low rendering the region exceptionally vulnerable to potential impacts. In many areas, even small changes in precipitation and water availability could have a devastating effect on agricultural output and therefore on food security. As climate change intensifies and its impacts deepen, adaptation will become increasingly difficult. Correspondingly, achieving targets set by the United Nations Millennium Development Goals (MDGs) will become more challenging.

Transboundary Environmental Issues

Chapter Two of the Atlas presents examples of transboundary environmental issues related to shared lands and waters, migrating animals and people, and pollutants that drift over borders of neighbouring countries. It highlights both emerging challenges and success stories in addressing these issues.

Africa has a number of large transboundary ecosystems—areas of land or sea that straddle one or more political boundaries. Some of these are officially protected areas which are extremely important for safeguarding Africa's remarkable animal populations and their habitats, truly one of the wonders of the

Carlo Tancredi/Flickr.com

world. The importance of transboundary protected areas is especially obvious for migratory species, for example the Great Limpopo Transfrontier Park which connects South Africa's Kruger National Park, Mozambique's Limpopo National Park and Zimbabwe's Gonarezhou National Park; and the Ai-Ais/ Richtersveld Transfrontier Park along the cost of South Africa and Namibia. Africa also has 59 international transboundary river basins, which cover about 64 per cent of the region's land area, contain 93 per cent of its total surface water, and are home to 77 per cent of the population. Multinational approaches are essential to conserving these shared areas, underscoring the need for cooperative management strategies among bordering countries.

Another transboundary issue of particular significance is the movement of air pollutants. Africa experiences the most extensive biomass burning in the world. Gaseous molecules emitted as a by-product of biomass burning can travel across national boundaries far from their original source. Fires contribute as much as 35 per cent to ground level ozone formation in Africa, bringing negative health consequences such as respiratory illnesses. The deserts contribute to dust storms that can drift over large areas.

Finally, political and economic difficulties give rise to refugee migrations, causing further pressure on the environment. Impacts resulting from masses of moving people affected by wars, conflicts, food and water shortages, and economic strife in one country may all extend into neighbouring countries. The Atlas displays a map of major refugee settlements scattered across the region, and images of their effects upon an already-stressed environment.

Tracking Progress Towards Environmental Sustainability

Chapter Three is the star attraction of this Atlas. It contains brief profiles of every African country, their important environmental issues, and a description of how each is faring in terms of progress towards the targets under the UN's Millennium Development Goal 7: ensure environmental sustainability. "Before and after" satellite images from every country highlight specific places where change is particularly evident.

This chapter also provides measures of progress towards the Millennium Development Goals' (MDG) environmental targets. The Atlas depicts whether or not each country has increased the percentage of its land area covered by forest, increased the land area covered by designated protected areas, decreased carbon emissions, improved access to clean water and sanitation, and reduced the slum population as a percent of urban population.

Between 1990 and 2004, a large number of countries witnessed real improvements in their efforts towards achieving the MDG targets that measure environmental progress. In many other cases, the improvements have been incremental, but promising (Figure 1). Most countries focused on improving those elements of the environment with direct relevance to human health (e.g., sanitation and water). Over 30 countries improved access to safe water and sanitation, and 23 countries reduced the percentage of people living in slums. A few countries have expanded protected areas. The most evident failure in progress towards the MDGs is in the loss of forest cover.

Figure 1: Progress Towards Environmental Sustainability (1990-2007)

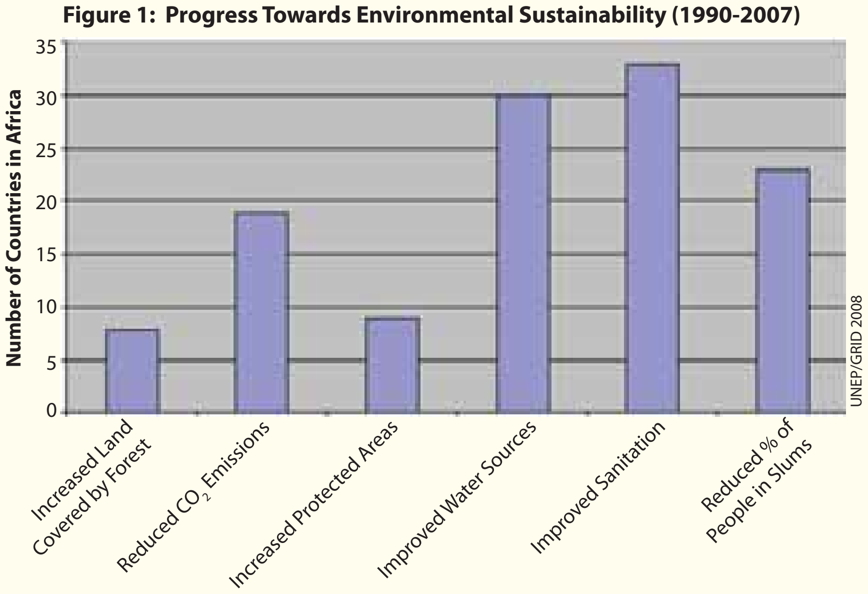
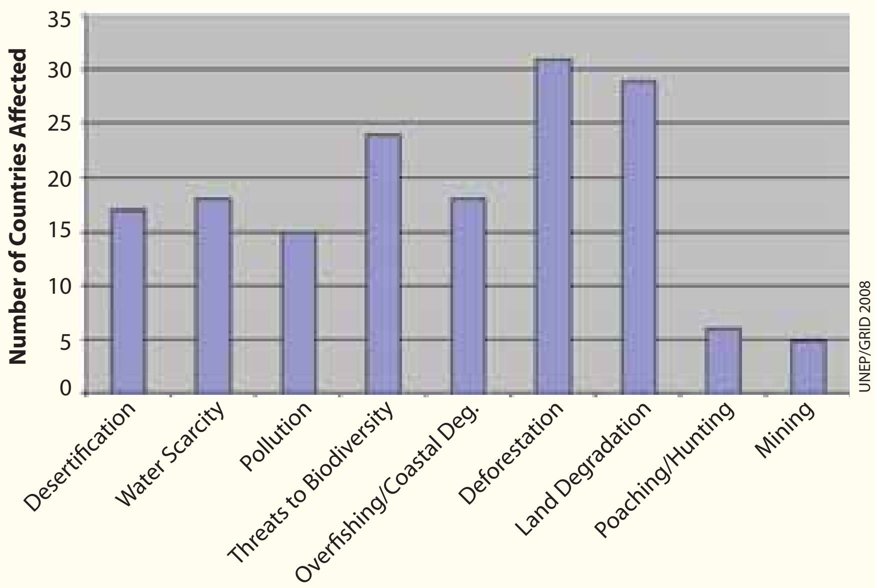


Figure 2: Examples of Important Environmental Issues in Africa



A comprehensive review was conducted using public information and peer-reviewed reports to identify the salient environmental issues each country faces, producing a unique environmental portrait of every African nation (see Table 1, page xiv-xv). The review indicates that deforestation is a main concern in 35 countries, land degradation is a key issue in 32 countries, and threats to biodiversity is a major issue in 34 countries. Overfishing and coastal degradation affect some 23 countries (Figure 2). Desertification, water scarcity, and air and water pollution are also critical issues. Many of the countries' separate issues of concern are interrelated, e.g., desertification and land degradation; and deforestation and threats to biodiversity. Although 'climate change' is not listed as an important issue, it is a possible driving force behind the problems noted.

Africa Then and Now: Images of a Changing Environment

The display of satellite images in Chapter Three provides scientific evidence of some of the scars that human activity and natural processes have left on the African landscape. These include but are not limited to: gouges made by mining operations; pock marks from bore holes; bald patches where forests once stood; and lakes that have completely disappeared. There are also images that reveal more diffuse, but nonetheless troublesome, change such as the swell of grey-coloured cities over a once-green countryside; threats to biodiversity by conversion of nature habitats; the tracks of road networks through forests; the erosion of deltas; and shrinking mountain glaciers.

Despite the numerous challenges, people across Africa are taking significant steps towards protecting and improving their environment. A number of images show the positive results of some of the many efforts undertaken to not only stem environmental destruction, but to reverse it. Success stories include land revitalisation evident by the growth of tree clusters in certain images of Niger, and in one instance, the expansion of wetlands resulting from a restoration project to control flooding in Mauritania.

In addition to well-publicised changes, such as Mount Kilimanjaro's melting glaciers, the shrinking of Lake Chad, and falling water levels in Lake Victoria, photographic evidence of a large number of new environmental hotspots is presented here for the first time. The following ten sites are examples selected from 104 such sites in this Atlas:

Ingenuity: a portable telephone, Uganda

©Paul Myhill

- The pressures of a dramatically growing population are illustrated in changing land use surrounding "W" National Park since the early 1970s. In contrast, the land cover within this protected savannah woodland in southeastern Burkina Faso remains relatively unchanged. The country's most pristine protected area is an important elephant habitat.
- The widening of corridors of deforestation surrounding local roads in the northern area of the Democratic Republic of the Congo since 1975 is depicted with two striking images. New roads for commercial logging and a proposed road improvement project threaten to bring even greater traffic to this biologically diverse rain forest.
- The impact of a population explosion on farmland and forest is clearly seen in contrasting images of the Maradi District in Niger. A large area of savannah woodland was converted to agriculture between 1976 and 2007. In addition, the lack of fallow land among farms in 2007 reveals the intensity of farming in this district.
- In the past half-century or so, the population of Senegal has soared, with much of the growth occurring in its urban areas. The dramatic expansion in the capital, Dakar, between 1942 and 2007 is shown via aerial photography from the 1940's and a recent high-resolution satellite image. Originally occupying a small centre of urban development at the tip of the Cap Vert Peninsula, the Dakar metropolitan area has grown to a population of nearly 2.5 million people spread over the entire area.
- A large portion of southwestern Madagascar's South Malagasy spiny forest has evidently disappeared between 1973 and 2003. Farming, and to a lesser extent, fuelwood gathering, have taken a large bite out of this biodiversity hotspot which is home to several endemic species.
- Protection from grazing in the Sidi Toui National Park in southeastern Tunisia produced a dramatic rebound in the natural ecosystem. Satellite images from 1987 and 2006 show the revival of grasses and scrub inside the park's boundaries, which appear like puzzle pieces dropped onto the otherwise degraded landscape. The Scimitar-horned oryx (*Oryx dammah*), now near extinction, was reintroduced to the park in 1999.
- Greenhouses can be seen replacing desert-fighting trees in images that show the striking transformation of the Souss-Massa Valley in Morocco since 1988. The greenhouses use scarce water resources more efficiently than unprotected agriculture. However, the loss of many of the Argan trees in the valley due to agricultural practices and a depleted water table, has removed one of nature's ways of combating desertification.
- A new management plan for the Itezhi-tezhi Dam in Zambia has helped to restore the natural seasonal flooding of the Kafue Flats. A satellite image from early 2007 captures the height of the first flood season where water was released from the dam to assist natural flooding.
- The remarkable appearance of a chain of lakes in the deserts of Egypt is captured in a series of satellite images beginning in the late 1980s. A massive volume of water was released through Lake Nasser's spillway to prevent flooding damage along the Nile Valley. The New Valley Project will

continue sending Nile water into the desert to support an enormous irrigation scheme.

- A large area of natural "fynbos" vegetation on the northern edge of Cape Town in 1978 is shown being replaced with large farms and suburban development, as Cape Town's growing population pushes outward. The "fynbos" vegetation accounts for 80 per cent of the plant varieties in the Cape Floristic Region, an area with over 6 000 plant species found nowhere else in the world.

Looking Forward

Those who read this Atlas and reflect upon its images will have gained a deeper understanding of the impacts upon Africa's land, plants, animals, air and waters. The pace and scale of change are hard to ignore. The Atlas also contains a few signs of hope in our ability to protect against, and even reverse environmental degradation. As shown throughout, there are inspiring photos of places where people have taken action—where there are more trees than 30 years ago, where wetlands have sprung back, and where land degradation has been stymied. These are beacons we need to follow to ensure the survival of our environment and of the world's peoples.

Observations and assessments of environmental change, as illustrated by this Atlas, not only help gauge how close or far we are from the targets of the United Nations Millennium Development Goals, they also contribute to the knowledge and understanding that are essential for adaptation and remediation. But significant differences exist between developed and developing countries and these realities cannot be ignored. "The developed countries want us to keep the forests, since the air we breathe is for all of us, rich countries and poor countries," said Ogar Assam Effa, 54, a tree plantation director and member of the state conservation board of Nigeria's southeastern Cross Rivers State. "But we breathe the air, and our bellies are empty. Can

Important Environmental Issues in African Countries

Algeria	• Desertification • Water Scarcity • Pollution
Angola	• Threats to Biodiversity • Access to Potable Water • Overfishing and Coastal Degradation
Benin	• Deforestation • Desertification • Threats to Biodiversity
Botswana	• Overgrazing and Desertification • Water Scarcity and Urbanisation • Wildlife of the Okavango Delta
Burkina Faso	• Water Scarcity • Land Degradation and Desertification • Deforestation
Burundi	• Land Availability and Degradation • Deforestation • Lake Tanganyika Ecosystems and Fisheries
Cameroon	• Land Degradation and Deforestation • Over-harvesting of Biological Resources • Degradation of Coastal and Marine Ecosystems
Cape Verde	• Soil Erosion and Land Degradation • Threats to Biodiversity
Central African Republic	• Subsistence and Commercial Poaching • Deforestation and Land Degradation • Diamond Mining and Pollution
Chad	• Drought • Desertification and Land Degradation • Access to Water and Sanitation
Comoros	• Deforestation and Soil Erosion • Threats to Coastal Ecosystems
Congo	• Wildlife Poaching • Threats to Coastal Ecosystems and Inland Wetlands • Deforestation
Congo, Democratic Republic of the	• Wildlife Poaching • Deforestation • Mining and Ecosystem Degradation
Côte d'Ivoire	• Deforestation • Threats to Biodiversity • Threats to Coastal Ecosystems
Djibouti	• Water Scarcity • Land Availability and Desertification • Marine Resources and Pollution
Egypt	• Urbanisation and Pollution • Soil Erosion and Land Degradation • Threats to Biodiversity
Equatorial Guinea	• Oil Production and Coastal Degradation • Deforestation • Bushmeat and Hunting on Bioko Island
Eritrea	• Water Stress • Land Availability and Degradation • Deforestation and Threats to Biodiversity
Ethiopia	• Water Availability and Access to a Safe Source • Livestock, Soil Erosion and Land Degradation • Threats to Biodiversity and Endemism
Gabon	• Threats to Biodiversity • Coastal Degradation and Industrial Pollution • Lack of Sanitation and the Urban Environment
Gambia	• Drought and Agricultural Productivity • Threats to Forest and Wetland Ecosystems • Overfishing and Coastal Erosion
Ghana	• Deforestation • Land Degradation and Coastal Erosion • Overfishing and Reduced Water Volume in Lake Volta
Guinea	• Deforestation and Refugees • Overfishing and Destruction of Mangrove Forests • Land Degradation
Guinea-Bissau	• Deforestation • Cashew Farming and Soil Erosion • Threats to the Bijagos Biosphere Reserve
Kenya	• Water Scarcity and Pollution • Desertification and Deforestation • Degradation of Freshwater Ecosystems
Lesotho	• Degradation of Rangelands • Threats to Biodiversity in the Lesotho Highlands • Water Resource Management and Pollution
Liberia	• Deforestation and Rubber Plantations • Threats to Biodiversity • Water Pollution
Libyan Arab Jamahiriya	• Water Scarcity • Land Conversion and Desertification • Oil Production and Pollution

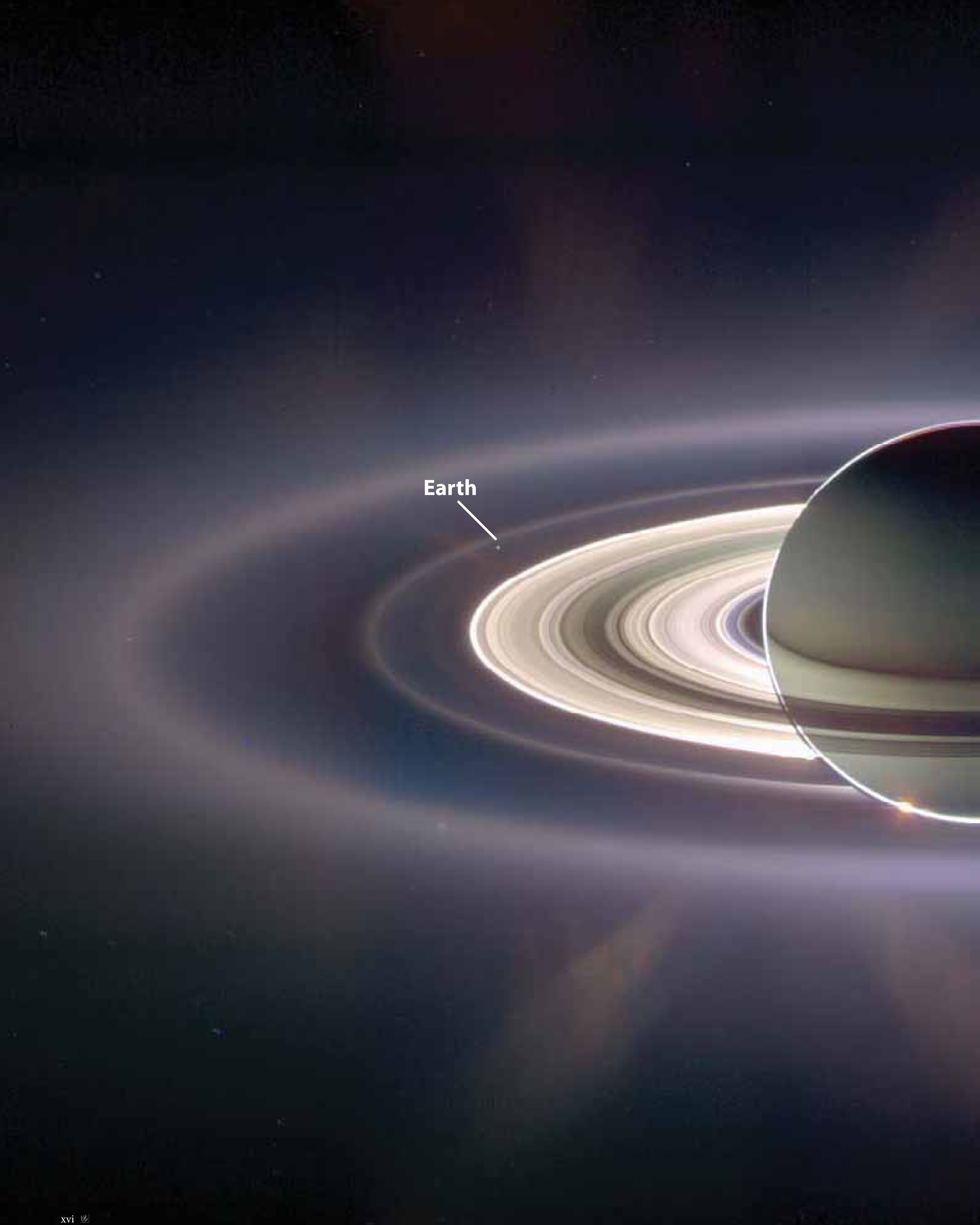
air give you protein? Can air give you carbohydrates?" he asked. "It would be easy to convince people to stop clearing the forest if there was an alternative" (Quoted from the chicagotribune.com—Rain Forests Fall at 'Alarming' Rate—By Edward Harris, Associated Press Writer February 3, 2008).

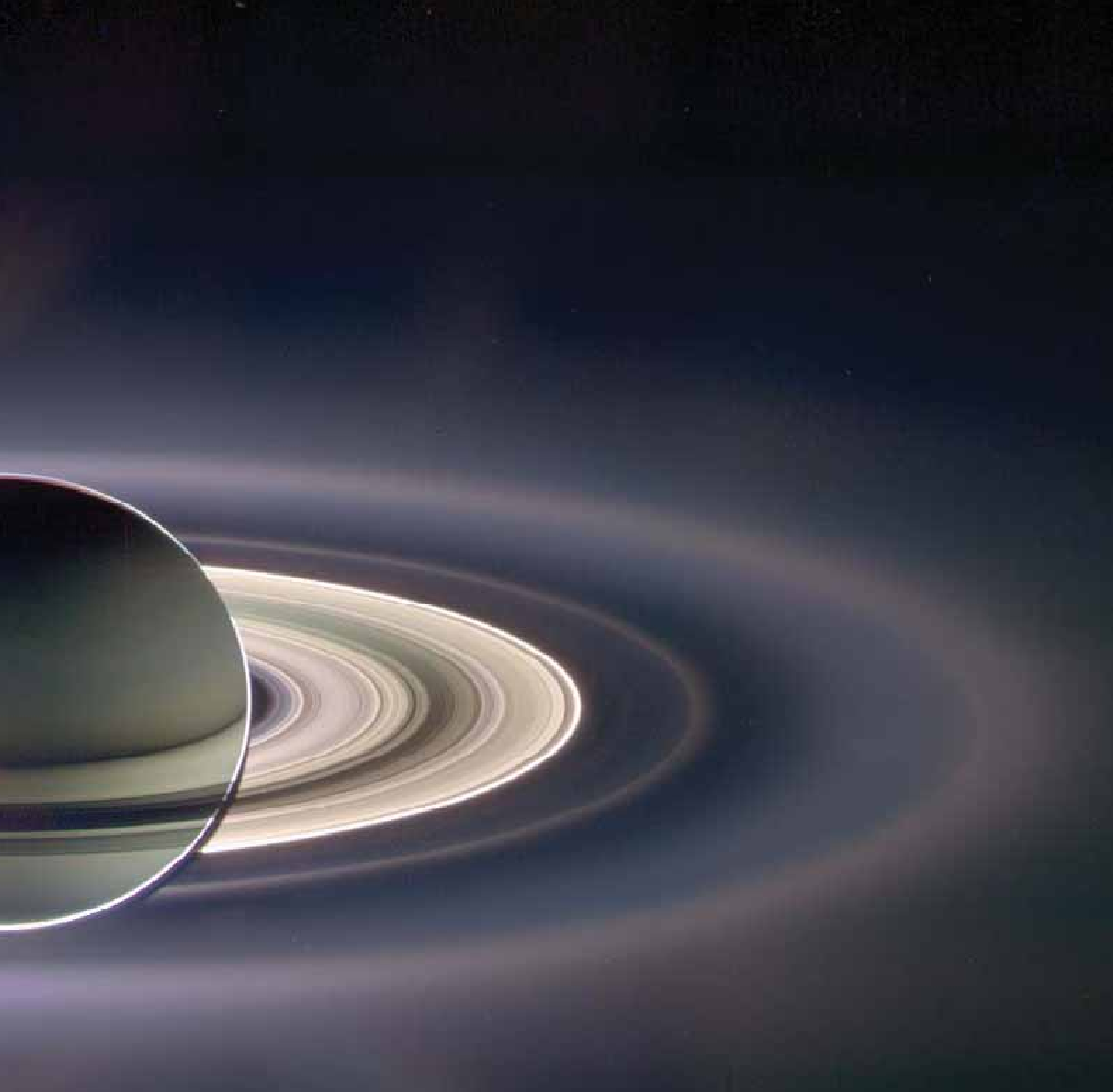
As for the people whose footprints we see so strikingly stamped on the pages, to some degree their ability to choose plays a role in the choices ultimately made. As Nelson Mandela, Nobel Laureate and Former President of the Republic of South Africa, tersely put it, "... For me, survival is the ability to cope with difficulties, with circumstances, and to overcome them."

Alleviation of poverty is a key step towards establishing an environment in which people are empowered to make sustainable choices. The economy of Africa can be expanded beyond its agricultural base to increased investment in the services and manufacturing sectors. Development for both local consumption and exports, balanced with environmental preservation, can bring Africa to a position where its wealth of natural resources is more accurately reflected in the economic status of its peoples. Coupled with education and training, and empowerment of women, a broadened economy in Africa would enhance local employment prospects as well as economic opportunities to trade in world markets.

Many factors, such as governmental policies, cultural and social milieu, play a role in whether we will achieve global environmental sustainability. But as is the case in environmental systems, all the pieces are interconnected. Once people are secure enough to choose, one can, if wise, opt for the land and resource-use alternatives that are sustainable and regenerative. In the absence of such opportunities, it is likely that people will continue to make expedient choices for their survival, which, voluntarily or involuntarily, can result in environmental degradation.

Madagascar	• Soil Erosion • Endemism and Threats to Biodiversity • Deforestation
Malawi	• Land Scarcity and Soil Erosion • Deforestation for Fuelwood • Water Pollution and Aquatic Biodiversity
Mali	• Desertification and Drought • Water Availability and Pollution • Threats to Biodiversity
Mauritania	• Desertification and Deforestation • Iron Mining • Fisheries and Coastal Ecosystems
Mauritius	• Coastal Water Pollution • Threats to Biodiversity
Morocco	• Drought and Desertification • Water Scarcity • Pollution
Mozambique	• Water Access and Natural Disasters • Land Use • Protecting Wildlife and Forests
Namibia	• Land Degradation and Desertification • Aridity and Water Scarcity • Threats to Biodiversity
Niger	• Desertification and Deforestation • Threats to Wildlife • Environmental Consequences of Mining
Nigeria	• Desertification • Deforestation and Threats to Biodiversity • Oil Pollution
Rwanda	• Population Pressure on Land • Soil Erosion and Sedimentation • Deforestation and Threats to Biodiversity
São Tomé and Príncipe	• Degradation of Forest Ecosystems • Threats to Biodiversity
Senegal	• Urban Pollution • Deforestation • Coastal Wetlands and Fisheries Over-exploitation
Seychelles	• Severe Weather and Coastal Erosion • Loss of Mangrove Forests and Protection of Coral Reefs
Sierra Leone	• Deforestation • Land Degradation • Overfishing
Somalia	• Threats to Biodiversity • Desertification, Overgrazing and Deforestation • Water Scarcity and Drought
South Africa	• Water Availability and Quality • Land Degradation • Threats to Biodiversity
Sudan	• Soil Erosion and Land Degradation • Poaching and the Ivory Trade • Forests and Fisheries
Swaziland	• Population Encroachment and Land Degradation • Irrigation and Soil Degradation • Threats to Biodiversity and Invasive Alien Species
United Republic of Tanzania	• Water Pollution and Aquatic Ecosystems • Land Degradation and Deforestation • Threats to Biodiversity and Ecosystems
Togo	• Land Degradation and Deforestation • Threats to Aquatic Ecosystems • Threats to Biodiversity
Tunisia	• Land Degradation and Desertification • Water Scarcity • Air and Water Pollution
Uganda	• Land Degradation and Deforestation • Habitat Degradation and Threats to Biodiversity • Water Availability and Pollution
Western Sahara (non-self-governing territory)	• Land Use and Food Production • Water Resources • Marine Fisheries
Zambia	• Copper Mining and Water and Air Pollution • Deforestation and Wildlife Depletion • Urbanisation
Zimbabwe	• Land Degradation and Deforestation • Water Access and Drought • Wildlife Poaching and the Black Rhinoceros


Earth



A View of Earth from Space

Seen through the rings of Saturn, Earth appears as little more than a shining dot in this satellite composite image taken by the Cassini spacecraft in 2006. At this distance, the nature of Earth is obscure. A closer view, however, reveals that our planet is unique in the solar system, home to seven major continents scattered across a network of oceans. Each of these continents, too, is unique. The second largest—Africa—spans the equator and stretches from northern temperate to southern temperate zones. Understanding Africa requires an understanding of its vastly diverse ecosystems, as well as the many challenges its people face both today and tomorrow.

Source: CICLOPS/NASA

Mark Knobil/Flickr.com

A new bride, Ethiopia

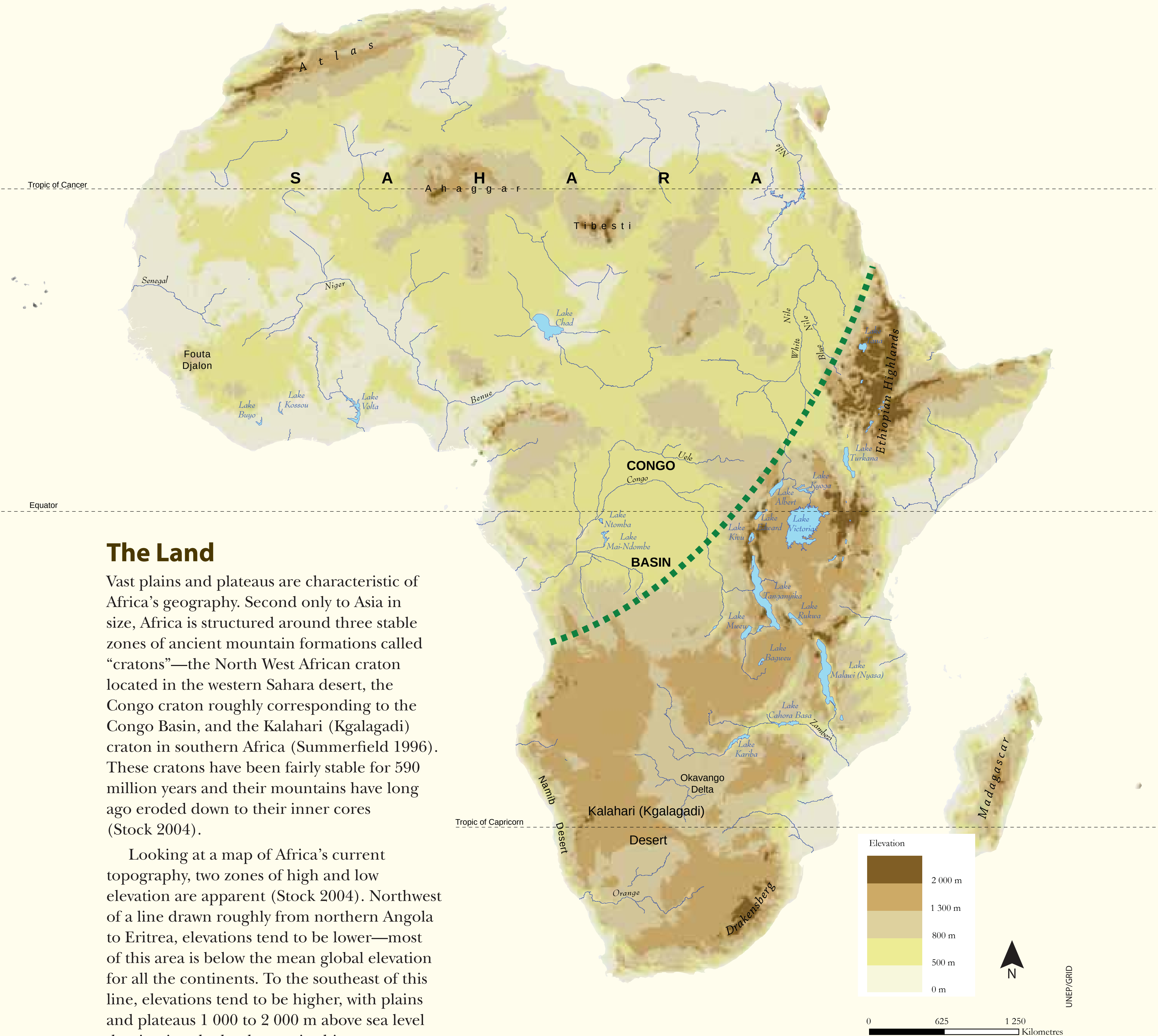
Chapter 1

Africa

LMODIS 500m 32-day Composite. NASA 2001, UNEP/GRID Sioux Falls

Introduction

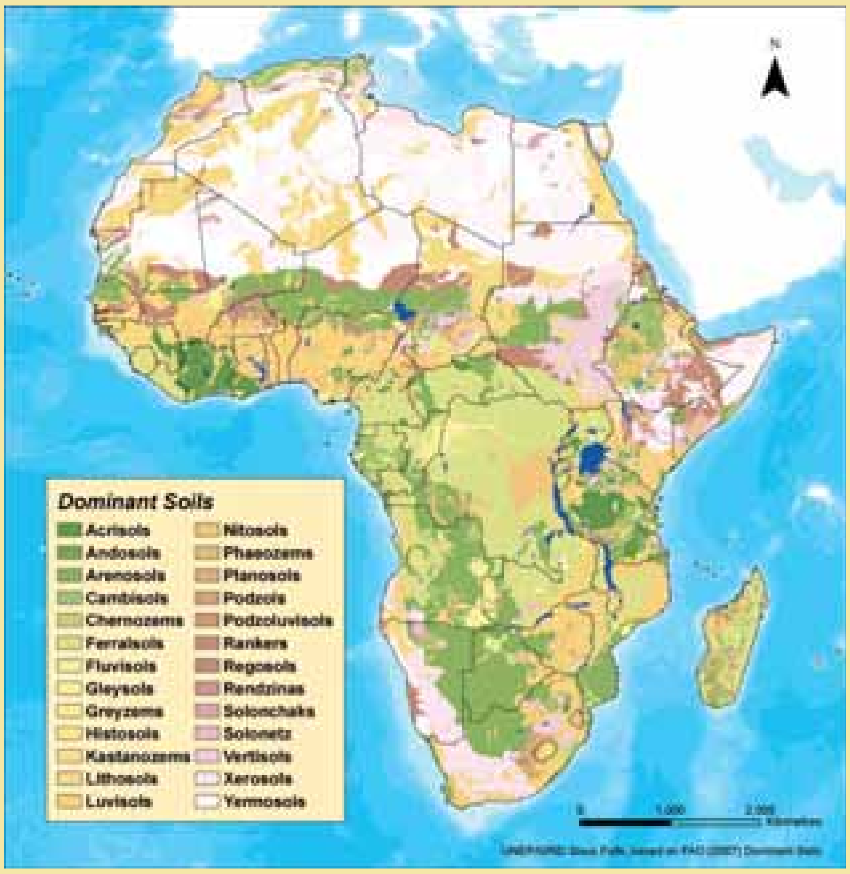
Geography is key to understanding any region of the world. Africa accounts for one-fifth of Earth's total land area. Widely regarded as the site where the human race originated, in 2007 Africa was home to more than 965 million people. The continent's population has undergone great change over time. That changing population has, in turn, altered African landscapes and ecosystems. While environmental change is not new to Africa, the pace of change has accelerated, as it has in many other parts of the world. Examining specific examples of change in Africa can help shed light on the causes of change, the problems engendered, and possible solutions. Earth observations, particularly those made using the tools of satellite remote sensing, are essential to such an endeavour.

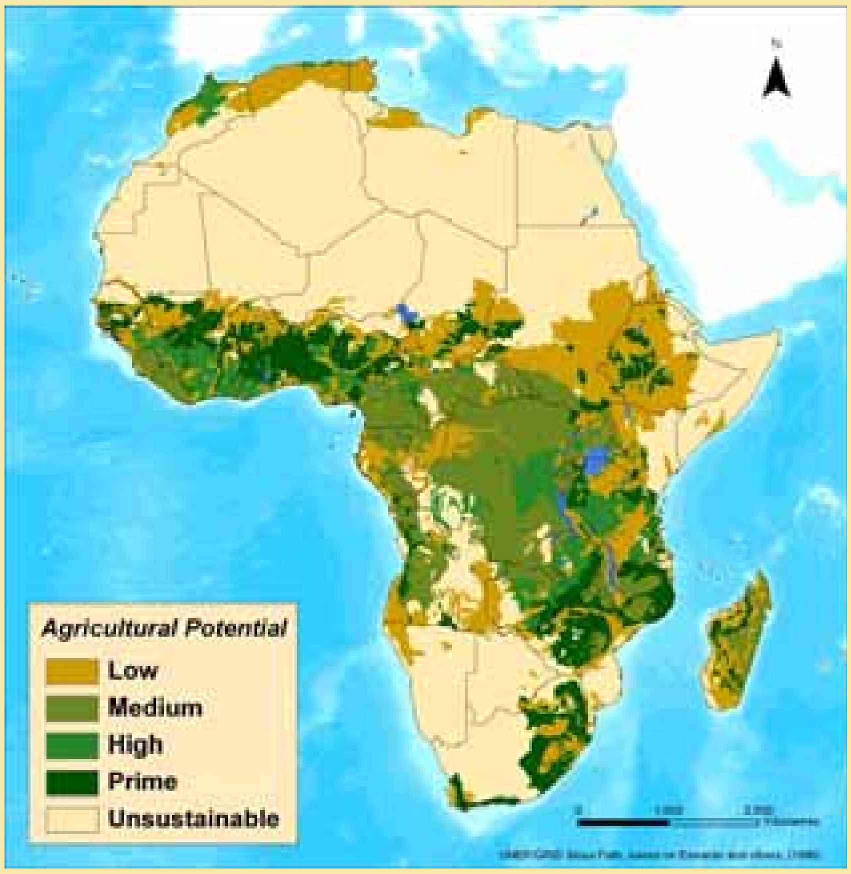


The Land

Vast plains and plateaus are characteristic of Africa's geography. Second only to Asia in size, Africa is structured around three stable zones of ancient mountain formations called "cratons"—the North West African craton located in the western Sahara desert, the Congo craton roughly corresponding to the Congo Basin, and the Kalahari (Kgalagadi) craton in southern Africa (Summerfield 1996). These cratons have been fairly stable for 590 million years and their mountains have long ago eroded down to their inner cores (Stock 2004).

Looking at a map of Africa's current topography, two zones of high and low elevation are apparent (Stock 2004). Northwest of a line drawn roughly from northern Angola to Eritrea, elevations tend to be lower—most of this area is below the mean global elevation for all the continents. To the southeast of this line, elevations tend to be higher, with plains and plateaus 1 000 to 2 000 m above sea level dominating the landscape; in this zone, most of the land lies above mean global elevation of the continents (Nyblade and Robinson 1994). In a significant respect, everything follows from these land forms—their relief, elevation, latitude, and scale underlie all that is Africa.





Soils

Arable land is not evenly distributed across Africa. Over half of Africa's land is either desert or is otherwise unsuited to agriculture. A further quarter of Africa's land area can be classified as having only medium to low potential, often requiring extensive management to be farmed sustainably (Eswaran and others 1996). Many soils classified as medium-potential are the characteristic laterite soils which are weathered, leached of minerals and nutrient-poor, requiring significant nutrient inputs for sustainable farming. Shifting cultivation, which uses the burning of natural vegetation to supply the needed nutrients, is the traditional practice in regions where such soil types predominate (Stock 2004). Chernozem soils located in and around the Congo Basin as well as in Sierra Leone and Liberia in western Africa, account for much of this land with moderate agricultural potential (FAO 2007). Along the margins of Africa's deserts, physical characteristics, acidity, alkalinity, salinity, or erosion generally result in soils which are of low agricultural potential and require careful management.

Some soils are ideally suited to agriculture in Africa. Around ten per cent of the farmland in Africa has deep permeable layers, adequate nutrients, and suffers little or no moisture stress (Eswaran and others 1996). Many of these prime agricultural lands are located south of the Sahel in Senegal, Mali, Burkina Faso, Ghana, Togo, Benin, Nigeria, and Chad. Areas of prime agricultural lands can also be found in southern Africa in countries such as Mozambique, Zambia, Zimbabwe, and South Africa. These resilient and productive farmlands are primarily soils designated by the Food and Agriculture Organization (FAO) as "andosols", mostly "mollic andosols" (FAO 2007).

Another seven per cent of Africa's agricultural land requires more management than prime farmland, but nevertheless has high agricultural potential. The majority of these areas have one of four major soil types. Large concentrations of glossic chernozems are found in Cote d'Ivoire, southern Ghana, and United Republic of Tanzania. In Democratic Republic of the Congo and Nigeria there are large areas of humic andosols. A large region of calcic chernozem is found in Zambia, while northern Morocco has a large area of mollic andosol.

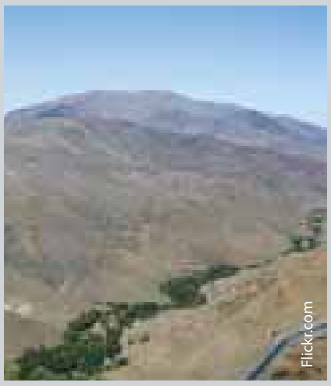
Deserts

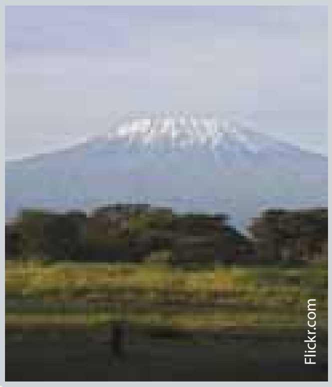
Arid lands cover approximately 60 per cent of Africa. The prominent deserts—the Sahara, the Namib, and the Kalahari (Kgalagadi)—are generally concentrated around the Tropic of Cancer in North Africa and Tropic of Capricorn in southern Africa. Droughts during the past three decades and degradation of land at the margins of the deserts, particularly the Sahara, have raised concerns of expanding desertification (Herrmann and Hutchinson 2005). The full nature of this problem and the degree to which human activities and climate change are contributing to it are still being determined. However, the negative impact that these degraded lands have on the livelihoods of the people who attempt to utilise them is well known (Smith and Koala 1999).

A view across the Namib desert of southwestern Africa

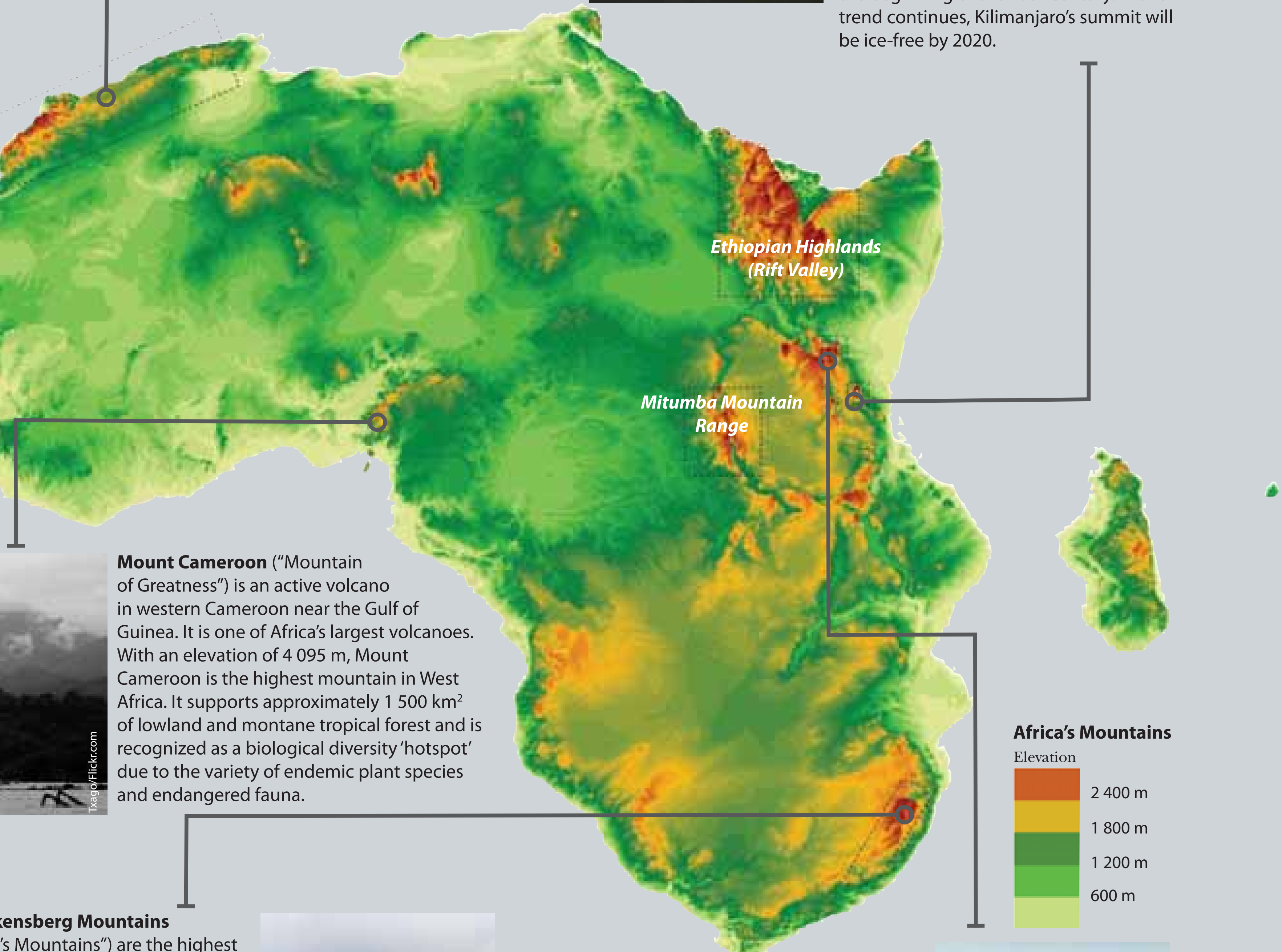
Flickr.com

The **Atlas Mountains** are the most northerly of Africa's mountain chains, extending 1 610 km across Morocco, Algeria, and Tunisia. To the north of this mountain chain lie coastlines bordering the Mediterranean Sea and Atlantic Ocean. To the south sprawls the Sahara Desert. The Atlas Mountains were formed by converging African and Eurasian tectonic plates. The region contains some of the world's largest and most diverse mineral resources, most of which remain largely untouched.



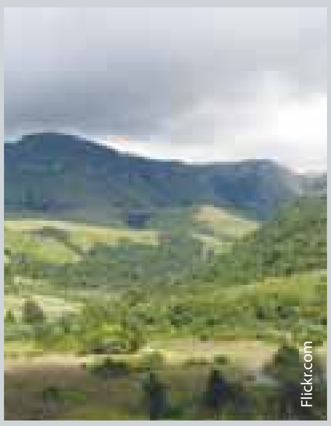


Mount Kilimanjaro is a volcano in East Africa. At 5 895 m, Uhuru Point on the mountain's summit is the highest point on the African continent. Kilimanjaro National Park is a World Heritage Site, and together with Kilimanjaro Forest Reserve, is renowned for its natural beauty and biodiversity, including 140 mammal species, many of which are endangered. The glaciers on the top of Kilimanjaro have been disappearing since the beginning of the 20th century. If this trend continues, Kilimanjaro's summit will be ice-free by 2020.



Mount Cameroon ("Mountain of Greatness") is an active volcano in western Cameroon near the Gulf of Guinea. It is one of Africa's largest volcanoes. With an elevation of 4 095 m, Mount Cameroon is the highest mountain in West Africa. It supports approximately 1 500 km^2 of lowland and montane tropical forest and is recognized as a biological diversity 'hotspot' due to the variety of endemic plant species and endangered fauna.

The **Drakensberg Mountains** ("Dragon's Mountains") are the highest in southern Africa, rising to an elevation of 3 482 m at Thabana Ntlenyana. Geologically, the Drakensberg Mountains are a remnant of the original African plateau. The uKhahlamba, or Drakensberg Park, is a World Heritage site well known for its diversity of habitats. The site protects a high level of endemic and globally threatened species, especially birds and plants.

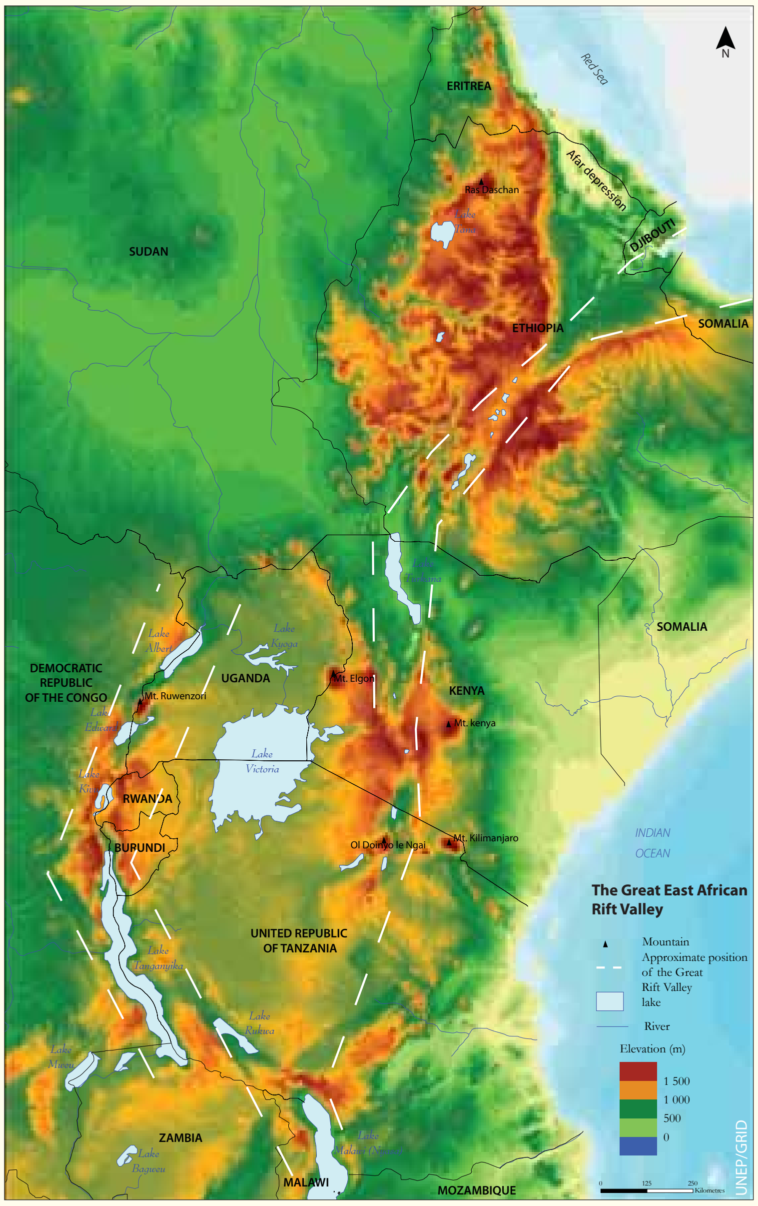


Mount Kenya, another World Heritage site, was formed by intermittent volcanic eruptions. At 5 199 m, it is the second highest peak in Africa. The entire mountain is deeply dissected by glacier-carved valleys radiating from the peaks. Approximately 2 000 km^2 of forests cover most of Mount Kenya. These forests provide invaluable natural resources and perform important environmental services such as providing the water catchment area of the Tana River, from which more than 50 per cent of Kenya's electricity is generated.

Other sources: National Geographic 2003; Peakware-World Mountain Encyclopedia 2007., LIMBE Botanical and Zoological Gardens 2002., NASA 2004, NASA 2005, UNESCO n.d.a, UNEP-WCMC 2008.

Mountains

Mountains in Africa generally occur as widely scattered exceptions to the plateaus and plains that dominate the landscape (Taylor 1996). At the northwestern edge of the continent are the Atlas Mountains, formed by the collision of the African and Eurasian tectonic plates (Taylor 1996). Extending northeast to southwest, they rise to a maximum height of 4 167 m (CIA 2007a). Across the continent, at its southern edge, the Drakensberg Mountains rise to 3 482 m at their highest point—Thabana Ntlenyana—known in Zulu as uKhahlamba, the "barrier of spears" (CIA 2007a). In East Africa, a number of mountain ranges surround the Eastern and Western Rifts including Kilimanjaro and Mount Meru in the United Republic of Tanzania, as well as Mount Kenya in Kenya, Mount Elgon on the border of Kenya and Uganda, and the Rwenzori Mountains, located on the border of Uganda and the Democratic Republic of the Congo (Taylor 1996). Many of East Africa's mountains are volcanoes created as magma rose through cracks created by the spreading crust (Kious and Tilling 1996).



The Great Rift Valley

East Africa's Great Rift Valley extends over 5 500 km, from the Somalia-Ethiopia border at the Red Sea, southwest toward Kenya, then south to Mozambique in southern Africa. Near where the Rift Valley crosses the equator it divides into the Eastern and Western Rifts, on either side of Lake Victoria (Nyamweru 1996). The Great Rift Valley—which includes the Mitumba Mountain Range—is one of Africa's best-known geological features. The complex geological processes associated with the Rift Valley are responsible for the creation of several of East Africa's largest lakes as well as much of its topography. The rugged escarpments bordering the Rift Valley are especially dramatic in Kenya and Ethiopia. Guraghe Escarpment in Ethiopia, for example, rises 1 000 m above the Valley floor (Nyamweru 1996). The Rift Valley is the result of spreading, or rifting, between tectonic plates, which, if it continues, may ultimately transform the Horn of Africa into an island in the Indian Ocean (Kious and Tilling 1996).

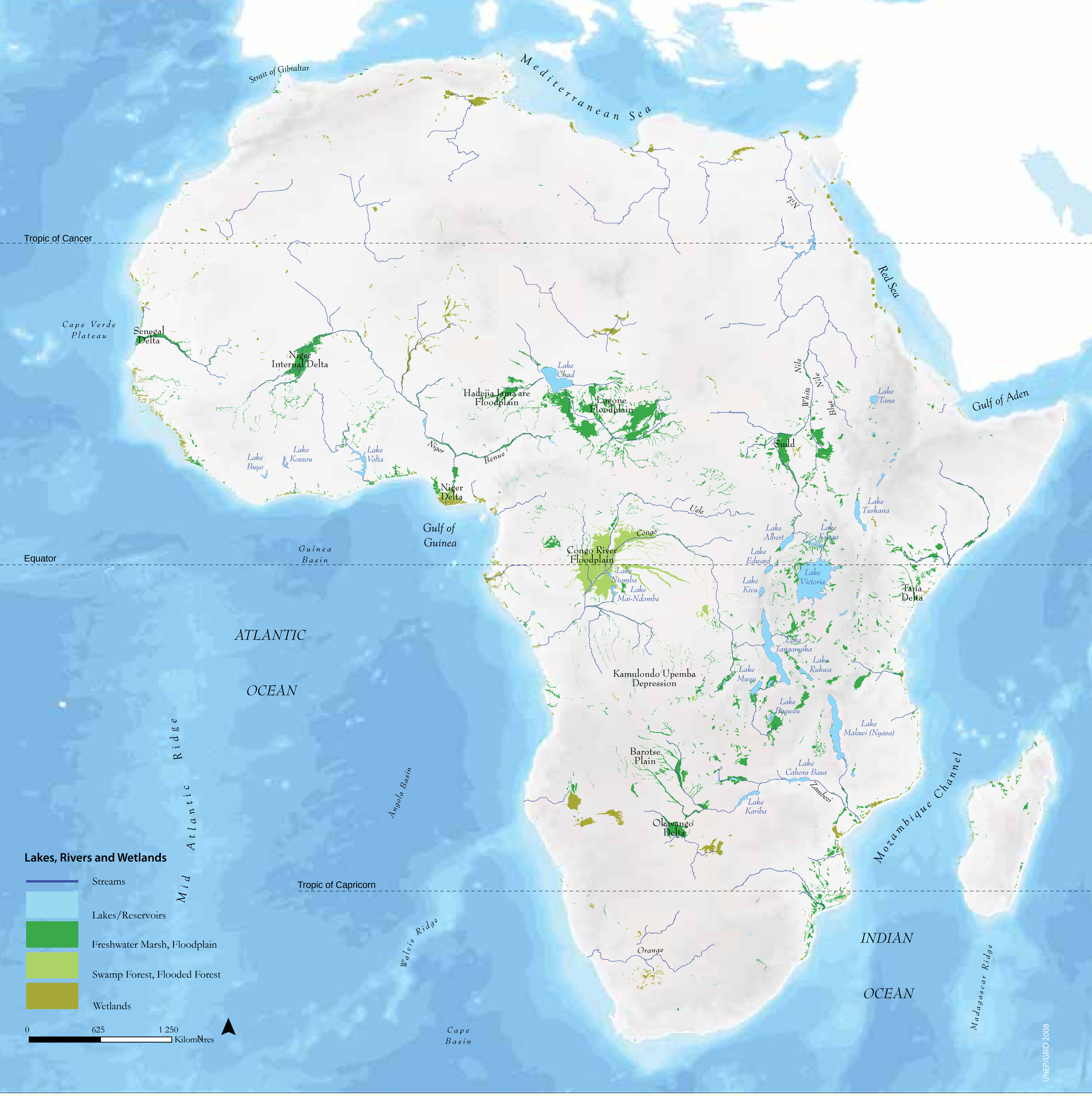
Overlooking the Rift Valley, Kenya

Coasts

Thirty-nine African countries, including the island nations, border an ocean. The continent's coastline is a mix of diverse ecosystems, including estuaries, deltas, barrier islands, lagoons, wetlands, mangroves, and coral reefs (Watson and others 1997). On the whole, the coastline is relatively straight, with a low-lying coastal belt and narrow continental shelf and few large natural harbours (Orme 1996). The major exceptions are located in West Africa from Senegal to Liberia, where coastal submergence has created deep inlets at the mouths of several rivers (Finkl 2004). This general lack of deep-water ports contributed to Africa's isolation in centuries past (Orme 1996).

The warm ocean currents that bathe Africa's eastern coast create ideal conditions for mangrove and coral reef ecosystems in many places (Orme 1996). In contrast, currents running along the continent's western coast are predominantly cold (Orme 1996). The Benguela Current that runs offshore from Angola, Namibia, and South Africa is a coastal upwelling of nutrient-rich cold water that creates one of the most biologically diverse marine environments in the world (O'Toole and others 2001).

Cape of Good Hope, South Africa



Water Resources

Africa is the world's second driest continent, after Australia (Revenga and Cassar n.d.). Freshwater is unevenly distributed across countries and regions due in large part to the variability of rainfall in different climatic zones. The countries that use the most water by volume are Egypt, Sudan, Madagascar, South Africa, Morocco, Nigeria, and Mali, but these are not necessarily the most water-rich nations. Egypt, for example, is in a climatic zone of low water availability, but is Africa's largest water consumer (61.7 km^3 per year). About 75 per cent of the African population relies on groundwater as its major source of drinking water, especially in northern and southern Africa. However, groundwater represents only about 15 per cent of the continent's total renewable water resources (UN 2006a).

Renewable water resources for the whole of Africa amount to about 3 930 km^3. That is less than nine per cent of global renewable water resources (Frenken 2005).

Rivers

The rivers of Africa are notable for their variety, which follows from the variation of rainfall across the continent—near 0 mm/yr in parts of the Sahara to 9 950 mm/yr near Mount Cameroon (Walling 1996). Many of the rivers in Africa show dramatic seasonal variability and inter-annual variation as well (Walling 1996). More than 1 270 large dams have been built along the continent's many rivers (World Commission on Dams 2001), altering the sedimentation and flooding patterns (Walling 1996). Africa's rivers tend to carry less sediment than rivers on other continents, due primarily to an overall lack of both tectonic activity and steep gradients and rapid water flows needed to transport sediment (Walling 1996).

Historically, Africa's rivers served as transportation arteries, fisheries, and water sources for irrigation for indigenous populations. The Congo, Niger, and other major rivers were also used by colonial Europeans as avenues into the African heartland (Chi-Bonnardel 1973).

Congo River, Democratic Republic of the Congo

LM TP/Flickr.com

Lake Bosumtwi, Ghana

Stig Nygaard/Flickr.com

Lakes

Africa, particularly East Africa, has numerous lakes that support important fisheries which provide livelihoods for millions of people and contribute significantly to the food supply (UNEP 2006c). Among these lakes are Lake Victoria, third largest in the world by area, and Lake Tanganyika, third largest by volume (WM Adams 1996). In addition to Africa's natural lakes, there are many large dams. The 53 largest of these account for 90 per cent of the total amount of water retained in reservoirs on the continent (Frenken 2005).

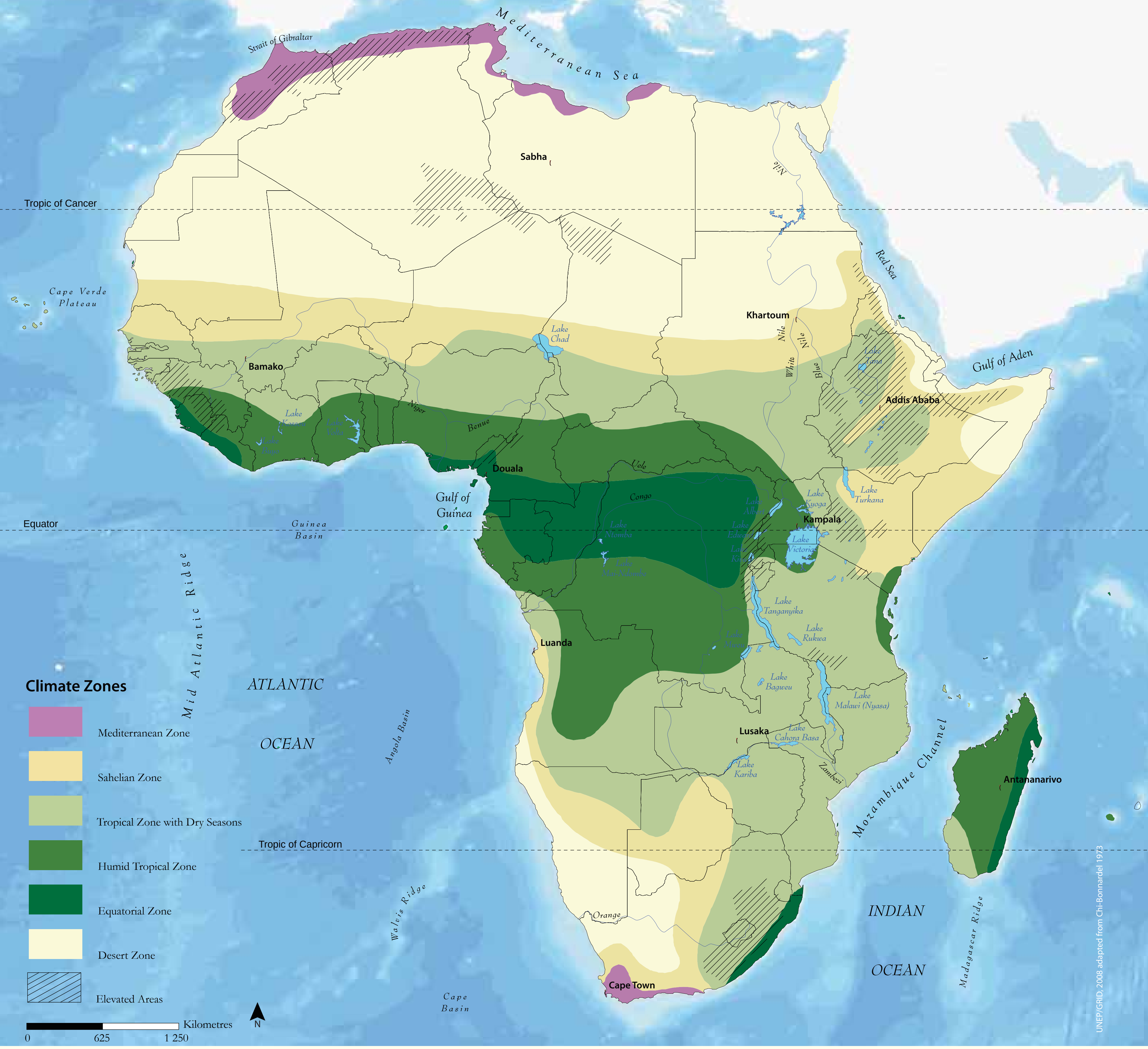
On a continental scale, Africa is second only to Asia in the global capture of inland fish (FAO 2006). Nile perch (*Lates niloticus*), and cichlids such as tilapia and cyprinids, represent the majority of the catch in Africa's top inland fishing nations, which include Uganda, United Republic of Tanzania, Egypt, Kenya, and Democratic Republic of the Congo (FAO 2006). As with many of Africa's natural resources, its lakes are directly linked to the livelihoods of many of its people and the economic well-being of its countries.

Wetlands

Wetlands are areas that are regularly saturated by surface water or groundwater such as swamps, bogs, fens, marshes, and estuaries. Wetlands are characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions (EPA 2006). Wetlands are important for the resources they contain and the ecological functions they provide. In Africa, wetlands cover about one per cent of the continent's total surface area, and are found in virtually all countries.

Wattled cranes in the Okavango, Botswana

Jean-Louis Vandevivère/Flickr.com

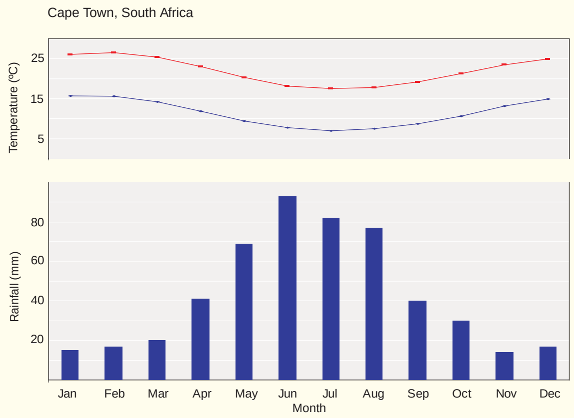


Climate Zones

The equator lies very near to the halfway mark of the African continent; it is 37 degrees from Africa's northernmost point and 35 degrees from its southernmost tip. Consequently, Africa's climate is predominantly tropical, with the majority of the continent having mean temperatures above 21 degrees Celsius for nine months of the year (Goudie 1996). Moving away from the equator, climate zones vary in nearly mirror-image patterns to the north and south. These patterns are not interrupted by the climatic influence of long mountain ranges comparable to those that divide the Americas and Eurasia (Goudie 1996).

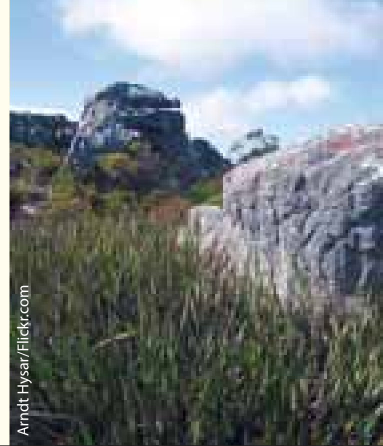
The primary determinant of precipitation in Africa is the air movement surrounding the Inter-Tropical Convergence Zone (ITCZ) and associated equatorial trough (Griffiths 1966). In simple terms, winds are pushed out from two sub-tropical high-pressure belts toward the equator, where they meet and force air and moisture upward. This upward movement cools the air, forcing the moisture out as precipitation. The now dry air cycles back toward the subtropics where it descends, producing arid climates at latitudes approximately 20 degrees north and south of the equator.

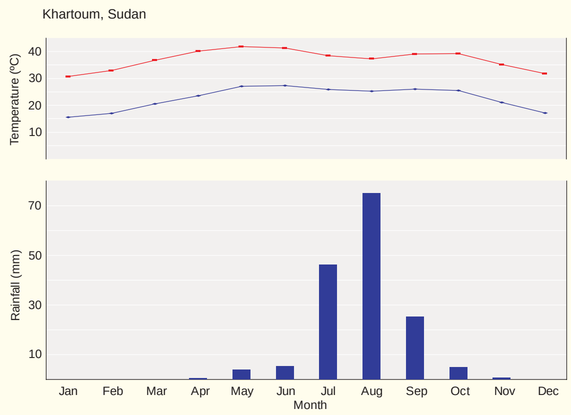
The mean temperature in the hottest and coldest months of the year varies little for most of equatorial Africa. For instance, mean temperature during summer and winter months at Barumbu, Democratic Republic of the Congo, varies only 1.4 degrees Celsius (Griffiths 2005). However, away from the equator and the coast, seasonal variation can be dramatic. In the heart of the Sahara Desert there can be up to a 24 degree Celsius difference between the mean temperatures of the coldest and hottest months (Griffiths 2005). Daily temperature variability is primarily influenced by proximity to a coast; generally, the further inland, the more extreme the variation (Griffiths 2005). Deep in the Sahara, the daytime and nighttime temperatures vary by an average of 20 degrees Celsius (Griffiths 2005).



Mediterranean Zone

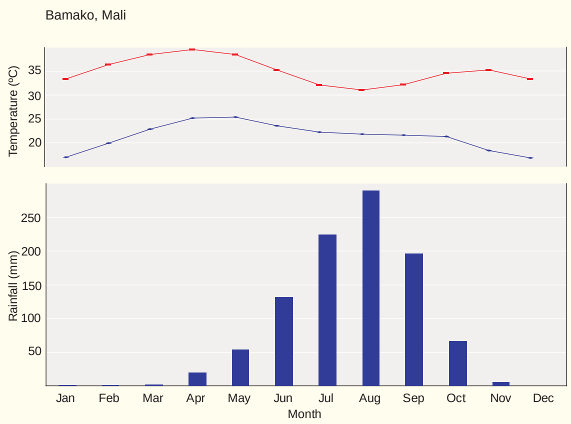
At the northern and southern extremes of Africa, there are zones of Mediterranean climate with hot dry summers and wet mild winters (Chi-Bonnardel 1973). A few locations receive as much as 700 mm of precipitation, but most receive less than 500 mm. In the summer, temperatures typically average around 25 degrees Celsius; however more inland locations often see freezing temperatures in the winter, especially at higher elevations (Chi-Bonnardel 1973).





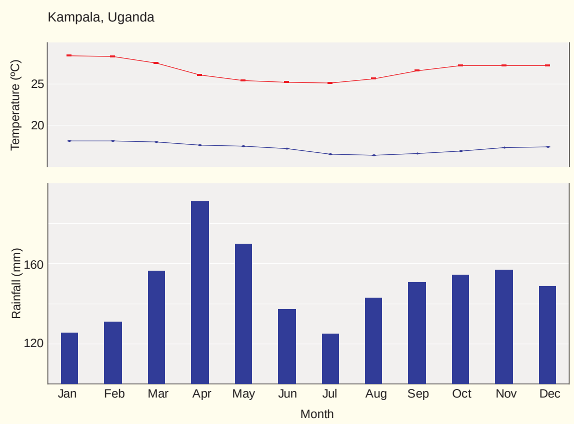
Sahelian Zone

Only about 250 to 500 mm of rain falls in the Sahelian climate zone (Stock 2004; FAO 2001). With considerable seasonal and inter-annual variation in rainfall, the potential for rain-fed agriculture is very low (IWMI 2001). Average annual temperatures in areas adjacent to the Sahara and in the Horn of Africa range from 26 to 29 degrees Celsius, with somewhat cooler temperatures in elevated areas (CRES 2002). Before the spring rains, daily maximum temperatures often reach 40 degrees Celsius (Chi-Bonnardel, 1973). Average annual temperatures in the Sahelian climate zones adjacent to the Namib Desert are several degrees cooler (CRES 2002).



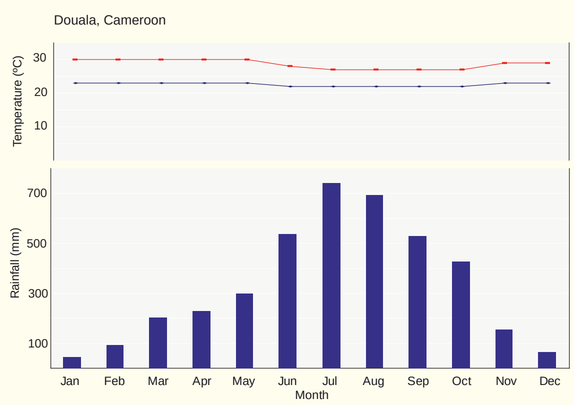
Tropical Zone With Dry Seasons

To the north and south of the humid tropical climate zone are zones of tropical climate, characterised by long dry seasons, where precipitation and temperature are more seasonal (Goudie 1996). Here, dry seasons last more than six months and tend to increase in length with distance from the equator (Chi-Bonnardel 1973). Annual average precipitation is generally 600 to 1 200 mm (FAO 2001) with pronounced inter-annual variation (Goudie, 1996). Both annual and daily temperatures vary more here than in the climate zones closer to the equator (Stock 2004).



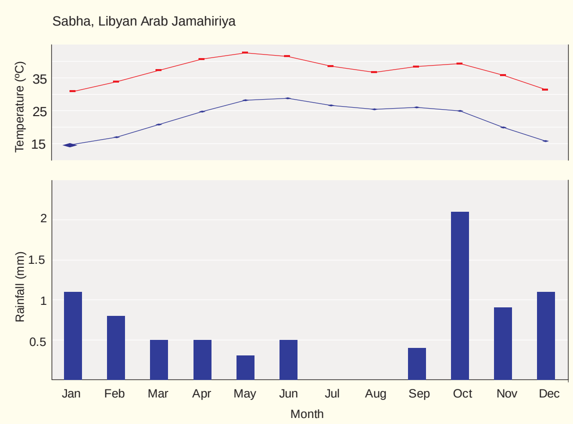
Humid Tropical Zone

The humid tropical zone exhibits peaks in precipitation and a short dry season. Some areas in this zone experience two rainfall maxima; the first occurs as weather systems associated with ITCZ migrate toward higher latitudes, while a second occurs as those weather systems move back toward the equator and toward the lower latitudes (Stock 2004). The average annual rainfall generally ranges between 1 100 mm and 1 800 mm in this zone (FAO 2001). Temperatures are relatively high, but with somewhat more seasonal variation than temperatures in the equatorial zone (Goudie 1996).



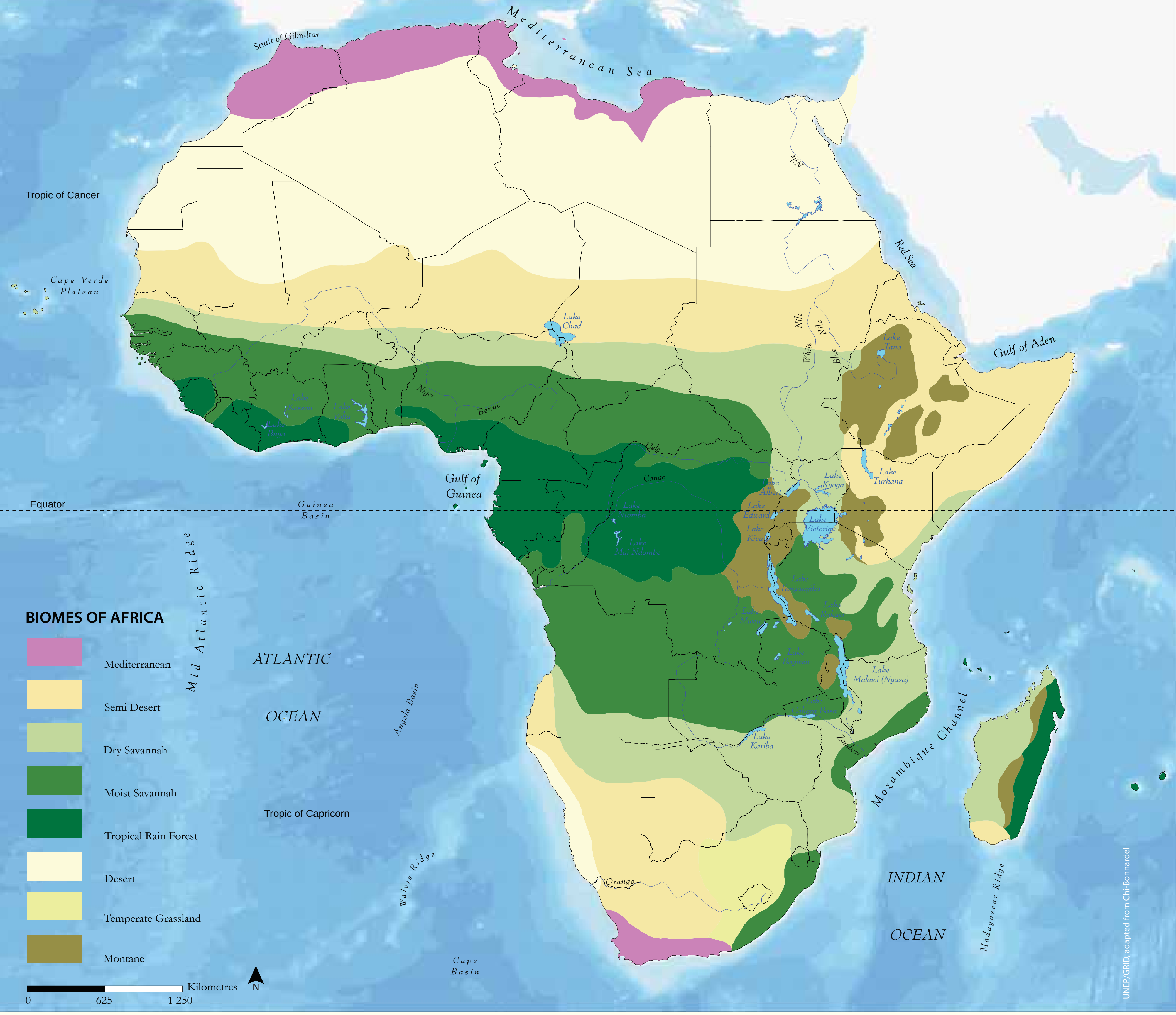
Equatorial Zone

Africa's equatorial climate zone is found along the equator from Gabon to Uganda, as well as in coastal Liberia and Sierra Leone and in eastern Madagascar. In this zone, rain falls throughout the year; if there is a dry period, it is very brief (Goudie 1996). Average annual rainfall generally exceeds 1 700 mm and reaches 3 000 mm at points along the Liberian and Sierra Leone coasts and in eastern Madagascar (FAO 2001). Mean annual temperatures are high, around 25 degrees Celsius, with very small variation throughout the year (Stock 2004).



Desert Zone

Africa's desert climates receive little precipitation and in the case of the Sahara, daytime temperatures can be extremely high. At Faya-Largeau, Chad, the daily maximum temperature for June averages 42 degrees Celsius (WMO n.d.). With little cloud cover, humidity or coastal influence in the Sahara, the average daily temperature range is as much as 15 to 20 degrees Celsius. Average annual precipitation is scant, exceeding 100 mm only in a few areas and tending to be below 25 mm for much of the Sahara and the western edge of the Namib Desert in southern Africa.



The Plants and Animals

Most of the flora and fauna currently found in Africa are descended from plant and animal species that were present on the continent when it separated from other land masses during the breakup of Gondwanaland, roughly 150 million years ago. As Africa slowly moved to its current location straddling the equator, its climate changed as well, and those original populations of plants and animals evolved into forms that adapted to the new climate conditions, eventually diversifying into the variety of species seen today. Around 20 million years ago, Africa arrived and has since remained at roughly its current latitude (Meadows 1996). However, climate change continues to impact Africa, as does the selective pressure for species to adapt to changing environments (Meadows 1996).

Taken as a whole, Africa's pattern of vegetation zones largely mirrors its climate zones. Areas with the greatest rainfall have the greatest volume of biomass or primary productivity (Stock 2004). In general, this high productivity is closely linked to high biodiversity (Waide and others 1999). Accordingly, Africa's equatorial climate zone is its most species-rich area (Meadows 1996). Timing of precipitation also influences the amount and nature of vegetation (Stock 2004). For example, savannahs with few trees and dry deciduous forests occur where there are long dry seasons, while dense rain forests occur where rainfall is consistent year round.

Biomes—large areas with ecologically similar communities of plants and animals—generally are defined by and result from climate, which in turn is largely shaped by temperature and precipitation. Biomes provide a useful tool for characterising flora and fauna at the broadest scale. Significant variation within these generalized vegetation zones results from local changes in elevation, soils, microclimate, wildlife, and human populations. A brief description of Africa's largest biomes provides a highly generalised but nevertheless useful picture of its habitat at a continental scale.

Mediterranean

The Mediterranean biome—found in northern Africa across the mountainous landscape stretching from Morocco to Tunisia and in southern Africa along the southwest coast of South Africa—has hot dry summers. Enough rain falls during the cool winter months to maintain continuous vegetation cover over most of the landscape (Allen 1996). Plants characteristic of the Mediterranean biome are drought tolerant, or xerophytic (Stock 2004) and able to survive occasional freezing winter temperatures in elevated and inland areas. The Cape Province of South Africa is famous for its tremendous biodiversity (MacDonald 2003). This region, known as the Fynbos, is considered a distinct floral kingdom and has the highest rate of generic endemism in the world (Allen 1996). The Mediterranean region of North Africa is almost as biologically rich, with many species endemic to that region (Allen 1996).

Semi-Desert

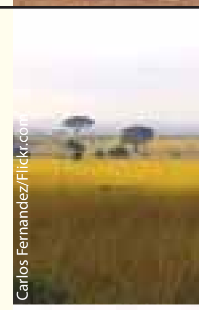
The Kalahari (Kgalagadi) and the Karoo in southern Africa and the Sahel in northern Africa fall into the category of semi-desert, a region of transition between savannah and desert. Limited, variable rainfall and extremes in temperature have produced a variety of adaptive responses in the plants and animals found here (Meadows 1996). Short grasses and scattered spiny plants predominate (Chi-Bonnardel 1973). Many plants adopt a strategy of avoidance such as surviving the long dry season as a seed and actively growing only during the short wet season (Meadows 1996). Trees generally have small waxy leaves and thick bark to reduce moisture loss. Many trees drop their leaves during the dry season, going dormant to conserve moisture (Stock 2004). The most important and characteristic trees here are the iconic acacias (Chi-Bonnardel 1973). Floral diversity is surprisingly high, particularly in the Karoo-Namib region where there may be as many as 7 000 plant species (Meadows 1996). Humans and animals must also adapt to these climate conditions and to the flora that result from them. Trapped by the lack of moisture and pasture to the north and by the tsetse fly and disease to the wetter south (Reader 1997), for centuries local pastoralists on the Sahel have moved their cattle seasonally to find adequate pasture. (Reader 1997).

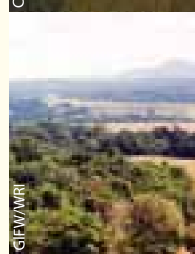
Dry and Moist Savannah

Covering two-thirds of the land area, Africa's savannah is the characteristic ecosystem of the continent (ME Adams 1996). It is found in a broad band flanking tropical rain forests in areas with a significant dry season. African savannahs are home to a greater diversity of large mammals than are found in similar ecosystems on other continents (MacDonald 2003).

The primary characteristics of savannah are seasonal precipitation, a more or less continuous cover of grasses tolerant of seasonal precipitation and intense sunlight, and tree cover that does not form a closed canopy (ME Adams 1996). Precipitation is the fundamental determinant of the savannah vegetation structure. However soils, wildlife, human population, and fire are factors as well (ME Adams 1996). Wet seasons produce abundant fire fuels and dry seasons create conditions that lead to frequent fires. The fires kill many shrub and tree seedlings before they are large enough to survive the flames, thus the savannah favours grasses which can quickly regenerate (ME Adams 1996).

Dry parkland savannah—also called Sudan savannah—is characterised by relatively long dry seasons supporting scattered trees, and relatively short grasses (Stock 2004). Moist woodland—or Guinean savannah—tends to be closer to the equator than dry savannah and is characterised by more precipitation. In moist savannah, trees are more closely spaced and gallery forests can be found along streams and rivers (Stock 2004).





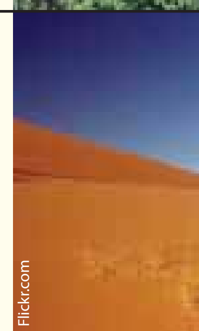
Tropical Rain Forest

Tropical rain forest vegetation generally forms in layers. A few of the very tall trees, some as tall as 50 m (Meadows 1996), rise above a dense, closed canopy formed by the crowns of slightly shorter trees; the canopy is so dense that only a little sunlight reaches the forest floor (MacDonald 2003). The layer of vegetation nearest the ground can be fairly open (Stock 2004; MacDonald 2003). A significant portion of rain forest vegetation is made up of vines and lianas, which climb up the trunks of trees to reach the sunlight (Mongabay n.d.).

The biodiversity in the tropical rain forest is the greatest of all terrestrial biomes. However, of the world's tropical rain forests, those in Africa have the fewest number of species (Meadows 1996). Many of the fauna in the tropical rain forest live primarily in the canopy, where most resources are concentrated (Chi-Bonnardel 1973). Madagascar's rain forests, isolated from those of the African continent, have a remarkable number of unique species. As many as 90 per cent of Madagascar's animal species and 80 per cent of its plant species are endemic to the island (Stock, 2004; KEW n.d.).

Desert

Desert vegetation is adapted to sparse and unpredictable precipitation, extremes of temperature, and very poor soils (Stock 2004). The seeds of many desert plants can lie dormant for years until rain brings about a brief explosion of life (Chi-Bonnardel 1973). Although some plants are adapted to the extreme heat and lack of moisture, Africa's deserts have much lower biomass than its other biomes (Jürgens 1997). The various African deserts have distinct communities of living things. For example, many plants in the Namib Desert differ genetically from plants in the Sahara Desert. This is probably the result of plants adapting to different environmental conditions over time as well as varied bio-geographical histories (Meadows 1996). In the Namib Desert, some plants are able to utilise moisture from fog that forms when warm air moving inland from the Atlantic Ocean passes over the cold waters of the Benguela current (Meadows 1996). In the Sahara, plants tend to cluster in dry river beds (wadis) where water will collect after rare rains.

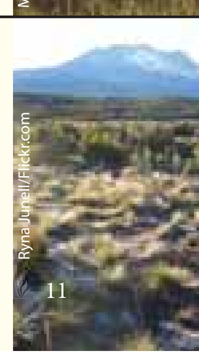


Temperate Grassland

A large expanse of temperate grassland is found in southern Africa where the Drakensberg Mountains and the Great Escarpment create an interior area of high elevation and moderate rainfall (Palmer and Ainslie 2005). These conditions, coupled with fertile soils, produce vegetation that is dominated by grasses with scattered trees (Stock 2004). Biomass decreases with precipitation along an east-to-west gradient (Palmer and Ainslie 2005). Although substantial expanses of native temperate grassland remain in this part of Africa, conversion of large tracts to dryland agriculture and livestock production has altered the plant species composition in these areas (Palmer and Ainslie 2005).

Montane

Relatively isolated areas of high-elevation montane forest, shrubland, and grassland are found in the Ethiopian Highlands, the Albertine Rift, and the Arc Mountains of East Africa. Beginning around 1 000 m and extending to above 3 500 m (CI n.d.b), the montane biome is characterized by a series of zones of vegetation that coincide with a gradient of increasing elevation and decreasing temperature (Meadows 1996), with montane forest and bamboo at lower elevations and heather and alpine tundra at higher elevations (Stock 2004). Few species can withstand the daily temperature swings and harsh conditions found on mountain summits (Meadows 1996). However, both the conditions and the isolation of these areas have led to the evolution of unique plant communities that are found nowhere else.



Olduvai Gorge in the United Republic of Tanzania has been the site of several important archaeological finds of early hominids. Among them was *Homo hablis* (right) discovered in the early 1960s by Mary and Louis Leakey and thought to be at least 1.6 million years old.

People

Africa is widely believed to be the birthplace of humankind (Stock 2004). Fossil evidence of ancestral hominids that lived 1.5 to 2.5 million years ago is abundant from Ethiopia to South Africa (Reader 1997). Around 1.6 million years ago, *Homo erectus,* predecessor to modern humans, emerged in Africa (Reader 1997). *Homo erectus* is found in the fossil record until around 200 000 years ago (Reader 1997). Fossil evidence indicates that modern humans, the species *Homo sapiens sapiens,* appeared approximately 130 000 years ago (Reader 1997).

Fossil, linguistic, and genetic evidence indicate that approximately 100 000 years ago a small number of these *Homo sapiens sapiens* left Africa and proceeded to populate all the other continents (Reader 1997). The fact that most of the world's population outside of Africa is derived from this very small gene pool is supported by genetic research, which shows much greater genetic variation within Africa than among all the rest of the world's population (Reader 1997).

This original group of emigrants—perhaps as few as 50 people (Stock 2004)—who left the continent 100 000 years ago evolved into many races and has now grown into a population of roughly 5 500 million people outside of Africa (UN 2007). Africa's population, however, did not grow as rapidly. Africa had an estimated one million inhabitants 100 000 years ago. By 2007, Africa's population had grown to an estimated 965 million (UN 2007).

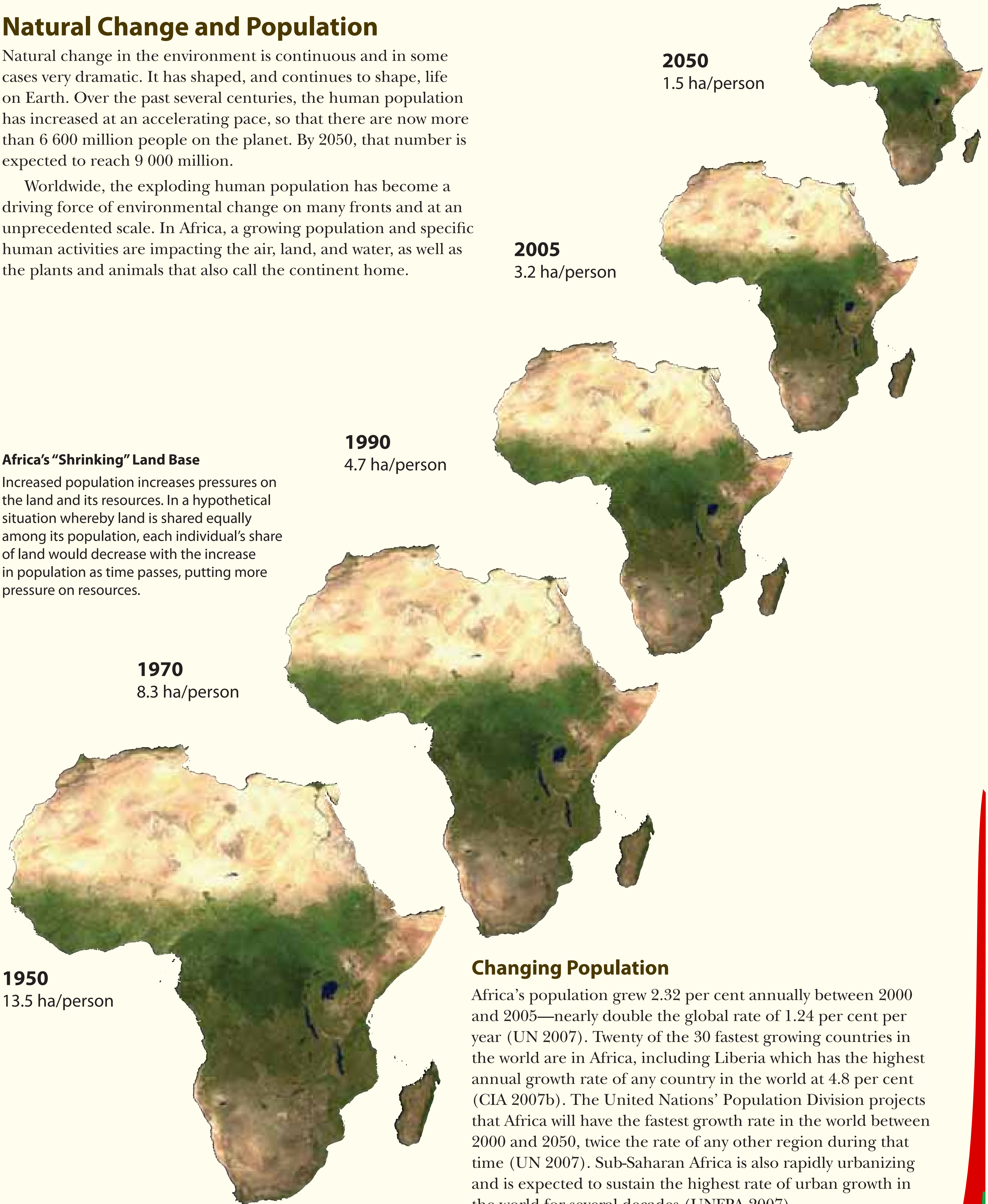
Currently, Africa is the second most populous continent after Asia (UN 2007). In 2007, Africa's average population density was 32.6 people per square kilometre (UN 2007). While parts of the continent such as the Sahara have few permanent settlements, other areas—including countries such as Nigeria, Burundi, Rwanda and regions such as the Nile Delta—are very densely populated.

Crowd in Malawi

Natural Change and Population

Natural change in the environment is continuous and in some cases very dramatic. It has shaped, and continues to shape, life on Earth. Over the past several centuries, the human population has increased at an accelerating pace, so that there are now more than 6 600 million people on the planet. By 2050, that number is expected to reach 9 000 million.

Worldwide, the exploding human population has become a driving force of environmental change on many fronts and at an unprecedented scale. In Africa, a growing population and specific human activities are impacting the air, land, and water, as well as the plants and animals that also call the continent home.



Africa's "Shrinking" Land Base

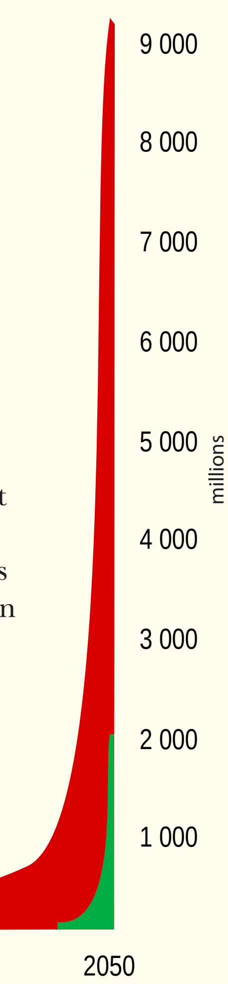
Increased population increases pressures on the land and its resources. In a hypothetical situation whereby land is shared equally among its population, each individual's share of land would decrease with the increase in population as time passes, putting more pressure on resources.

Source: NASA Data Source: CIESIN

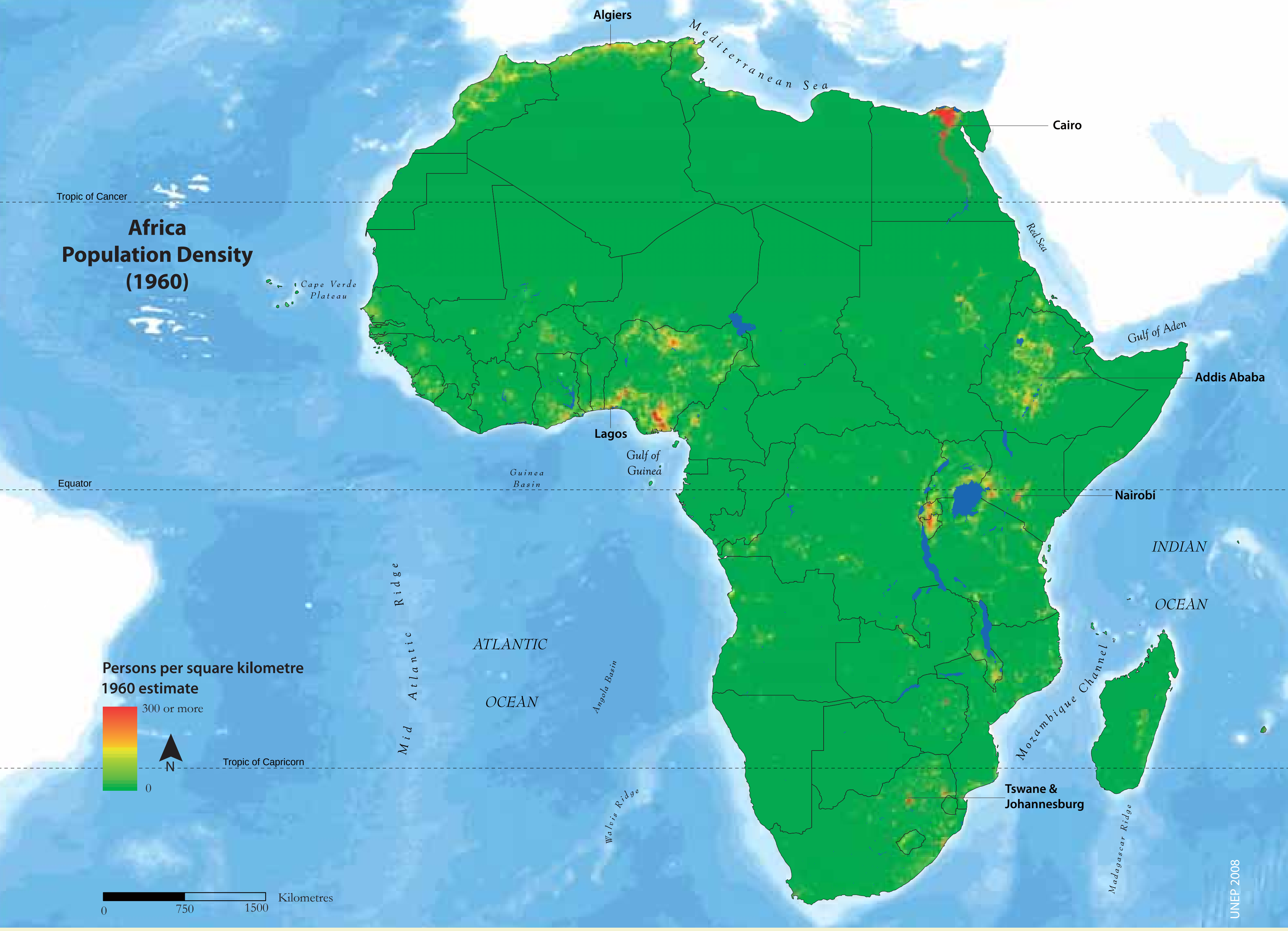
Changing Population

Africa's population grew 2.32 per cent annually between 2000 and 2005—nearly double the global rate of 1.24 per cent per year (UN 2007). Twenty of the 30 fastest growing countries in the world are in Africa, including Liberia which has the highest annual growth rate of any country in the world at 4.8 per cent (CIA 2007b). The United Nations' Population Division projects that Africa will have the fastest growth rate in the world between 2000 and 2050, twice the rate of any other region during that time (UN 2007). Sub-Saharan Africa is also rapidly urbanizing and is expected to sustain the highest rate of urban growth in the world for several decades (UNFPA 2007).

With more people to feed, Africa must devote more land to agriculture. However, increasing agricultural lands means



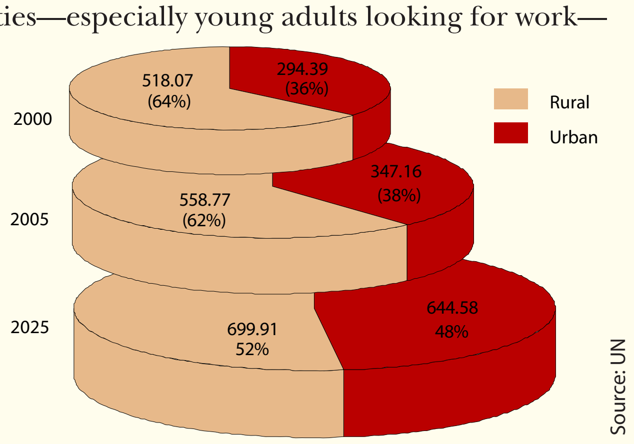
Source: US Census Bureau, UN 2007, CIESIN



decreasing forests and other types of land cover, and reducing or eliminating natural habitats and their resources. In some cases, increased human impact has caused serious environmental damage in Africa. For example, the loss of West Africa's rain forests and their associated goods and services has contributed to social unrest and exacerbated poverty across the region (Gibbs 2006).

Urban Population

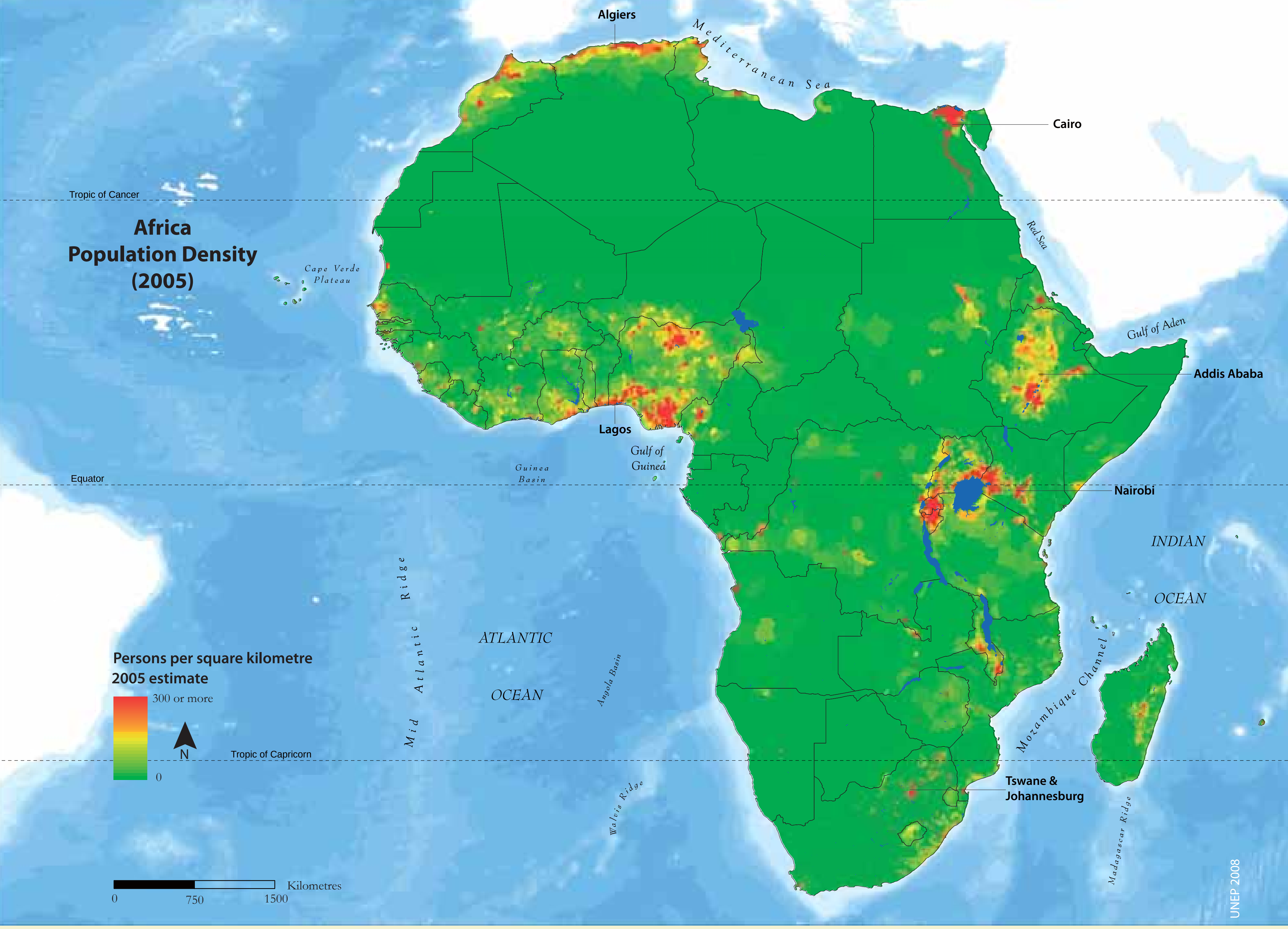
More than 60 per cent of Africa's population was still living in rural areas in 2005. But Africa has the fastest urban growth rate in the world. This trend is mainly due to people migrating from rural communities to cities—especially young adults looking for work—as well as high urban birth rates (IUSSP 2007). Cities and towns, growing at twice the rate of the rural population, are expected to add 400 million people to

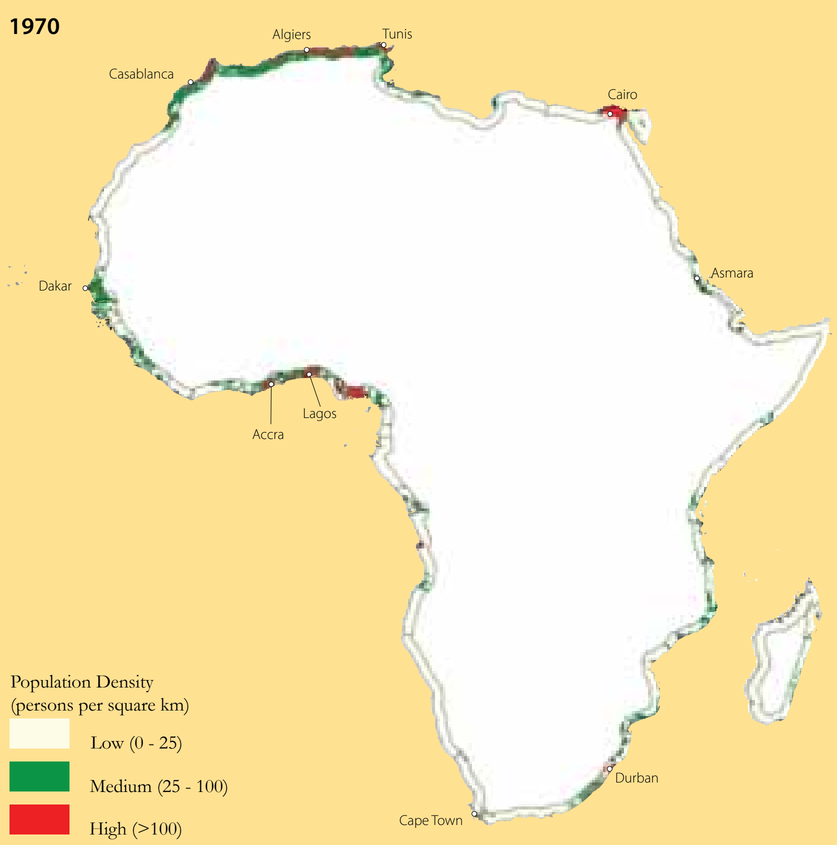


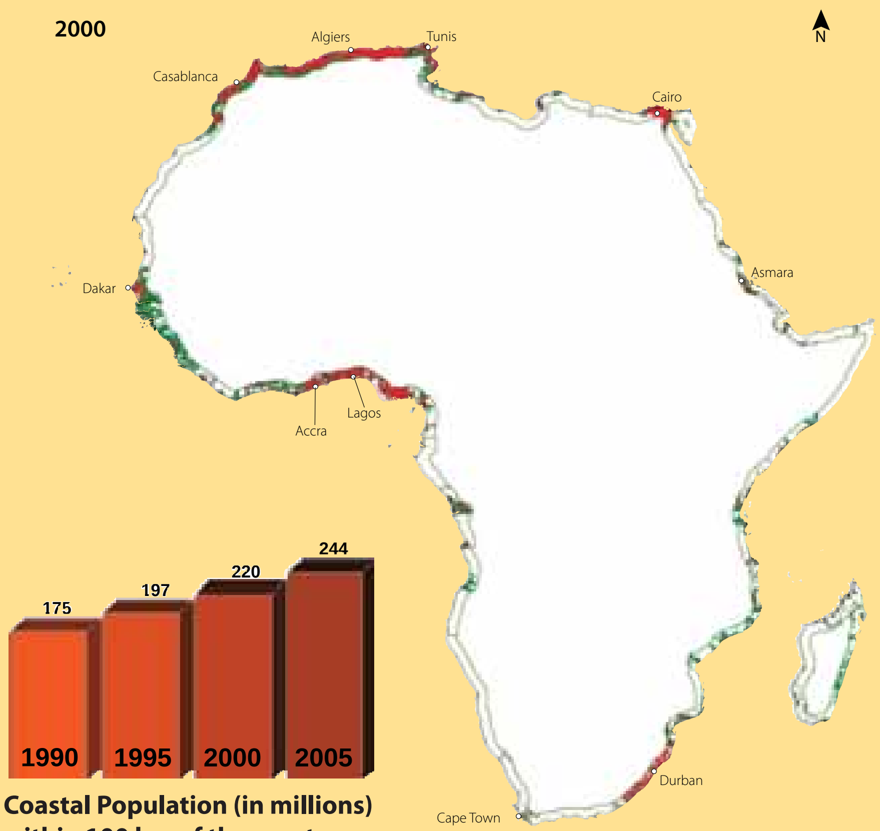
Africa's urban population over the next 25 years (Auclair 2005). By 2025, more than half of Africa's population will live in urban areas (Tibaijuka 2004; UN-HABITAT 2006).

Coastal Population

About 2.7 per cent of Africa's population lives within 100 km of the coast. Since the 1980s, coastal urban areas have been growing by four per cent a year or more (ODINAFRICA Project 2007). Poorly planned and managed coastal cities, the lack of adequate sanitation treatment, as well as pollution from land-based activities such as agriculture and industry, threaten human health and the quality of habitat for fish and other marine life (UNEP 1998; O'Toole and others 2001). Human-induced activities such as construction, dredging and mining for sand, and harvesting corals have led to severe problems of coastal erosion. The Niger River Delta is losing 400 hectares of land a year to erosion (Hinrichsen 2007). The Intergovernmental Panel on Climate Change (IPCC) projects that toward the end of the 21st century, climate change will have caused sea-level rises that will affect Africa's highly populated low-lying coastal areas. Adaptation costs could amount to at least 5-10 per cent of GDP (Adger and others 2007).







Coastal Population (in millions) within 100 km of the coast

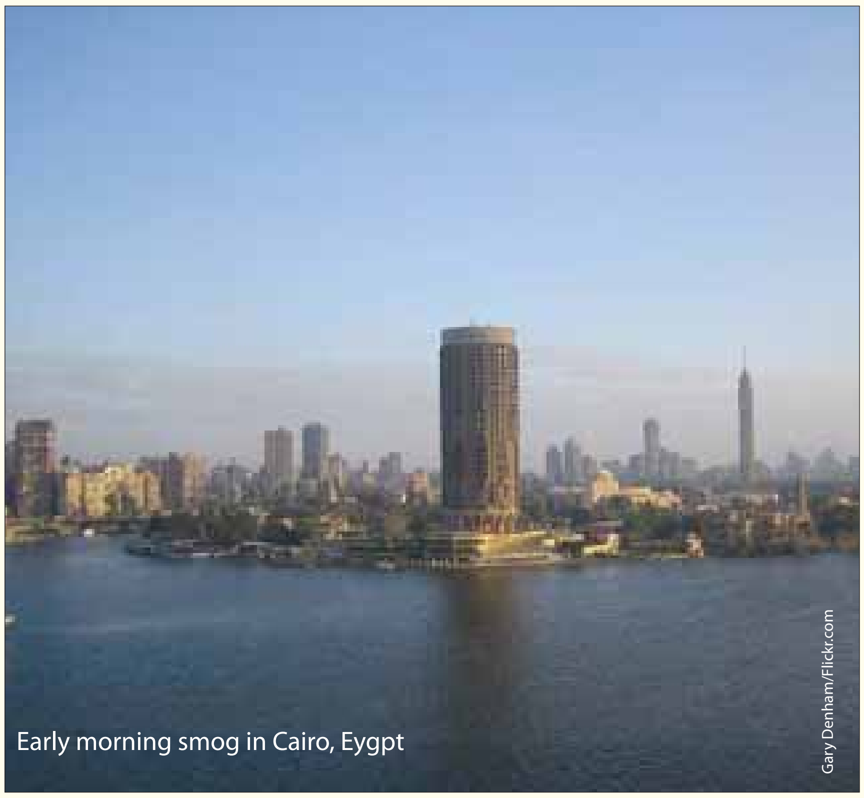
Source: UNEP

Air and Atmosphere

Given Africa's relatively low level of industrial development, air pollution is not as severe or as widespread as in some other parts of the world. However, in Africa's most populous cities, long-term exposure to congested traffic and poor air quality is a health hazard. In rural areas, biomass burning releases unhealthy particulates into the air, contributing to air pollution and health problems such as respiratory illnesses and allergies.

Like the rest of the world, Africa is seeing changes in its atmosphere. Global warming, an increase in the world's average surface temperature, is affecting every continent, including Africa. The main cause of global warming is human activities—particularly the burning of coal, oil, and natural gas, deforestation, and certain agricultural practices—that add heat-trapping gases to the atmosphere, primarily carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). Global warming is already changing the climate in some parts of the world. In the coming decades, climate change is expected to negatively impact many natural systems worldwide.

Africa is particularly vulnerable to climate change. Computer models project major changes in precipitation patterns on the continent, which could lead to food shortages and increased desertification. Yet on the whole, African nations lack the resources and technology to address such changes (Adger and others 2007; UNECA 2001).



Early morning smog in Cairo, Eygpt

Gary Denham/Flickr.com

Traditional African societies are agrarian or pastoral, depending directly on the environment to meet peoples' daily needs from what they can grow, raise, catch, or gather. Three-fifths of African farmers subsist by directly utilising land resources (Dlamini 2005). Two-thirds of the population of sub-Saharan Africa lives in rural areas, and therefore depends on the natural resource base more than people in any other part of the world (EIA 2003). Africa's land resources are rapidly changing, and in some cases shrinking, due to changes in land cover, land use, and land productivity.

Land Cover and Land Use

Land cover refers to the physical attributes of the Earth's surface that can be seen readily, such as water, trees, grass, crops, and bare soil. Land use refers to the social and economic purposes for which land (or water) is managed, such as grazing, timber extraction, conservation, irrigation, and farming.

More People, More Trees: A Success Story in Niger

In the thirty years since the great drought of the 1970s, Niger's population has more than doubled. Most of the people are rural, securing their livelihoods in Africa's biggest dryland—the Sahel. Rainfall levels are still well below the 1950-1970 average, and the threat of environmental degradation and desertification continues to dominate thinking in the development community. Yet, despite the statistics of more people living with major constraints of aridity, variable rainfall, and soils with low natural fertility, Niger's rural communities have somehow coped and continue to live and evolve in a harsh environment. Indeed, people in the development community who knew Niger in the 1970s now speak of environmental improvement and increasing agricultural productivity resulting from investments in ecosystem management.

Preliminary findings by a team of United States Geological Survey (USGS) scientists, who have been monitoring environmental change in Niger, suggest a human and environmental success story at a scale not seen before in the Sahel. The team started by selecting a dozen village-based sites in two ecological regions—the rocky plateau and valley country known as the "Ader-Doutch-Maggia" east of Tahoua, and the vast sandy agricultural plains that stretch across south-central Niger. To get a sense of how the vegetation and land use had changed, they compared historical aerial photographs from 1975 to images they acquired from the air in 2005. The comparisons were dramatic—giving the team the first real evidence of a major environmental transformation. At every study site in south-central Niger, sandy fields with few trees were now punctuated with many trees. Today, agricultural parklands replace the wind-swept fields of the 1970s. On-farm tree densities have increased ten to twenty-fold. Village sizes have also dramatically increased in the area, generally by a factor of three, a direct indicator of rural population growth. The changes were equally surprising on the rocky slopes and plateaus east of Tahoua. Almost totally denuded in 1975, a patchwork of terraces and rock bunds now extends throughout the regions that were constructed to stem soil erosion, trap precious rainfall, and create micro-catchments for planting and nurturing trees. As a result, trees now occur on most plateaus, and farmers have taken advantage of the new environment to plant fields of millet and sorghum between the ribbons of trees. Windbreaks of mature trees crisscross the wide Maggia Valley and its tributaries. Many of the valleys now have dikes and low dams to create ephemeral lakes. As their waters recede in the dry season, farmers plant vegetables. A vibrant dry season market gardening economy has developed. Large tracts of valley lands are now green with produce—including onions, lettuce, tomatoes, sweet potatoes, and peppers.

Locals gathered around an aerial map, Niger

Gray Tappan/SAIC/USGS

Table 1.1 - Recent changes in Africa's population and land cover/land use area (1 000 hectares) for selected years

Topic	1980	1990	2000
Population (1 000) Medium Variant	364 132	637 421	820 959
Land area	2 962 648	2 962 648	2 962 648
Agricultural area	1 102 575	1 124 531	1 136 660
Arable land	158 354	167 137	181 409
Permanent crops	19 776	22 935	25 328
Permanent pasture	898 595	907 134	900 198
Forest	N/A*	699 358	655 611
Woodland	N/A*	444 433	471 190

Source: UN ESA 2004; FAO 1997

*** Not Available**
Note: Land areas do not add up to the total because of overlap in definitions.

Land Conversion

Land conversion is the process of changing land use or land cover. Land conversions may be natural or human-induced. Human-induced conversion may be deliberate or unintentional. Table 1.1 shows changes in land cover and land use brought about in Africa due to increasing human population.

Deforestation is a form of land conversion that is most evident in Africa. Forests and woodlands provide multiple goods and services that contribute to social and economic development. At the local level, forests provide construction materials, food, energy, medicine, catchment protection, soil protection, shelter and shade, habitat for wildlife, and grazing, as well as sites of cultural significance such as sacred groves. Forests and woodlands also help ensure water quality, regulate river flows (and thus hydropower potential), and prevent soil erosion; they represent sources of energy, timber products, and non-timber products such as fruits, resins, and gums as well as genetic resources that can be used in developing pharmaceuticals. At the global level, Africa's forests and woodlands are valued for their role in climate regulation and as repositories for biodiversity (UNEP 2006c).

Vegetables planted between wind rows

Gray Tappan/SAIC/USGS

Early findings from the team's groundwork are equally compelling. Many interviews with village informants at all sites confirm that there has been notable environmental improvement since the 1970s. Farmers point to the increase in woody cover, to the diversity of high-value trees, and to the rehabilitation of the productive capacity of tens of thousands of hectares of degraded land. The projects of the 1970s and 1980s demonstrated what could be done, giving villagers options. Since then, there has been a huge spread effect, particularly in farmer-managed natural regeneration—a significant change in the way farmers maintain their fields, allowing high value trees to grow in their fields. This change also represents an increased sense of land tenure security. Trees are no longer considered the property of the State, and farmers have more control over this resource. Another significant improvement has been a rise in the local water table in many villages. In Batodi, for example, the ground water rose from a depth of 20 m in 1992 to three metres in 2005. Women have organized themselves to start dry season vegetable gardens that they manually irrigate from a shallow well. The local economy has strengthened as the systems of production have diversified. There are new local markets for vegetables, firewood, and forest products. Farmers are even buying and selling degraded plateau land, since they see the potential for its rehabilitation.

One of the most significant findings in environmental improvement is the sheer scale of farmer-managed natural regeneration of field trees in the vast sandy agricultural plains of south-central Niger. This region comprises some 6.9 million hectares. The research team believes that farmers are actively protecting tree regeneration in over at least half this area, leading to the formation of a dense agricultural parkland with up to 200 trees per hectare. Farmers have observed that crop production is better in fields with trees, not to mention trees' benefits as sources of fruit, leaves, traditional medicines, and firewood. In 2004, many crops failed following poor rainfall, leading to a real food crisis in 2005. In Dan Saga, one of the study villages, farmers pointed out that not a single child died of hunger because families were able to rely on their trees as a resource by selling wood for cash. The trees made a huge difference in their coping strategy.

The team soon hopes to provide definitive conclusions on the conditions that have led to the positive biophysical and economic trends that they are seeing in these two regions of Niger. They believe that farmers have reacted proactively to the large-scale land degradation that occurred during the droughts of the 1970s and 1980s, and have begun protecting their resources on a massive scale, encouraging natural regeneration, rebuilding their soils, and harvesting scarce rainfall. Beyond the physical efforts, there has been a notable change in Niger's environment policy, in particular a reform in the rural development code that mandates a decentralized approach—thus empowering local people to manage their own resources.

Source: Tappan 2007

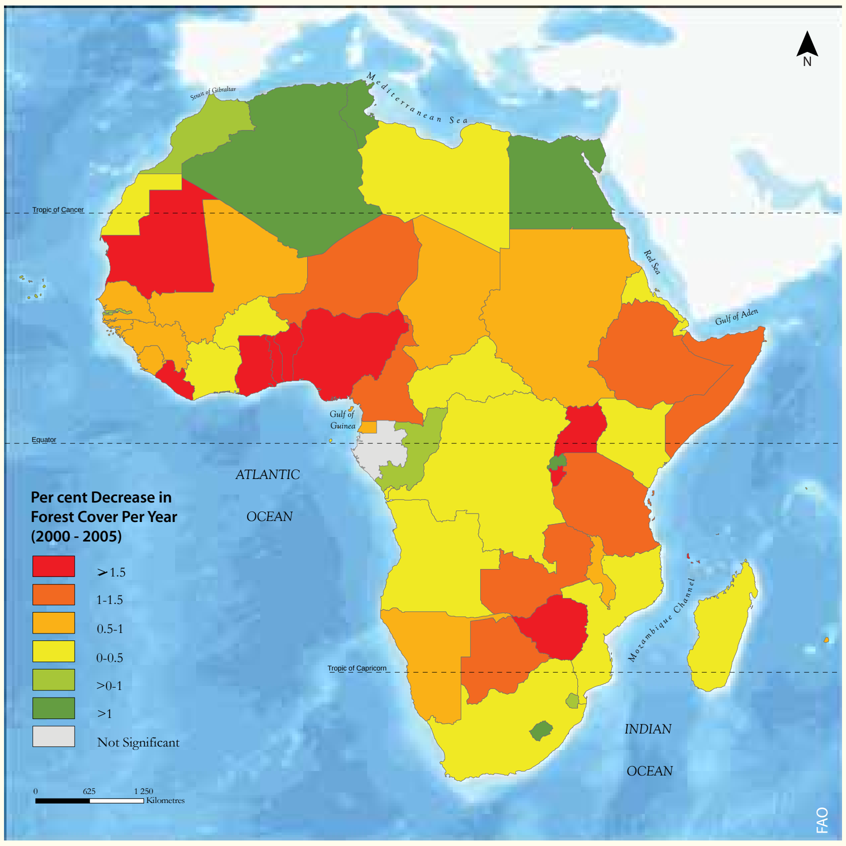
Deforestation

Deforestation is the conversion of forested area to non-forested land for use as arable land, pasture, urban development, logged area, or wasteland. Generally, the removal or destruction of significant areas of forest cover results in a degraded ecosystem with reduced biodiversity.

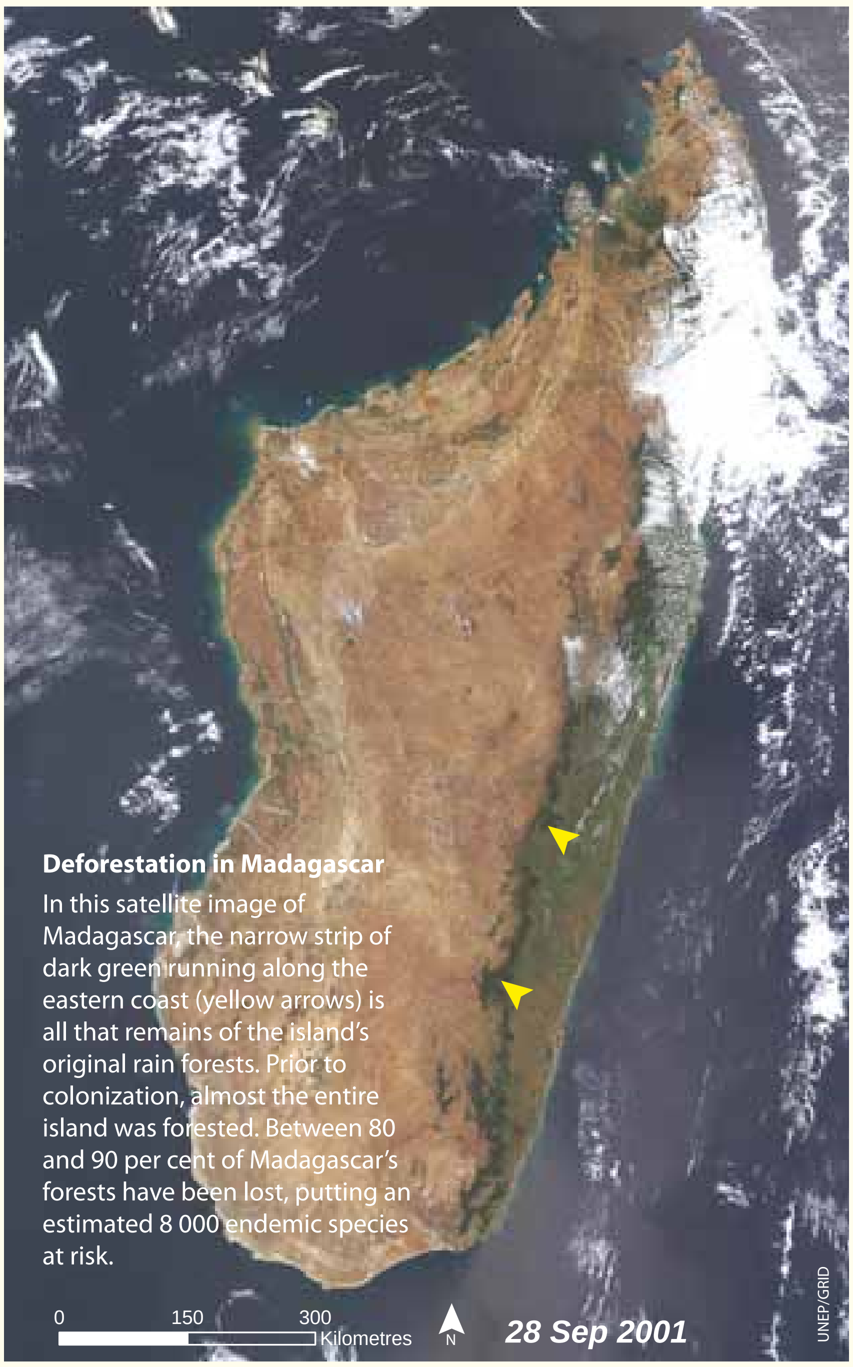
Forests cover over one-fifth of Africa's 30 million km² of land area (Kelatwang and Garzuglia 2006). The rate of deforestation is higher in Africa than on any other continent, although the rate of deforestation has slowed since the 1990s (Kelatwang and Garzuglia 2006). Of the ten countries in the world with the largest annual net loss of forested area, six are in Africa (FAO 2005). Africa loses an average of 40 000 km², or 0.6 per cent, of its forests annually, with the greatest losses occurring in heavily forested countries (FAO 2005). Logging, land conversion to agriculture and settlements, wildfires, cutting for firewood and charcoal, and civil unrest are the primary causes of deforestation in Africa; many of these pressures are driven by population growth.

Converting forests to agricultural land is necessary for food production but such deforestation negatively impacts local ecosystems as habitats are lost. Deforestation also impacts the global carbon cycle; carbon released when trees are cut, burned, or as they decompose enters the atmosphere as CO_2 and contributes to global warming (Willcocks 2002). Deforestation is a major reason for land degradation in Africa, especially when followed by over-cultivation and overgrazing (Slack 2002). This is especially true in areas not suited to agriculture where soil is easily eroded.

Deforestation Rates



Globally, deforestation continues at a rate of about 13 million hectares per year. At the same time, planting and natural expansion of forests have significantly reduced the net loss of forest area (FAO 2007).



Deforestation in Madagascar

In this satellite image of Madagascar, the narrow strip of dark green running along the eastern coast (yellow arrows) is all that remains of the island's original rain forests. Prior to colonization, almost the entire island was forested. Between 80 and 90 per cent of Madagascar's forests have been lost, putting an estimated 8 000 endemic species at risk.

A sifaka (*Propithecus verreauxi*) in Madagascar

Picking tea leaves, Kenya

Changes in Land Productivity

Changes in land productivity may be positive (such as irrigating or fertilizing the soil) or negative (such as pollution or erosion). As with land conversion, land productivity changes may be natural or human-induced, and if human-induced, may be accidental or deliberate. Environmental concern in Africa surrounds negative changes in land productivity due to land degradation and desertification.

Land Degradation

Land degradation is the process of reducing the capacity of land to produce food or materials. An estimated 65 per cent of Africa's agricultural land is degraded due to erosion and/or chemical and physical damage. Thirty-one per cent of the continent's pasture lands and 19 per cent of its forests and woodlands also are classified as degraded (FAO 2005).

As of 2000, over 19 per cent of African grasslands had been converted to agricultural land, and 0.4 per cent to urban areas. Other grassland areas were lost to land degradation, often due to overgrazing by livestock (White and others 2000). Grasslands support some of the continent's highest concentrations of cattle.

More than one-quarter of Africa's arid and semi-arid lands are degraded (White and others 2000) due to soil erosion, loss of soil nutrients, pollution, or salinization. Poor farmers often have little choice but to cultivate crops or graze cattle on marginal lands, which can lead to a cycle of increasing soil erosion and land degradation. Land degradation in arid and semi-arid regions can eventually lead to desertification.

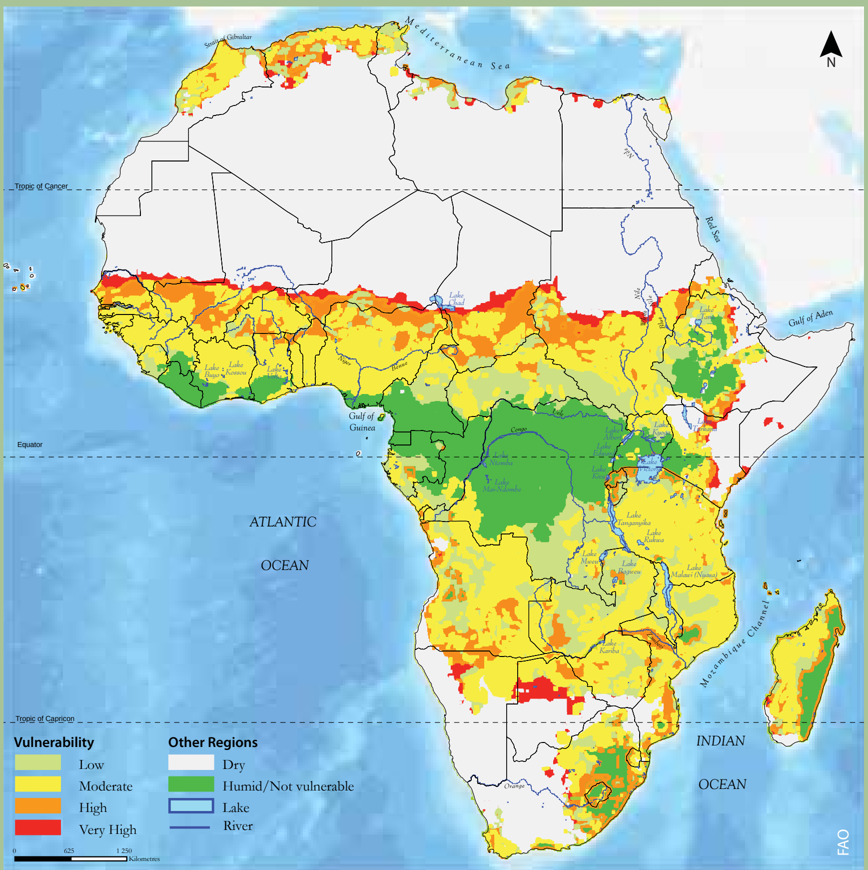
Desertification

Desertification is one of the most severe forms of land degradation. Dry lands that form desert margins, such as those found in Sudan, the Sahel, and southern Africa are most prone to desertification. Such vulnerable lands—which occupy about five per cent of Africa's land mass—are home to 22 million people (Reich and others 2001).

Erosion and desertification are fundamentally linked. It is estimated that some areas in Africa are losing over 50 metric tonnes of soil per hectare per year. This is roughly equivalent to a loss of 20 000 million metric tonnes of nitrogen, 2 000 million metric tonnes of phosphorus, and 41 000 million metric tonnes of potassium per year. Areas of serious erosion can be found in Sierra Leone, Liberia, Guinea, Ghana, Nigeria, Democratic Republic of the Congo, Central African Republic, Ethiopia, Senegal, Mauritania, Niger, Sudan, and Somalia (FAO 1995).

Land degradation and desertification processes result from both human activities and climatic variability. People use controlled fire to manage grasslands and savannahs for livestock production and wildlife, control pests, clear dying vegetation, and convert wild lands to cropland (Trollope and Trollope 2004). Fires are necessary to maintain the health and extent of grassland and savannah ecosystems, but if the interval between fires is too short, the land can be degraded beyond its ability to sustain farming and grazing. Land degradation and desertification can occur quickly when fire is used too much or too often in fragile arid and semi-arid areas.

Vulnerability to Desertification

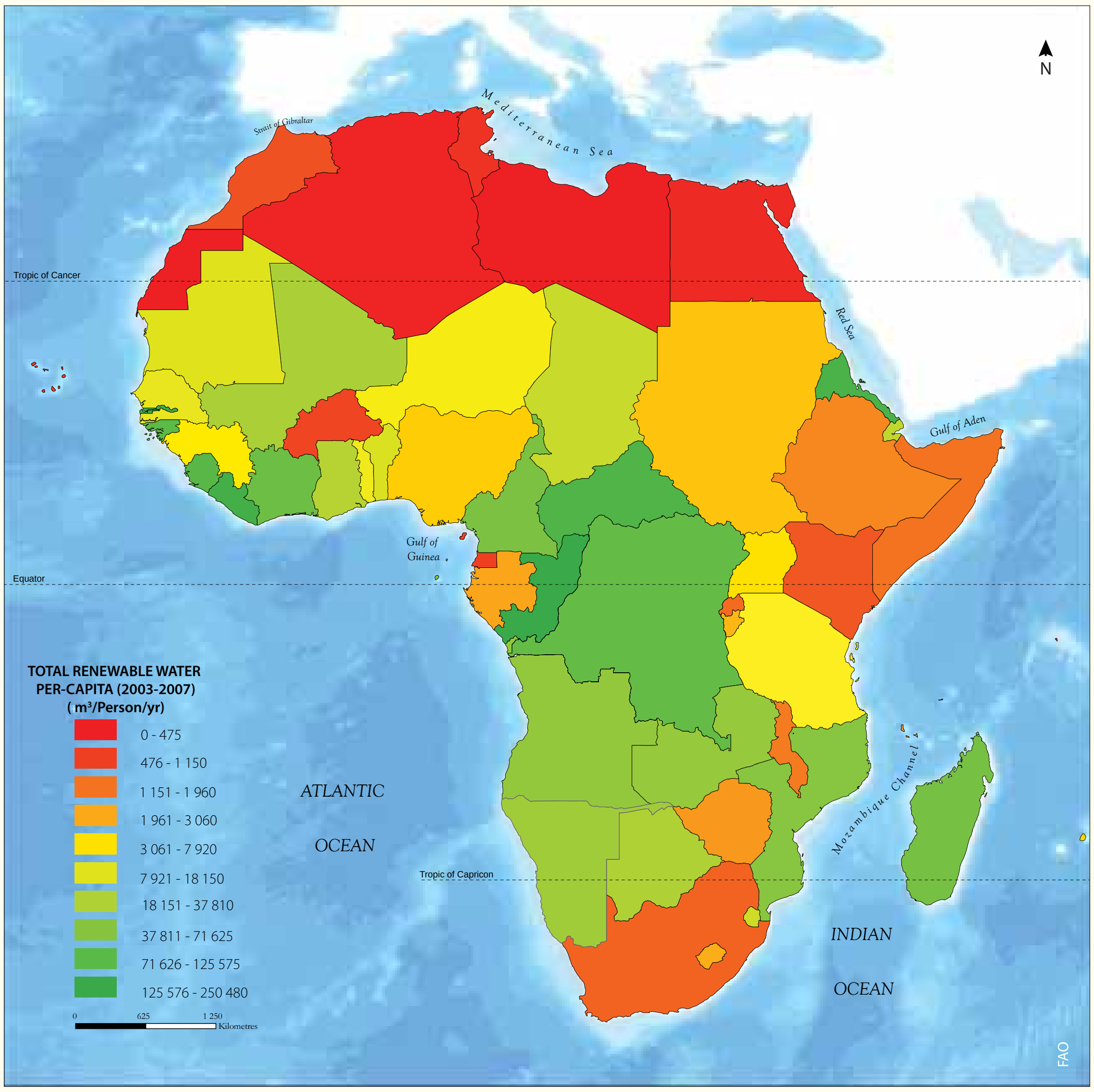


Water

Changes in water quality and quantity —in freshwater environments (lakes and rivers) and in coastal and marine environments—rank among the most challenging environmental and social issues that Africa currently faces.

An increasing population and a decreasing water supply leads to water scarcity and stress. Water scarcity is defined as less than 1 000 m^3 of potable water available per person per year, while water stress means less than 1 700 m^3 of potable water is available per person per year (UNEP 2002).

Per Capita Renewable Water



Freshwater

The availability of fresh water is essential to development in Africa. Nevertheless, the per capita water consumption in Africa, 31 m^3 per year, is still comparatively lower than other regions—eg. North America—221 m^3 per year (UNESCAP 2007). Agriculture, by far, accounts for most of the water consumption and withdrawal in Africa, followed by reservoirs, municipal use, and industrial use.

In terms of agriculture, water consumption can be defined as the amount of surface and groundwater absorbed by crops and transpired, or used directly in the building of plant tissue, together with water that evaporates from the area where crops are located. Water consumption also includes all activities where the use of water results in a loss of the original water supplied, such as industrial or community consumption (UNESCO 2007). Withdrawal is the extraction of water from surface or subsurface reservoirs (UNESCO 2007).

Engineered water transfers and dams, as well as the exploitation of nonrenewable groundwater supplies, account for the overuse of freshwater supplies throughout the world. In Africa, irrigation of agricultural lands occurs in the arid and semi-arid regions in northern and southern regions of the continent and along the Sahel. In these areas, much of the surface and groundwater resources are highly exploited.

While water consumption and withdrawal in Africa has been increasing over time, the continent's water resources have been decreasing, mainly as a result of persistent droughts and changing land use patterns. The volume of water estimated to have been

Freshwater Fish

An estimated one-fifth of all animal protein in the human diet is derived from fish. In the coastal countries of Equatorial Guinea, the Gambia, Guinea, Senegal, and Sierra Leone, at least half of the total animal protein intake comes from fish (FAO 2006). Even in many of Africa's land-locked countries, fish is the primary protein source (Finlayson and D'Cruz 2005). Urban and rural poor in Malawi get a remarkable 70 to 75 per cent of their protien from wild and aquaculture fish (Revenga and Cassar n.d.). As with other inland fisheries that depend on natural production, Africa's inland fish resources are being exploited at or above sustainable yield levels (Revenga and Cassar n.d.).

Africa is second only to Asia in the global capture of inland fish. Nile perch, tilapia, and cyprinids represent the majority of the catch in Africa's top inland fishing nations, which include Uganda, United Republic of Tanzania, Egypt, Kenya, and Democratic Republic of the Congo. Aquaculture is gaining importance in Africa. Egypt is the largest producer of fish by aquaculture, and is second only to China in the production of tilapia, a native African species (FAO 2006). Despite its potential, local populations often do not benefit from the introduction of aquaculture (or new fish species), since they usually cannot afford the technologies needed to harvest the resource (Revenga and Cassar n.d.).

Tub of tilapia

K. Santos/Flickr.com

The abundance of fish in a number of Africa's major river systems has declined (as it has in Asia, Australia, Europe, the Middle East, North America, and South America) due to targeted fishing for large freshwater species (FAO 2006). Many species, including the Nile perch, are destined for export, thereby reducing the availability of fish for local consumption (Revenga and Cassar n.d.). In addition to unsustainable harvests, inland fisheries are affected by environmental degradation and exotic species introductions (Balirwa 2007).

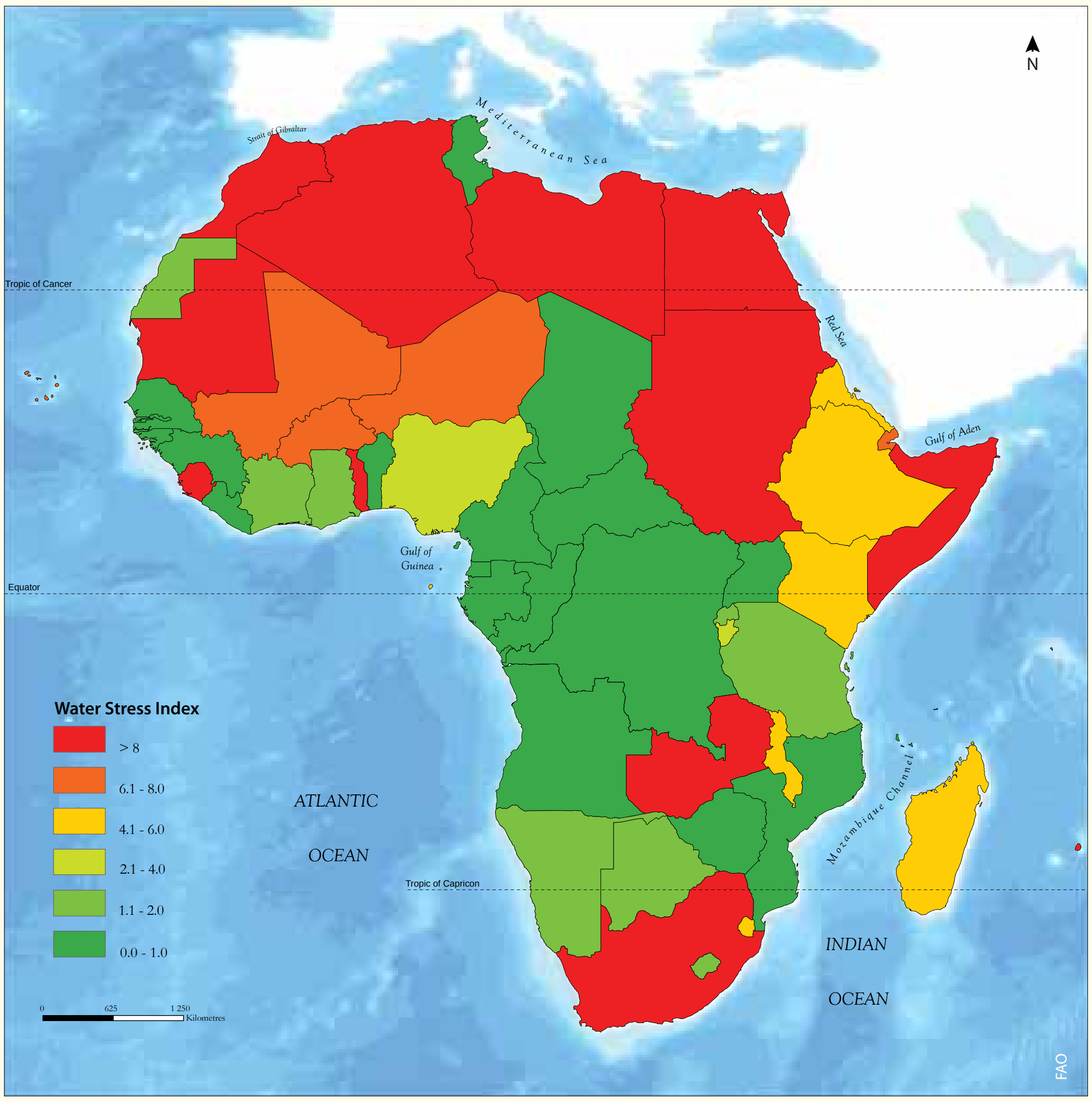
Getting water from a well, Nigeria

lost from the African land mass during a three-year period ending in approximately 2006 was about 334 km^3, which is as much water as Africans consumed over the same period (Amos 2006).

Lack of water often constrains farming and human activities, while water pollution diminishes its availability and is a source of waterborne disease. An increase in the need for fresh water by growing populations, coupled with a history of periodic drought and evidence of recent increased rainfall variability due to climate change, has created conditions of water scarcity and water stress in many regions throughout Africa.

Continued climate change will aggravate this situation. By 2050, it is expected that areas experiencing water shortages in sub-Saharan Africa will have increased by 29 per cent. By 2100, water flow in the Nile River region is expected to decrease by 75 per cent, with damaging consequences for irrigation practices. Declining water levels in many rivers and lakes is expected to affect water quality, exacerbate waterborne diseases, and reduce available hydropower (UNEP 2006c). Lack of clean water and sanitation leads to a wide range of potential diseases including malaria, yellow fever, filariasis, river blindness, sleeping sickness, guinea worm, bilharzia, trachoma, and scabies. Most importantly, dirty water is often the cause of childhood diarrhoea, a leading killer of African children (AMREF 2008).

Water Stress



Water pollution exacerbates water scarcity and impacts fisheries. Dams and water transfer can affect water quality. The damming of the Nile River at Aswan, for example, has reduced the level of nutrients so much that the sardine catch in the Nile Delta has fallen from 22 618 million metric tonnes in 1968 to under 13 500 million metric tonnes in 2002, and it is still declining (Bird and Medina 2002).

It is estimated that over 300 million people in Africa face water scarcity conditions. By 2025, 18 African countries are expected to experience water stress (UNEP 1999).

Wetlands

Africa's many types of wetlands, from West Africa's saline coastal lagoons to East Africa's fresh and brackish-water lakes, provide natural resources for many rural economies. Rising poverty, increasing population, periodic droughts, and exploitation by private landowners have degraded these ecosystems to the detriment of wetland organisms and local populations (Schuijt 2002).

There are few data concerning wetland losses in Africa. A 2005 review of wetland inventories in ten countries in southern Africa found significant losses in two areas in KwaZulu Natal: Tugela Basin, where over 90 per cent of wetland resources have been lost in parts of the basin, and the Mfolozi catchment (10 000 km^2), where 58 per cent of the original wetland area (502 km^2) had been lost (Taylor and others 1995). Another study in 1992 reported an overall loss of 15 per cent of wetland area in Tunisia and 84 per cent wetland loss in the region's Medjerdah catchment (Moser and other 1996). Losses may be due to land conversion, water extraction, and climate change.

Coastal and Marine Environments

Africa's coastal and marine resources have great ecological, social, and economic importance, both locally and for the global community (UNEP 2002). Local communities are heavily dependent on coastal resources such as mangrove trees for construction, for medicinal and food products, and for subsistence or small-scale trade. Commercial fishing, tourism, and the oil and gas industry all make substantial contributions to the national economies of coastal African countries as well (UNEP 2002). Many of these activities, however, are over-exploiting, degrading, and polluting Africa's marine and coastal resources and habitats.

Countries whose main source of revenue comes from oil extraction, such as Nigeria and Angola, have been unable to protect their coastal and marine environments from damaging oil spills from refineries, wells, ports, and transportation routes (EIA 2003). Coastal development and modification is also undermining the ability of natural landforms and other features to protect and stabilize shorelines. Coastal communities have suffered economic and social losses related to the depletion of fish stocks, the deterioration of recreational and tourism attractions, and rising costs for water treatment and coastal protection (UNEP 1999).

Benguela Current Large Marine Ecosystem

The Benguela Current Large Marine Ecosystem (LME) is located along the southwest coast of Africa, alongside Angola, Namibia, and South Africa. It is the world's most powerful wind-driven coastal upwelling. It is also a highly productive ecosystem—its mean annual primary productivity of 1.25 kg of carbon per square metre is about six times higher than that of the North Sea ecosystem. It thus harbours a globally significant reservoir of biodiversity and biomass of marine organisms. There are also rich deposits of precious minerals and oil and gas reserves in near-shore and off-shore sediments. The Benguela Current LME is subject to high variability. Local fisheries are periodically affected by episodic warming in the eastern Atlantic that causes sea temperatures to rise offshore of Namibia and southern Angola. These events displace fish stocks and cause massive marine-life mortalities. The region is also subject to harmful algal blooms (HABs), since much of the water is naturally hypoxic (lacking in oxygen), a condition exacerbated by local oxygen depletion processes. For many decades, a large variety of fish species have been exploited in this region, especially pilchards and mackerels, ground fish, rock lobster, high seas tuna, shrimps, and deep-sea species. The artisanal fishery provides food and income to many coastal communities. The commercial fisheries off the coast of Namibia have been over-exploited, but generally other marine activity has been minor. However, a number of new or increasing developments in oil, gas, and diamond extraction, as well as aquaculture, industrial fishing, and tourism are poised to expand posing new or more serious threats to the Benguela Current LME. In addition, the ecosystem is very vulnerable to the potential impacts of climate change, further increasing the challenge to manage its resources sustainably.

In 1995, the governments of Angola, Namibia, and South Africa initiated the BCLME Programme to manage the Benguela Current LME in a sustainable way, recognizing that a coordinated ecosystem approach is needed to deal with issues such as migrating or straddling fish stocks, invasive alien species, pollutants, and HABs that cross national boundaries, and that there are economic benefits to be gained from such an effort.

Sources: BCLME n.d.; Shannon and O'Toole 2003; UNEP/RSP 2006

The Skeleton Coast Park spans over 16 400 km², running 500 km north from the Ugab River in Namibia to the Kunene River along Angola's coast.


Rwenzori Mountains National Park, Uganda

Christian Lambrechts/UNEP

Biodiversity

Biological diversity, or biodiversity, is the term used to describe the full array of life in a region, including species richness, ecosystem complexity, and genetic variation. Biodiversity may be the greatest natural resource, as it is a source of food, medicines, clothes, energy, building materials, clean air, clean water, psychological well-being, and countless other benefits (Norse and others 1986). The effective use of biodiversity at all levels—genetic material, species, communities, and ecosystems—is a precondition for sustainable development. However, human activities are the root cause of declining biodiversity worldwide; losses of plants, animals, and other species are taking place at a rate far higher than the natural background rate of extinction (UNEP 2008).

It may be too late to stem the loss of biodiversity in certain parts of the world; however, in most of Africa the opportunity still exists for proactive intervention (Biodiversity Support Program 1993). Africa's competitive advantage is enhanced not only by the fact that its environment is among the world's richest biologically but also by the fact that it has not yet sacrificed its endowment of these resources (Biodiversity Support Program 1993). Africa's living things account for almost one-third of global biodiversity, with the greatest concentrations occurring in the African equatorial ecosystems and those that border them.

Of the world's 4 700 mammal species, one-quarter occur in Africa. Huge populations of mammals are found in the eastern and southern savannahs, including at least 79 species of antelope (UNEP and McGinley 2007). Africa also has more than 2 000 species of birds—one-fifth of the world's total—and at least 2 000 species of fish, more than any other continent.

In addition, Africa has about 950 amphibian species. New species of amphibians and reptiles are still being discovered. For example, during the 1990s, discoveries of new amphibian and reptile species in Madagascar alone increased the number of known species of these organisms by 25 per cent and 18 per cent, respectively (Anon 2007).

The African mainland has between 40 000 and 60 000 plant species. Southern Africa alone has at least 580 families and about 100 000 known species of insects, spiders, and other arachnids (Anon 2007).

Eight of the world's 34 biodiversity hotspots are in Africa (CI 2007c). To qualify as a hotspot, a region must contain at least 1 500 species of vascular plants (> 0.5 per cent of the world's total) as endemics, and it must have lost at least 70 per cent of its original habitat (CI 2007b).

Scientists have designated the African biodiversity hotspots on the basis of both existing biodiversity and the threats to that biodiversity with the intention of focusing protection efforts on these valuable areas. Over the last 30 years, the efforts to protect and sustain biodiversity have strengthened. More recently, there has been a shift toward focusing on the sustainable use of biodiversity resources and the sharing of their benefits.

Nevertheless, biological diversity in Africa continues to decline (UNEP 2002). Over 120 plant species are extinct, with another 1 771 threatened (Bird and Medina 2002). Threats to species are both direct (such as bushmeat hunting) and indirect (such as habitat loss). Some species, such as the Bonobo or pygmy chimpanzee (*Pan paniscus*), exist in very limited areas. Loss of habitat in these relatively small areas can lead to the rapid extinction of species (Brooks and others 2002). Much effort has gone into designating protected areas in Africa with the hope of saving these areas of crucial habitat.

Table 1.2 - African Hotspots and Their Vital Signs

Hotspot	Vital signs									
	Hotspot Original Extent (km^2)	Hotspot Vegetation Remaining (km^2)	Endemic Plant Species	Endemic Threatened Birds	Endemic Threatened Mammals	Endemic Threatened Amphibians	Extinct Species†	Human Population Density (people/km^2)	Area Protected (km^2)	Area Protected (km^2) in Categories I-IV*
Cape Floristic Region	291 250	29 125	1 750	2	6	4	0	52	50 889	11 343
Coastal Forests of Eastern Africa	291 250	29 125	1 750	2	6	4	0	52	50 889	11 343
Eastern Afromontane	1 017 806	106 870	2 356	35	48	30	1	95	154 132	59 191
Guinean Forests of West Africa	620 314	93 047	1 800	31	35	49	0	137	108 104	18 880
Horn of Africa	1 659 363	82 968	2 750	9	8	1	1	23	145 322	51 229
Madagascar and the Indian Ocean Islands	600 461	60 046	11 600	57	51	61	45	32	18 482	14 664
Maputaland-Pondoland-Albany	274 136	67 163	1 900	0	2	6	0	70	23 051	20 322
Succulent Karoo	102 691	29 780	2 439	0	1	1	1	4	2 567	1 890

† Recorded extinctions since 1500 *Categories I-IV afford higher levels of protection

Source: Conservation International: Biodiversity Hotspots, 2007

8 Biological Hotspots of Africa

Guinean Forests of West Africa

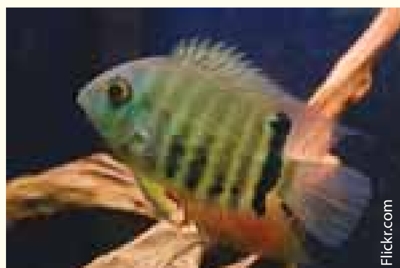
The Guinean Forests of West Africa are home to more than a quarter of Africa's mammals, including more than 20 species of primates. These and other species are threatened by logging, mining, hunting, and ever-increasing numbers of people.

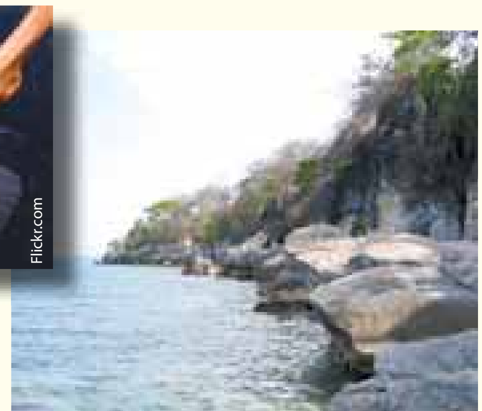
Cape Floristic Region

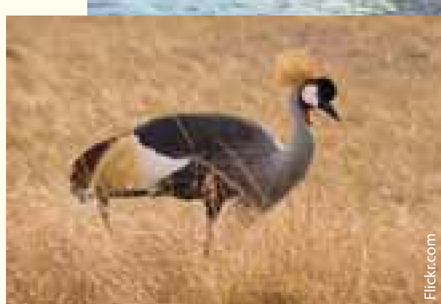
This is one of the world's five Mediterranean climate zone hotspots and contains its largest non-tropical concentration of higher vascular plant species. It is the only hotspot encompassing an entire floral kingdom.

Succulent Karoo

The Succulent Karoo of South Africa and Namibia boasts the world's richest succulent flora and exceptional plant endemism—69 per cent of its plants are found nowhere else—as well as a number of unique reptile species. It is one of only two of the world's completely arid hotspots. Grazing, agriculture, and mining threaten this fragile region.





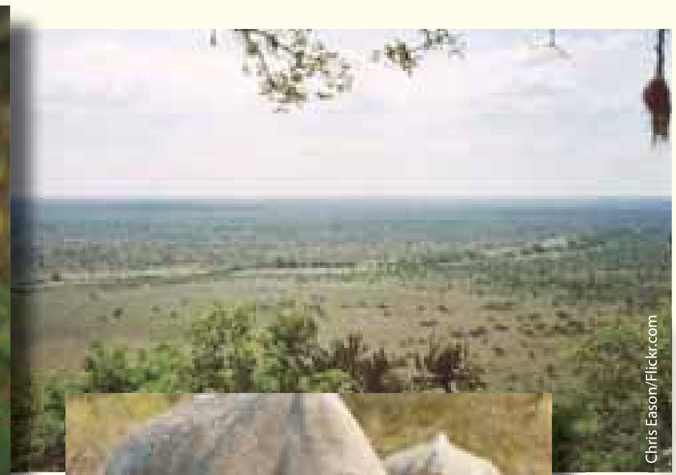


Eastern Afromontane

This hotspot is formed by scattered mountains with very similar plant communities. The Albertine Rift has more endemic mammals, birds, and amphibians than any other African region. The Eastern Afromontane also contains some of the world's most extraordinary lakes, which harbour about 617 endemic fish species. Agricultural expansion of crops such as bananas, beans, and tea, as well as the growing demand for bushmeat, are threatening the region's biodiversity.

Maputaland-Pondoland-Albany

Maputaland-Pondoland-Albany, which stretches along the east coast of southern Africa, is an important centre of plant endemism, with nearly 600 tree species alone. This region has the world's highest tree diversity of any temperate forest. One of the region's most well-known endemic plants is the Bird of Paradise flower (*Strelitzia reginae*). This hotspot is also world-renowned for its conservation efforts to save the southern subspecies of white rhinoceros from extinction. Commercial and local small-scale farming and the expansion of grazing lands are encroaching on the extensive grassland habitats here, threatening many of its large mammals.

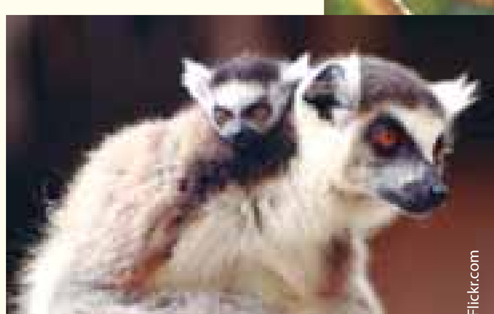


Coastal Forests of Eastern Africa

This tiny and fragmented hotspot has exceptional levels of biodiversity. It is the original source of the world's lucrative trade in cultivated African violets and is home to a wide variety of threatened primates, including some that are endemic. The expansion of both commercial and subsistence agriculture is severely threatening this habitat.

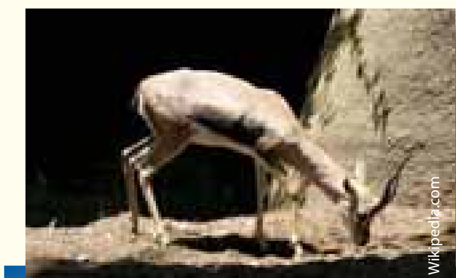
Madagascar and the Indian Ocean Islands

Madagascar and the Indian Ocean Islands have exceptional biodiversity: eight plant families, four bird families, and five primate families that are found nowhere else on Earth. Madagascar has more than 50 lemur species, although 15 others have become extinct since the arrival of humans. A number of critically endangered bird species inhabit the Seychelles, Comoros, and Mascarene islands in the Indian Ocean.



Horn of Africa

The Horn of Africa is one of the two entirely arid global hotspots and is renowned for its biological resources. It has Africa's highest number of endemic reptiles and a number of endemic and threatened antelope. With only five per cent of its original habitat remaining, this hotspot is also one of the world's most degraded. It has been devastated by overgrazing and charcoal harvesting.



A Few African Species Extinct in the Wild

Barbary Lion

Panthera leo leo

North Africa

The Barbary (also called Atlas or Nubian) lion was found throughout northern Africa from Morocco to Egypt. Studies have concluded that the Barbary lion was most closely related to Asian lions. The last known individual in the wild was killed in the Atlas Mountains in 1922.

Pinstripe Dambo

Paretroplus menarambo

Madagascar

The pinstripe dambo was endemic to a small region of Madagascar but is presumed extinct in the wild. Despite targeted surveys, no specimens have been collected in recent years. However, breeding populations of this species are maintained in captivity. The main causes for the loss of this species were deforestation, introduced alien species, and overfishing.

West African Black Rhino (Extinct)

Diceros bicornis longipes

Central West Africa

Among two of Africa's most threatened rhinoceros subspecies is the West African Black Rhino. According to the African Rhino Specialist Group of the International Union for the Conservation of Nature and Natural Resources (IUCN) Species Survival Commission, the West African Black Rhino is now feared extinct. An intensive survey of the West African black rhino in early 2006 has failed to locate any sign of their continued presence in their last refuges in northern Cameroon. Poaching for rhino horn is the main cause of their demise.

Scimitar Oryx

Oryx dammah

Algeria, Burkina Faso, Chad, Egypt, Israel, Libyan Arab Jamahiriya, Mali, Mauritania, Morocco, Niger, Nigeria, Senegal, Sudan, Tunisia, Western Sahara

The scimitar oryx, or scimitar-horned oryx is a species of oryx which once inhabited the whole of North Africa and was one of the most common large mammals of the region. There are conflicting reports as to whether it is extinct in the wild, or whether small populations still survive in central Niger and Chad. Currently listed as extinct on the IUCN Red List, the scimitar oryx is now part of a major captive breeding and reintroduction programme.

Dodo (Extinct)

Raphus cucullatus

Mauritius

The Dodo was a flightless bird that lived on the island of Mauritius. Related to pigeons and doves, it stood about one metre tall, lived on fruit, and nested on the ground. The dodo has been extinct since the mid-to-late 17th century. It is commonly used as the archetype of an extinct species because its extinction occurred during recorded human history and was directly attributable to human activity. The birds were killed by sailors and settlers for food, and their eggs and young were devoured by cats, dogs, and other non-native animals that were introduced to Mauritius.

Blue Antelope or Bluebuck (Extinct)

Hippotragus leucophaeus

South Africa

The bluebuck, or blue antelope, was the first large African mammal to become extinct in historical times. Bluebuck numbers began dropping about 2 000 years ago and the species was already rare by the 1700s. Various factors have been suggested as the cause of their extinction, including the change of grassland into bush and forest when the climate became warmer, and the human introduction into their habitat of livestock, particularly sheep, at about that time. Competition with sheep, diseases, or hunting may all have contributed to a decline in bluebuck. The last bluebuck was reportedly killed in 1799.

Giant Tortoise

Cylindraspis

Mauritius, Seychelles

Giant tortoises were considered extremely valuable by early mariners for food as they could survive for months in captivity without food and water. Their flesh and oil was considered a cure for scurvy. Sadly, thousands were wastefully harvested, with many specimens being left to rot after their valuable liver and oil had been removed. Most sub-species became extinct in the early years of the 18th century.

Egyptian Barbary Sheep

Ammotragus lervia ornata

Eygpt

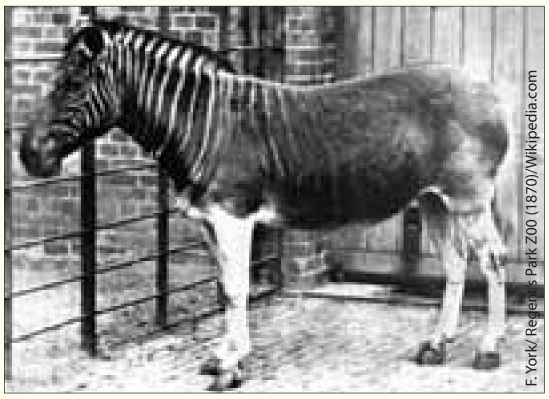
The native range of the Egyptian Barbary sheep was the arid hills east of Cairo, Egypt, and the rugged terrain bordering both sides of the Nile River in southern Egypt. It is thought that the Egyptian Barbary sheep probably became extinct in the wild in the 1970s or 1980s. The species does survive, however, in captive breeding programmes.

Seychelles Parakeet (Extinct)

Psittacula wardi

Seychelles

The Seychelles parakeet was endemic to Mahé and Silhouette, two islands in the Seychelles group. This small, primarily green parrot was already rare when it was first described by Europeans in the 1860s. The Seychelles parakeet was finally driven to extinction in 1906, largely due to the clearing of its forest habitat for coconut plantations and eradication efforts to keep it from eating crops.



Quagga (Extinct)

Equus quagga

South Africa

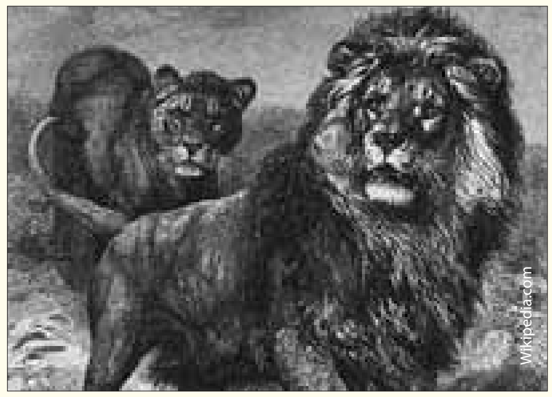
The quagga, a grazing mammal closely related to zebras, was native to desert areas of southern Africa. It was especially abundant in South Africa's Cape Province. Quaggas were distinguishable from zebras by the fact that they had brown-and-tan stripes on the front part of the body only. The stripes faded toward the hindquarters, which were solid brown. Prized for its meat and hides, the quagga was hunted to extinction in the 1870s. The last specimen in captivity died in 1883.

Mauritius Blue Pigeon (Extinct)

Alectroenas nitidissima

Mauritius

This beautiful red, white, and blue pigeon was also named Pigeon Hollandais because of its resemblance to the colours of the Dutch flag. It was hunted extensively and had already become rare by the 1730s. Monkeys and rats preyed on the pigeon's eggs and chicks, and deforestation fragmented its habitat. The last specimen was collected in 1826, and hunting and habitat loss eventually brought about the species' extinction in the 1830s. There are three surviving skins of this species, one in Edinburgh, England, one in Paris, France and one in the Mauritius Institute, the latter belonging to the last surviving individual.



Cape Lion (Extinct)

Panthera leo melanochaitus

Cape of South Africa

The Cape lion was once found throughout southern Africa from the Cape of Good Hope to the Province of KwaZulu Natal. Cape lions were the largest and darkest of all sub-Saharan lions. The last known Cape lion in the wild was killed in 1858. Until recently, researchers disputed whether the extinct Cape lion was a true species, or merely a subspecies, of African lion. Genetic research, published in 2006, did not support the "distinctness" of the Cape lion. It now seems probable that the Cape lion was only the southernmost population of the extant southern African lion.

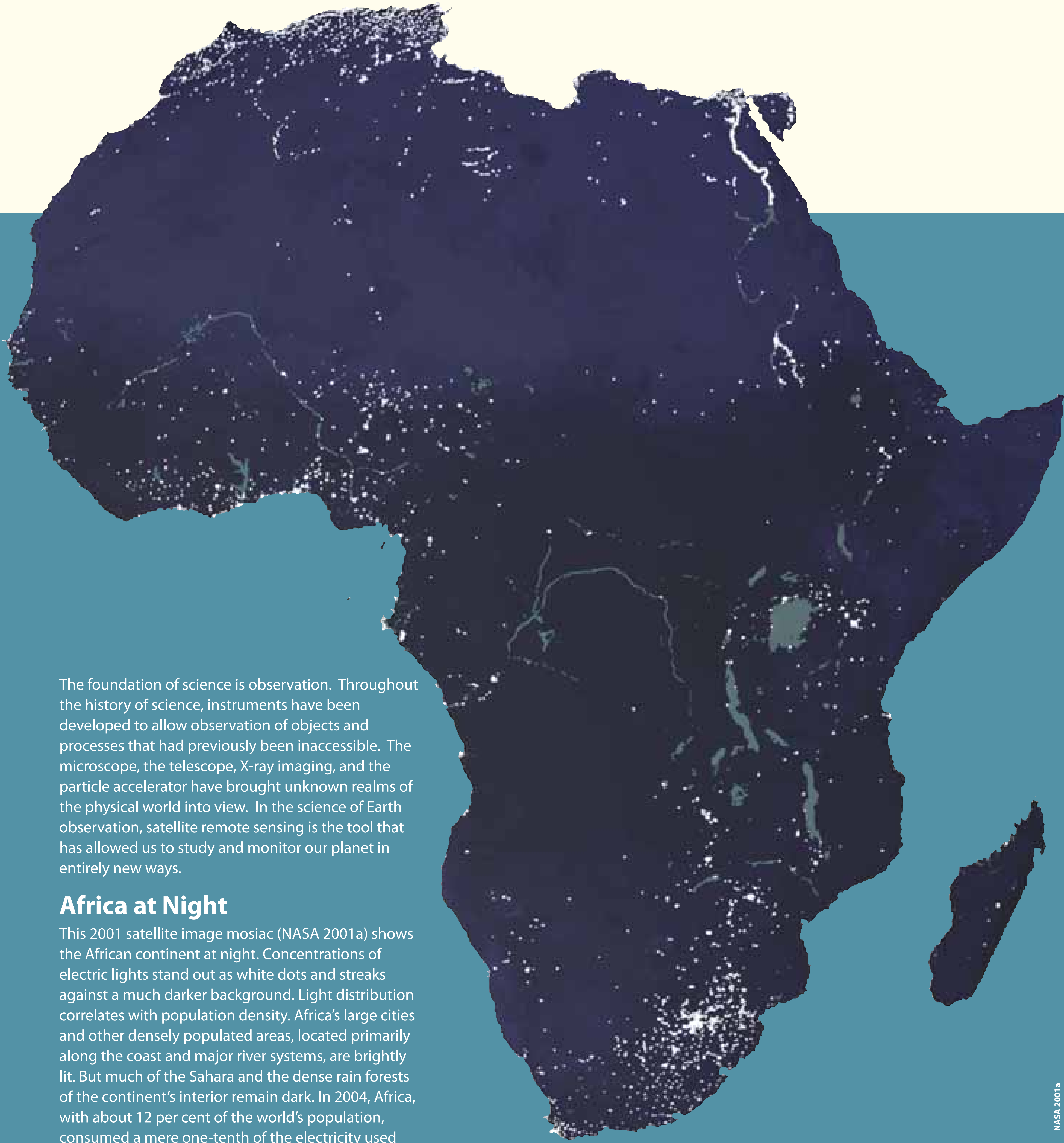
Haplochromis Ishmaeli

syn. Labrochromis ishmaeli

Lake Victoria in Kenya, United Republic of Tanzania, Uganda

Haplochromis ishmaeli—a specialized snail eater—is not only extinct in the wild but also rare in the aquarium fish industry. This small muscular fish eats mollusks. But unlike other snail-eating fish, which extract the mollusk from its shell, *Haplochromis ishmaeli* ingests the entire animal, shell and all.

Sources: Creighton, B 2000, IUCN n.d., National Geographic News 2006, The Bay Science Foundation, Inc. 2007, Pedersen, M. 1999, Mass, P. 2007, Preservation Station Inc. 2005, Steeves, G. and A. 2007



NASA 2001a

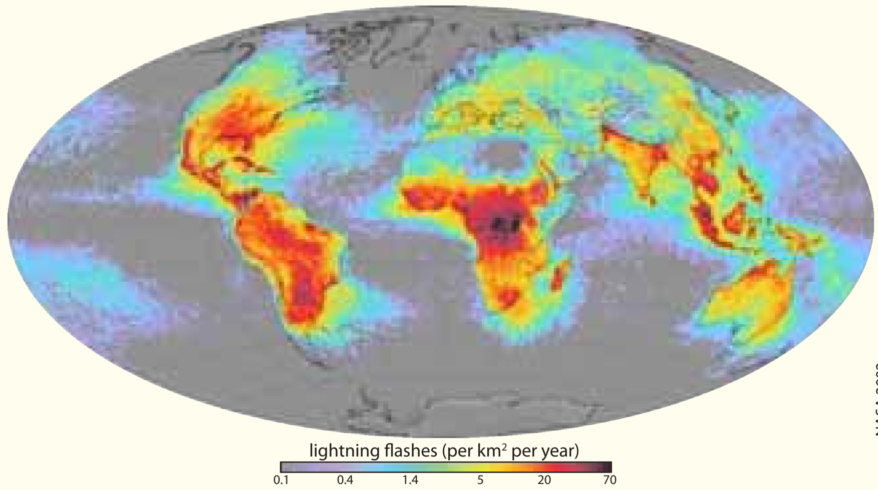
The foundation of science is observation. Throughout the history of science, instruments have been developed to allow observation of objects and processes that had previously been inaccessible. The microscope, the telescope, X-ray imaging, and the particle accelerator have brought unknown realms of the physical world into view. In the science of Earth observation, satellite remote sensing is the tool that has allowed us to study and monitor our planet in entirely new ways.

Africa at Night

This 2001 satellite image mosiac (NASA 2001a) shows the African continent at night. Concentrations of electric lights stand out as white dots and streaks against a much darker background. Light distribution correlates with population density. Africa's large cities and other densely populated areas, located primarily along the coast and major river systems, are brightly lit. But much of the Sahara and the dense rain forests of the continent's interior remain dark. In 2004, Africa, with about 12 per cent of the world's population, consumed a mere one-tenth of the electricity used in North America, which had 5.1 per cent of global population (IEA 2005).

Africa—Lightning Centre of the World

Lightning, a discharge of energy during severe storms, may affect public safety, electrical and transportation systems, and may even trigger wildfires. Detecting lightning helps scientists to understand Earth's climate system and monitor changes in severe storms and precipitation patterns over time. The map (right) shows the average yearly number of lightning flashes per square kilometre based on data collected between 1995 and 2002. The places with the highest number of lightning flashes per square kilometre per year appear as dark red patches. Although lightning is common across much of Africa, it is very common near the heart of the continent. It is probably no coincidence that this is also the region where most of Africa's wildfires occur (NASA 2002a). Africa has more lightning flashes per square kilometre than anywhere else on Earth.

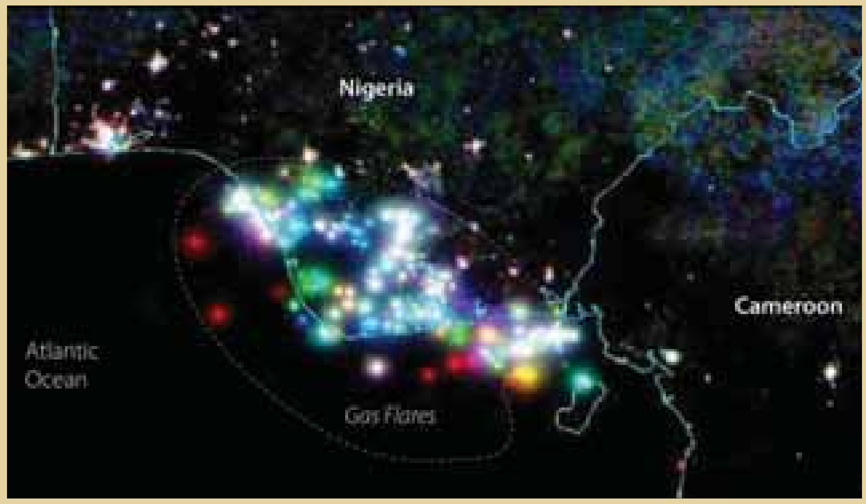


NASA 2002a

Gas Flaring in the Niger Delta

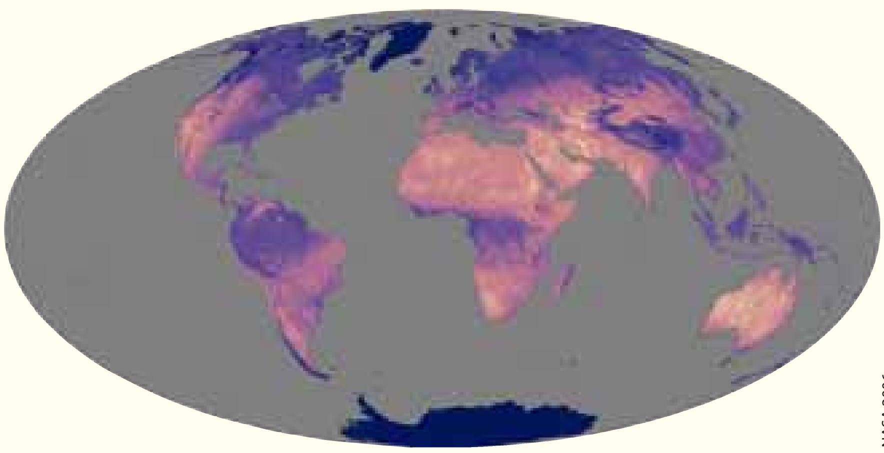
Nigeria has significant petroleum and natural gas reserves in its Niger River delta region. During the production of petroleum, most of the associated natural gas ends up being burned off, or flared. The flaring of gas has been practiced in the Niger Delta region for over four decades. Alongside carbon dioxide emissions, about 4 580 million kilowatts of heat are discharged into the atmosphere above the Niger Delta from flaring 548.6 million cubic metres of gas every day. This practice not only has economic implications in terms of wasted resources that could be used in energy generation, but is also a source of environmental degradation.

Nigeria, however, has been gradually reducing the amount of gas flared, with the aim of stopping the practice altogether. This change is confirmed by analysis of a series of satellite images produced by the World Bank in collaboration with the U.S. National Oceanic and Atmospheric Administration (NOAA) over a period of 14 years. The composite satellite image (above) shows a reduction in gas flaring in Nigeria over 14 years. The year 2006 is in red, 2000 is in green and 1992 is in blue.



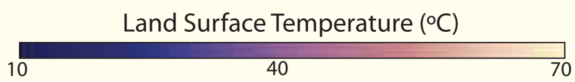
Source: Uyigue and Agho 2007; World Bank 2007

Global Land Surface Temperature



NASA 2006a

This image shows the highest land surface temperatures recorded worldwide between 2003 and 2005. Africa is one of the world's hottest regions. The hottest places, shown in light pink, are largely barren or sparsely vegetated deserts. These areas are prevalent in northern Africa, southern Asia, Australia, and parts of western North and South America. Densely vegetated areas are much cooler and appear purple in the image (NASA 2006a).



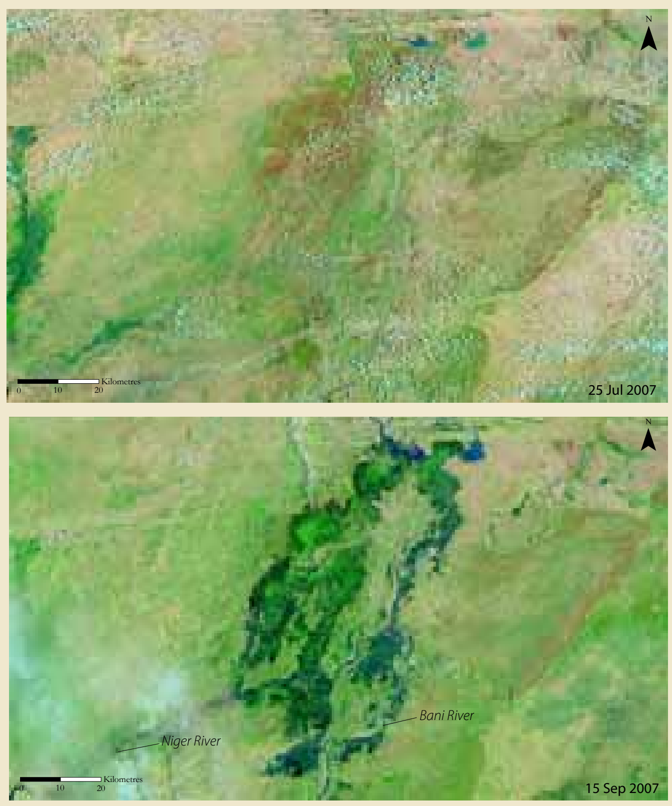
Flooding in Mali

Like many other countries in Africa's Sahel region, Mali was flooded in September 2007. Heavy rains pushed the converging Niger and Bani Rivers over their banks and filled the surrounding wetlands with water.

The 25 July 2007 satellite image taken before the heaviest rains settled in, shows smudges of light blue along the left edge, which are water-soaked ground typical of flooding, indicating that the floods had already started. The Niger and Bani Rivers, however, were still too small to be seen clearly.

By 15 September 2007, the rivers had widened, expanding into pools throughout the surrounding wetlands. In the September 2007 image, water is black or dark blue, in contrast to the pale tan earth and the bright green plant-covered areas (clouds are light blue and white). The Niger River remained flooded along its entire length, through Mali and Niger, and into Nigeria. A further testament to the rainfall is the greening of the landscape. Wetlands bordering the rivers went from tan-red, a colour typical of recently burned areas where few or no plants are growing, to vivid green. The floods extended far beyond the region. As many as 17 countries and more than a million people were affected by flooding across Africa.

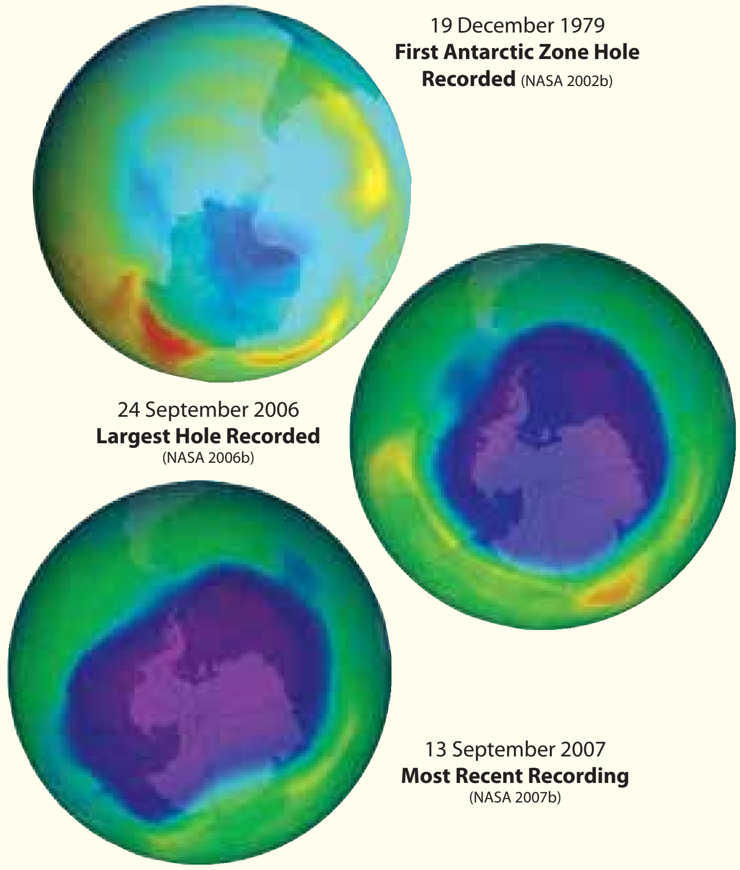
Source: NASA 2007a



Africa and Ultra Violet (UV) Exposure

The ozone layer in the upper atmosphere provides a shield that blocks harmful ultraviolet rays from reaching the Earth's surface. Human-made ozone-depleting substances such as chlorofluorocarbons and related chemical compounds have led to a thinning of the ozone layer. As a result of ozone loss worldwide, more dangerous UV radiation reaches the Earth's surface, increasing the potential risk of skin cancer in people and adversely impacting marine organisms, plants, and animals.

In addition to general loss of atmospheric ozone worldwide, massive ozone loss occurs each austral spring over Antarctica, resulting in what is known as the Antarctic "ozone hole." In the Northern Hemisphere, a similar although less extensive ozone hole forms over the North Pole each spring. Although the protective ozone layer thins each year significantly more at the poles than at the equator, Africa and other equatorial regions tend to receive more UV radiation than do higher latitudes. One reason for this is because UV radiation is somewhat blocked by cloud cover, and at certain times of the year, many regions in Africa are relatively cloud-free. Another factor is that equatorial regions receive more sunlight than higher latitudes where the sun's rays strike at oblique angles, spreading UV radiation over a wider surface area (NASA 2008b; Allen 2001).

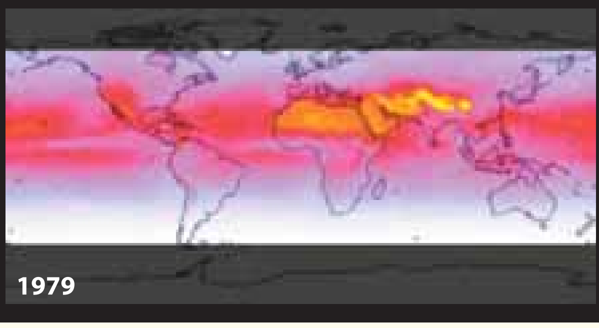


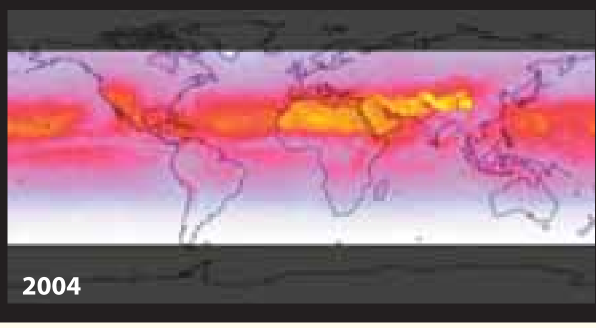
19 December 1979
First Antarctic Zone Hole Recorded (NASA 2002b)

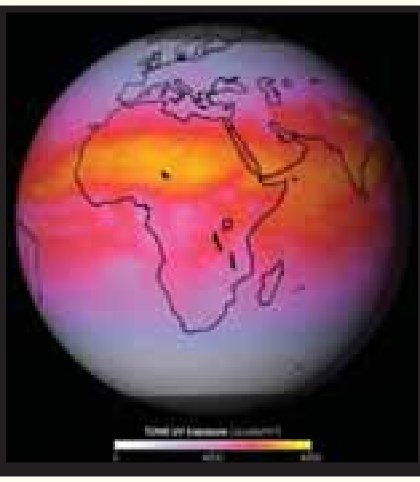
24 September 2006
Largest Hole Recorded
(NASA 2006b)

13 September 2007
Most Recent Recording
(NASA 2007b)

This image shows UV radiation levels based on data collected during the month of July in 1979 (below left) and 2004 (below right). Very high UV levels, represented by orange and yellow colouration, appear over the Sahara, Saudi Arabia, the southwestern United States, and the Himalayan Mountain regions in northern India and southern China.



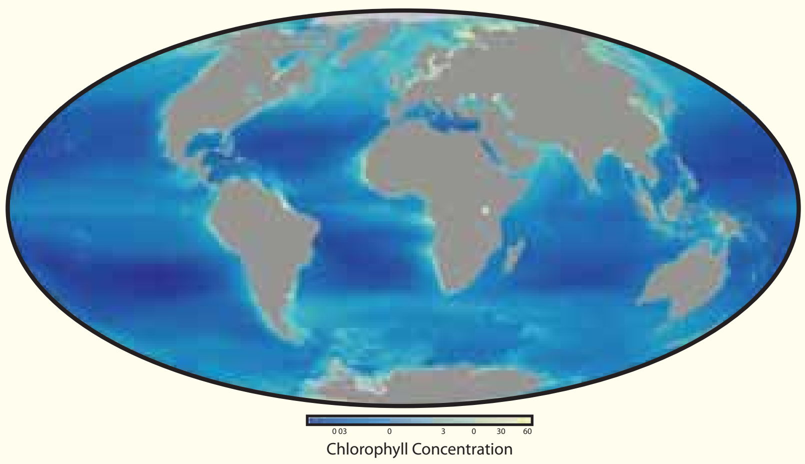




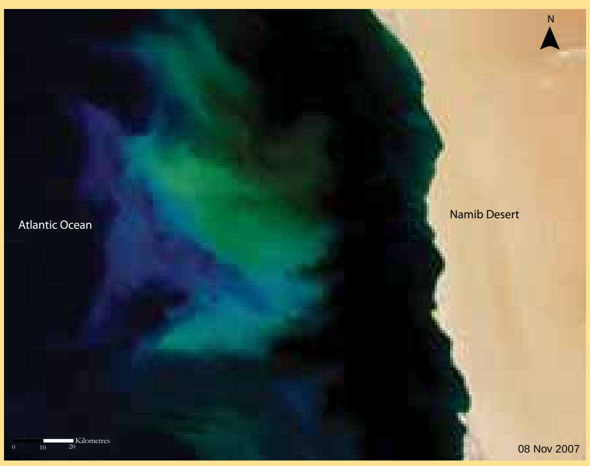
Global Phytoplankton Distribution

This image represents a decade of satellite observations showing average chlorophyll concentrations in the Earth's oceans from mid-September 1997 through the end of August 2007. Satellite sensors record the amount of light characteristically absorbed by chlorophyll in algae and other marine organisms that carry out photosynthesis. Photosynthesis is the biochemical process in which water and carbon dioxide are converted into sugar (glucose) and oxygen using energy from sunlight.

In general, high chlorophyll concentrations correspond with high numbers of these marine photosynthesizers, which form the base of nearly all ocean food webs. Where these organisms thrive, the ocean appears light blue to yellow in the image; less productive regions are dark blue. Thus, this image gives an overall view of global ocean productivity, although it should be noted that productivity in polar regions is seasonal. Marine algae and other photosynthesizing ocean organisms absorb more carbon dioxide than any other group of living things on Earth, including dense tropical forests. Since CO_2 is an important greenhouse gas, these organisms play an important role in mitigating global warming (NASA 2007c).



NASA 2007c



Phytoplankton Bloom off Namibia

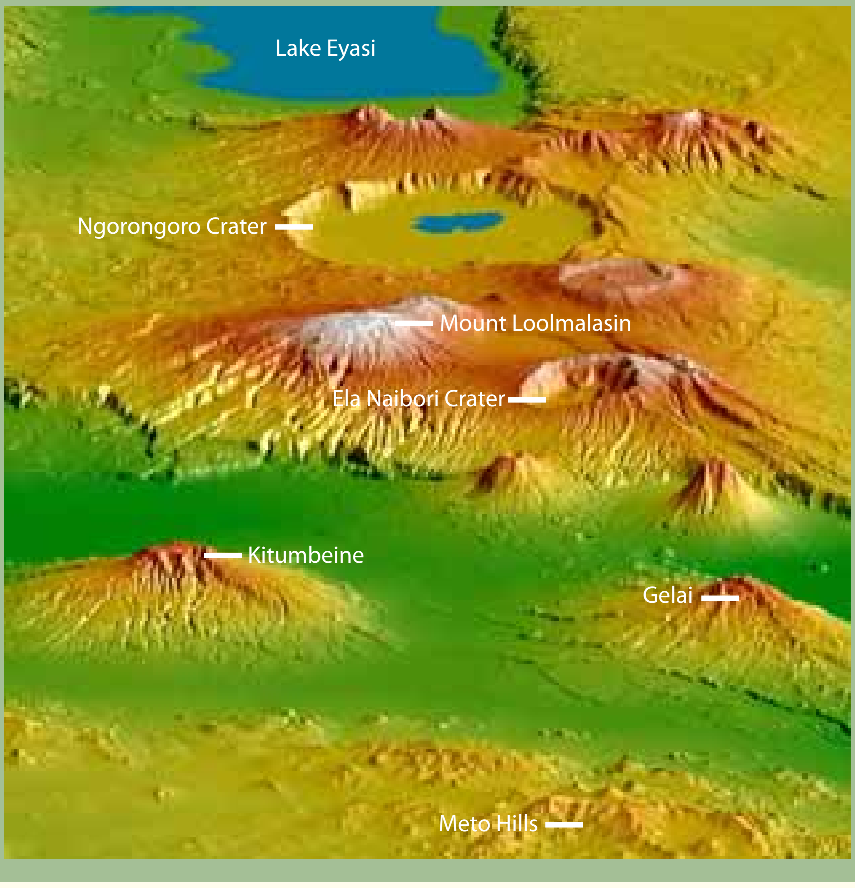
Phytoplankton are tiny photosynthesizing algae and other organisms that make up the vast drifting mass of marine life known as plankton. Phytoplankton "blooms" are common off the coast of Namibia. The eventual death and decomposition of the vast numbers of organisms in these blooms robs the water of dissolved oxygen. This creates an oxygen-depleted "dead zone" where fish cannot survive.

This satellite image, captured in 08 November 2007, shows a phytoplankton bloom (light blue and green areas) stretching along hundreds of kilometres off the Namibian coast. Such blooms are common in the coastal waters off southwest Africa. Cold, nutrient-rich currents flowing north along the ocean floor from Antarctica rise to mix with warmer surface waters. Phytoplankton thrive where such upwellings occur. (NASA 2007d).

Crater Highlands, United Republic of Tanzania

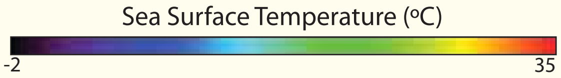
Plate tectonics, volcanism, landslides, erosion and deposition—and their interactions—are all very evident in this computer-generated view of the Crater Highlands, along the East African Rift (based on satellite and other data). The lower elevations are shown as green while higher elevations appear as brown; snow-capped peaks are white. These Crater Highlands rise far above the adjacent savannahs, capture moisture from passing air masses, and are home to dense rain forests.

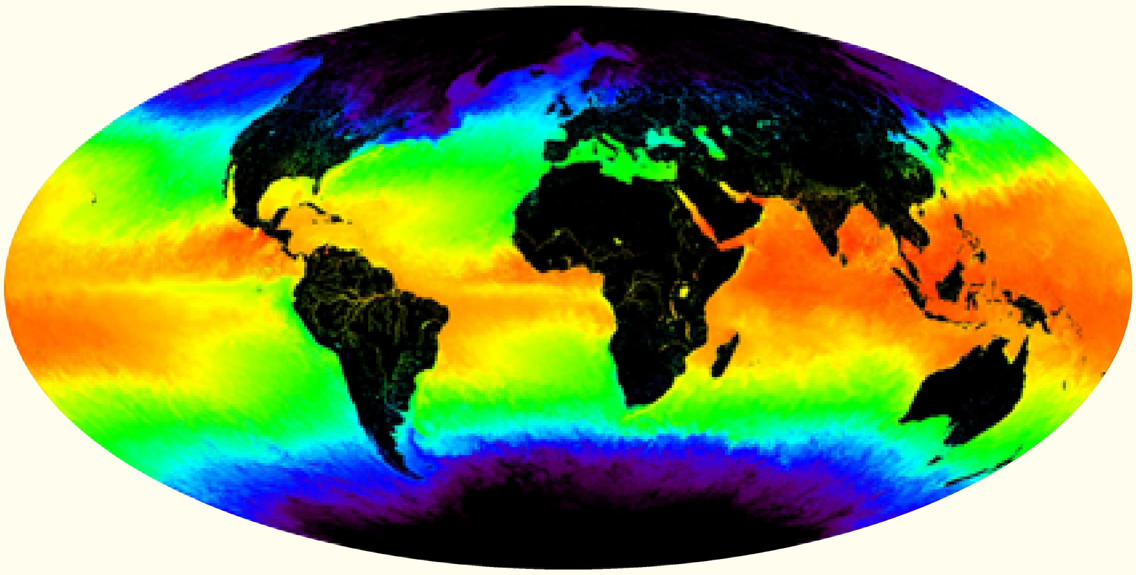
The East African Rift is a zone of spreading, or rifting, between the African tectonic plate (on the west) and Somali tectonic plate (on the east). Two branches of the Rift intersect in the United Republic of Tanzania, resulting in distinctive and prominent landforms. One rift runs from southwest to northeast (top to bottom in this southwest facing view). The other rift, running southeast to northwest, corresponds to the band of low elevation crossing the bottom of the image (green). Volcanoes are often associated with spreading rift zones where magma, rising to fill gaps between moving plates, reaches the surface, erupts, and builds cones. Craters form when part of a volcano explodes. Calderas, such as Ngorongoro Crater, are a type of crater that forms when a volcano collapses into itself. *Source: NASA 2000*



Global Sea Surface Temperature

In this May 2001 image, red and yellow indicate warmer ocean waters, blue and purple represent colder waters, and green represents water of an intermediate temperature. Sea surface temperature images such as these are useful in studies of global temperature anomalies, and of how air-sea-ocean interactions drive changes in weather and climate patterns. Note the warm tongue of water extending south from Africa's east coast to well below the Cape of Good Hope. *Source: NASA 2001b*

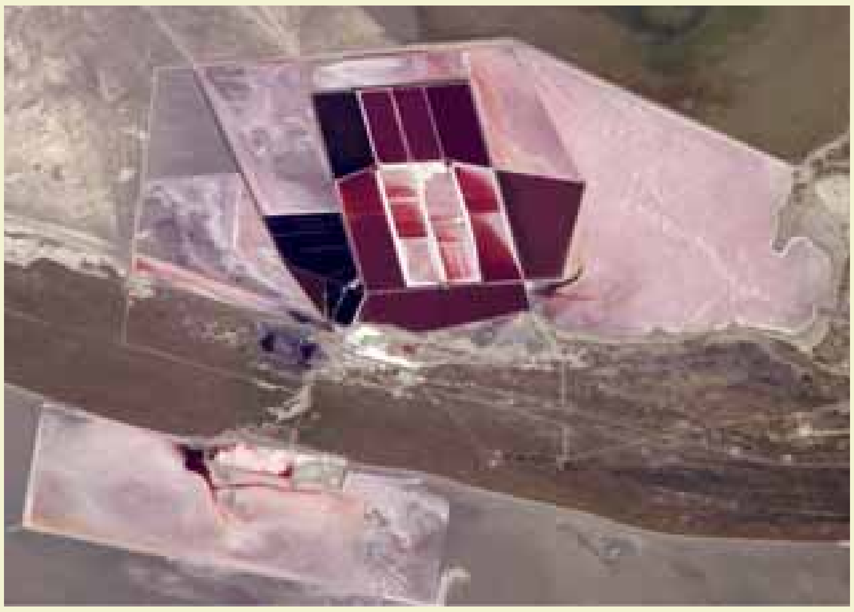




Botswana Salt Pans

The Makgadikgadi Pans complex is situated in the northeastern part of Botswana, southeast of the Okavango Delta. Covering over 12 000 km², it is one of the largest saltpan complexes in the world. The Makgadikgadi Pans are in a geographic depression (the Kalahari (Kgalagadi Basin) that once held an enormous lake that spanned most of what is now northern Botswana. The formation of various faults at the southern end of the East African Rift Valley diverted the flow of rivers away from the ancient lake, causing it to slowly dry up. This drying process concentrated salts in the lake bed, eventually leaving flat, salt-saturated clay-pan expanses: the Makgadikgadi Pans complex. The harsh conditions in and around the Makgadikgadi Pans are unsuitable for most animals. The only fauna to permanently inhabit the pans are highly specialized invertebrates. These invertebrates, mainly crustaceans, are adapted to withstand the long dry periods and to reproduce very quickly after a rain. After heavy rains the pans are transformed into a vibrant paradise, attracting thousands of waterbirds that come to feed and breed. The most spectacular visitors are greater and lesser flamingos (*Phoenicopterus ruber* and *Phoeniconaias minor*, respectively) that flock to the pans by the thousands. The greater flamingos feed on the newly hatched crustaceans while their smaller relatives feast on the blue-green algae (cyanobacteria) that also thrive in the salt pans.

Source WWF 2001: NASA 2007e

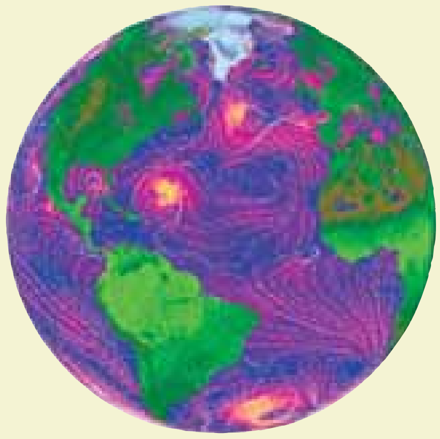


Flamingos at Makgadikgadi Pans, Botswana

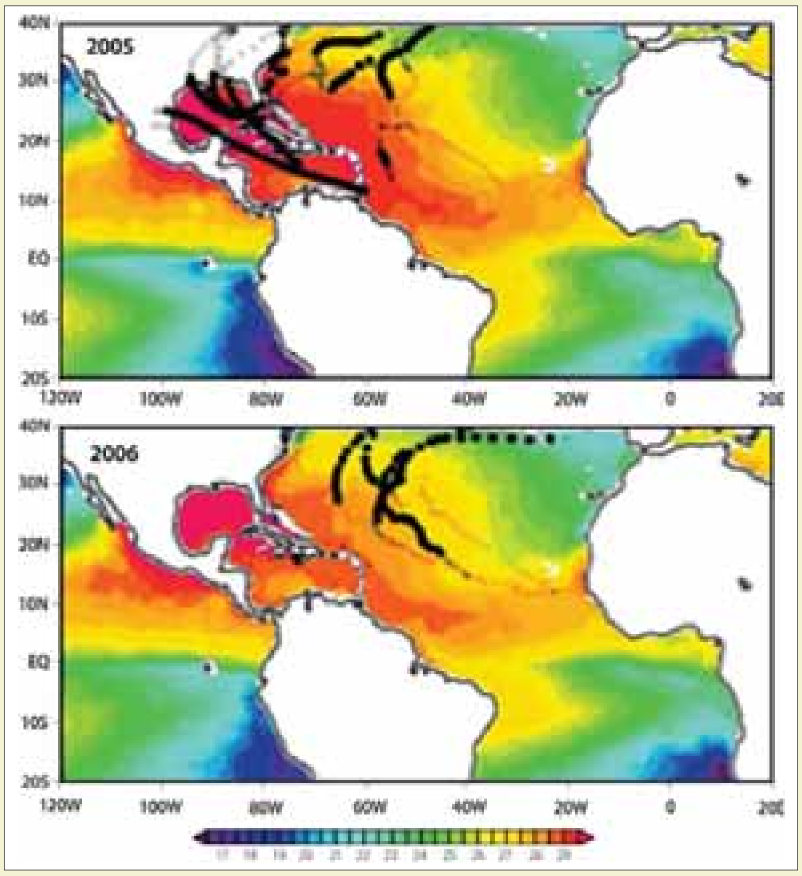
Kirsten Weeks/Flickr.com

Saharan Dust Has Chilling Effect on the North Atlantic

Dust and other aerosols can both absorb and reflect sunlight, and thus affect surface temperature in different parts of the Earth. For years, however, research on the impact of aerosols was largely confined to global climate modeling. (Miller and Tegen, 1998; Schollaert and Merrill 1998). A recent study by the National Aeronautics Space Administration (NASA), however, makes made use of aerosol data and satellite earth observation techniques to suggest that the 2006 hurricane season was relatively calm as a result of an abundance of dust blowing off the West African coast and over the Atlantic Ocean (NASA 2007f).



This figure shows the pattern of ocean winds from West Africa across the Atlantic Ocean



In June and July 2006, there were several significant dust storms over the Sahara Desert in Africa. As this dust traveled westward into the Atlantic, satellite data showed that the particles blocked sunlight from reaching the ocean surface, causing ocean waters to cool.

Sea surface temperatures in 2006 across the prime hurricane-breeding regions of the Atlantic and Caribbean were found to be as much as one degree Celsius cooler than in 2005. Following the most significant dust outbreak, which occurred in June and July, ocean waters cooled abruptly in just two weeks, suggesting that the dust had an almost immediate effect. These cooler waters may have impeded some the development of hurricanes, since the storms rely on warm waters to form.

Cooler ocean waters in 2006 did result in fewer summertime tropical storms and hurricanes in the Atlantic than in 2005. Average sea surface temperature in degrees Celsius for the July-September period are shown for 2005 (top) and 2006 (bottom). During 2005, there were nine distinct tropical storms (open circles) and hurricanes (black circles) in the western Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico. During the same period in 2006, only two tropical storms formed and none developed into hurricanes.

The dust worked to cool the ocean, but it also warmed the atmosphere by absorbing more of the sun's energy. This temperature difference resulted in a shift in the large-scale atmospheric circulation. As air rose over West Africa and the tropical Atlantic, it sank and became less moist over the western Atlantic and Caribbean. This pattern helped to increase surface winds that enhanced ocean evaporation and churned deeper, colder waters, causing the area of cool seas to expand.

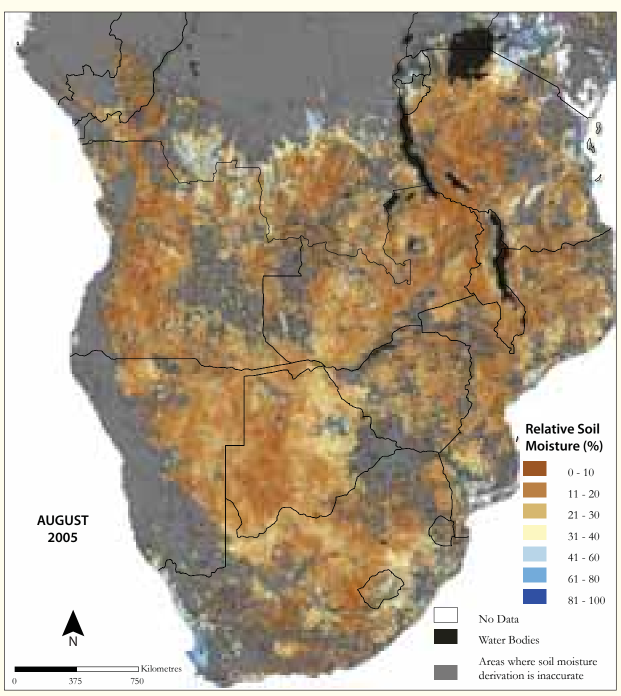
Credit: NASA 2007g

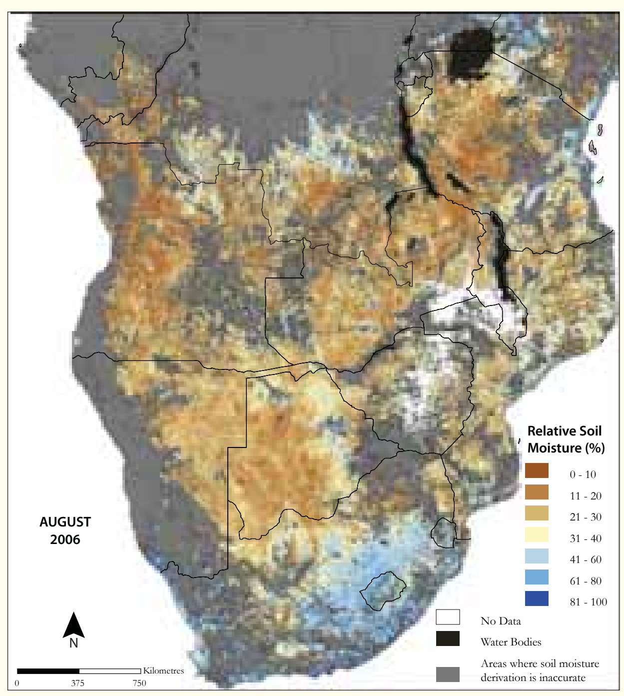
Soil Moisture Monitoring in Southern Africa

Active radar instruments onboard satellites have been successfully used for scientific studies in hydrology, oceanography, geomorphology, and geology. Radar instruments generate and transmit electromagnetic energy, making them independent of solar energy and allowing them to acquire data both during the day and at night. These sensors can also monitor changes in soil water content, as well as soil moisture patterns (Wagner and others 2007).

Radar was used in monitoring soil moisture in countries of the Southern African Development Community (SADC) (SHARE 2008). Data from the Advanced Synthetic Aperture Radar (ASAR), an active remote sensing instrument onboard the European Space Agency Environmental Satellite (ENVISAT) platform, were used to derive the soil moisture levels. The maps show marked differences in soil moisture between August 2005 and August 2006, as a result of above average rainfall in 2006.

The use of satellite technology in soil moisture monitoring eliminates the disadvantages associated with conventional monitoring methods. Conventional in-situ methods are labour intensive, costly, non-uniform, and local in scale. ENVISAT presents an opportunity for monitoring soil moisture patterns over large regions with, at the same time, high temporal resolution. Such information can then be used to help predict and monitor floods and droughts (Scipal and others 2005).





Smart Sensing of Volcanoes

The Democratic Republic of the Congo in central Africa is home to two active volcanoes: Nyiragongo and Nyamuragira. At 3 470 m high, Nyiragongo Volcano is a stratovolcano, a steep-sloped structure composed of alternating layers of solidified ash, hardened lava, and rocks ejected by previous eruptions. Prior to its 2002 eruption, this volcano wrought havoc in 1977 when it emptied a lava lake at its summit and caused a very fluid, fast-moving lava flow. Nyamuragira Volcano is a shield volcano, composed of old lava flows. Lava flows from this volcano cover some 1 500 km^2, and the volcano rises very gradually, reaching an altitude of 3 058 m. Despite its subtler shape, this volcano drained its own lava lake in 1938, sending lava flows all the way to Lake Kivu.

Besides their proximity to Lake Kivu, these volcanoes have both produced catastrophic eruptions since the early 20th century. Their tendency to release catastrophic lava flows prompted volcanologists to look for innovative ways to monitor the behaviour of both volcanoes, and even develop "smart" sensing systems that can act independently to collect observations as quickly as possible.

This satellite image above, taken on 31 January 2007, shows Nyamuragira and Nyiragongo, about five years after Nyiragongo sent a devastating lava flow through the town of Goma. Lava flows from neighboring Nyamuragira, however, are more prominent in this picture with their sombre shades of brown and purplish-black contrasting with the lush green of surrounding vegetation. Nyiragongo shows evidence of continued activity. The dark pink dot at its summit is a hotspot where the satellite sensor has detected unusually warm surface temperatures. The bright white plumes in the image are clouds, likely resulting from water vapour released by the volcano. The blue area near the clouds is part of the volcanic plume. Along the shores of Lake Kivu, areas of purple-brown indicate bare ground and human-made structures.

NASA 2007h

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The Eye of Mauritania

Also known as the Richat Structure, this prominent geographic feature in Mauritania's Sahara Desert was first thought to be the result of a meteorite impact because of its circular, crater-like pattern. However, Mauritania's "Eye" is actually a dome of layered sedimentary rock that, through time, has been eroded by wind and windblown sand. At 50 km wide, the Richat Structure can be seen from space by astronauts because it stands out so dramatically in the otherwise barren expanse of desert.

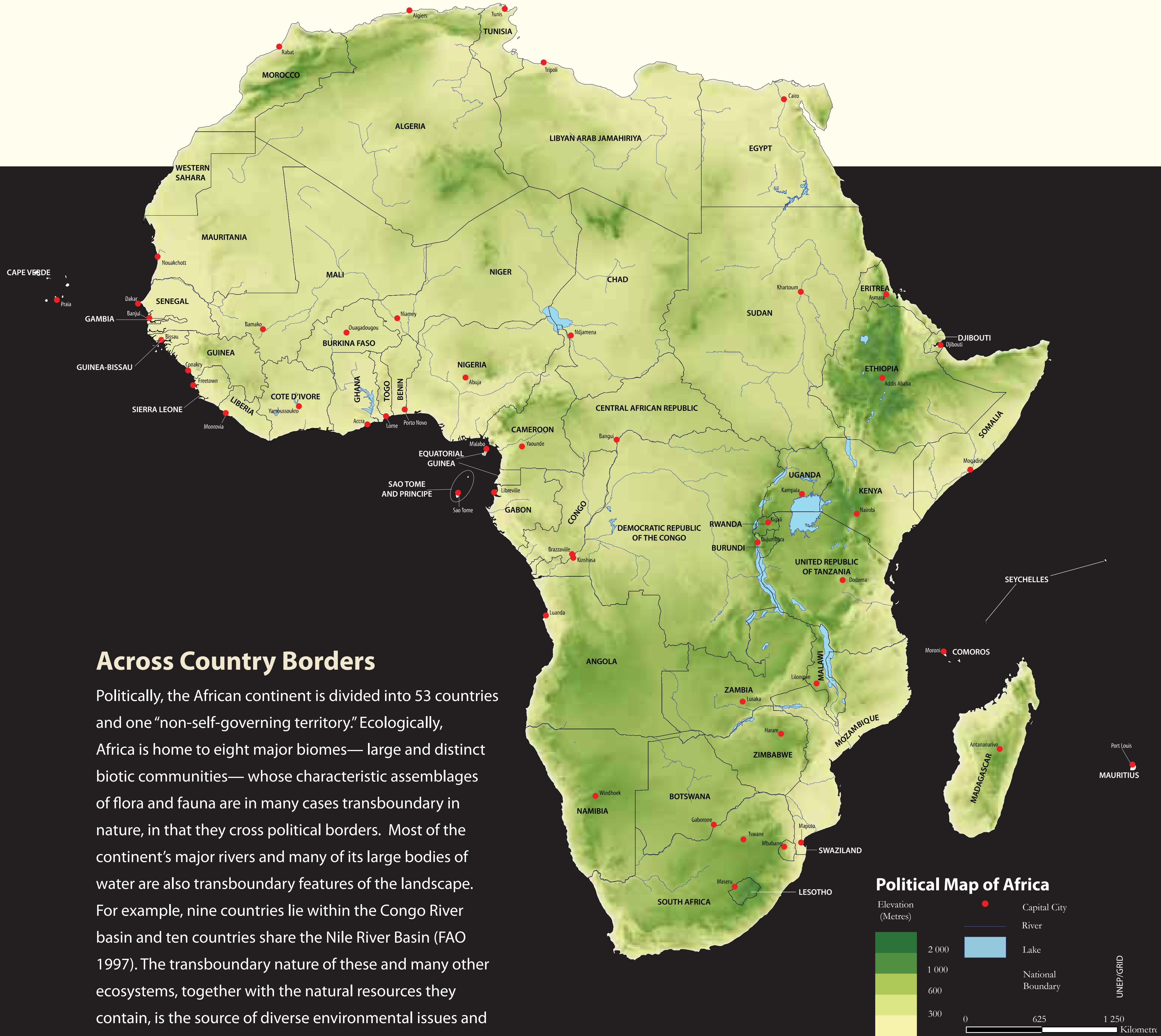
Source: NASA

A man singing by himself on the Jemaa Fna Square, Morocco

Charles Roffey/Flickr.com

Chapter 2

Transboundary Environmental Issues



Across Country Borders

Politically, the African continent is divided into 53 countries and one "non-self-governing territory." Ecologically, Africa is home to eight major biomes— large and distinct biotic communities— whose characteristic assemblages of flora and fauna are in many cases transboundary in nature, in that they cross political borders. Most of the continent's major rivers and many of its large bodies of water are also transboundary features of the landscape. For example, nine countries lie within the Congo River basin and ten countries share the Nile River Basin (FAO 1997). The transboundary nature of these and many other ecosystems, together with the natural resources they contain, is the source of diverse environmental issues and presents unique management challenges throughout Africa and, in some cases, beyond the continent itself.

Hippos in the Maasai Mara National Reserve, Kenya

Christian Lambrechts/UNEP

Given that transboundary environmental issues involve more than one nation, they are often addressed using varying political and management approaches that employ different laws and regulations (Gauthier and others 2003). The sustainable use of natural resources such as those derived from forest ecosystems and the monitoring, management, and conservation of flora and fauna shared by various countries, are problems of major concern in Africa. Efforts have been made to introduce management mechanisms that involve some international cooperation, especially in regard to transboundary waterways. But there are inadequacies in such mechanisms when it comes to dealing with many of Africa's other shared resources, such as forest belts and protected areas.

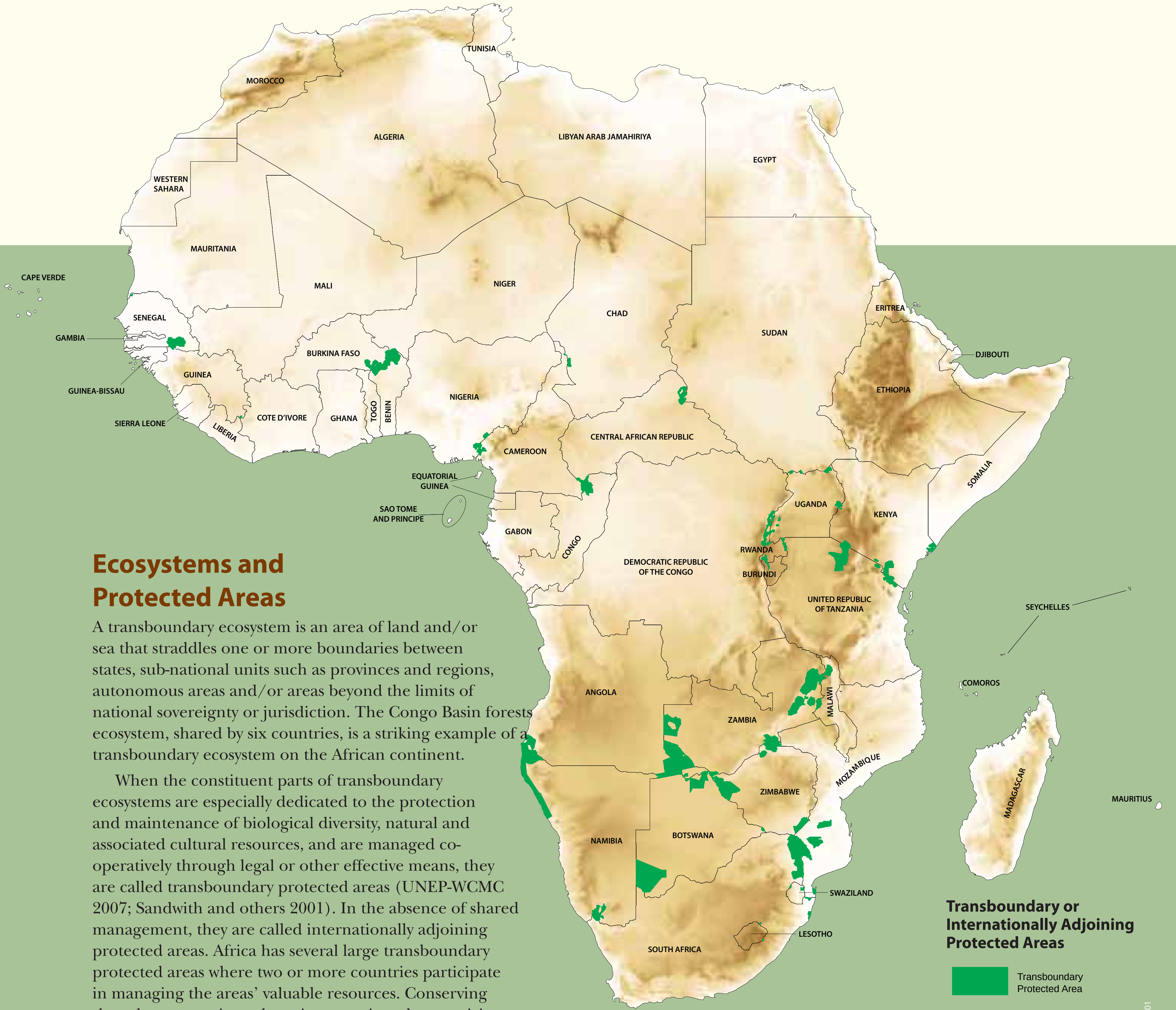
Environmental problems and the impact they have on people and their livelihoods are often similar among neighbouring countries. In many cases, regional approaches to these problems are advantageous. In some cases, cooperation across country borders is essential to solve specific problems. Examples of problems where a cooperative regional approach is vital and can benefit all parties include: the protection of crucial habitats shared by two or more countries; the protection and management of water resources that lie or flow across borders; and the integrated management of invasive, non-native species.

This chapter presents examples of four transboundary issues of importance to Africa:

1. Transboundary ecosystems and protected areas;
2. Transboundary water resources;
3. Transboundary movement of people; and
4. Transboundary movement of pollutants.

African landscape

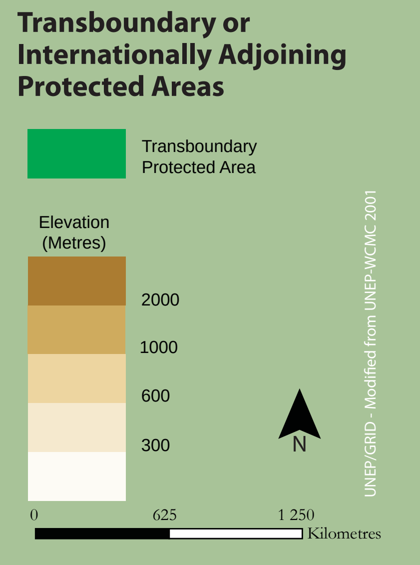
Christian Lambrecht/UNEP



Ecosystems and Protected Areas

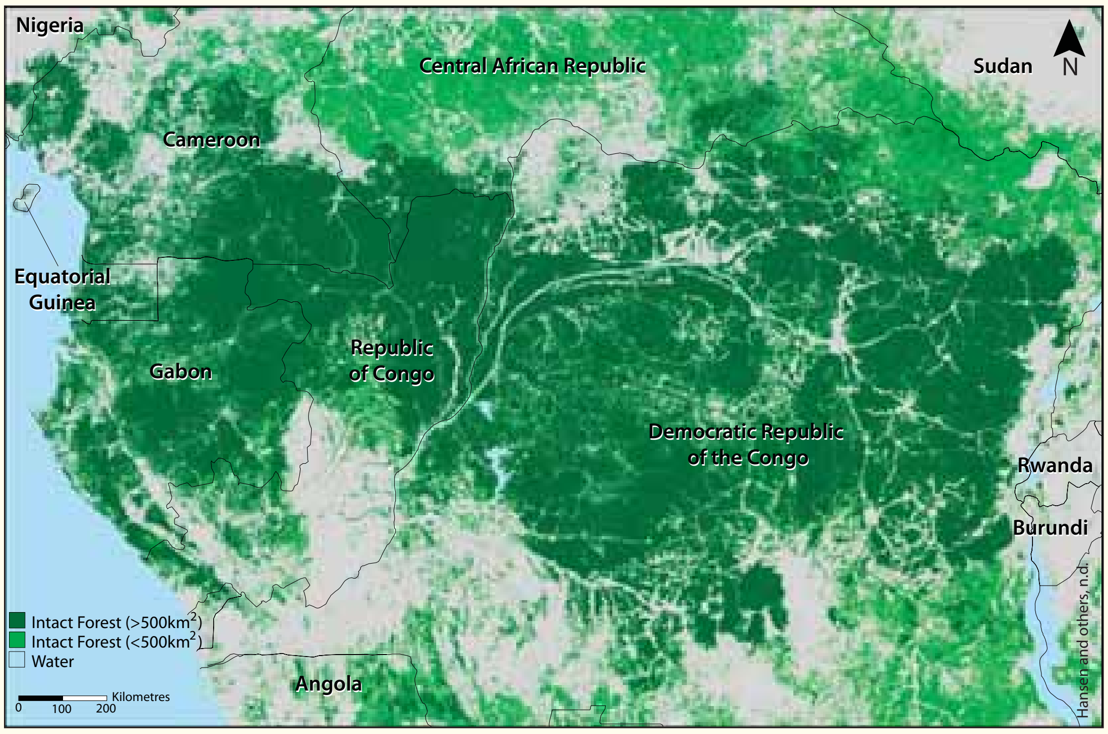
A transboundary ecosystem is an area of land and/or sea that straddles one or more boundaries between states, sub-national units such as provinces and regions, autonomous areas and/or areas beyond the limits of national sovereignty or jurisdiction. The Congo Basin forests ecosystem, shared by six countries, is a striking example of a transboundary ecosystem on the African continent.

When the constituent parts of transboundary ecosystems are especially dedicated to the protection and maintenance of biological diversity, natural and associated cultural resources, and are managed co-operatively through legal or other effective means, they are called transboundary protected areas (UNEP-WCMC 2007; Sandwith and others 2001). In the absence of shared management, they are called internationally adjoining protected areas. Africa has several large transboundary protected areas where two or more countries participate in managing the areas' valuable resources. Conserving shared resources in such settings requires characterizing and quantifying threats to those resources and devising strategies to address concerns that transcend political and cultural differences (Gauthier and others 2003). Examples of transboundary protected areas in Africa include Nyungwe Forest (Rwanda)/Kibira National Park (Burundi); Great Limpopo Transfrontier Park (South Africa, Zimbabwe, and Mozabique); and The W-Arly-Pendjari complex in Benin, Burkina Faso, and Niger.



Transboundary Ecosystems

The Congo Basin Forests



Location of the Congo Basin forests

After the Amazonian forests of South America, the forests of Africa's Congo Basin constitute the second largest area of dense tropical rain forest in the world. Congo Basin forests form a transboundary ecosystem shared by Cameroon, Central African Republic, Republic of Congo, Equatorial Guinea, Gabon, and Democratic Republic of the Congo. This immense, biologically diverse ecosystem ranges from the Gulf of Guinea in the west to the mountains of the Albertine Rift near the eastern border of Democratic Republic of the Congo and spans about seven degrees of latitude on either side of the equator. Congo Basin forests constitute over 80 per cent of the total area of the Guinea-Congo forest structure and include the Afromontane forests in western Cameroon and eastern Democratic Republic of the Congo (CARPE 2006). Table 2.1 compares forest area in each of the six countries that share the Congo Basin forests transboundary ecosystem.

The dense rain forests of the Congo Basin were once among the most pristine on Earth. However, the relatively recent expansion of industrial logging and the networks of roads that accompany it are now threatening the future of this important and unique ecosystem.

About 60 per cent of the total forest area in the Congo Basin is considered to be industrially exploitable. The area allocated to logging has increased significantly in the last few years. In 2004, for example, the area allocated to logging throughout the Congo Basin forest ecosystem was 494 000 km² (CARPE 2006). By contrast, in 2007, more than 600 000 km² were under logging concessions (Laporte and others 2007).

Important impacts of logging in this transboundary ecosystem include alteration of ecosystem composition and biodiversity, the opening up of remote areas to poaching, and the modification of many other functional ecosystem attributes (Laporte and others 2007).

In addition to industrial timber harvesting, other activities or events are negatively impacting the Congo Basin forest ecosystem. These include the production of palm oil, immigration, population growth, commercial hunting, growing access to distant markets, and road construction. Together with logging, these activities have overwhelmed traditional systems of natural resource management (CARPE 2006).

Furthermore, the construction of railways and road networks for the extraction and removal of natural resources has strongly influenced the distribution of human populations within and around the Congo Basin forests. In many places, intensive permanent agriculture has replaced the forest ecosystem.

Although some vast, still-intact forest areas with no roads or navigable watercourses do remain in the Congo Basin, the pressure of human encroachment is increasing. The construction of villages along roads, for instance, creates rings, or halos of human impact in the forest. When these individual settlements converge, they form long strips of deforestation and degradation and result in fragmentation of remaining forested areas. The pattern in eastern Democratic Republic of the Congo is somewhat different. There, highland populations do not live in villages, but are more or less dispersed throughout the countryside where they practice intensive agriculture marked by short fallow periods. This lifestyle has created a pattern of high population density with local areas of overpopulation (CARPE 2006).

As various pressures on the forests of the Congo Basin increase, so does the need for appropriate management of this unique ecosystem. The transboundary nature of this ecosystem calls for a multinational approach for the conservation and sustainable use of its resources.

Table 2.1 – Forest area, by country, in the Congo Basin forest transboundary ecosystem

Country	Forest Status in 2005 (FAO) (1 000 hectare)
Cameroon	21 245
Central African Republic	22 755
Republic of Congo	22 471
Equatorial Guinea	1 632
Gabon	21 775
Democratic Republic of the Congo	133 610
Total	223 488

Source: FAO 2005, CARPE 2006

Vast expanse of jungle, Democratic Republic of the Congo

Nyungwe Forest, Rwanda

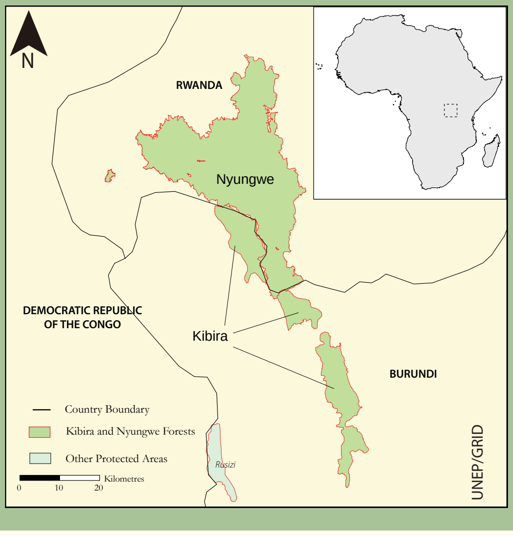
Transboundary Protected Areas

In total, Africa contains 3 044 protected areas (UNEP-WCMC 2007), including 198 Marine Protected Areas, 50 Biosphere Reserves, and 80 Wetlands of International Importance. For the purpose of this Atlas, the term transboundary protected areas describes protected areas shared by two or more countries, irrespective of the nature of collaboration.

The African continent is home to some of the richest and most biologically diverse habitats in the world. Africa's amazing animal populations are truly among the wonders of the world and from an ecological standpoint, endow the continent with special distinction. Yet these enormously rich natural resources are in jeopardy due to habitat destruction, poaching, burgeoning rural populations, urbanisation, and changes in land use. Thus, protected areas are extremely important for the safe-guarding and preservation of Africa's wildlife and the biodiversity of its ecosystems.

The importance of transboundary protected areas is especially obvious for migratory species. For example, thousands of bird species migrate across Africa performing a north-south, often cross-equatorial, seasonal migration between northern subtropical breeding grounds and southern homes. Thus, distinct and separate ecosystems can be linked by the migratory species that travel back and forth between them (UNEP 2006b).

Nyungwe Forest in Rwanda contains 980 km^2 of tropical montane forest, and is contiguous with the Kibira National Park in Burundi. Combined, these two protected areas form the largest block of forest in East Africa. It lies at an altitude between 1 500 and 2 300 m.



Migratory birds and other migratory animals are a significant component of transboundary environmental resources. The destruction or degradation of one or more of the ecosystems along a migration route can threaten the survival of migrating species. The map below illustrates global migratory bird routes and shows that Africa has the highest concentration of such routes. Where ecosystems along migration routes are formally protected, Africa's migratory birds have the greatest chance for survival.

Major migratory bird routes of the world

UNEP/GRID – Data Source: Perrins and Elphick 2003

Migrating wildebeest crossing a river, Kenya

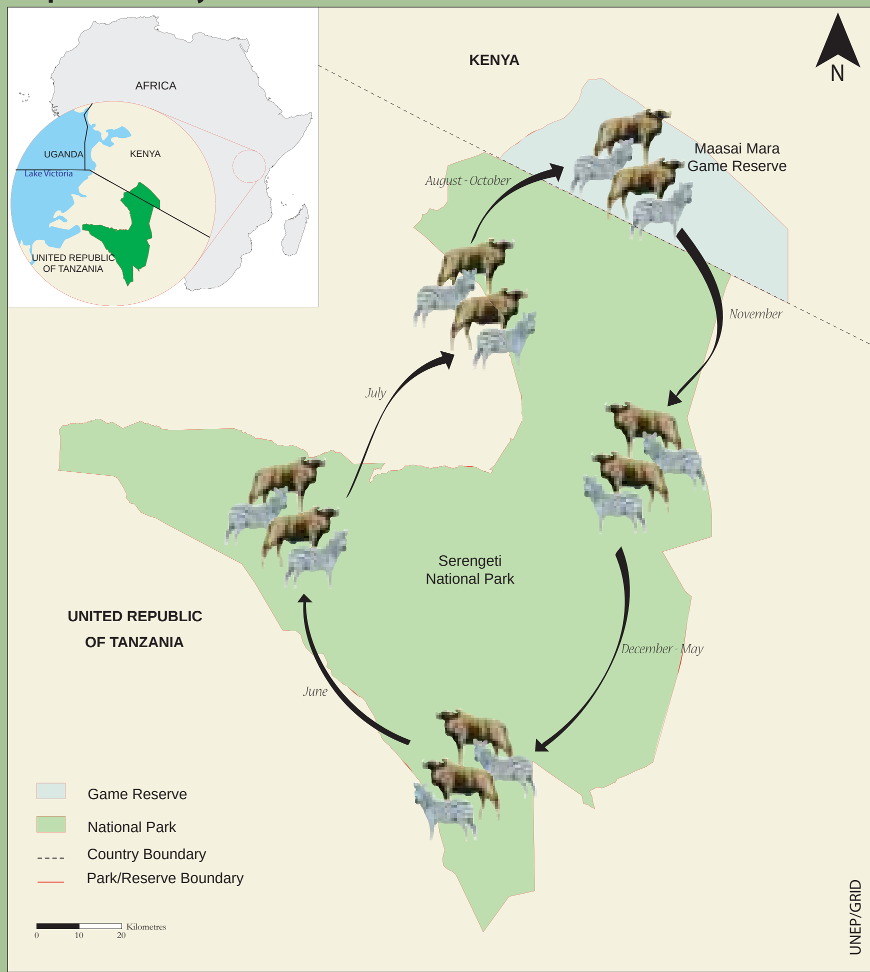
Flickr.com

Maasai Mara – Serengeti Protected Areas in East Africa

Kenya's Maasai Mara Game Reserve and United Republic of Tanzania's Serengeti National Park are two neighboring transboundary protected areas endowed with diverse fauna and flora, including vast herds of seasonally migrating wildebeest (*Connochaetes taurinus*). As the seasons progress in this East African savannah ecosystem, thousands of wildebeest, as well as other herbivores such as zebras (*Equus burchelli*), progressively migrate to greener pastures throughout the ecosystem. Predators follow the wildebeest migration closely, as the herds make their way into different territories. Timing of the wildebeest migration is linked to rainfall and other seasonal changes and is therefore slightly different from year to year (Douglas and others 2004). Generally, calving takes place in the eastern Serengeti between January and mid-March; by June the herds begin heading toward the western Serengeti and ultimately northward, toward Maasai Mara (Go2Africa 2003).

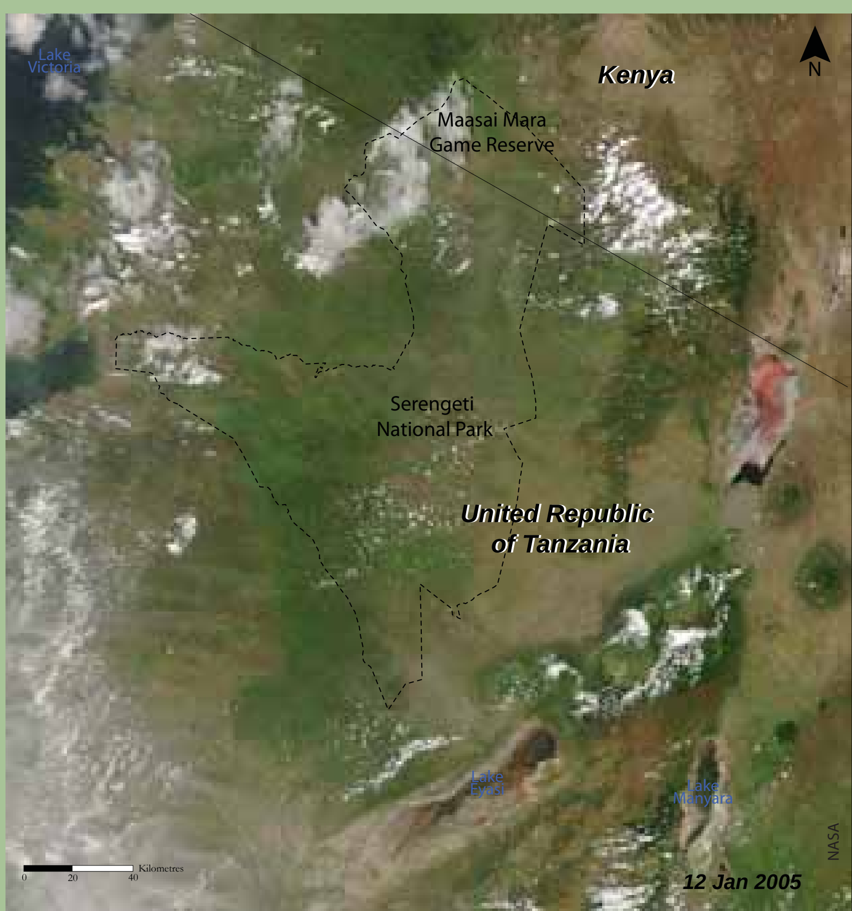
In January 2006, widespread drought in East Africa due to the late arrival of seasonal rains severely affected wildlife in the Serengeti and Maasai Mara protected areas. The drought partially disrupted the migration of more than 1.5 million wildebeest, zebras, and other herbivores from Maasai Mara to Serengeti (Ngowi 2006). In the pair of satellite images below, the contrast between the relatively lush vegetation of January 2005 and the barren, parched landscape of January 2006 reveals the intensity and extent of the drought. Lake Eyasi and Lake Manyara, visible in the lower right-hand corner of each image, were almost completely dry in 2006. The East African drought of 2006 underscored the need for cooperative natural resource management strategies between countries sharing transboundary-protected areas, which are home to migratory species.

Map of the study area



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

A pair of images comparing green vegetation in 2005 to the parched, brown landscape in 2006 (NASA 2006a)



W-Arly-Pendjari Parks Complex

The W-Arly-Pendjari (WAP) Parks Complex straddles the countries of Benin, Burkina Faso, and Niger, and is one of the largest contiguous protected areas in Africa. The "W" portion of the Complex's name comes from the angular "W" path followed by the Niger River as it flows through the northern foothills of Benin's Atakora Mountains. The WAP Parks Complex is a mix of terrestrial, semi-aquatic, and aquatic ecosystems and home to more than half of West Africa's elephant population. Furthermore, WAP is the only natural refuge remaining for most of the vulnerable and/or threatened animal species in Benin, Burkina Faso, and Niger.

Land cover changes around the W-Arly-Pendjari Complex

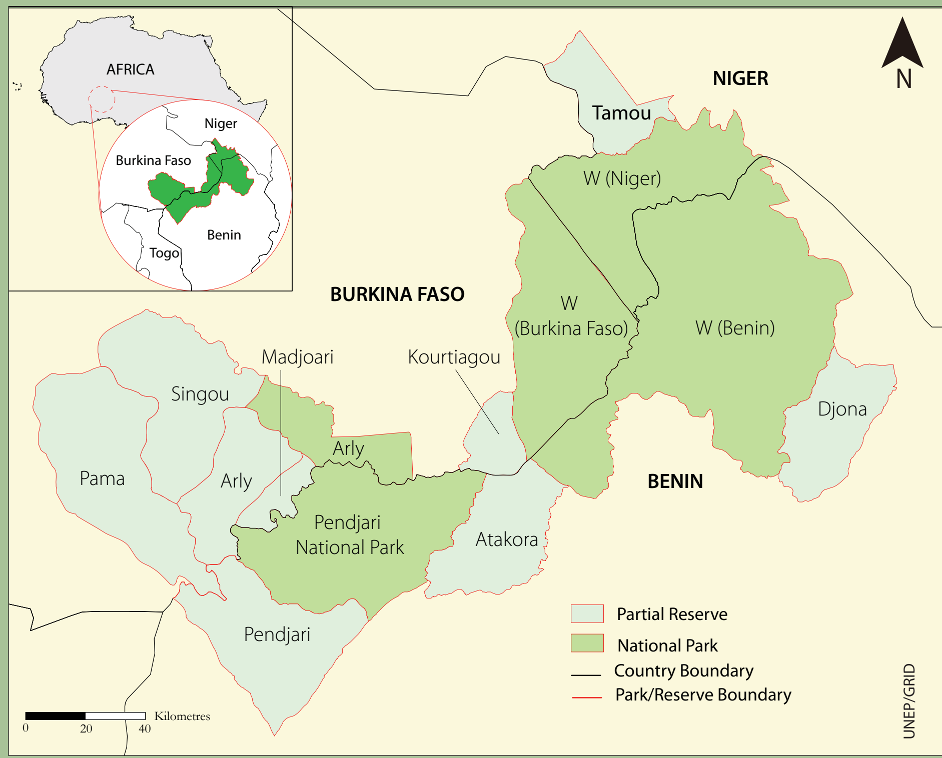
Areas surrounding parts of the WAP Complex are undergoing significant land-use and land-cover change. One of the most striking examples of change is in northern Benin, where the growth of the so-called "cotton belt" has markedly altered the natural vegetation over the last 20 years. During this time, protected lands of the Complex have become almost completely surrounded by agricultural lands, reducing biodiversity and increasing potential contact between humans and wildlife. As the availability of natural resources in non-protected areas dwindles, the protected areas, as the sole remaining repositories of fuelwood, forage, and bush meat in the region, increasingly are becoming a focus for poaching, illegal cattle grazing, and other human activities that impact the sustainability of this part of the WAP Complex (Eva and others 2006).

Table 2.2 – Land use/ land cover changes in the areas surrounding the parks (1975-2002)

	1975 (km^2)	2002 (km^2)	Increases (%)
Agriculture - Intensive	2 813	4 997	78
Agriculture - Mosaic	3 600	5 644	57
Degraded savannahs	3 281	4 264	30
Savannahs	10 059	4 924	-51

Source: Eva and others 2006

Map of the study area




Zebra and wildebeest in Great Limpopo Park
© Kim Wolhuter/Wildcast.net

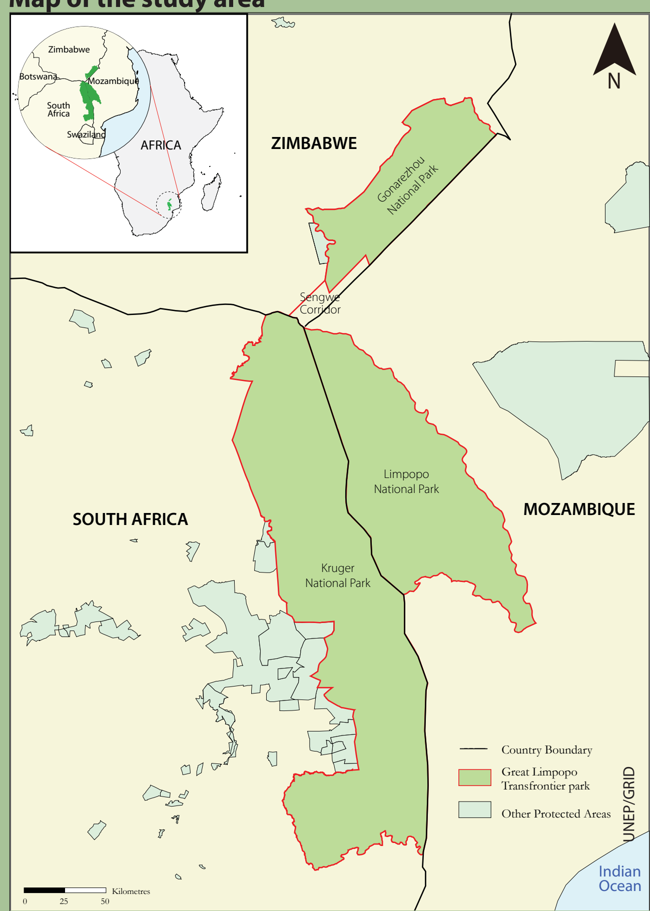
The Great Limpopo Transfrontier Park

The Great Limpopo Transfrontier Park (GLTP) is Africa's largest transboundary protected area. The GLTP is formed by South Africa's Kruger National Park, Mozambique's Limpopo National Park, and Zimbabwe's Gonarezhou National Park and is jointly managed by all three countries (AWF 2003). The GLTP covers 35 000 km² and is centred on the point where its three components meet along the Limpopo River.

Geographically, the main landscapes in the GLTP are: a lowland plains savannah ecosystem with a somewhat hilly granite plateau in the western portions; the Lebombo Mountains that rise to an average of only 500 m above sea level and follow the border between South Africa and Zimbabwe; and floodplains along the Save, Changane, Limpopo, Olifants, Shingwedzi, and Komati Rivers (SANParks 2007).

The GLTP brings together some of the best and most established protected areas for wildlife in southern Africa. It is home to important populations of endangered elephants, black rhinoceroses, and wild dogs, as well as vulnerable species such as lions, leopards, giraffes, buffaloes, and numerous types of antelope (MSN Encarta 2007). GLTP's wildlife population includes at least 147 mammal species, 116 reptile species, 49 species of fish, 34 frog species, and an extraordinary 500 or more species of birds. In addition, at least 2 000 plant species have been identified (SANParks 2007). The GLTP is an example of a recent success in establishing transboundary conservation and peace parks, and is characterized by a diverse array of natural resource management approaches (Rogers 2005).

Map of the study area

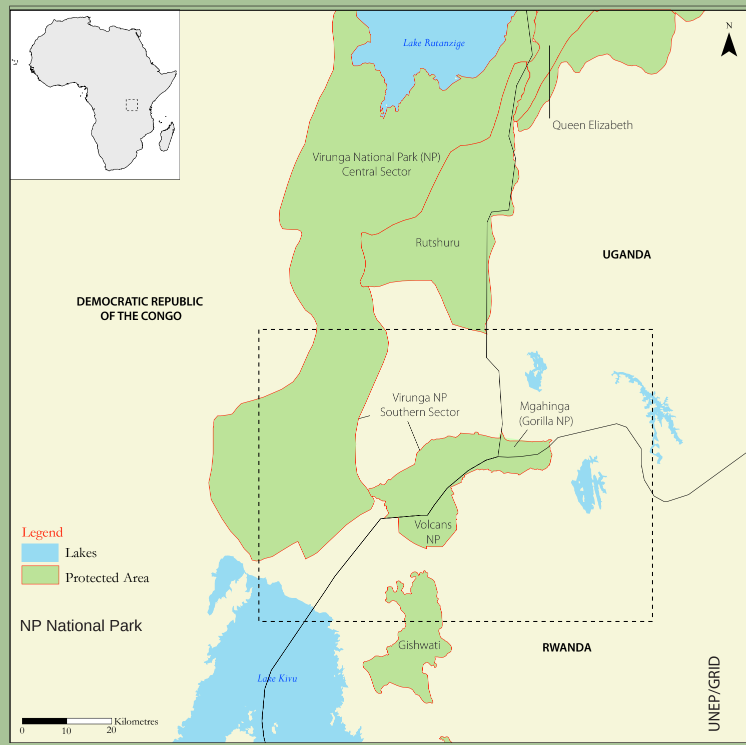


Gorilla in Volcanoes National Park, Rwanda

Darren Kumasawa/Flickr.com

Mountain Gorilla Conservation in the Virunga Heartland

Map of the study area



The Virunga Heartland in the central Albertine Rift region of east-central Africa spans the borders of Democratic Republic of the Congo, Rwanda, and Uganda. It includes the World Heritage site of Virunga National Park (Africa's oldest National Park) and supports lush Afromontane forests. Here, volcanic highland mountains shelter the last of the world's mountain gorillas (*Gorilla beringei beringei*). Chimpanzees, golden monkeys, forest elephants, and a rich variety of birds, reptiles, and amphibians also share this incredibly biodiverse ecosystem. Because Virunga Heartland encompasses parts of three countries, transboundary natural resource management is critical to maintaining landscape integrity. However, joint management efforts have suffered since 1990 due to war and political unrest in the region.

Historically, poaching, the spread of disease, and habitat loss from population pressures and civil unrest have threatened mountain gorillas in Virunga's forests. However, due to anti-poaching efforts and a unique gorilla-based ecotourism scheme, the Virunga gorilla population increased by 17 per cent between 1988 and 2003. Together with the 320 gorillas living in the Bwindi Impenetrable National Park in Uganda, the total number of mountain gorillas is now approximately 700.

Nevertheless, despite reasons for optimism, death and extinction are constant threats to the mountain gorillas. In 2007, seven mountain gorillas were killed; four of these deaths occurred in the Virunga region. The continued slaughter of these critically endangered primates demonstrates the challenges faced by gorilla preservation programmes and the urgent need to improve transboundary park management in this region of Africa.

Sources: McCrummen 2007, MSNBC 2007, WWF 2007

Gazelle, kob, and tiang

Paul Elkan and J. Michael Fay/National Geographic

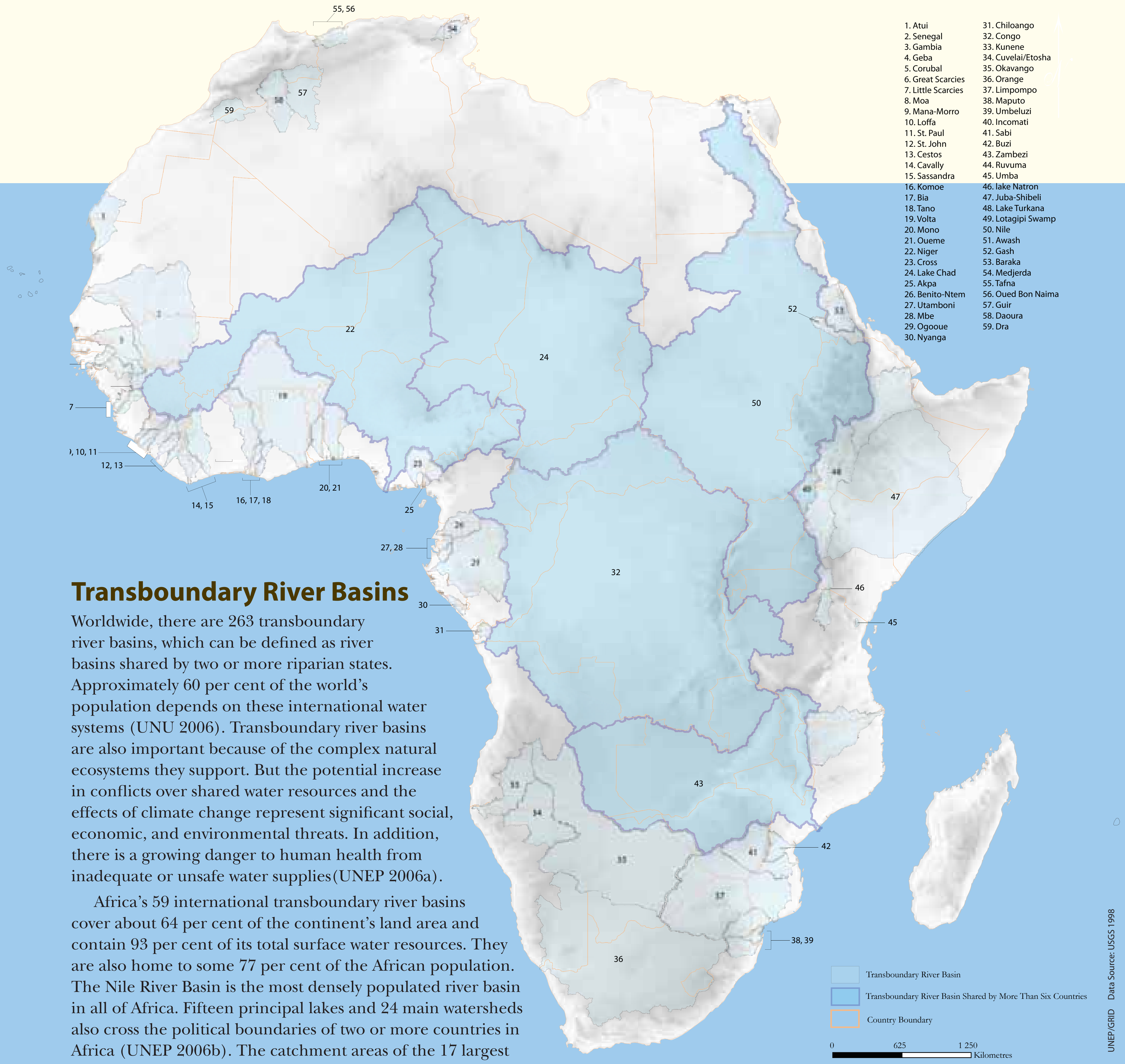
Southern Sudan: A Survival Surprise

Map of the study area

Southern Sudan covers an area of 582 759 km² and sits between the Sahara Desert and Africa's belt of tropical forests. Wildlife biologists have long recognized that grasslands, woodlands, and swamps in southern Sudan are home to elephants, zebras, giraffes, and other animals.

Before the civil war (1983-2005), a 1982 survey showed an estimated 900 000 white-eared kob (*Kobus kob*)—a kind of antelope—migrating to southern Sudan from bordering areas. Recently, the first aerial survey of southern Sudan in 25 years revealed that vast migrating herds have managed to survive over 20 years of civil war. In this new survey, biologists estimated 1.3 million kob, tiang, and gazelle in their research area, a number that may even surpass the Serengeti's herds of wildebeest, long considered to be the world's biggest migration of mammals. Estimates include 250 000 Mongalla gazelle, 160 000 tiang, 13 000 reedbuck, 8 900 buffalo, and 2 800 ostrich. Other animals such as elephants, ostriches, lions, leopards, hippos, and buffalo are also thriving in parts of southern Sudan. In addition several East African oryx (*Oryx beisa*), a species thought to be extinct in this region, were seen here. On the other hand, some species in southern Sudan are faring badly. For example, the recent survey revealed no zebras in Boma National Park and only a few elsewhere in the region, compared to the estimated 20 000 in Boma tallied during the 1982 survey.

Source: WCS 2007, Pilkington 2007, Mongabay 2007



Transboundary River Basins

Worldwide, there are 263 transboundary river basins, which can be defined as river basins shared by two or more riparian states. Approximately 60 per cent of the world's population depends on these international water systems (UNU 2006). Transboundary river basins are also important because of the complex natural ecosystems they support. But the potential increase in conflicts over shared water resources and the effects of climate change represent significant social, economic, and environmental threats. In addition, there is a growing danger to human health from inadequate or unsafe water supplies(UNEP 2006a).

Africa's 59 international transboundary river basins cover about 64 per cent of the continent's land area and contain 93 per cent of its total surface water resources. They are also home to some 77 per cent of the African population. The Nile River Basin is the most densely populated river basin in all of Africa. Fifteen principal lakes and 24 main watersheds also cross the political boundaries of two or more countries in Africa (UNEP 2006b). The catchment areas of the 17 largest river and lake basins on the continent exceed 100 000 km^2 in size (UNU 2006). Africa also has 38 transboundary aquifer systems, about which little is known.

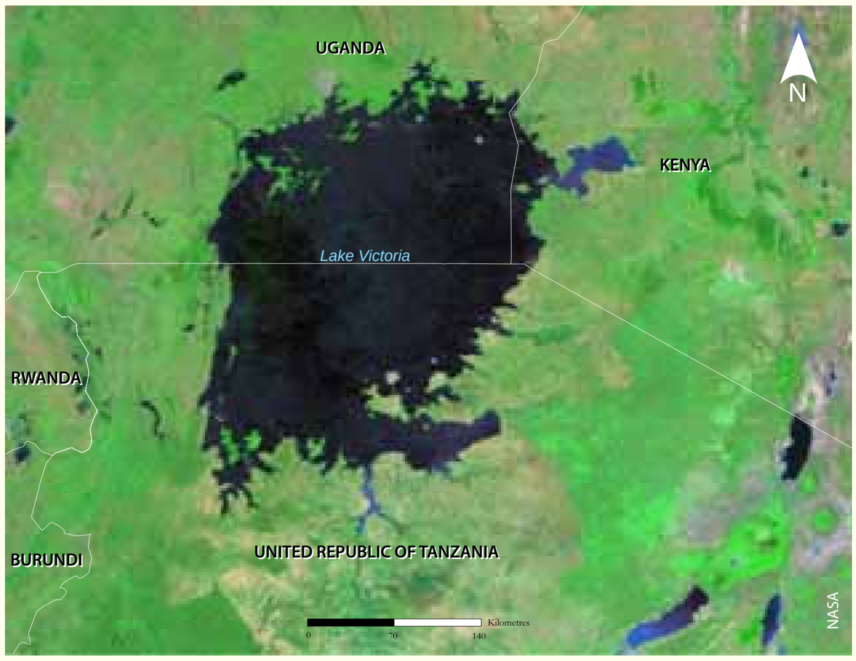
Most Africans live in rural areas and are still heavily dependent on agriculture for their livelihoods, making water a vital economic and social commodity. Along with a growing population, the extreme variability of rainfall on Africa's landscapes—from arid northern and southern regions to the continent's belt of tropical forests—poses many challenges to providing safe drinking water and sanitation for millions of people. Consequently, transboundary water resource management requires an enabling environment that encourages cooperation on numerous fronts.

Water hyacinth growing near a dock, Lake Victoria, Kenya

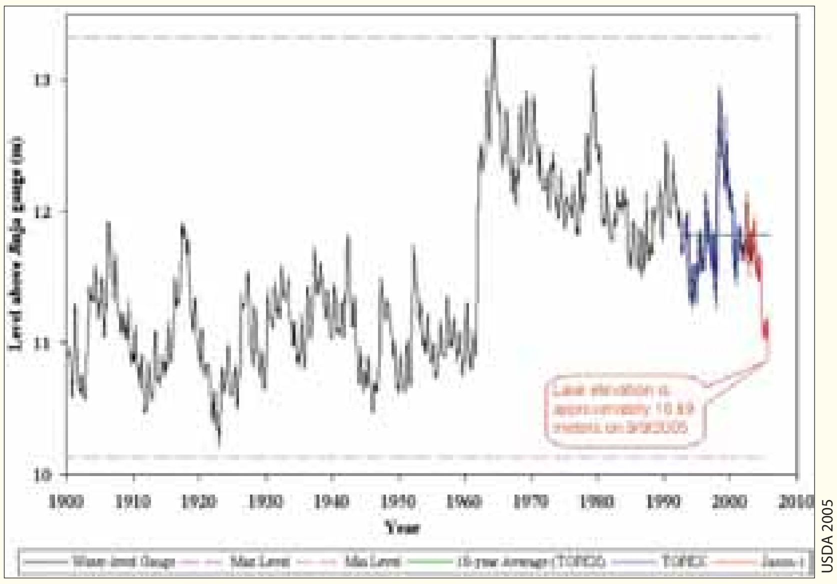
Lake Victoria: Africa's Largest Freshwater Lake

Lake Victoria is Africa's largest, and the world's second-largest, freshwater lake. It has a total catchment of about 250 000 km², of which 68 870 km² is the actual lake surface (URT 2001). Located in the upper reaches of the Nile River Basin in East Africa, the waters of Lake Victoria are shared by Kenya, Uganda, and United Republic of Tanzania. Lake Victoria faces myriad environmental problems, including invasive species, water quality, and fluctuating water levels.

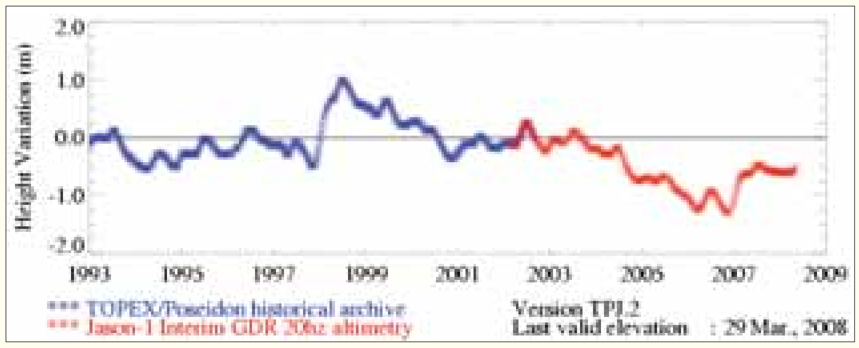
In the 105-year history of accurate water-level measurements on Lake Victoria (measured at Jinja, Uganda), levels have fluctuated widely. In 1961 and 1962, for example, heavy rains drove water levels up by an astounding two metres. Since then, levels have been generally declining over time. In December 2005, water levels dropped to an all-time low of 10.89 m (NASA 2006a), a figure confirmed by satellite measurements of the lake's elevation. In the past few years, water levels have increased slightly.



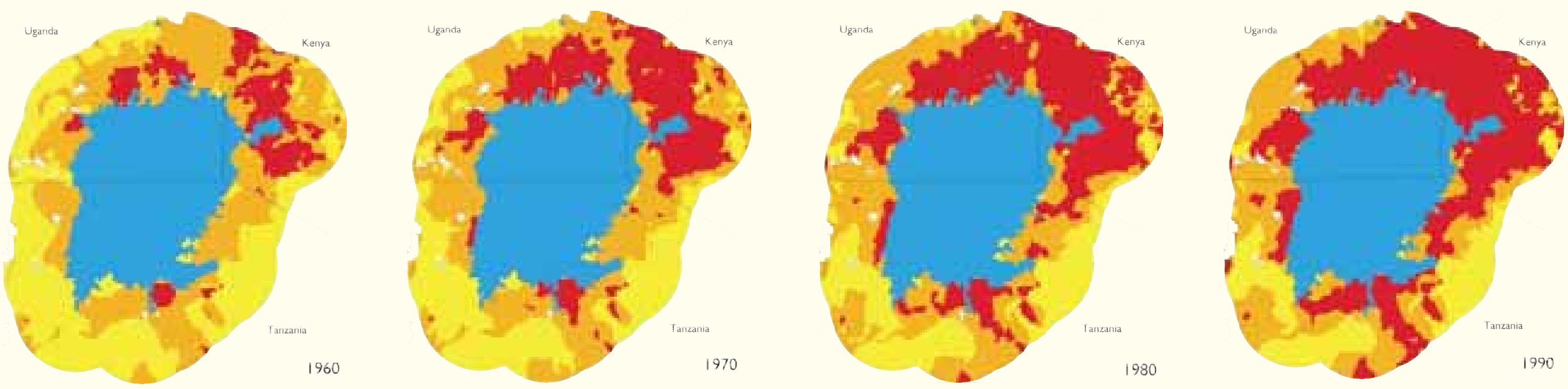
Historical water level elevations of Lake Victoria



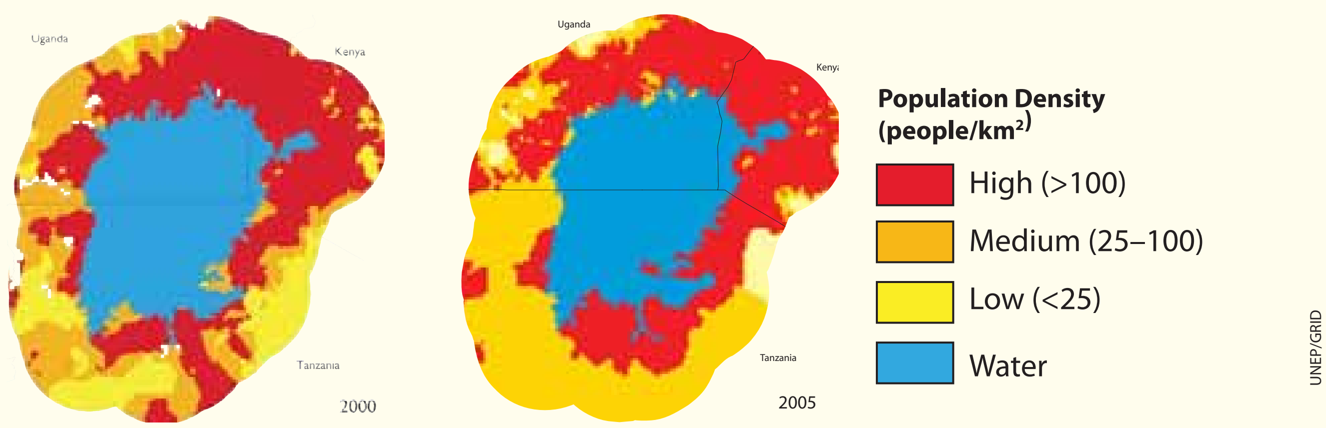
Height variations in Lake Victoria

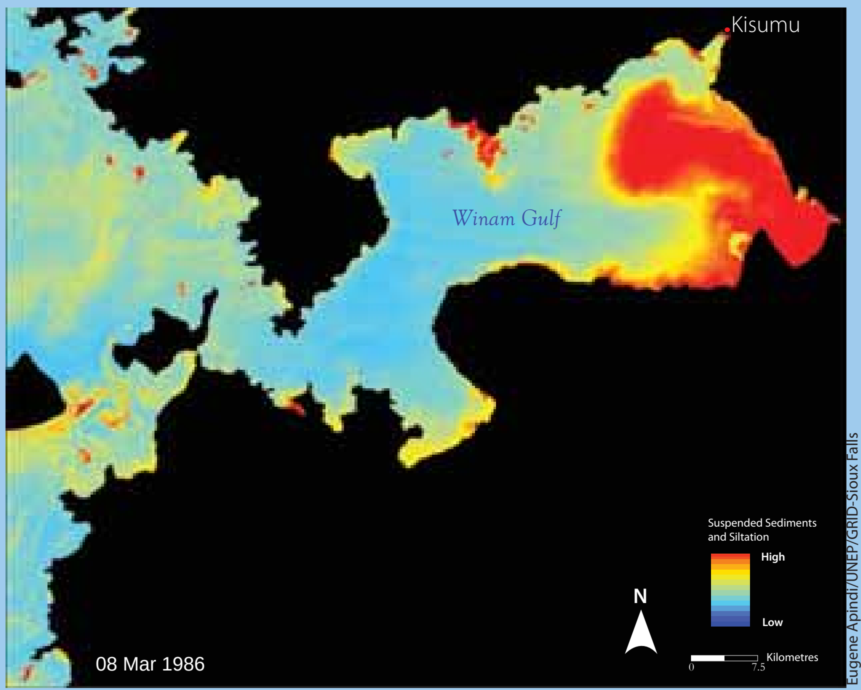


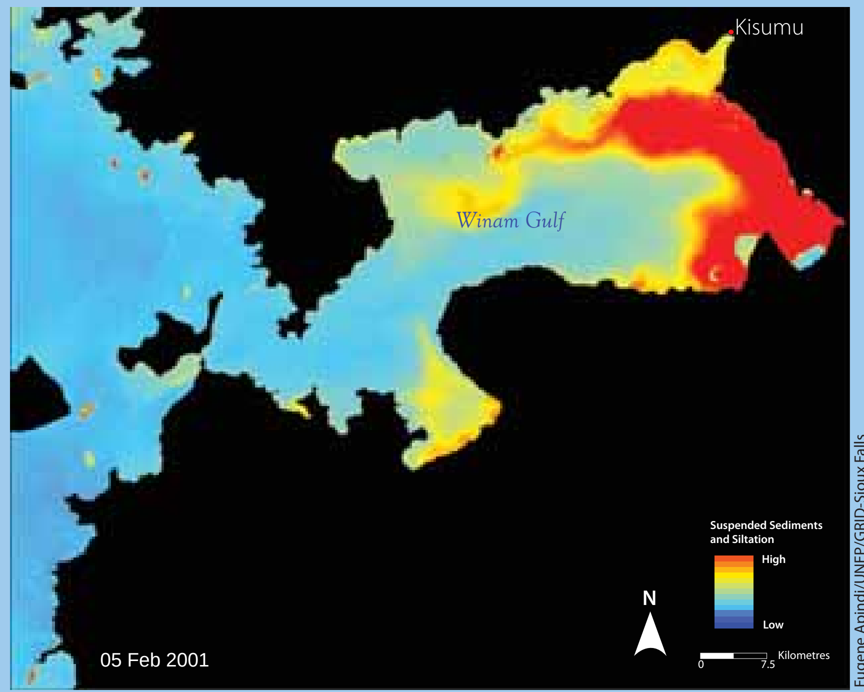
High population growth around Lake Victoria



In a 100-km radius around Lake Victoria, population is increasing at a higher rate than the continental average. At the same time, there has been a long-term decline in the Lake's water levels (UNEP 2006b). This pattern of increasing population and decreasing water resources is a source of concern for East African countries bordering Lake Victoria, as well as those in the Nile River Basin.







Images showing increased siltation and suspended sediments

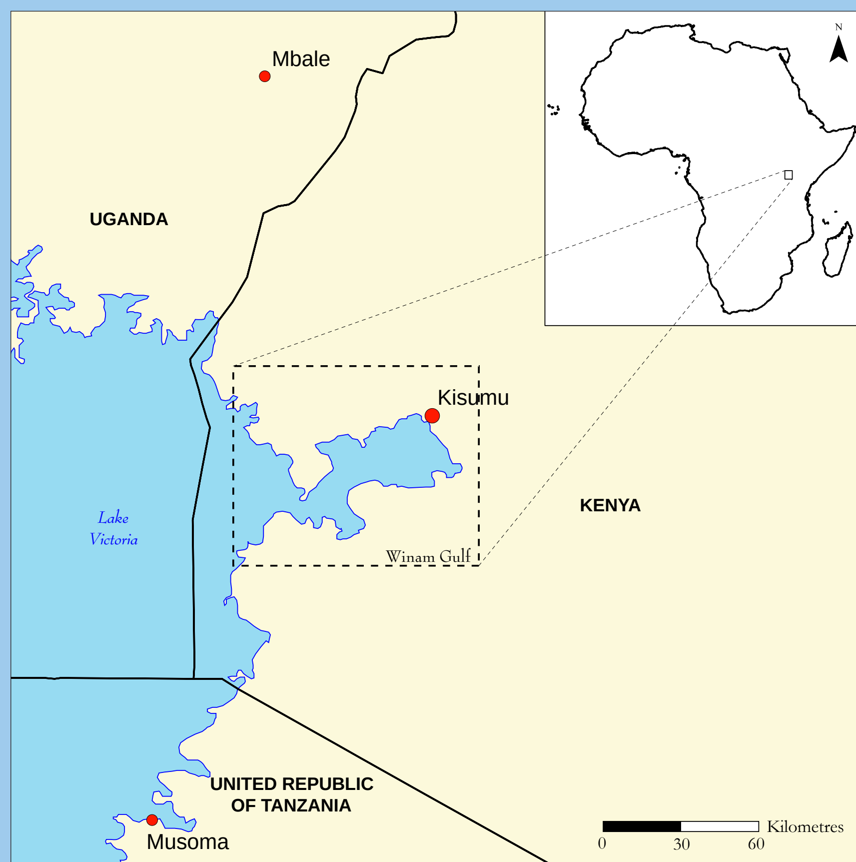
Lake Victoria's Winam Gulf

Winam Gulf is a large arm of Lake Victoria that extends east into Kenya. The Gulf is roughly 100 km from east to west and 50 km from north to south, with a shoreline measuring about 550 km. The Gulf is relatively shallow, with a recorded average depth of six metres (Osumo 2001).

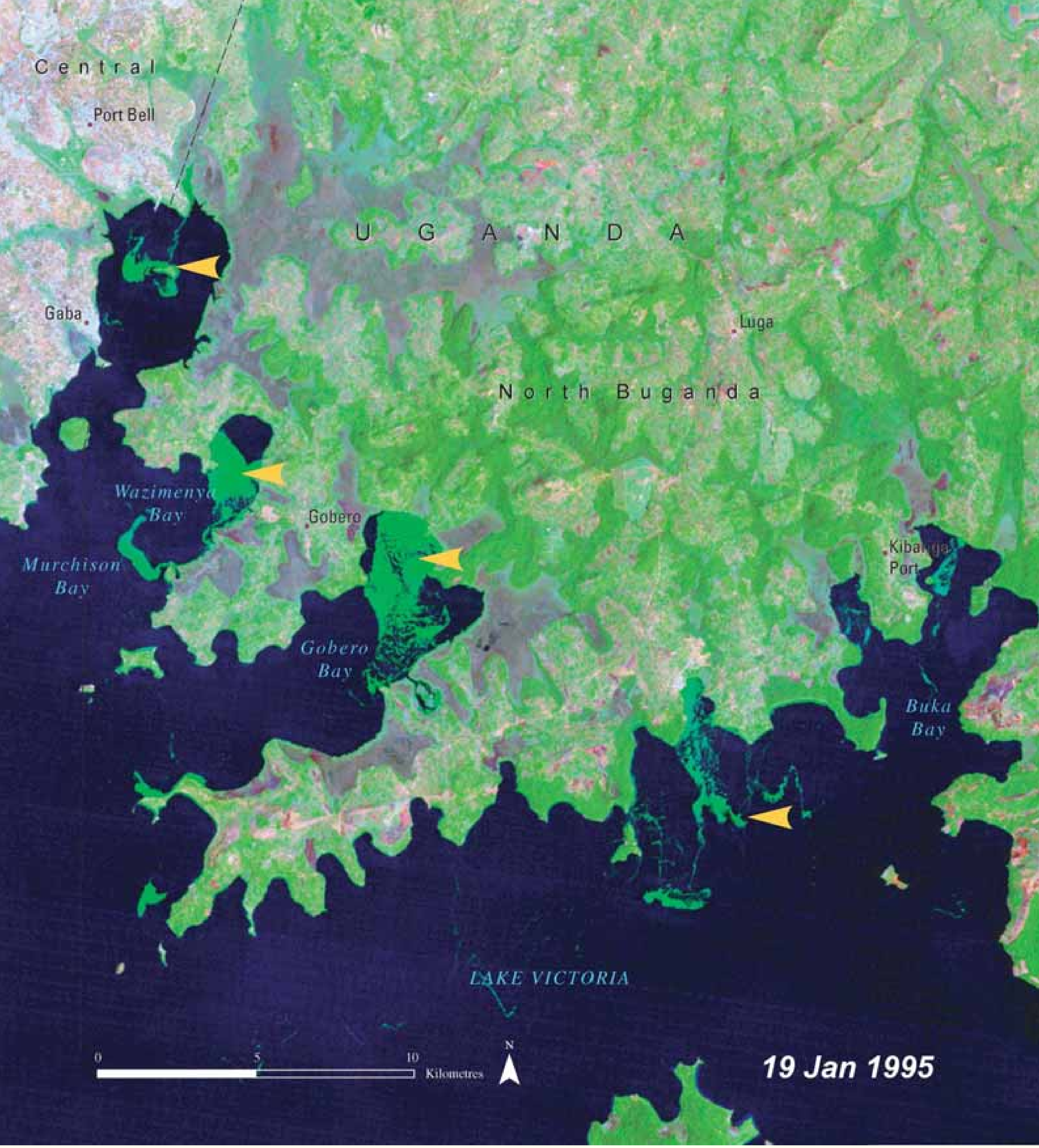
Like Lake Victoria of which it is part, Winam Gulf faces numerous environmental challenges. These include, but are not limited to, siltation, sedimentation, toxic contamination, and eutrophication. The underlying force of change is explosive population growth in the lake's basin, along with associated farming practices and urbanisation. Four major rivers—Sondu-Miriu, Kibos, Nyando, and Kisat—discharge an average of 231 m^3 of water per second into the Gulf (Osumo 2001). Untreated sewage and wastewater from surrounding towns and organic and inorganic nutrients washed down from cultivated areas flow first into these rivers, and then into the Gulf. In addition, excessive soil erosion in parts of the lake's catchment has led to heavy siltation and sedimentation in certain areas, especially in the Winam Gulf. The above images show increased siltation and suspended sediments in the Winam Gulf waters between 8 March 1986 (upper left) and 5 February 2001 (upper right). Highly affected areas appear in red while least affected areas are blue.

When water hyacinth *(Eichhornia crassipes)* invaded Lake Victoria in the 1990s, Winam Gulf was one of the most severely affected regions. As much as 17 231 hectares of the Gulf's surface were covered by the plant. By 2000, however, the area invaded by water hyacinth had been reduced by control measures to about 500 hectares. Five years later, as the December 2005 satellite image (below left) shows, the Gulf appeared to be essentially free of the plant. Approximately one year later, however, unusually heavy rains flooded the rivers that flow into the Gulf, which in turn raised Gulf water levels and contributed nutrient-rich sediment to the aquatic environment. As a result, water hyacinth quickly reinvaded the Gulf, as the 2006 satellite image (below right) shows.

Map of the study area



Images showing water hyacinth choked bays



Water Hyacinth in Lake Victoria, 1995-2001

In the 1990s, Lake Victoria suffered an infestation of water hyacinth (yellow arrows), an introduced species that thrives on the nutrients running into the lake from increased fertilizer applications on adjacent agricultural lands. The plants disrupted transportation and fishing, clogged water intake pipes for municipal water, and created habitat for disease-causing mosquitoes and other insects. To address the problem, a Lake Victoria Environmental Management Project began in 1994. The Project's focus was to combat water hyacinth infestations on the Lake, particularly in the region bordered by Uganda, which was one of the most severely affected areas.

The 1995 satellite image shows water hyacinth infestations in or near Murchison, Wazimenya, Gobero, and Buka bays (yellow arrows). Initially, the plants were manually removed from the Lake, but they quickly re-grew. Later, natural insect predators of water hyacinth were introduced as a control measure, with better results. By late 2001, essentially all of the floating weeds had disappeared from the aforementioned locations.

Vendor selling wares, Chad

Lake Chad: Africa's Shrinking Lake

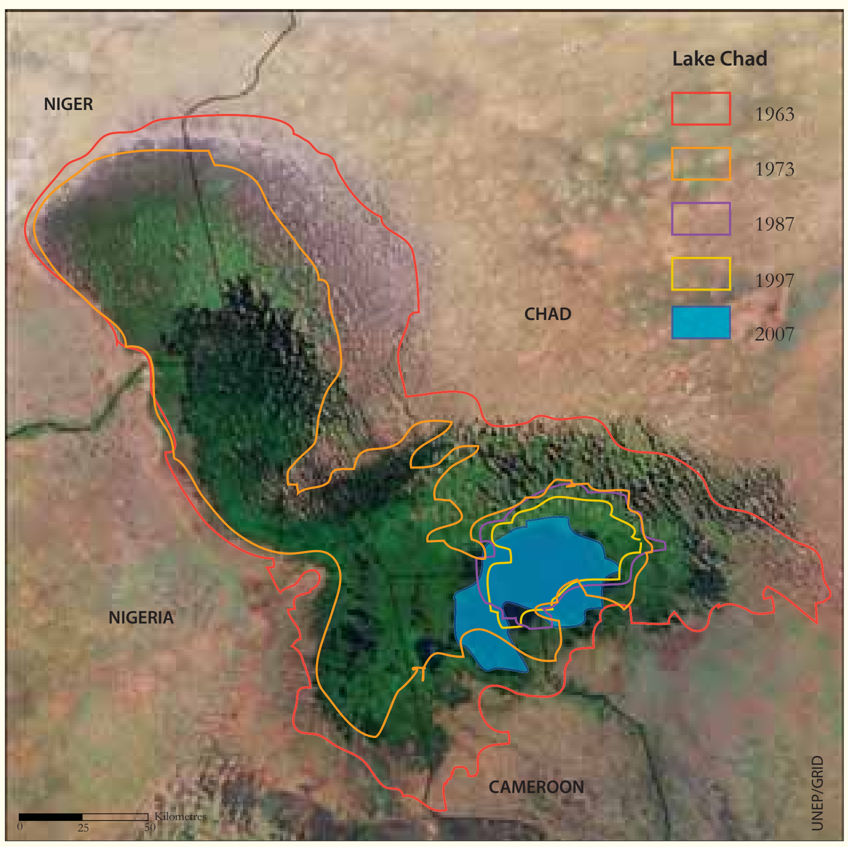
Located at the southern edge of the Sahara Desert, Lake Chad is bordered by Nigeria, Niger, Chad, and Cameroon. The lake was once the second-largest wetland in Africa, supporting a rich diversity of endemic animals and plant life.

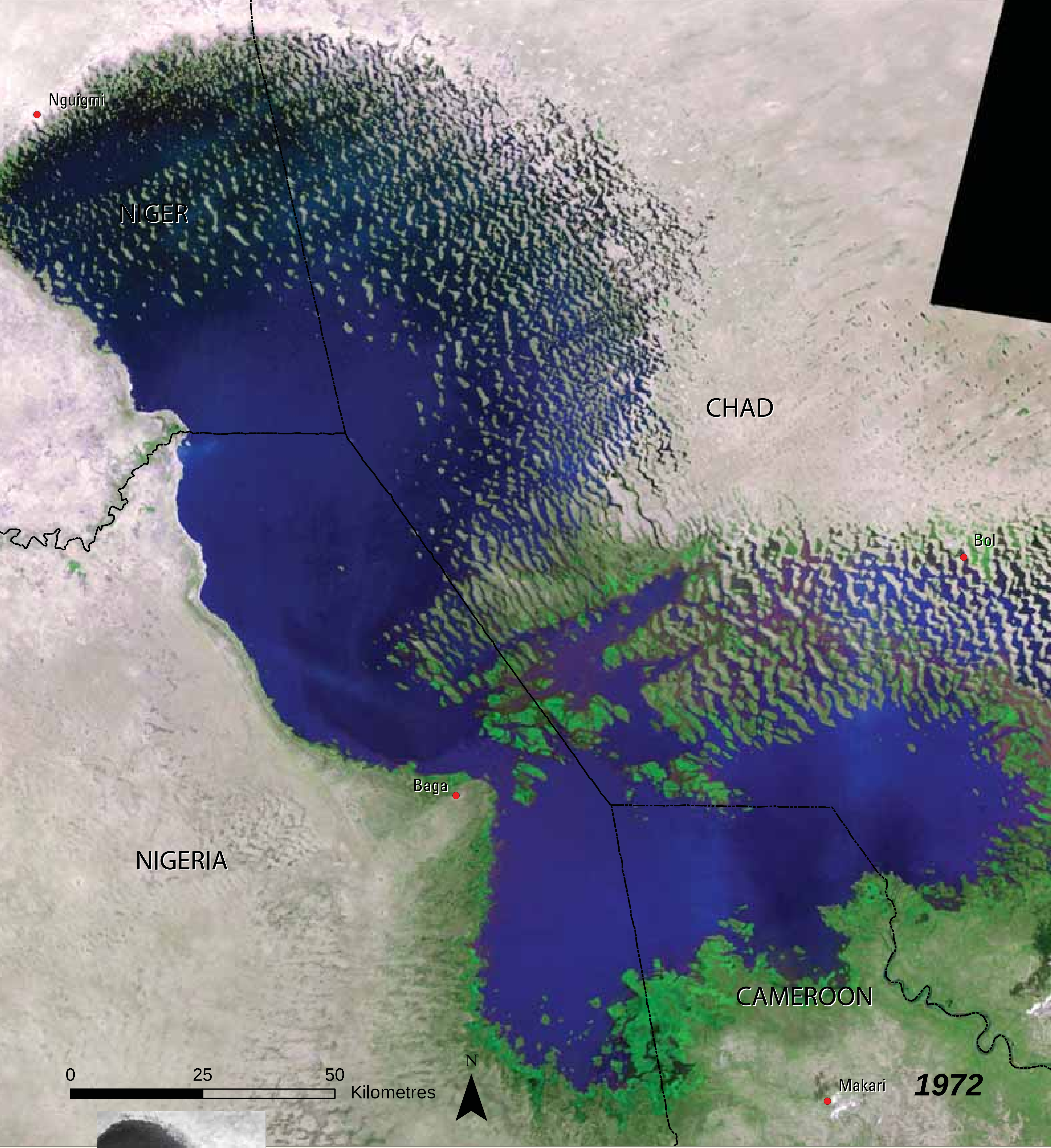
The Lake Chad drainage basin, a 2 500 000 km² hydrologically closed catchment, extends to eight countries: Algeria, Libyan Arab Jamahiriya, Niger, Chad, Sudan, Central African Republic, Cameroon, and Nigeria. It is home to over 20 million people who derive direct or indirect livelihoods from the lake. Most of the region's rainfall occurs in the southern one-third of the Lake Chad drainage basin, contributing about 90 per cent of the basin's runoff. The northern two-thirds, however, are dominated by arid conditions (Coe and Foley 2001).

Climate variability and increased water consumption by the area's inhabitants have changed the water balance within the Lake Chad drainage basin, and continue to do so. Since the early 1960's, rainfall over the basin decreased significantly while irrigation increased dramatically over the same period (Coe and Foley 2001). The lake is especially susceptible to climatic variability as it is rather shallow, with an average depth of 4.11 m (NASA 2001a). As a result of decreased rainfall and increased water usage, the extent of Lake Chad decreased by 95 per cent over roughly 35 years. More recently, water levels in Lake Chad have increased slightly. But the lake still remains a remnant of its former self.

Lake Chad drainage basin

Shrinking of Lake Chad

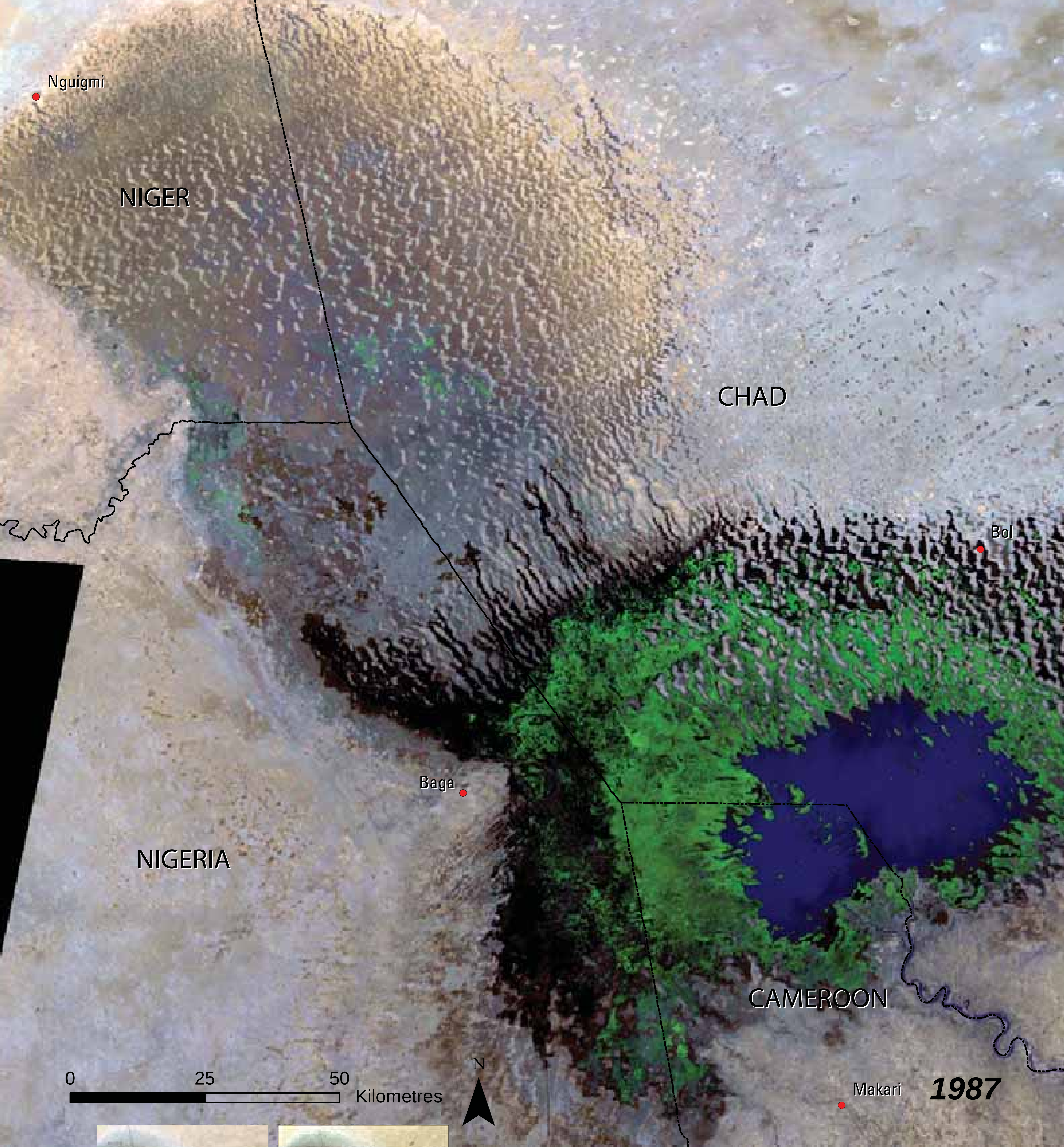


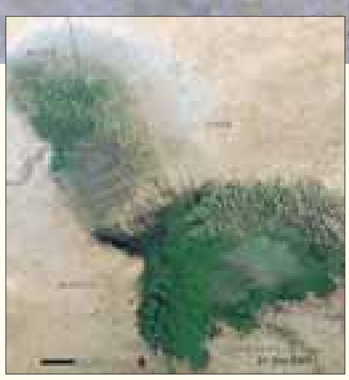


Declining Water Levels in Lake Chad, 1972-2007

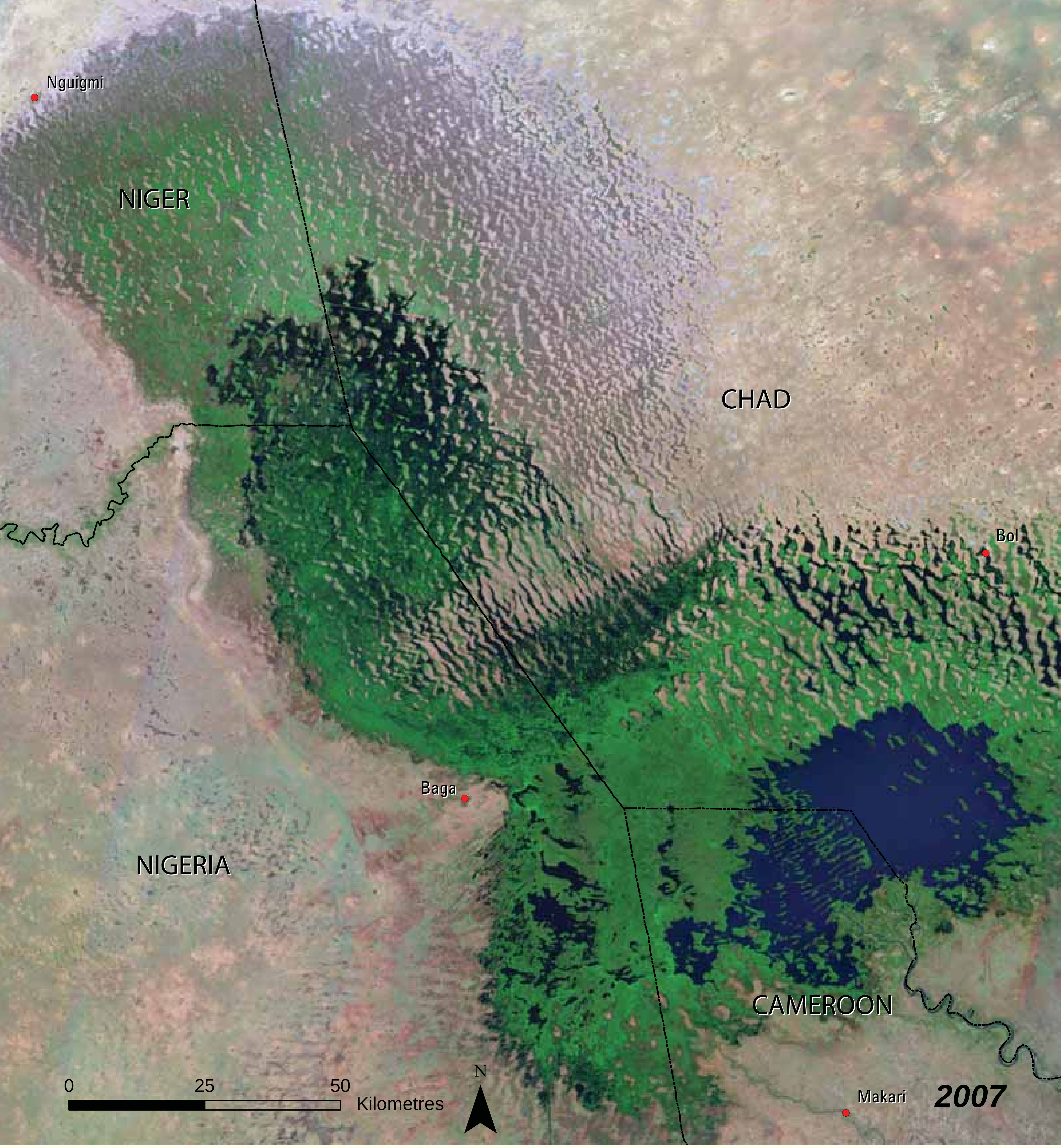
Lake Chad, located at the junction of Nigeria, Niger, Chad, and Cameroon, was once the sixth-largest lake in the world and the second-largest wetland in Africa. The lake was highly productive, and supported a great diversity of wildlife.

Persistent droughts and increased agricultural irrigation have reduced the lake's extent in the past 35 years to one-tenth of its former size. Despite the lake's large drainage basin, almost no water flows in from the dry north. Ninety per cent of the lake's water flows in from the Chari River.





With a flat and shallow lakebed, Lake Chad is very responsive to changes in rainfall. When rainfall decreases, water levels in the lake drop rapidly. Diversion of water by human activities from the lake and from the Chari River may be significant at times of low flow, but rainfall is still the determining factor in water levels and the lake's extent. As these



satellite images from 1972, 1987, and 2007 show, the surface area of the lake has declined dramatically over time. The 2007 image shows significant improvement over previous years, but the extent of Lake Chad is still far smaller than it was three to four decades ago.


Aerial view of the Okavango Delta

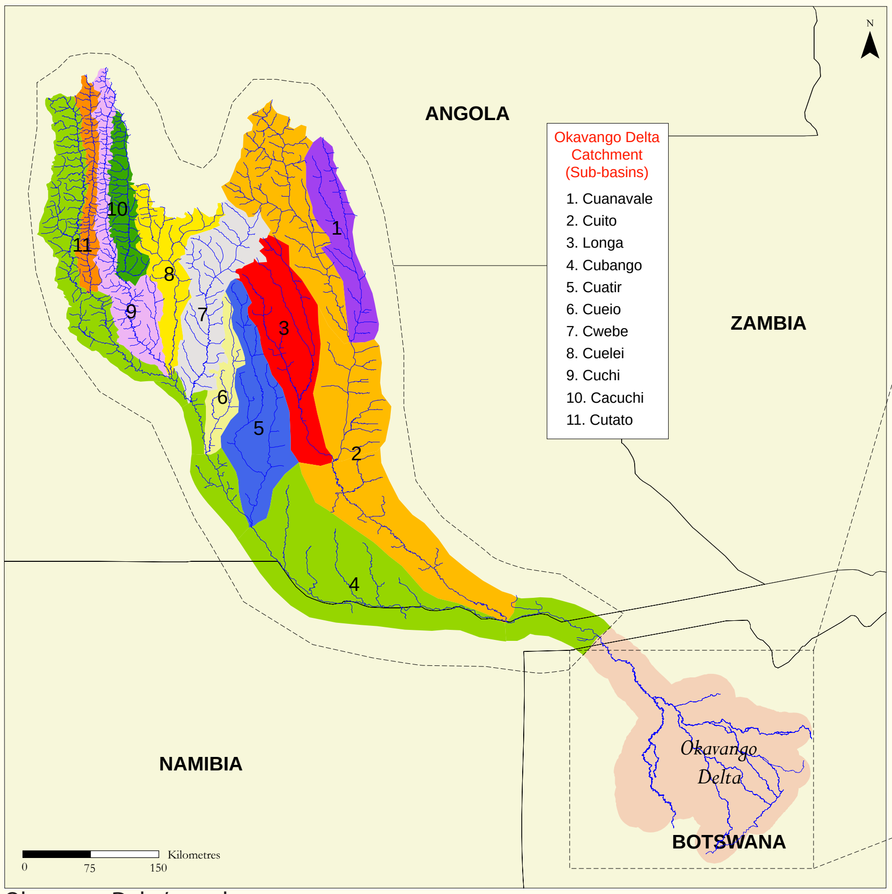
Justin Hall/Flickr.com

Okavango: The World's Largest Inland Delta

The Okavango Delta (or Okavango Swamp), a globally renowned Ramsar Wetland Site, is the world's largest inland delta. Angola, Namibia, and Botswana share the Okavango River catchment area that feeds the Okavango Delta. Spanning approximately 15 000 km², the Delta is a rich and varied freshwater habitat for diverse flora and fauna. It is home to 2 000 to 3 000 plant species, over 162 arachnid species, more than 20 species of large herbivores, over 450 bird species (Monna 1999), and approximately 70 species of fish (Kolding 1996). The area was once a part of Lake Makgadikgadi, an ancient lake that dried up some 10 000 years ago. Today, the Okavango River has no outlet to the sea. Instead, it flows out onto the sands of the Kalahari (Kgalagadi) Desert, watering 15 000 km² of that arid landscape. Each year some 11 km³ of water reach and sustain the Okavango Delta.

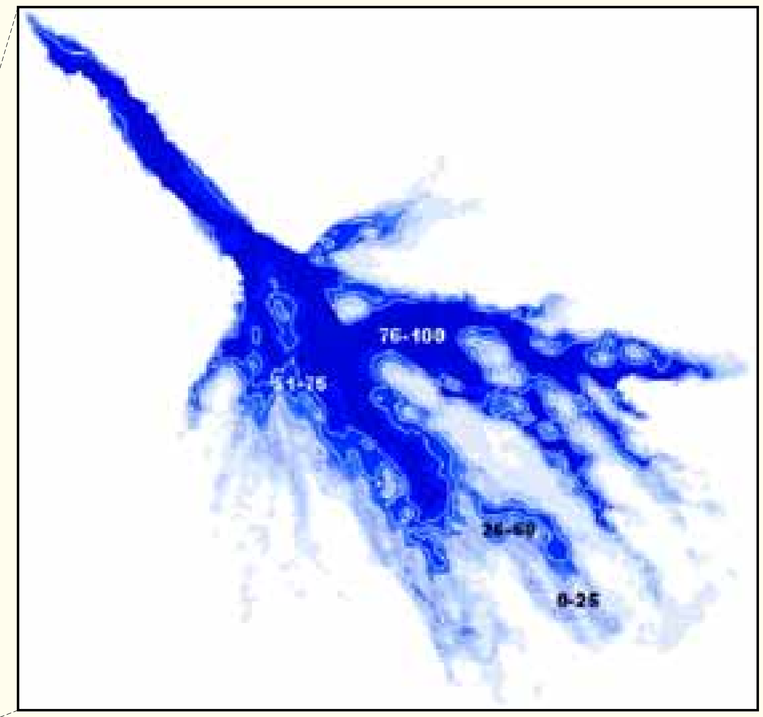
The inundated area of the Okavango Delta changes annually and seasonally, depending on the regional precipitation over the catchment area in the Angolan highlands (McCarthy and others 2003). The Delta's flooding begins about mid-summer in the north and six months later in the south. Water entering the Delta passes through the sand aquifers of numerous islands and evaporates, leaving behind enormous quantities of salt. The vegetation disappears in the centre of the islands and thick salt crusts form around their edges. Islands can disappear completely during the times of peak flooding, and reappear at the end of the season as waters recede. Constantly changing water levels have huge environmental and social implications since the Delta enjoys rich biodiversity and is a major source of livelihoods for local communities. The map below shows the percentage of time between 1985 and 2000 that areas of the delta were inundated. Dark blue areas indicate permanently inundated regions while lighter blue to white areas represent less inundation time (McCarthy and others 2003). The Delta's inundation has always varied from year to year. A study by McCarthy and others (2003) showed that the wetland area varied in extent from 2 450 km² to 11 400 km² between 1972 and 2000.

Map of the catchment area of the Okavango Delta



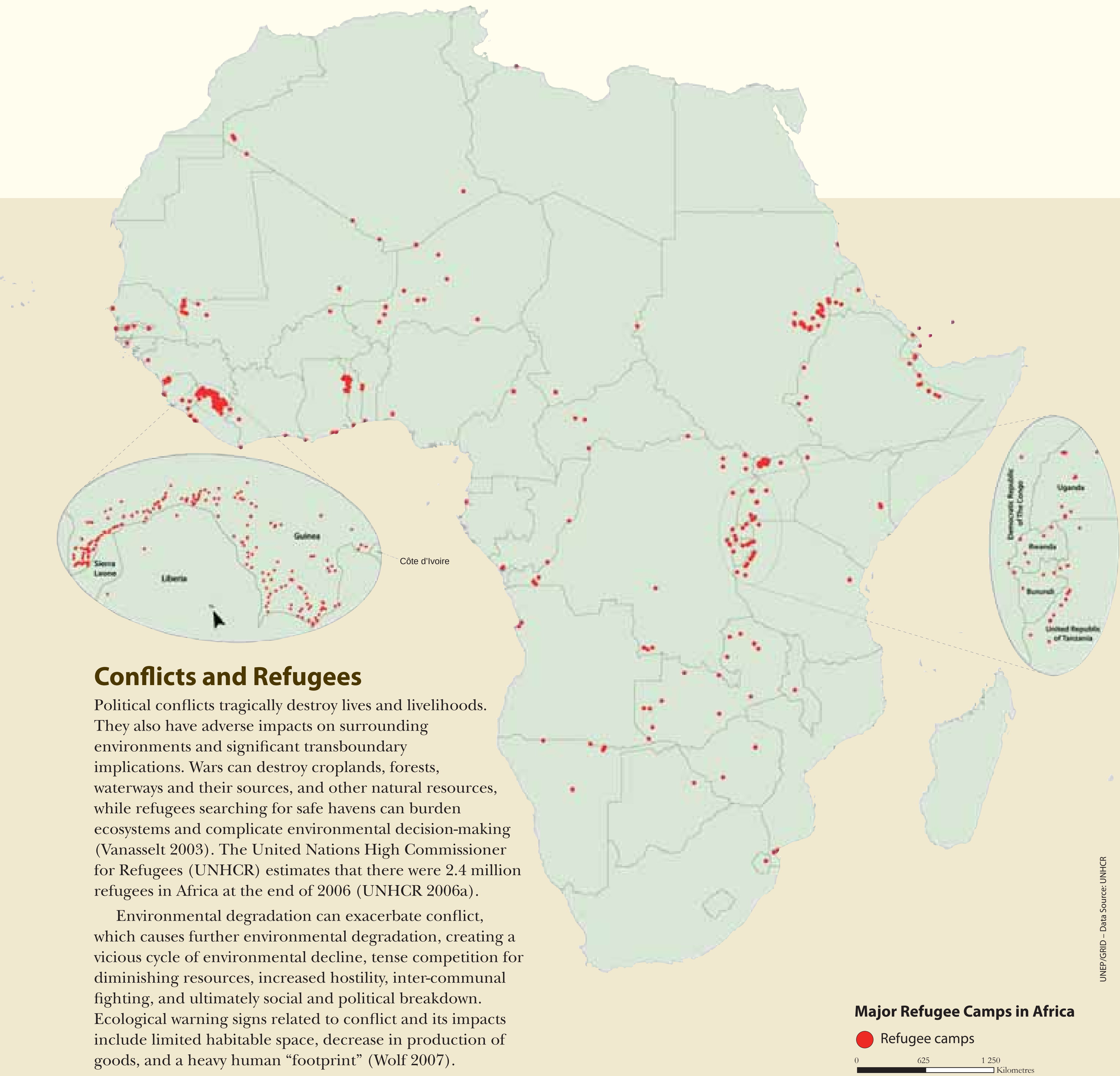
UNEP/GRID

Okavango Delta's catchment area



McCarthy and others 2003

Some parts of Okavango Delta remain inundated year round even in dry years, however, much of the delta is inundated only seasonally or in wet years. This image shows the percentage of time various areas of the delta were inundated between 1985 and 2000.

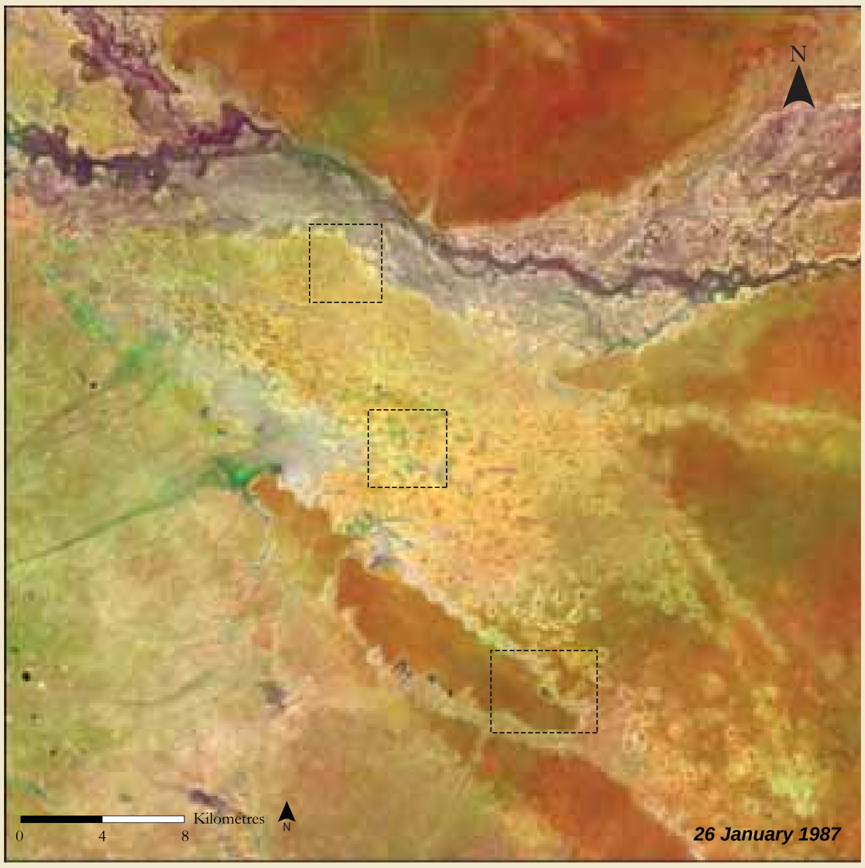


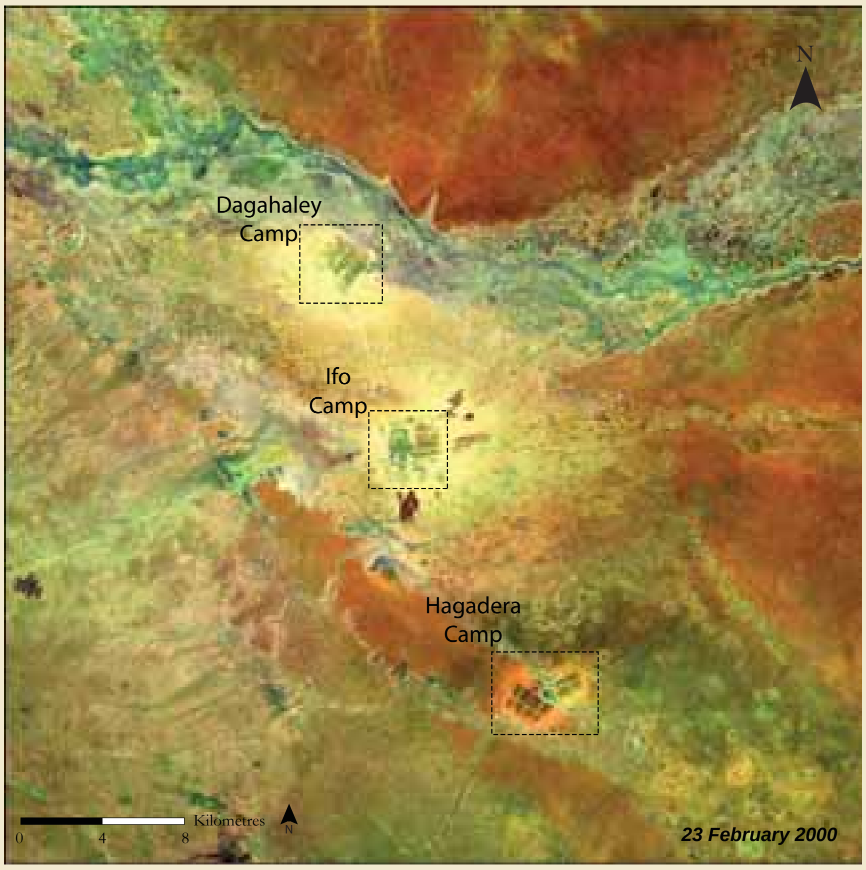
Conflicts and Refugees

Political conflicts tragically destroy lives and livelihoods. They also have adverse impacts on surrounding environments and significant transboundary implications. Wars can destroy croplands, forests, waterways and their sources, and other natural resources, while refugees searching for safe havens can burden ecosystems and complicate environmental decision-making (Vanasselt 2003). The United Nations High Commissioner for Refugees (UNHCR) estimates that there were 2.4 million refugees in Africa at the end of 2006 (UNHCR 2006a).

Environmental degradation can exacerbate conflict, which causes further environmental degradation, creating a vicious cycle of environmental decline, tense competition for diminishing resources, increased hostility, inter-communal fighting, and ultimately social and political breakdown. Ecological warning signs related to conflict and its impacts include limited habitable space, decrease in production of goods, and a heavy human "footprint" (Wolf 2007).

Changes to the landscape in and around the Dadaab Refugee Camp between 1987 and 2000



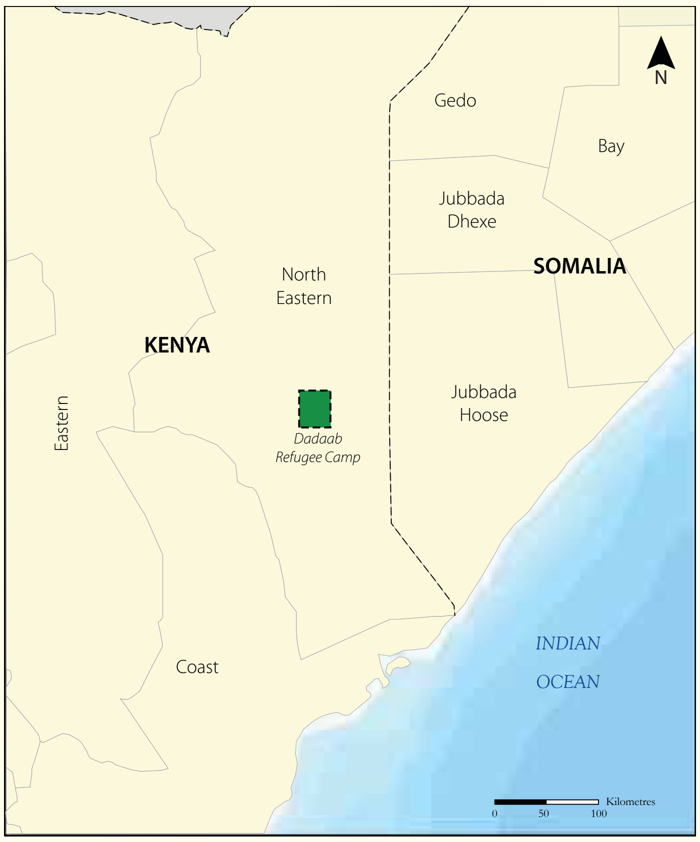


Dadaab Refugee Camp

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.

The 1987 satellite image above shows a fairly intact landscape dominated by shrub vegetation that is characteristic of the semi-arid area. In the 2000 image, the Ifo, Dagahaley, and Hagadera refugee camps stand out distinctly, revealing the presence and impact of a high concentration of over 100 000 refugees 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.

Map of study area



UNEP/GRID

In the refugee camps, most households have several buildings—sleeping rooms, a kitchen, maybe a storage area—and lots of outside communal space where families can cook, socialize, clean, do laundry and other activities. It is not uncommon for families to keep goats, donkeys, or chickens within the household area.

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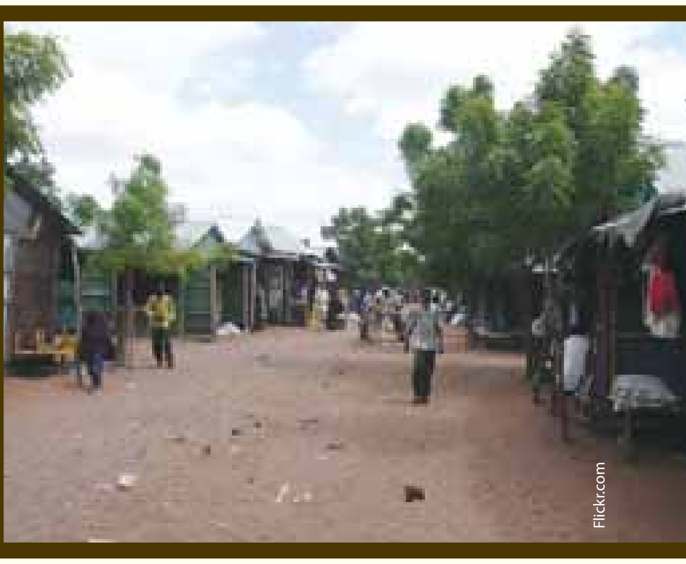


Flickr.com

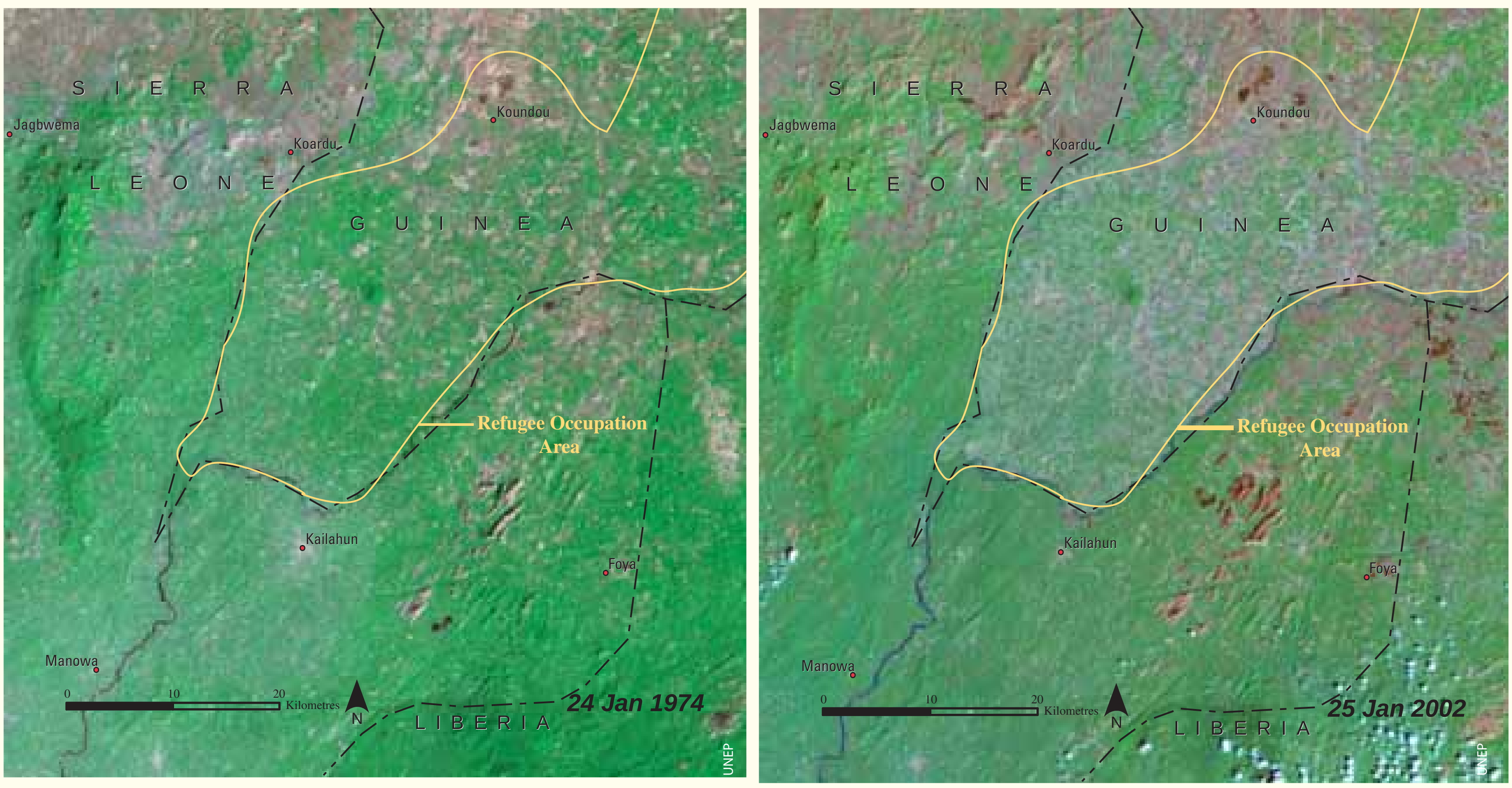
A street scene in Guinea

Courtney/Flickr.com

The Parrot's Beak Region

"Parrot's Beak" is a small strip of land belonging to Guinea, situated between Sierra Leone and Liberia. In the 1990s, civil wars in Sierra Leone and Liberia forced hundreds of thousands of people to seek the relative safety of Guinea. Many of these refugees settled in the Parrot's Beak region. The impact on the region can be seen in the two satellite images below. In the 1974 image, prior to the influx of refugees, small flecks of light green scattered throughout the deep-green forest of the Parrot's Beak region represent compounds of villages surrounded by agricultural plots. Contrast this with the light green colour of the 2002 image. This is the result of deforestation where refugees have settled. Many of the refugees integrated into local villages, converting forest into family agricultural plots to such an extent that the Parrot's Beak was largely denuded of trees. In early 2003, the United Nations High Commissioner for Refugees (UNHCR) helped 16 500 Sierra Leonean refugees living in Guinea return to their homeland; roughly half of these returning refugees traveled through the Parrot's Beak region.

Changes in the Parrot's Beak region between 1974 and 2002



Darfur Conflict

The Darfur conflict is a complex crisis in the Darfur region of western Sudan. The combination of decades of drought, desertification, and overpopulation are among the contributing factors that led nomads searching for water to drive their livestock south into regions mainly occupied by farming communities. Eventually, tensions between the two groups escalated into conflict. The United Nations estimates that as many as 450 000 people have died from violence and disease and about 2.5 million are thought to have been displaced as of October 2006 (UNHCR 2006b).

On 16 June 2007, United Nations Secretary General Ban Ki-moon released a statement in which he proposed that the impact of climate change is directly related to the Darfur conflict, as desertification has added significantly to the stress on the livelihoods of pastoralist societies, forcing them to move south to find pasture (Ban Ki-moon 2007). Apart from the millions internally displaced, more than 200 000 refugees are currently hosted in 12 UNHCR-run camps across the border in Chad (UNHCR 2006b). Their presence is a transboundary environmental problem, since the need for fuelwood has led refugees to destroy forests around the camps and dig new bore holes for water, which are depleting aquifers.

Bir Kedouas is a two square kilometre settlement within Chad, just west of Sudan's Darfur region (see below). On 16 December 2005, Janjawid nomadic fighters attacked the village settlement, burning at least 60 homes and causing widespread destruction (Amnesty International 2006).

Map of study area

Changes in Bir Kedouas, Chad, between 2004 and 2006

Before and after the 2005 attack (images from Quickbird/Digital Globe)

Dust Storms and Fires

Dust storms and biomass burning are two significant sources of transboundary air pollution in Africa. Desertification—a major environmental issue—contributes to dust storms, while biomass burning releases unhealthy particulates into the air, causing air pollution that in turn leads to respiratory illnesses, allergies, and other health problems.

Dust storm in Cairo, Egypt

Keith and Gabriela Fultonne/Flickr.com

Dust Storms

Dust storms are severe weather hazards. They are characterized by strong winds and dust-filled air over an extensive area, often drifting from one country to another. They are common in arid and semi-arid regions. The dust in such storms is either natural in origin, from volcanic eruptions or from soil eroded by wind, or the result of human activities, such as mining and various industries.

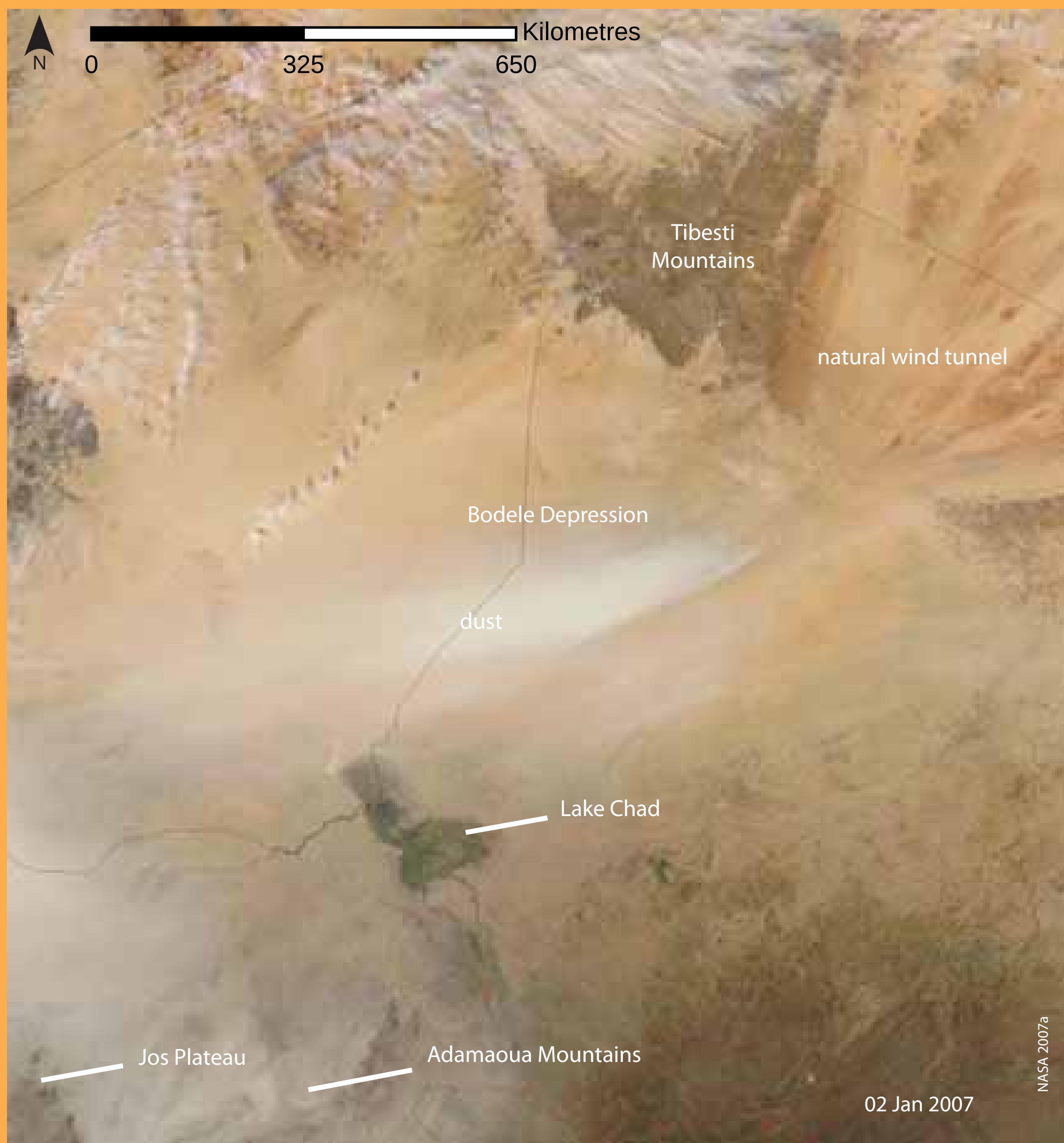
Africa is one of the largest dust-producing regions in the world (Washington and others 2006a). Niger, Chad, Mauritania, northern Nigeria, and Burkina Faso are among the countries most affected by the loss of top soil by wind erosion. Saharan dust storms were once relatively rare, but in the past half-century they have increased ten-fold. In Mauritania, the number of dust storms rose from two per year in the early 1960s to 80 per year in more recent times (Brown 2007).

Transboundary transport of African dust—across continents and even oceans—can result in a number of environmental hazards such as eutrophication (decreased oxygen) in estuaries and lung infections in humans. The loss of fine soil particles through erosion and dust storms deprives the land of fertility as well as biological productivity (Brown 2007), and can affect the weather by reflecting the sun's rays back into space (NASA 2004a). Dust storms are thus increasingly viewed as a key component of change in some terrestrial and marine ecosystems and as a potentially significant source of pathogens and contaminants (Ila 2006).

Dust Storm in the Bodele Depression

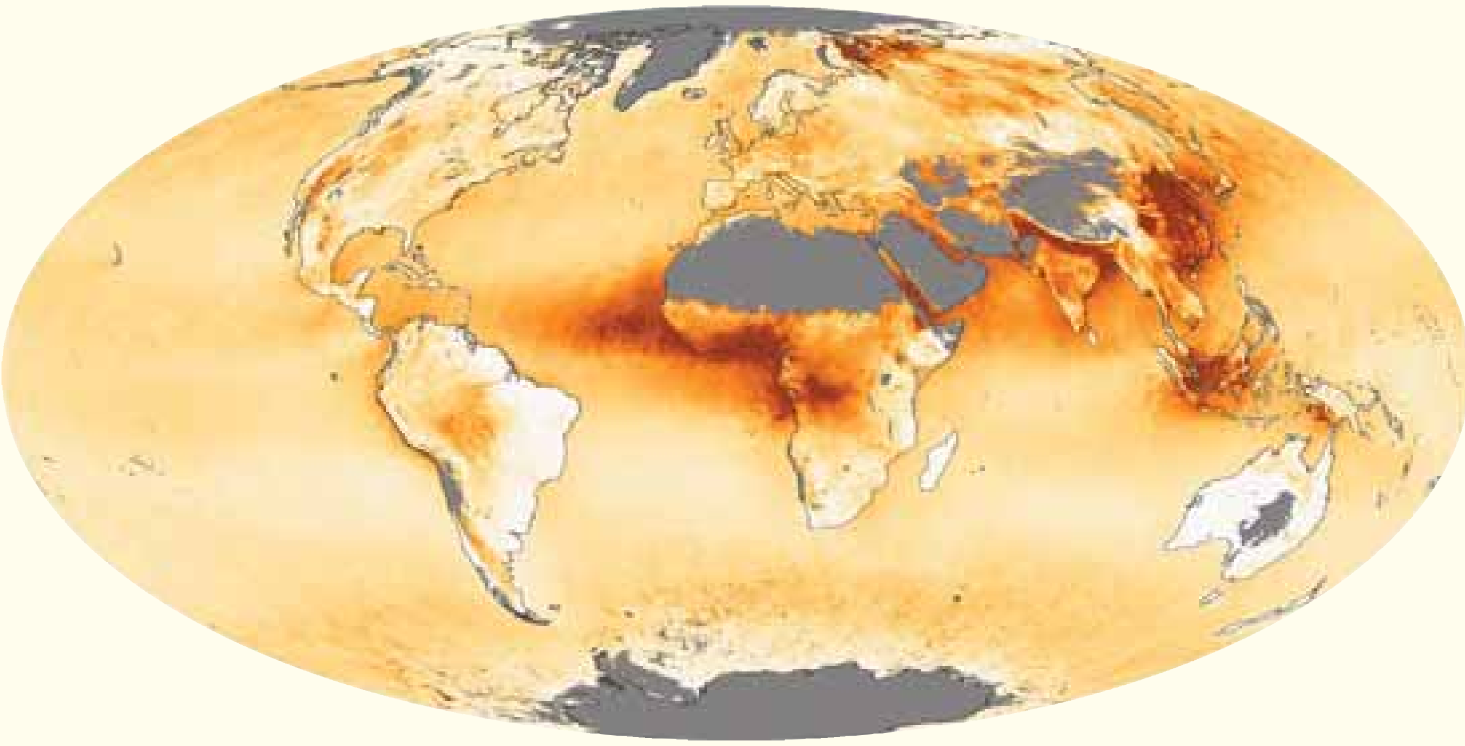
The Bodele Depression, located at the southern edge of the Sahara Desert in north-central Africa, is one of the largest sources of airborne dust in the world. Nested between two mountain ranges in Chad and downwind from a natural wind tunnel, the Bodele Depression provides a steady supply of Saharan dust plumes. This January 2007 satellite image (right), shows a dust storm brewing in the Bodele Depression. Clearly visible is a bright streak of dust that arcs southwest across the Depression toward Lake Chad. During winter in the Northern Hemisphere, northeasterly winds routinely blow across this part of northern Africa. The dust spreads westward across the Atlantic Ocean on the easterly trade winds. Eventually, the dust reaches the Amazon River Basin in South America, where it replenishes mineral nutrients that are continually depleted from the soil by heavy, tropical rains. About half of the 40 million metric tonnes of dust that are swept across the Atlantic from the Sahara to the Amazon each year come from the Bodele Depression, an area that accounts for only 0.2 per cent of the Sahara (NASA 2007a).

Based on satellite data and computer models, scientists estimate that Saharan dust storms generate an average of about 0.7 million metric tonnes of dust during winter days.



Dust storm, Bodele Depression

Richard Washingtonne/BodEx



This image shows the annual mean aerosol optical depth for 2006. Optical depth is the degree to which aerosols prevent incoming sunlight from reaching the Earth's surface. High aerosol concentrations were observed over western and central Africa due to dust from the Sahara and smoke from biomass burning. Gray zones on the map represent areas were aerosol data could not be collected (NASA 2006c).

This April 2000 image of Africa shows dust blowing from the Sahara Desert into the Atlantic Ocean, represented as areas where aerosols absorb ultraviolet radiation. High concentrations of aerosols are indicated in brown and lower concentrations in yellow (NASA 2000).

Aerosols

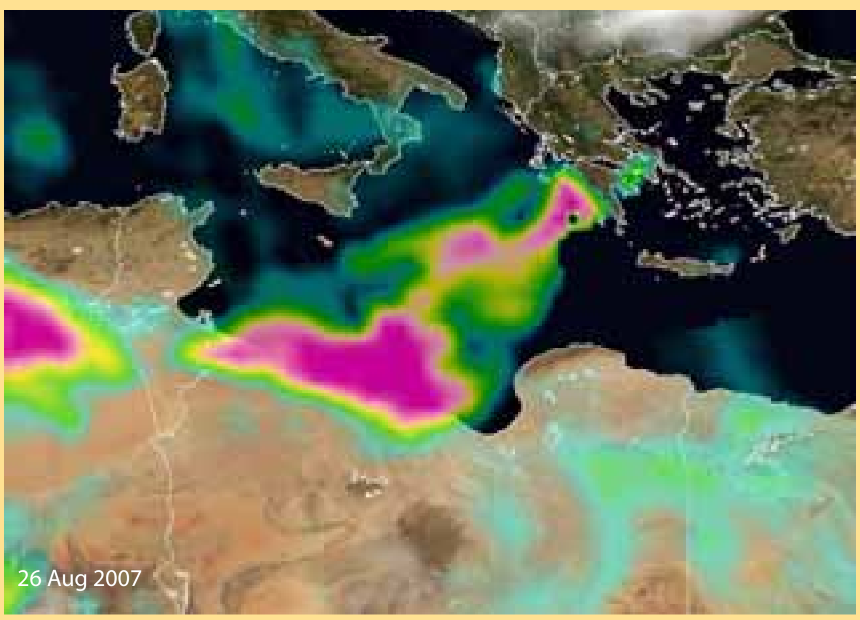
Aerosols are tiny particles suspended in the air. They tend to have a cooling effect on the Earth's surface by reflecting some of the sun's rays back into space. Aerosols also absorb ultraviolet radiation.

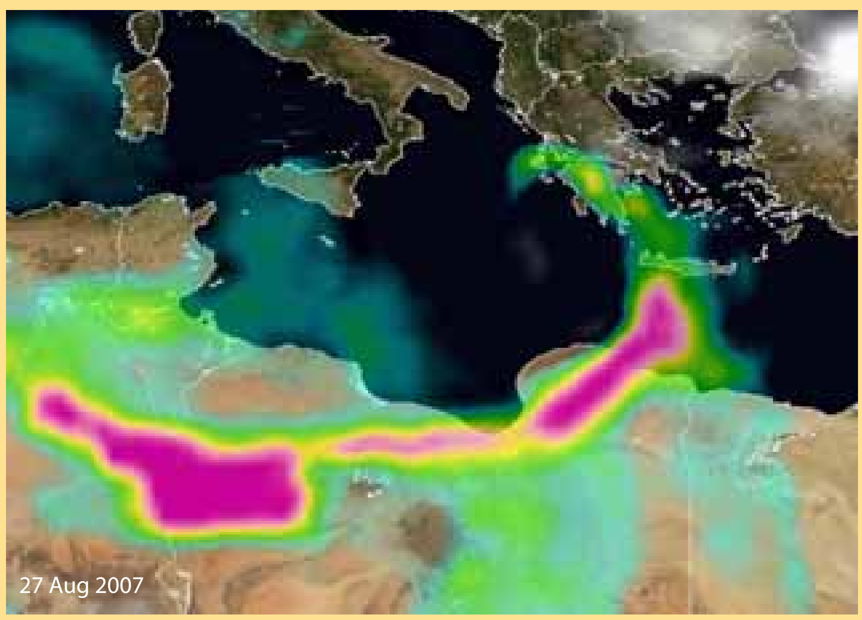
Aerosols can originate from natural sources such as volcanoes, forest fires, and dust storms, or from anthropogenic sources such as the burning of fossil fuels. Averaged over the globe, aerosols resulting from human activities currently account for about 10 per cent of the total amount of aerosols in the atmosphere (Hardin and Kahn n.d.). Most of that 10 per cent is concentrated in the Northern Hemisphere, especially over industrial sites, agricultural regions, areas where slash-and-burn agriculture is practised, and overgrazed grasslands.

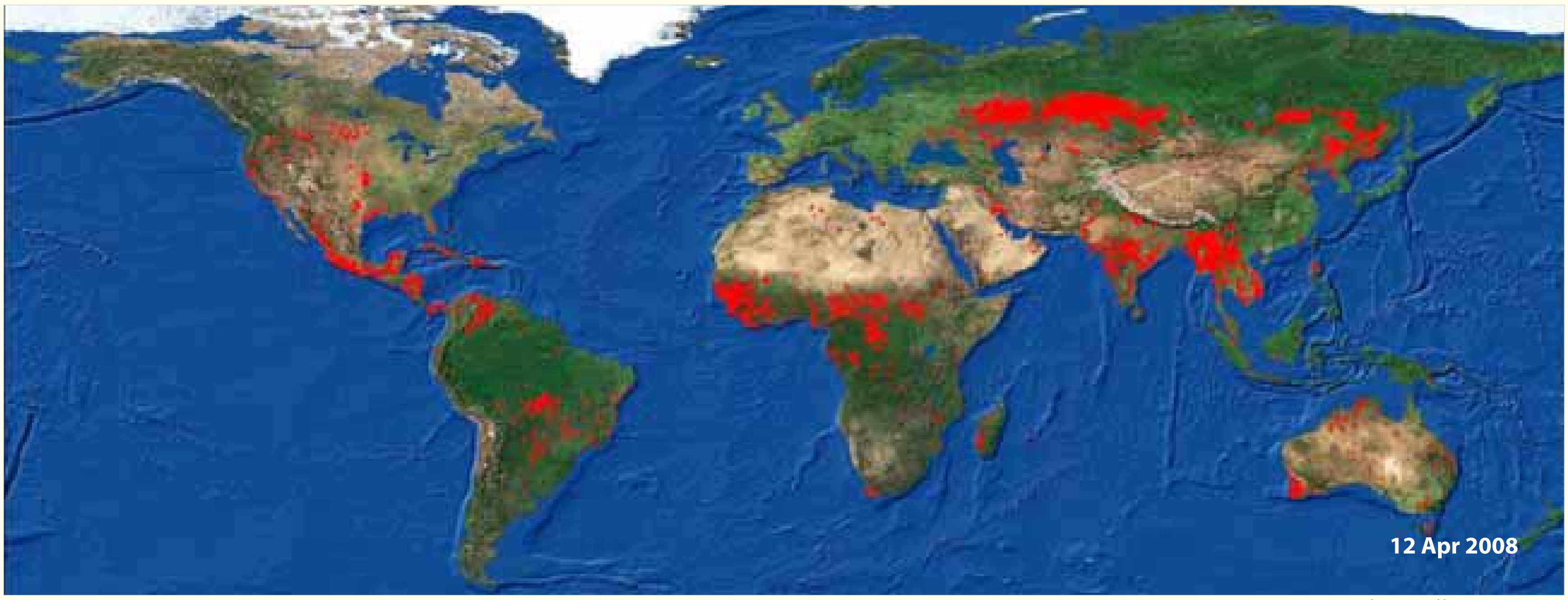
This 2007 image shows actively burning fires in red—a line of fires stretches along the western coast of Greece's Peloponnesus Peninsula. To the northeast, a single fire casts a plume of smoke over the Greek capital of Athens.

Smoke Spreading From Greece to Africa

Fires burning in southwestern Greece in August 2007 released aerosols that winds carried to Africa. On 26 August 2007, aerosols from the fires took a fairly direct route across the Mediterranean Sea to collect on the western part of the Libyan Arab Jamahiriya coast. On 27 August 2007, the aerosols took a different path, spreading southward in a clockwise direction from Greece, across the island of Crete, and ultimately concentrating over eastern Libyan Arab Jamahiriya. In these images, the highest aerosol concentrations are represented in pink, with lower concentrations in yellow and green; relatively clear air is transparent (NASA 2007c).







This image shows the global distribution of fires, represented by red dots. Fire distribution in Africa indicates the highest biomass burning in the world (images based on night-time measurements).

Image Credit: NASA n.d.b; Data Source: GLCF

Fires

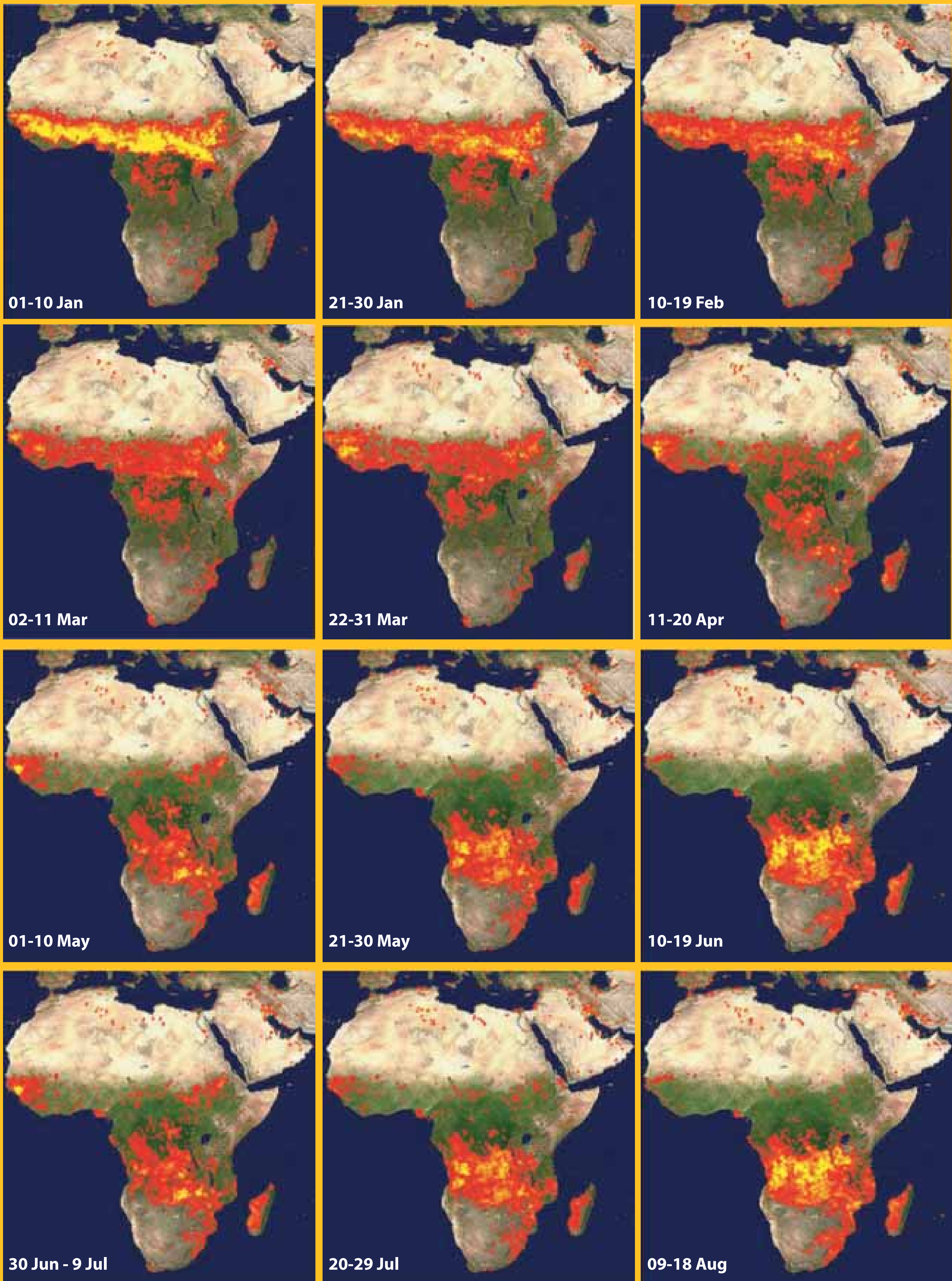
The frequent and large-scale burning of grasslands in Africa contributes to transboundary air pollution through the release of airborne particles (aerosols) and gases into the atmosphere, many of which can have an impact on climate and human health. For example, fires also release carbon monoxide, hydrocarbons, and nitrogen oxides. When exposed to sunlight, some of these substances react chemically to create ground-level ozone. Unlike the ozone in the stratosphere, which absorbs dangerous ultraviolet light, ozone near the Earth's surface is a harmful air pollutant that can lead to respiratory illnesses and allergies in people. While urban and industrial contributions to pollution go on year round, wildfires can add to global pollution levels in intense seasonal bursts. Fires contribute as much as 35 per cent of ground-level ozone formation in Africa.

Biomass Burning in Africa

Biomass burning is the burning of living and dead vegetation and includes the burning of forests, savannahs, and agricultural lands. Wildfires are responsible for half of the biomass burning that occurs in Africa, while shifting cultivation accounts for 24 per cent, deforestation for ten per cent, domestic burning for 11 per cent, and the burning of agricultural waste for five per cent (UNEP 2005b). Studies show that biomass burning has increased on a global scale over the last 100 years. Savannahs in Africa experience the most extensive biomass burning in the world (NASA 2001b). Because two-thirds of the Earth's savannahs are located in Africa, the continent is now recognized as the "burn centre" of the planet (Levine and others 1995).

Burning brush in Kenya

Christian Lambrechts/UNEP



NASA 2005

Seasonal Pattern of Wildland Fires

This series of images shows the seasonal pattern of wildland fires in Africa during 2005. Fires appear as red, orange, or yellow dots, with yellow indicating the greatest number of fires. Some of the highest levels of biomass burning in the world occur in southern Africa. For thousands of years farmers and herders south of the Sahara Desert have used fire to clear land for farming or renew grazing land. Fire locations shift with the seasons. The burning of tropical savannahs is estimated to release nearly three times as much carbon (as carbon dioxide) into the atmosphere as the burning of tropical forests. Extensive biomass burning in Africa not only releases carbon dioxide, the principle greenhouse gas, into the atmosphere but also contributes carbon monoxide. Furthermore, if burned vegetation does not regenerate, it can no longer act as a carbon sink. Denuded landscapes also hasten desertification.

Biomass burning results in carbon monoxide pollution

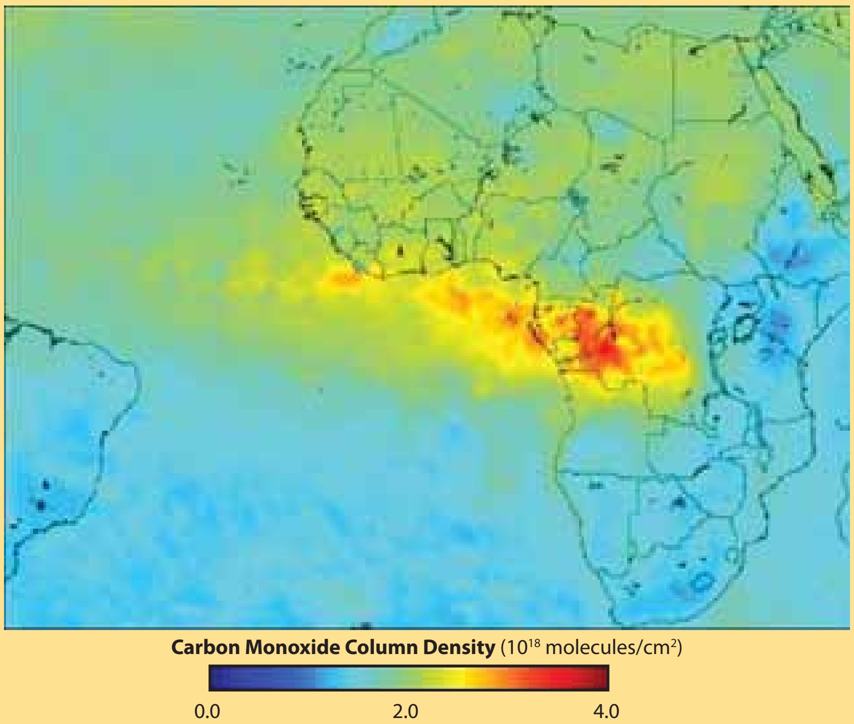
Carbon Monoxide Pollution: A Result of Biomass Burning

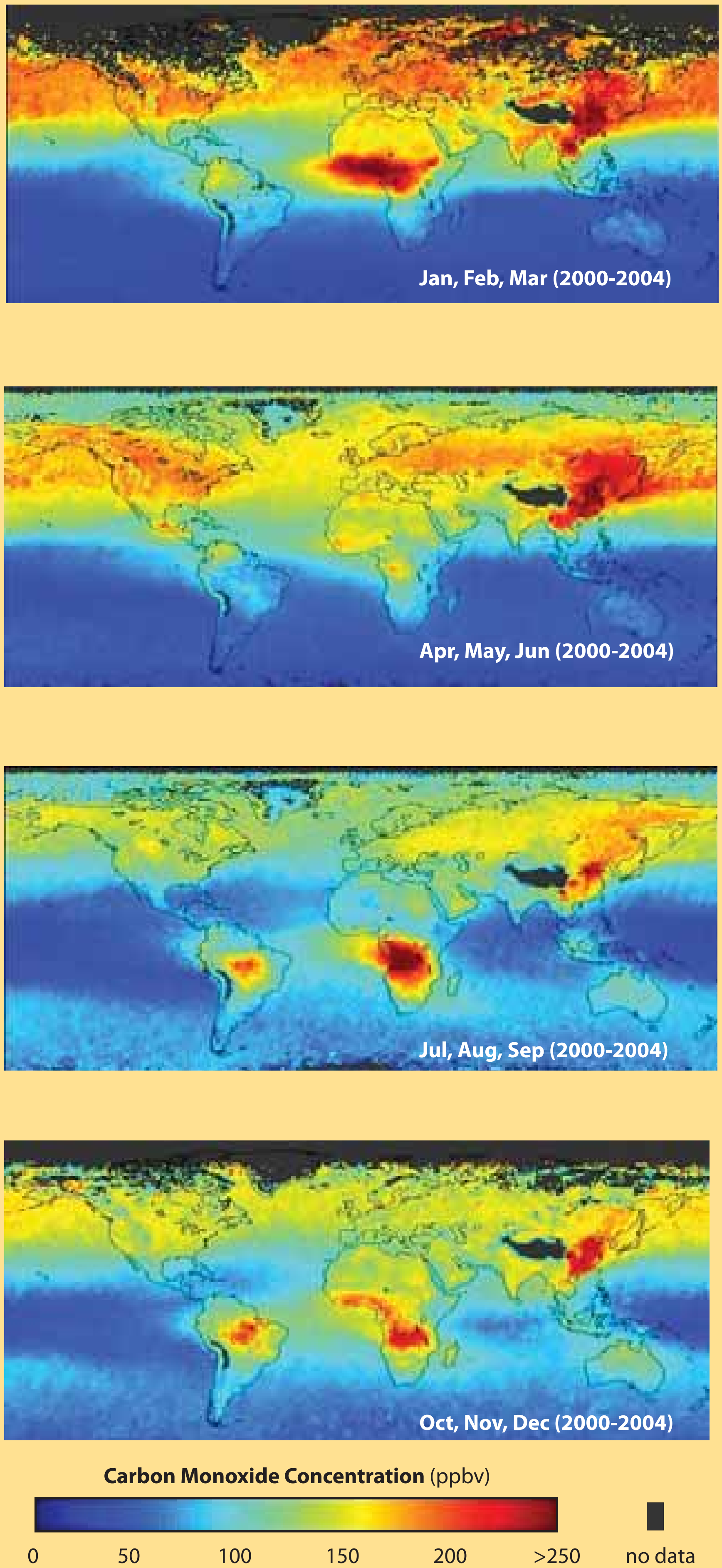
A colourless, odourless, and poisonous gas, carbon monoxide (CO) is a by-product of the burning of fossil fuels in industry and automobiles, as well as the burning of forests and grasslands. A major air pollutant, carbon monoxide is created when carbon-based fuels—like fossil fuels or fuelwoods—do not burn completely or efficiently. High levels of CO pollution are found in many parts of the world, and they result from different types of burning in different locations. In central Africa, high levels of atmospheric CO are linked to widespread fire activity from agricultural burning and wildfires. Carbon monoxide molecules can last from a few weeks to several months in the atmosphere and can travel across national boundaries. Because of its transboundary movement, CO can affect air quality in regions far from its original source (NASA 2000-2004).

Widespread fires release high levels of CO

This vertical series of images (right) shows a record of global CO production from March 2000 through February 2004. Blue areas have little or no atmospheric CO, while progressively higher CO levels are shown in green, yellow, orange, and red. In January through March, carbon monoxide levels are in the "red zone"—more than 200 parts per 1 000 million—across much of the Northern Hemisphere. They are even present as far north as the Arctic and extending out over the Atlantic and Pacific Oceans because of transboundary movement (NASA 2000-2004). CO levels are especially high over central Africa for much of the year.

In this June 2004 image, red and yellow indicate high carbon monoxide levels, while light- and dark-blue hues represent low values (NASA 2004b). A vast plume of carbon monoxide extends from Africa over the Atlantic Ocean.



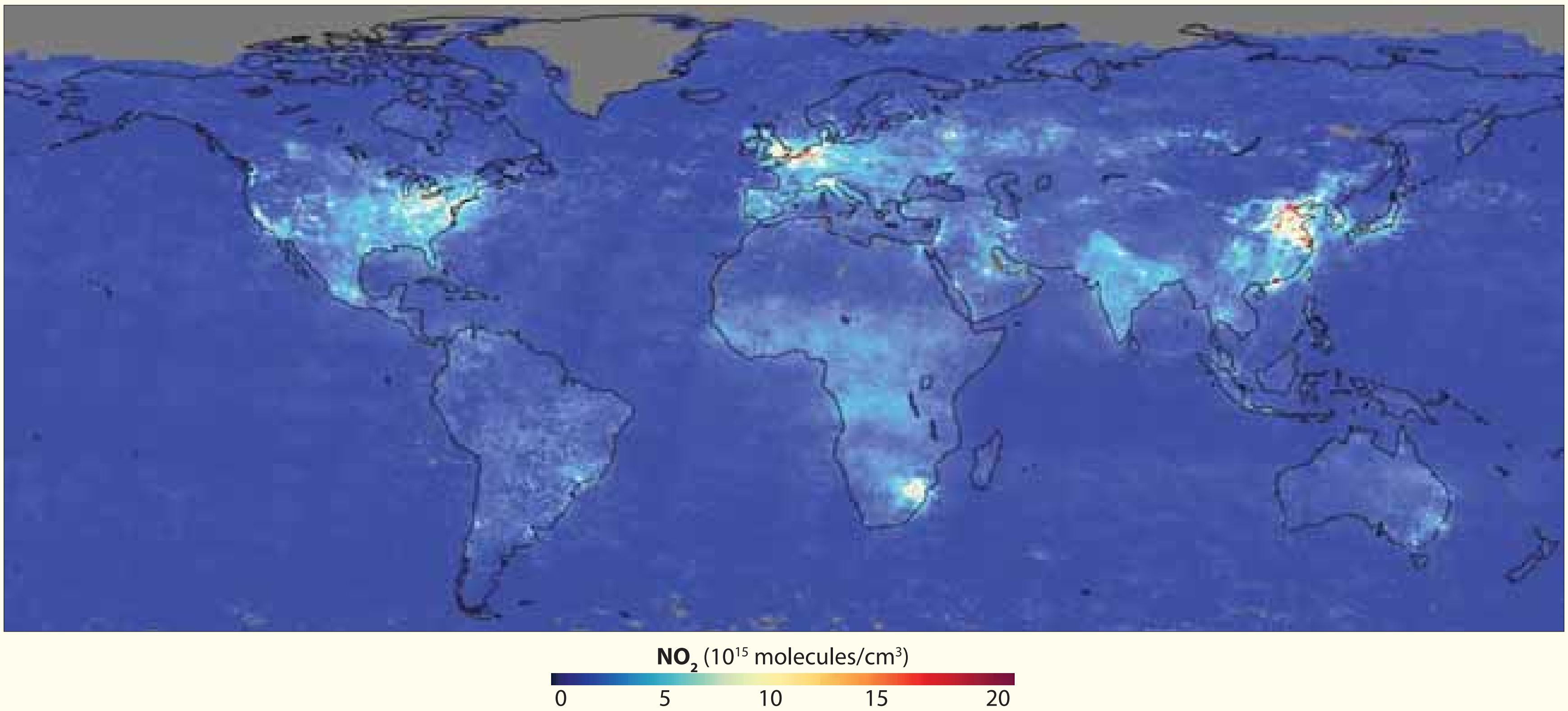


Southern Africa: Hotspot for Nitrogen Dioxide (NO_2)

Nitrogen oxides are created from lightning, soil microbial activity, both natural and anthropogenic fires, automobile exhaust, the burning of fossil fuels and biomass, and the photo-degradation of nitrous oxide (N_2O) in the stratosphere. Nitrogen oxides in the atmosphere eventually form acid rain that damages plants and agricultural crops (EPA 2002). Nitrogen dioxide can impact human health, causing lung damage and respiratory problems. It also contributes to urban pollution, since it is a reactant in the production of ground-level ozone.

A global map of nitrogen dioxide (NO_2) in the troposphere in 2003

This 2003 image shows the locations of high levels of nitrogen dioxide worldwide. High concentrations of NO_2 tend to be associated with large urban or industrial areas. In Africa, NO_2 concentrations are particularly high over coal-fired power stations in South Africa. Lower, but widespread, concentrations of the gas—produced by biomass burning—are visible across much of the African continent (NASA 2003).



2.5 Conclusion

The illustrated case studies and examples in this chapter have underscored how Africa's ecosystems and their plant and animal inhabitants are not confined by political jurisdictions, but are often shared by many countries. Furthermore, the impact of human activities can often be felt far beyond the borders of the countries in which the activities take place. For these reasons, common approaches and complementary actions by neighbouring countries and entire regions are needed to effectively conserve Africa's biodiversity and the natural resources its people depend upon for their livelihoods.

Taking wood to market

Christian Lambrechts/UNEP

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The Hemispheres of Earth

Land, sea, sky, and shining city lights—gathered from various satellite missions over decades of remote sensing—form this beautiful image of the Earth that is a fusion between science and art. Created by a team of NASA scientists and graphic artists, these layers of global satellite data depict everything from polar sea ice to the light reflected by the chlorophyll in multi-millions of microscopic photosynthesizing organisms growing in the oceans. The images of Africa in the pages that follow are both a showcase for remote sensing technology and a source of inspiration for appreciating the beauty of our planet and better understanding how land, ocean, atmosphere—and even life itself—interact on Earth.

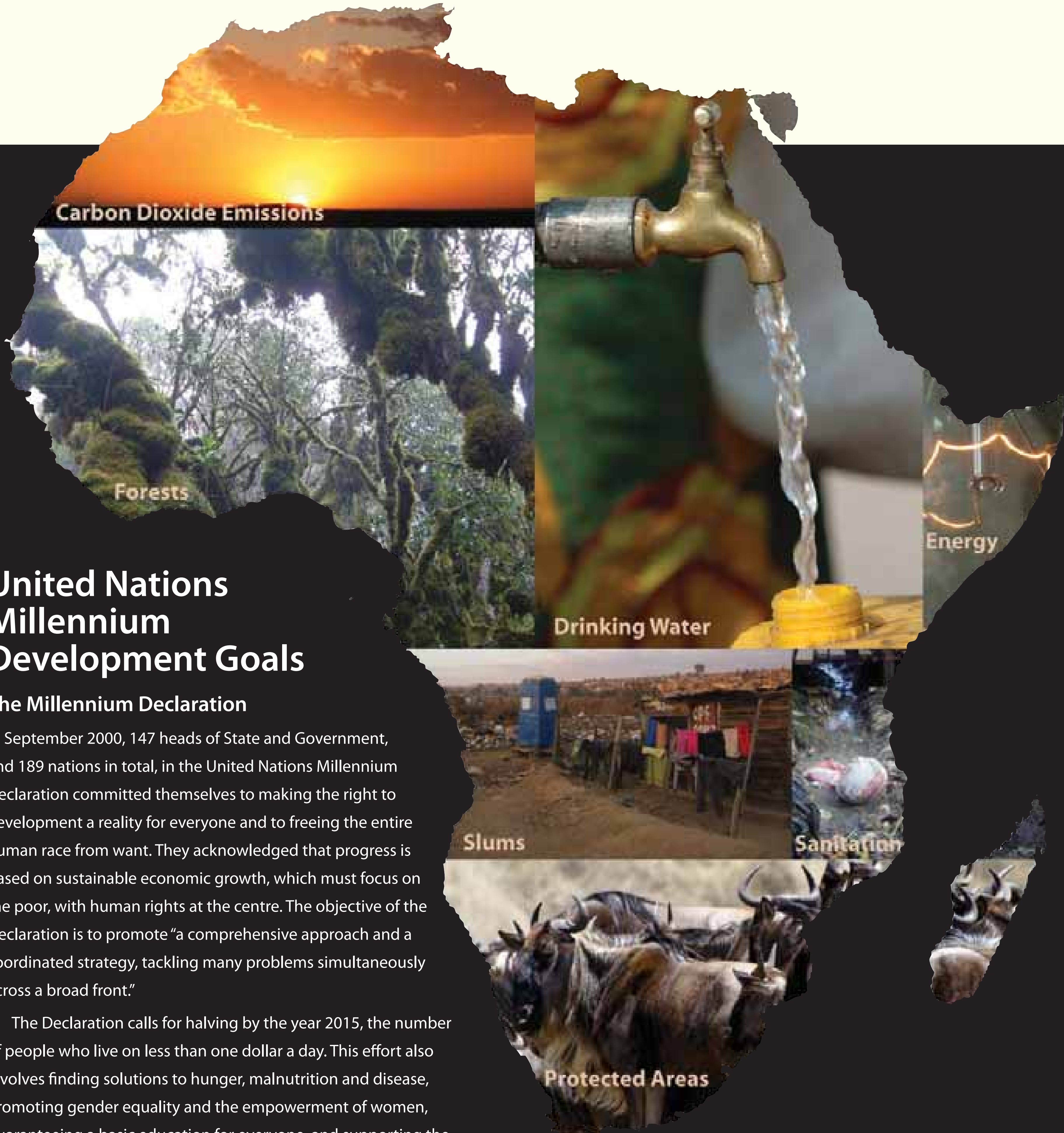
Source: Earth Observatory/NASA


Maasai, Kenya

Photo: Jacqui Goodwin/Flickr.com

Chapter 3

Tracking Progress Towards Environmental Sustainability



Millennium Development Goal 7:
Ensure Environmental Sustainablilty

United Nations Millennium Development Goals

The Millennium Declaration

In September 2000, 147 heads of State and Government, and 189 nations in total, in the United Nations Millennium Declaration committed themselves to making the right to development a reality for everyone and to freeing the entire human race from want. They acknowledged that progress is based on sustainable economic growth, which must focus on the poor, with human rights at the centre. The objective of the Declaration is to promote "a comprehensive approach and a coordinated strategy, tackling many problems simultaneously across a broad front."

The Declaration calls for halving by the year 2015, the number of people who live on less than one dollar a day. This effort also involves finding solutions to hunger, malnutrition and disease, promoting gender equality and the empowerment of women, guaranteeing a basic education for everyone, and supporting the Agenda 21 principles of sustainable development. Direct support from the richer countries, in the form of aid, trade, debt relief and investment is to be provided to help the developing countries.

Millennium Development Goals (MDGs)

Effective 15 January 2008

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	Some of the indicators listed below are monitored separately for the least developed countries (LDCs), Africa, landlocked developing countries and small island developing States.
Includes a commitment to good governance, development and poverty reduction—both nationally and internationally	***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.*

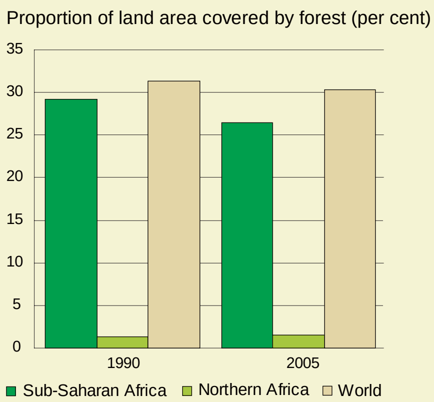
[b] *The actual proportion of people living in slums is measured by a proxy, represented by the urban population living in households with at least one of the four characteristics: (a) lack of access to improved water supply; (b) lack of access to improved sanitation; (c) overcrowding (3 or more person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

Source: UN 2007b

This vision took the shape of eight Millennium Development Goals, which provide a framework for development planning for countries around the world, and time-bound targets by which progress can be measured. To help track progress on the commitment made in the year 2000 in the United Nations Millennium Declaration, international and national statistical experts selected relevant indicators to be used to assess progress over the period from 1990 to 2015, when targets are expected to be met. Each year, the Secretary-General presents a report to the United Nations General Assembly on progress achieved towards implementing the Declaration, based on data on the 60 selected indicators, for 21 targets aggregated at global and regional levels.

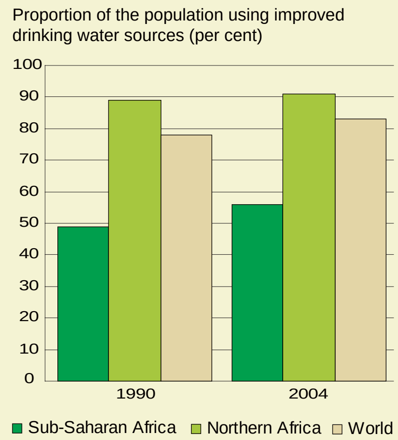
Forested land as percentage of land area:

From 1990 to 2005, the world lost three per cent of its forests, an average decrease of 0.2 per cent a year. Deforestation, primarily due to the conversion of forests to agricultural land in developing countries, continues at an alarming rate—about 13 million hectares a year. The rate of loss has been fastest in some of the world's most biologically diverse regions, including sub-Saharan Africa (UN 2007c). While the proportion of forested land stood at one per cent for both time periods in northern Africa, that of Sub-Saharan Africa dropped by three per cent, from 29 per cent in 1990 to 26 per cent in 2005.



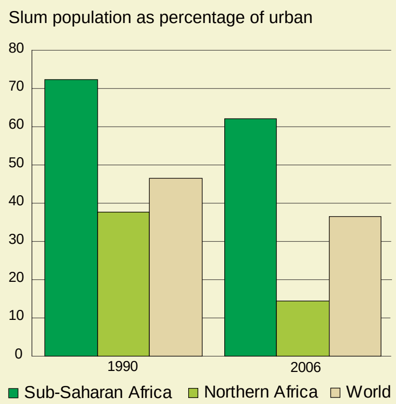
Proportion of population with sustainable access to an improved water source:

In Africa, only 42 per cent of people in rural areas had access to clean water, according to the latest 2004 data, and 63 per cent of the entire population lacked access to basic sanitation facilities—down only barely from 68 per cent in 1990, and far from the target of cutting this proportion in half by 2015 (UN 2007a).



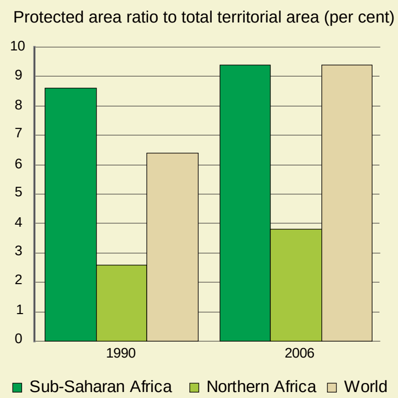
Proportion of households with access to secure tenure:

Already, nearly half the world's population lives in cities and towns. But due to urban migration and rapid population growth, the number of urban dwellers will continue to expand, from 3 200 million people today to nearly 5 000 million by 2030, with most of the growth taking place in Africa and Asia. In 2005, one out of three urban dwellers was living in slum conditions—that is, lacking at least one of the basic conditions of decent housing: adequate sanitation, improved water supply, durable housing or adequate living space. Even if the growth rate of slum dwellers decreases, the rapid expansion of urban areas will make it challenging to improve living conditions quickly enough to meet the target. Sub-Saharan Africa is still one of the regions where lack of adequate shelter among urban populations is most acute. Looking beyond the regional averages, the situation is even more discouraging. In countries including Chad, the Central African Republic and Ethiopia, four out of five urban dwellers live in slums. Northern Africa has the fewest people living in non-durable housing (UN 2007c).



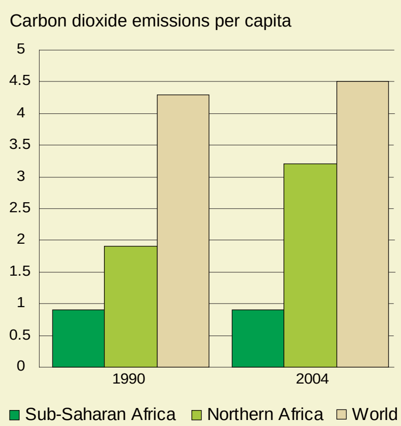
Ratio of area protected to maintain biological diversity to surface area:

The proportion of protected areas globally has steadily increased, and a total of about 20 million km^2 of land and sea were under protection by 2006. However, not all protected areas are effectively managed for conservation. Further clouding the picture is the fact that only a fraction of these areas—about two million km^2—are marine ecosystems, despite their important role in the sustainability of fish stocks and of coastal livelihoods (UN 2007c). In Africa, more protected areas have been set aside than ever before. Between 1990 and 2006, Sub-Saharan Africa increased the proportion of area protected from 8.6 per cent to 9.4 per cent. Likewise, northern Africa increased the proportion from 2.6 per cent to 3.8 per cent.



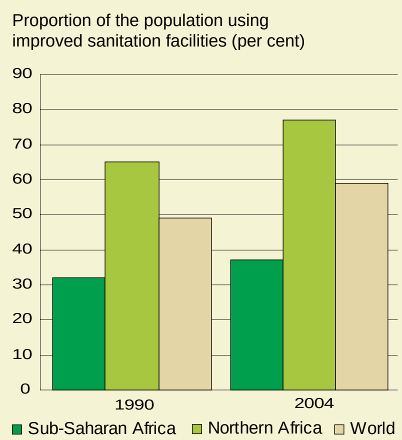
Carbon Dioxide Emissions (per capita) and Consumption of Ozone-Depleting CFCs (ODP tonnes):

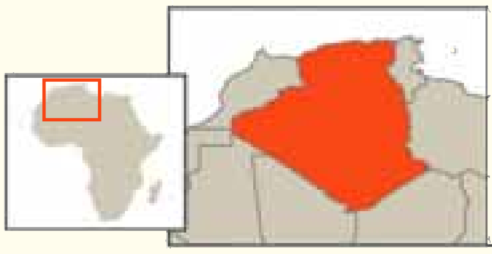
Worldwide, the carbon dioxide emissions reached 2 900 million metric tonnes in 2004 and continue to rise, as evidenced by increasing concentrations of CO_2 in the atmosphere. In northern Africa, emissions more than doubled between 1990 and 2004, increasing from 1.9 to 3.2 metric tonnes of CO_2 per capita. At an average of 0.9 metric tonnes of CO_2 per capita that did not change between 1990 and 2004, an individual in sub-Saharan Africa accounts for less than one tenth of the CO_2 produced by an average person in the developed world (UN 2007c).



Proportion of population with access to improved sanitation:

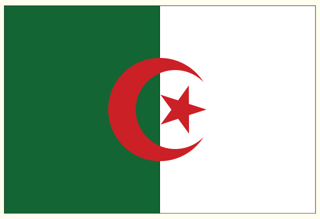
An estimated 1 600 million people will need access to improved sanitation over the period 2005-2015 to meet the MDG target. Yet if trends since 1990 continue, the world is likely to miss the target by almost 600 million people. In the African continent, only northern Africa is on track to halve the proportion of people without basic sanitation by 2015. In sub-Saharan Africa, the absolute number of people without access to sanitation actually increased—from 335 million in 1990 to 440 million people by the end of 2004. This number may increase even further if trends do not improve (UN 2007c).





People's Democratic Republic of Algeria

Total Surface Area: 2 381 741 km²
Estimated Population in 2006: 33 354 000



Credit: © Flagart.com

Algeria is the second largest country in Africa after Sudan. A narrow and mountainous coastal zone constitutes the country's most fertile region, one that enjoys a hospitable Mediterranean climate. As a result, this part of Algeria is densely populated, with approximately 96 per cent of the population occupying less than one-fifth of the country's land (UNCCD 2004). In contrast, 87 per cent of Algeria lies within the bounds of the Sahara Desert. In this region, population density is a mere seven inhabitants per km² (FAO 2005). Average rainfall varies dramatically, ranging from 1 600 mm per year in the coastal mountains to less than 100 mm per year in the Sahara.

Important Environmental Issues

- Desertification
- Water Scarcity
- Pollution

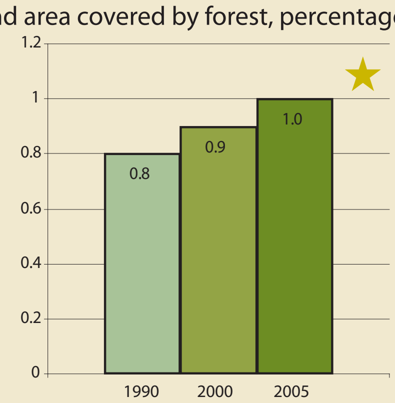
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

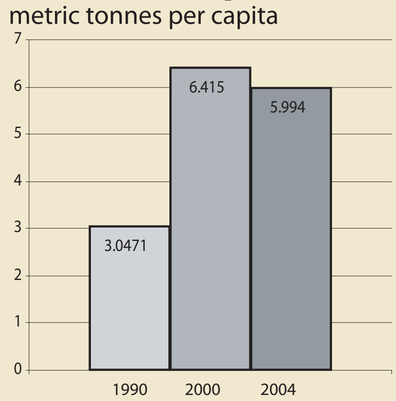
Water shortages, aggravated by regular droughts, are a major problem for Algeria and a limiting factor in the availability of safe drinking water. Encroachment of the desert into the fertile northern section of the country is Algeria's other principal environmental problem. Nevertheless, Algeria has seen an increase in forested area. The country's extent of protected area has remained unchanged for the past 15 years.

★ Indicates progress

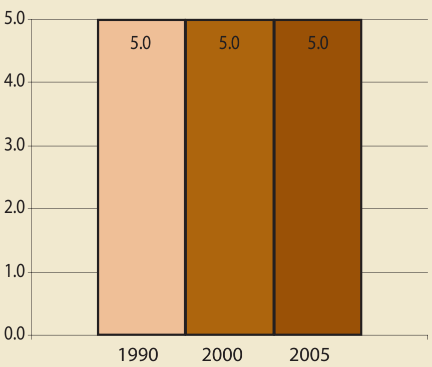
Land area covered by forest, percentage



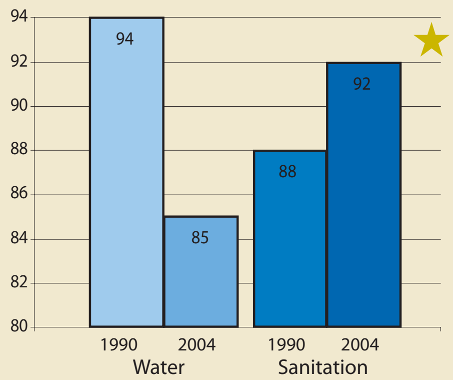
Carbon dioxide (CO_2) emissions, metric tonnes per capita



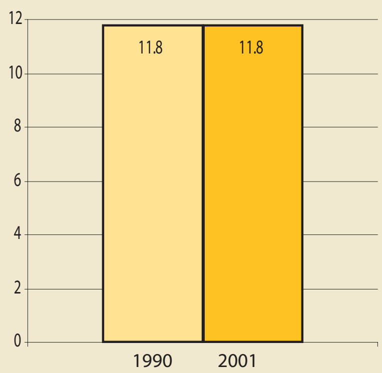
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

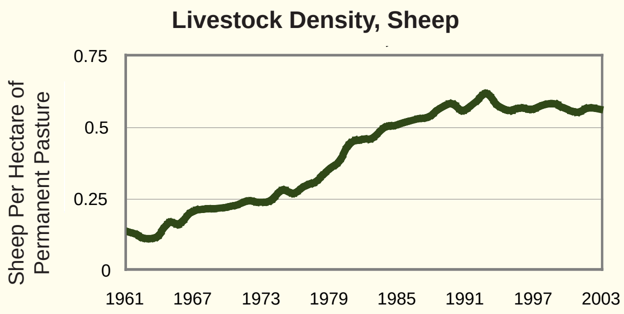


Over 90 per cent of Algerians live along the Mediterranean coast on only 12 per cent of the country's land.

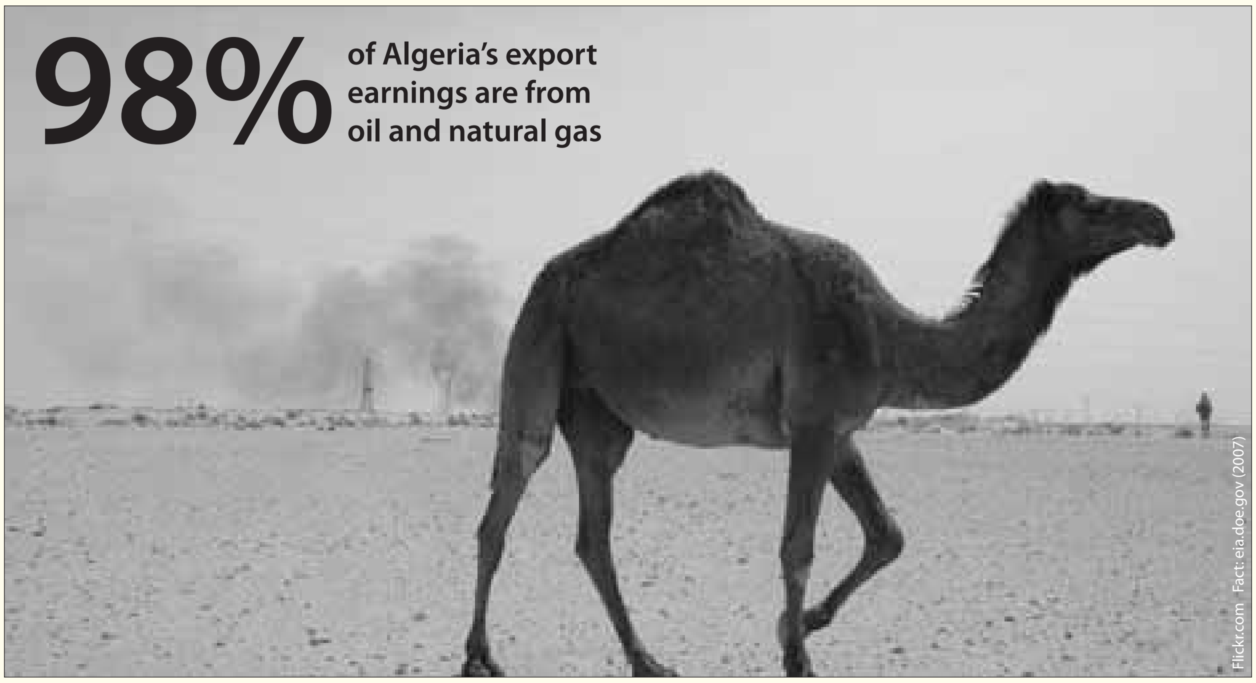
Desertification

Desertification has affected over 130 000 km² of land in Algeria over the past decade (Recelma 2006), of which almost four per cent is thought to be unrecoverable (Nedraoui 2001). The government has initiated reforestation and restoration schemes, but irrigation-induced soil salinity, overgrazing, and forest fires (both intentional and accidental) continue to degrade vulnerable lands, especially in the semi-arid plains just north of the Sahara Desert.

Sheep represent roughly 80 per cent of livestock production (FAO 2007a), which is heavily concentrated in the high plateau region that accounts for only one-tenth of Algeria's surface area. It is estimated that sheep stocks are ten times greater than the carrying capacity of the utilized pasture land (FAO 2007a), thereby exposing soils to significant water and wind erosion.

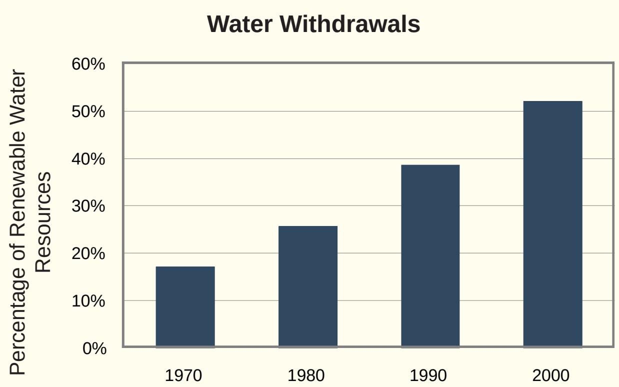


Source: FAOSTAT



Water Scarcity

Algeria is the second most water-scarce country in Africa with only 355 m³ available per person per year (FAO 2007b), which is far below the international water scarcity threshold of 1 000 m³. The vast majority of freshwater resources occur in the north, where overexploitation of coastal groundwater has resulted in saltwater intrusion. The Algerian government has embarked on several hydro-infrastructure projects to maximize access to existing water resources, such as constructing new dams, reducing dam silting, and preventing water loss and waste. Additionally, Algeria is one of only a few countries in the world practising desalination of ocean water.

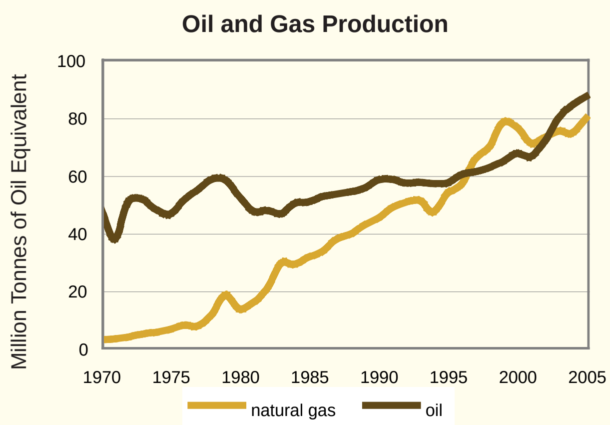


Source: AQUASTAT

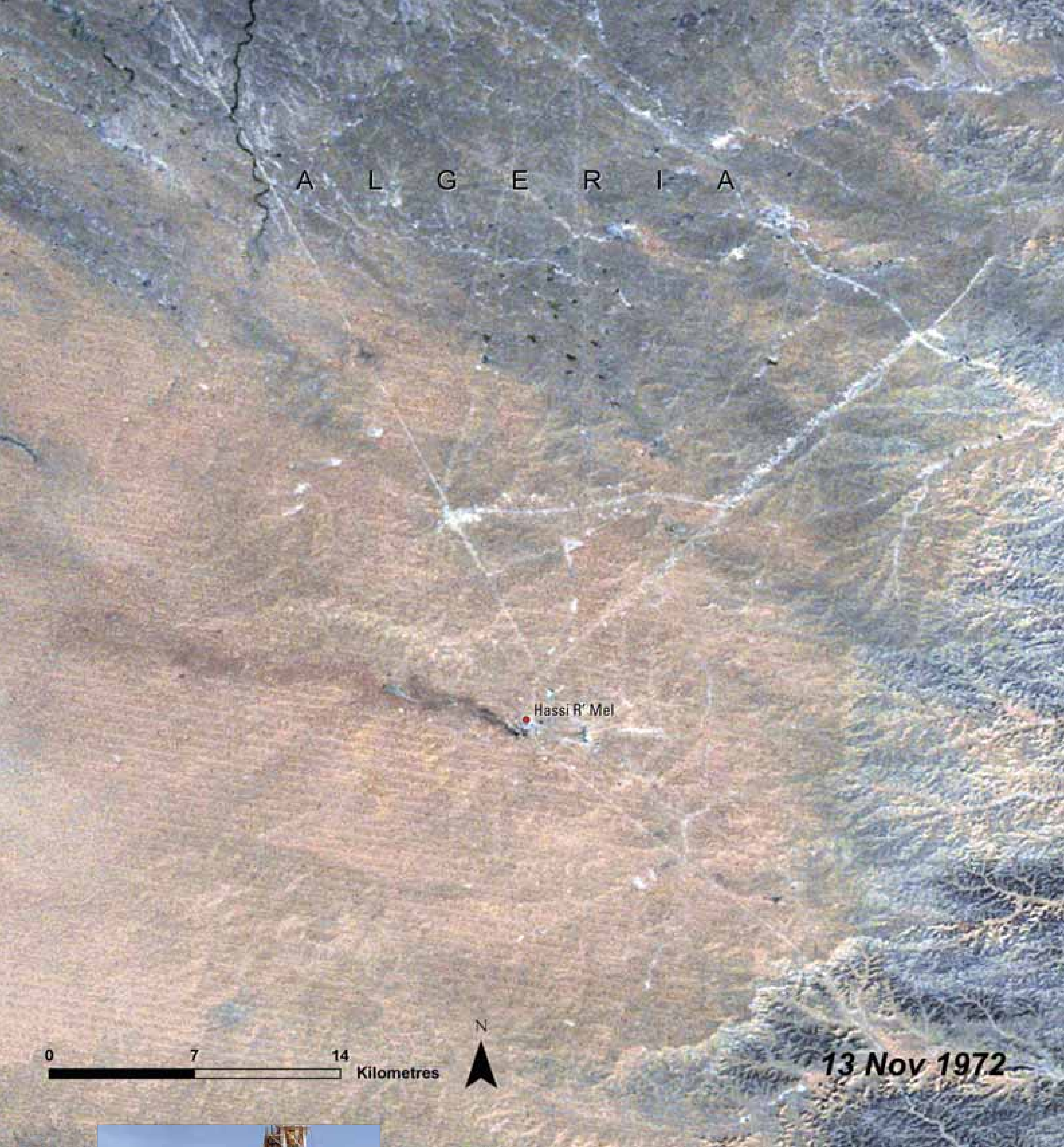
Pollution

Pollution of freshwater and marine resources is a significant problem in northern Algeria, where most of the population resides. Agricultural runoff and untreated municipal and industrial wastewater result in significant contamination of surface water. Industries alone are estimated to discharge roughly 200 million cubic metres of effluent per year into the environment (METAP n.d.).

Petroleum refining wastes are a major contributor to the increasingly severe pollution of the Mediterranean Sea. Algeria ranks third and second in Africa for proven reserves of oil and natural gas, respectively (DoE 2007).



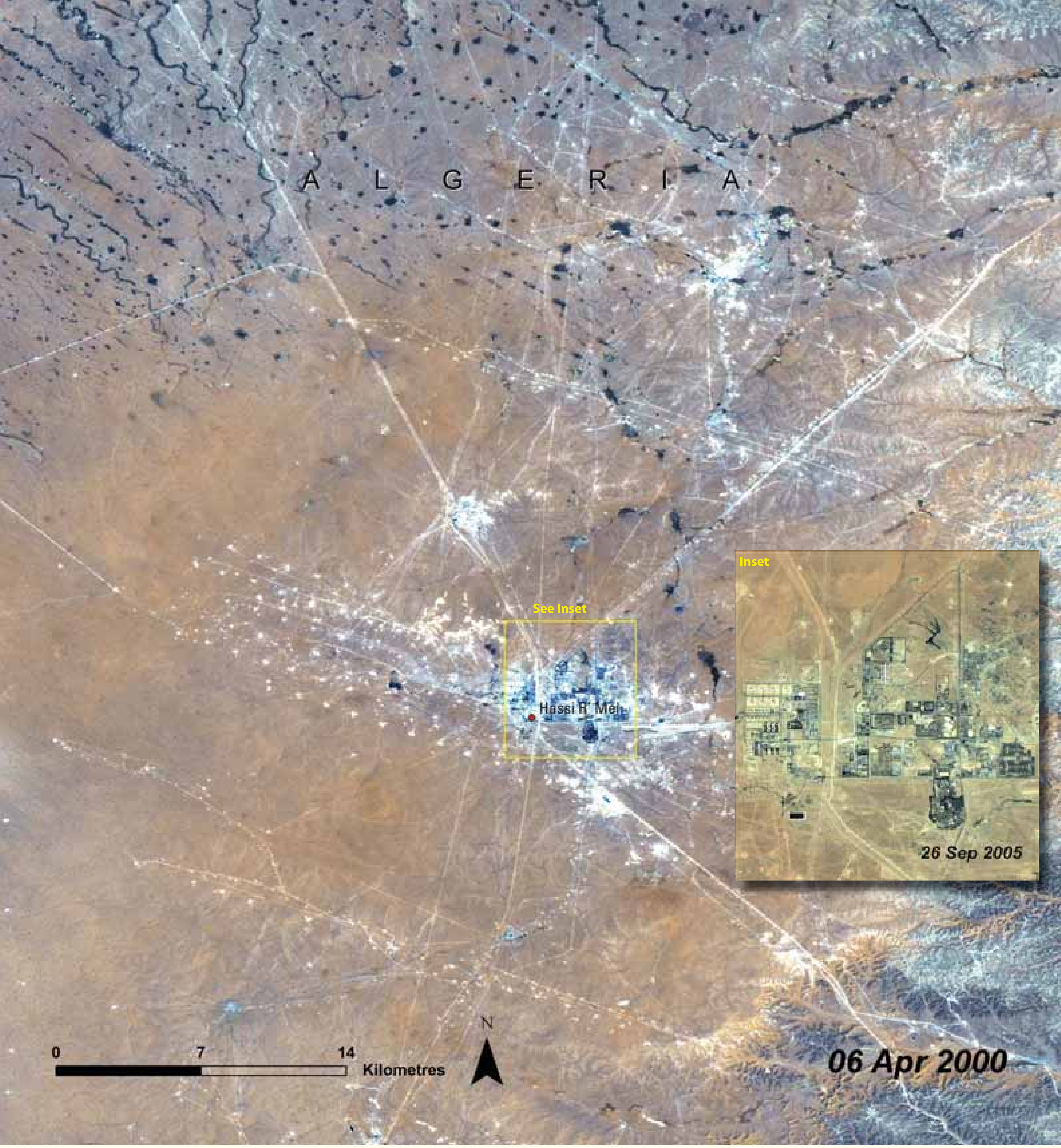
Source: BP Statistical Review of World Energy 2007



Gas Fields Across the Desert: Hassi R' Mel, Algeria

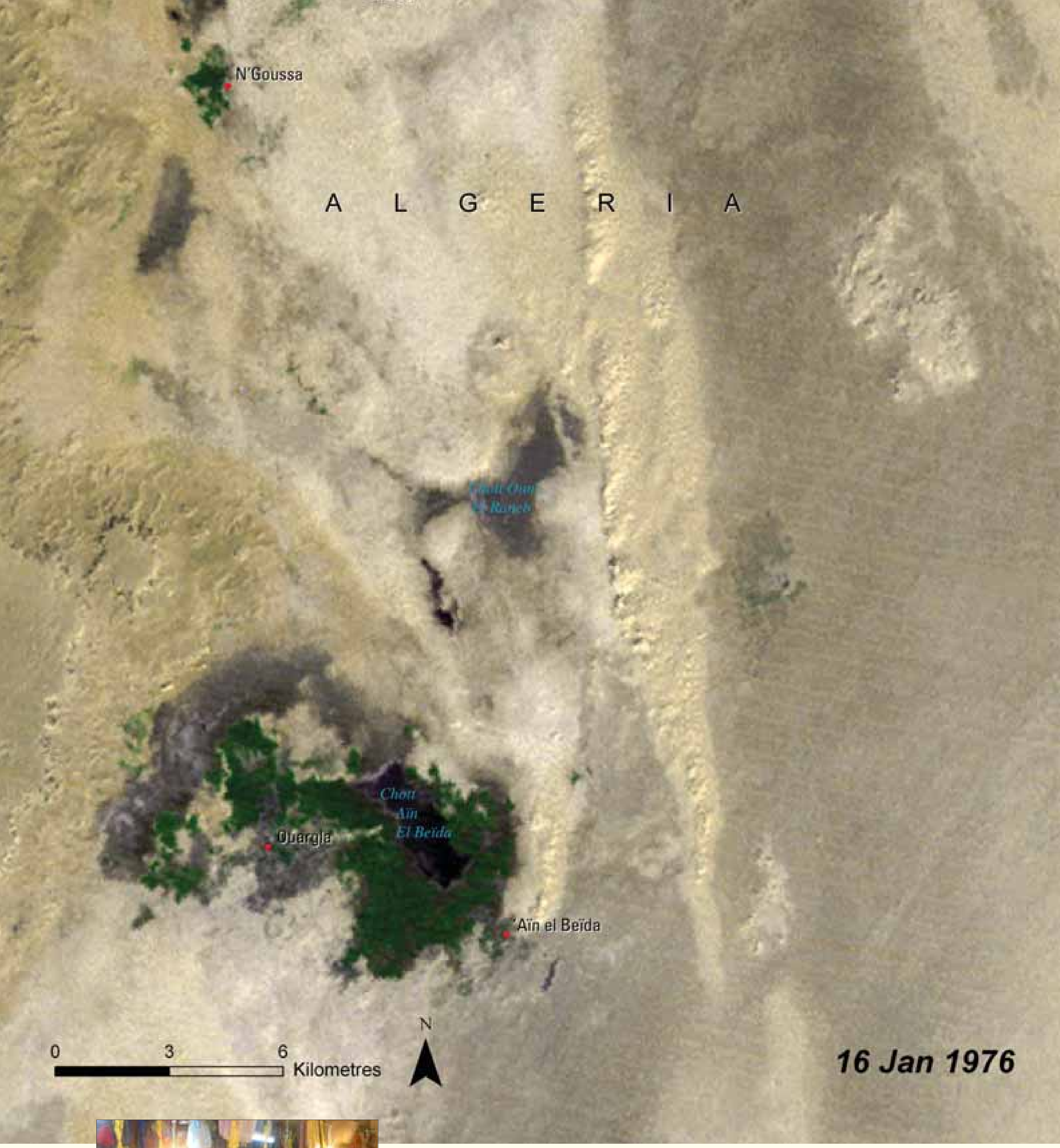
In 2006, oil and natural gas exports made up 98 per cent of Algeria's total exports. A major portion of these fuels came from the Hassi R'Mel gas fields, located about 550 km south of Algiers. The fields were discovered in 1956; initial production started in 1961, and has since become one of the world's largest gas fields.

These two satellite images show the dramatic development of the area in the last three decades. In the 1972 image, changes to the landscape are minor compared to the 2000 image,



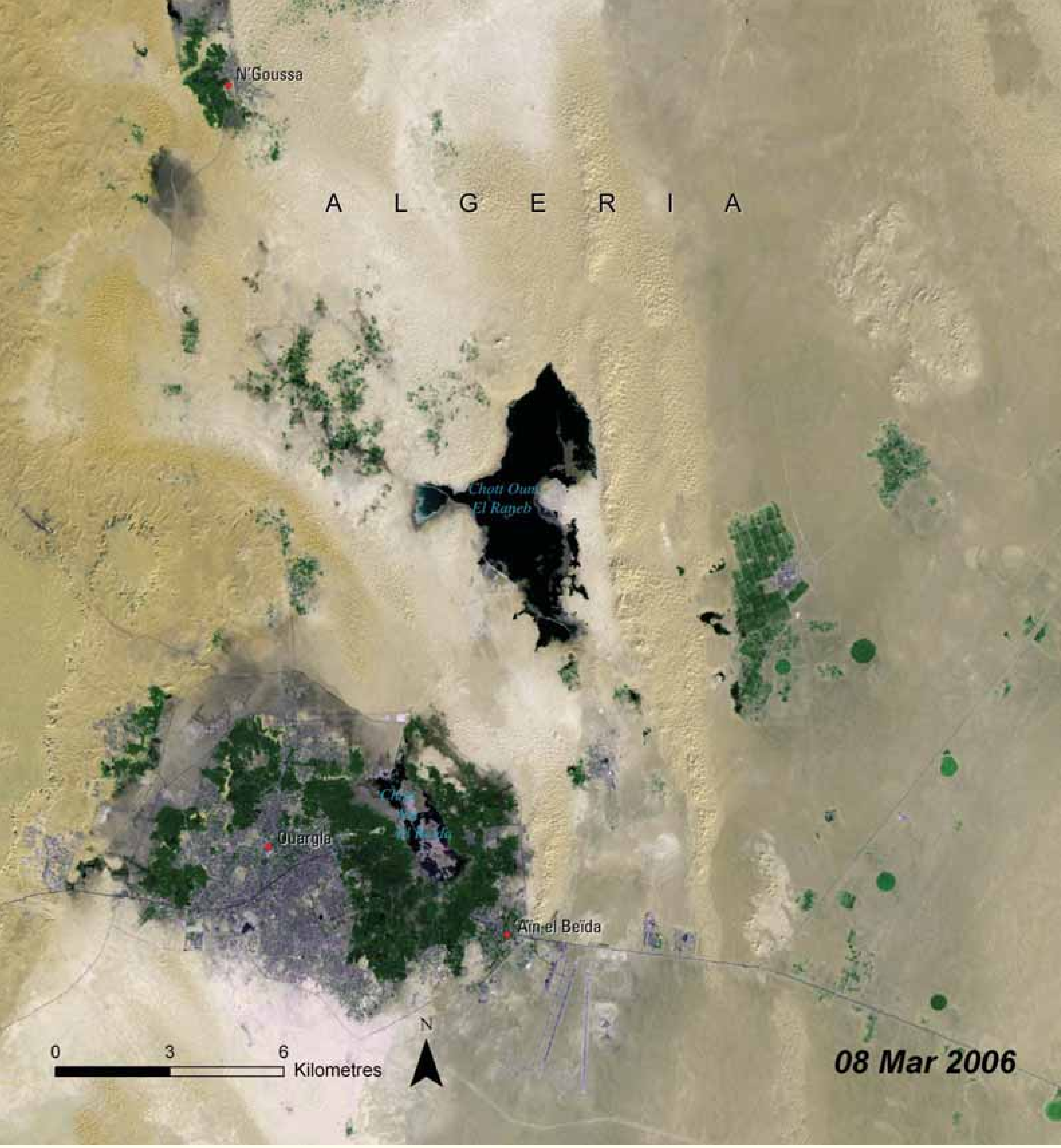
which reveals vastly expanded infrastructure, mainly related to the gas fields. The high resolution image from 2005 shows more detail (see inset).

In addition to gas production, Algeria began building a hybrid gas and solar power generating facility at Hassi R'Mel in July 2007. It will produce 150 megawatts of electricity, with 25 megawatts coming from 180 000 m^2 of parabolic reflectors. The first of its kind, this facility is expected to be operating by 2010. By 2020 Algeria hopes to be exporting 6 000 megawatts of power to Europe—roughly the equivalent of 10 per cent of Germany's current consumption.



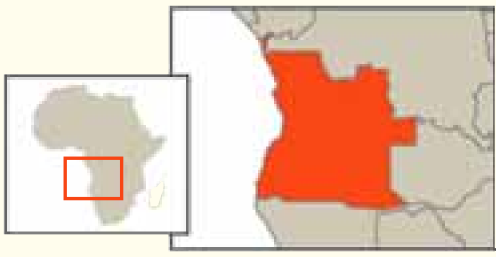
Modern Irrigation: Ouargla Oasis, Algeria

Ouargla, located in the sands of the northern Sahara Desert, overlies the North-West Sahara Aquifer (NWSA) which extends underneath Algeria, Tunisia and Libyan Arab Jamahiriya. Use of the superficial water table of the NWSA extends back to ancient times. In the 19th century, bore holes were drilled to access deeper parts of the aquifer. By the1970s there were roughly 2 000 bore holes on the NWSA. These wells now provide water to irrigate approximately 500 000 date palms surrounding Ouargla.



The region's traditional irrigation methods used sustainable amounts of water. Modern, more intensive irrigation methods can lead to degraded water quality, decreased water levels, and loss of artesian pressure, as well as salinization of the superficial water table and the soil. Natural drainage conditions and insufficient engineered drainage have already led to accumulation of water near the surface and a concentration of minerals. This salinized water at a depth of 0.5 to 1.5 m below the soil surface is detrimental to palm trees.

The 1976 image shows date palms surrounding Ouargla and Chott Aïn El Beïda, a saline depression that has collected irrigation runoff for generations. The 2006 image shows a proliferation of irrigated land, which, without proper management, will not be sustainable.



Republic of Angola

Total Surface Area: 1 246 700 km²
Estimated Population in 2006: 16 400 000

Credit: © Flagart.com

Angola is the seventh largest country in Africa. The climate is semi-arid in the south and along the narrow coastal plain, which rises abruptly to a vast inland plateau that accounts for two-thirds of the total land area and receives substantial rainfall. The country is endowed with dense tropical rain forests in the north as well as substantial oil and mineral resources. Soils, however, are generally poor and susceptible to erosion. The Zambezi River and several tributaries of the Congo River originate in Angola.

Important Environmental Issues

- Threats to Biodiversity
- Access to Potable Water
- Overfishing and Coastal Degradation

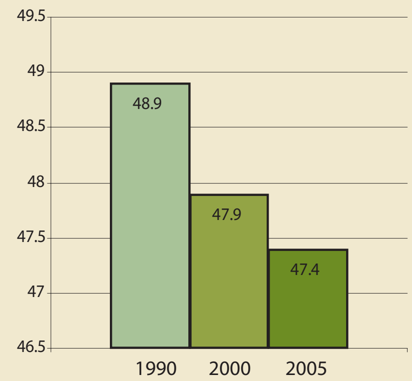
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

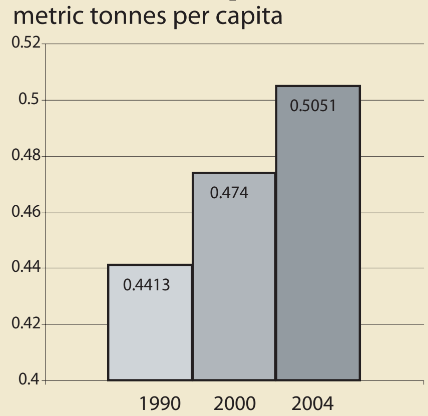
About 47.4 per cent of Angola is classified as forest and woodland. Between 1983 and 1993 Angola's forest and woodland declined at the rate of 3.1 per cent. Since then, decline has slowed, but still continues. Angola's land productivity is continually threatened by drought and soil erosion, which contribute to water pollution and silt deposits in rivers and dams. However, access to safe drinking water and sanitation show signs of improvement.

★ Indicates progress

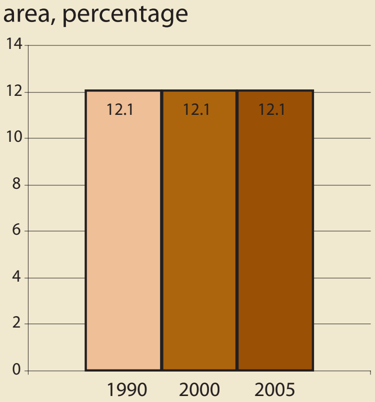
Land area covered by forest, percentage



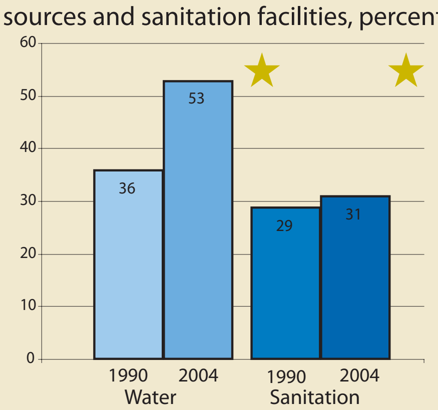
Carbon dioxide (CO_2) emissions, metric tonnes per capita



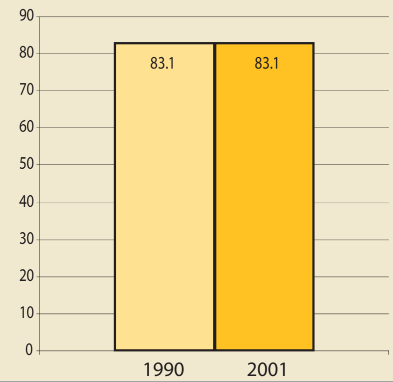
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



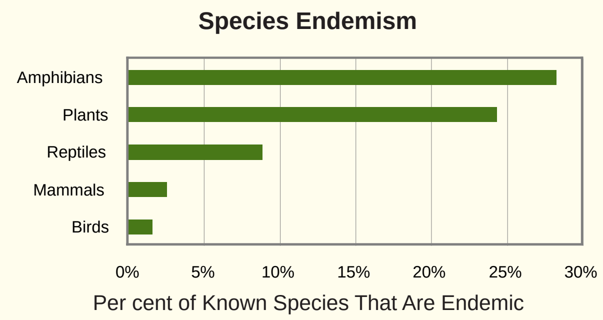
The rainforests of northern Angola are threatened by subsistence agriculture, which provides food for almost 90 per cent of the population.

rainforests.mongabay.com (2007)

Threats to Biodiversity

Angola has exceptional and unique biological resources owing to its large size and topographical variation, including 1 260 endemic plant species and 92 per cent of southern Africa's known bird species (CDB 2006). Nearly three decades of civil unrest, however, have hindered meaningful protection, and uncontrolled logging, bush-burning, and poaching threaten numerous species.

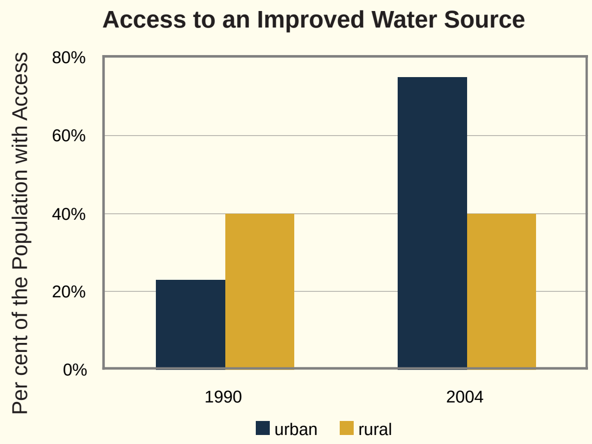
Elephants, for example, have been reduced from over 12 000 individuals in 1981 to approximately 250 today (Thompson 2006). Angola remains the only African country with a significant population of elephants not to ratify CITES, an international treaty that restricts trade in endangered species. As a result, it remains a major conduit for selling ivory obtained illegally from all over the African continent.



Source: IUCN

Access to Potable Water

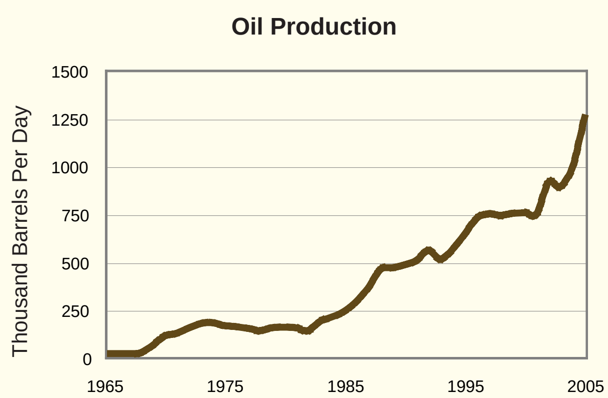
Freshwater resources are relatively abundant in Angola, with over 10 000 m^3 available per person per year (FAO 2007). However, water infrastructure is lacking, and soil erosion from poor land management has resulted in heavy siltation of rivers and dams. Thus, access to potable water is low in the country, particularly in rural areas, where only 40 per cent of the population has access to an improved drinking water source (compared to 75 per cent in urban areas) (UN 2007). As a consequence, Angola has Africa's second highest mortality rate in children younger than five; approximately one out of every four children will die before reaching the age of five, primarily due to water and sanitation related diseases (UNICEF 2006).



Source: MDG Indicators

Overfishing and Coastal Degradation

Strong coastal upwelling and the presence of several estuaries support productive and diverse marine life along the 1 650 kilometre-long Angolan coast. However, overfishing by both local and foreign fishing fleets has significantly reduced fish stocks, threatening some species with extinction. In addition, increasing poverty and growth among coastal communities have contributed to the destruction of coastal mangrove forests for fuelwood. Finally, pollution from offshore oil production (Angola is the second-largest oil producer in sub-Saharan Africa (BP 2007)) presents yet another risk to the marine environment.



Source: BP Statistical Review of World Energy 2007

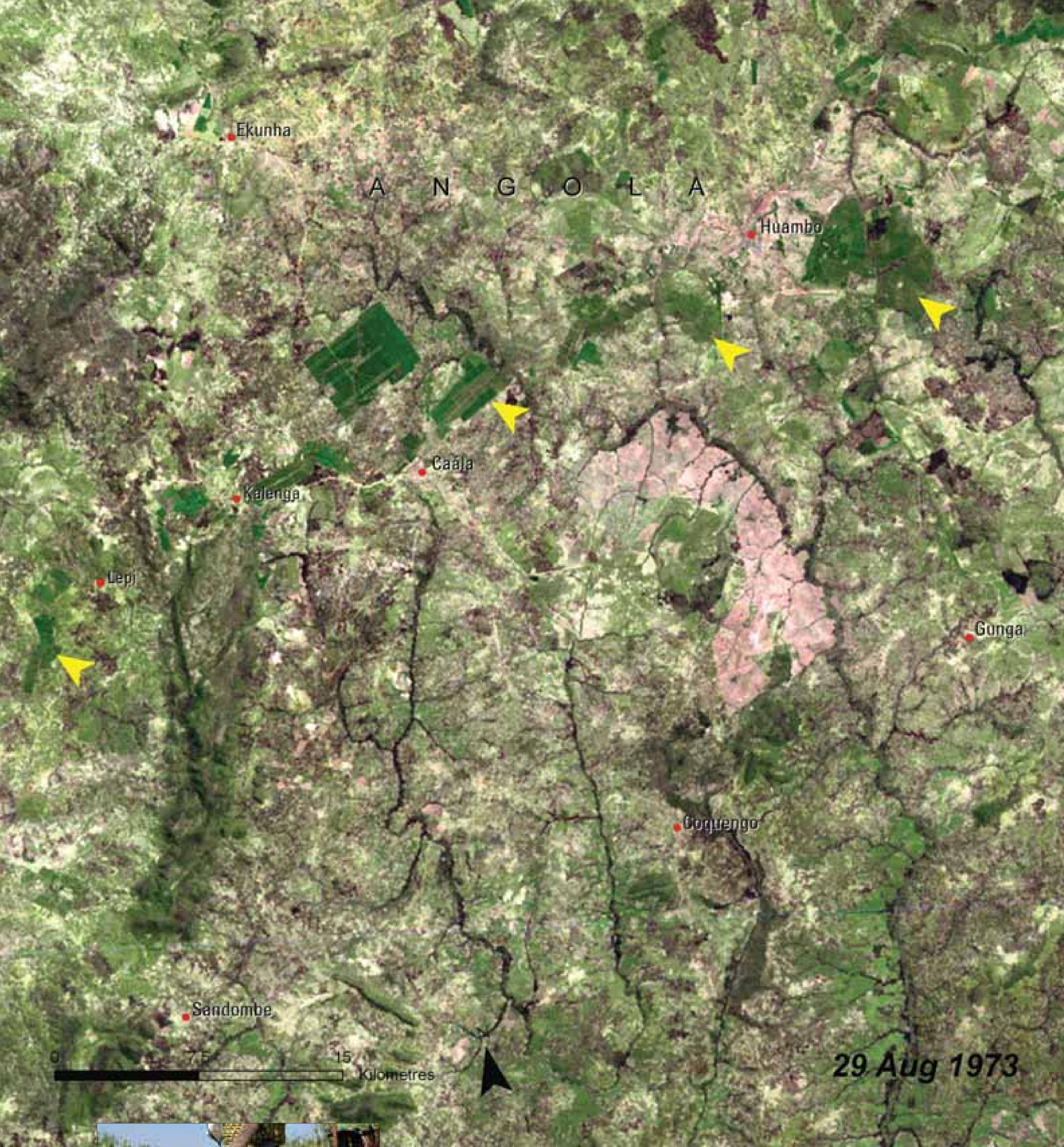
Catoca Diamond Mine: Angola

The Catoca kimberlite pipe (diamond-rich geological formations) in the Lunda Sul province of Angola is the world's fourth largest in terms of surface area, with diamond reserves of at least 40 million carats. The Catoca Mine was constructed between 1994 and 1997. In 2003, the mine produced 2.5 million carats worth US$ 189 million.

Mining, by its very nature, significantly alters the landscape. Satellite images from 1990 and 2006 show the extent of change at Catoca over that 16-year period. Diamond mining is a

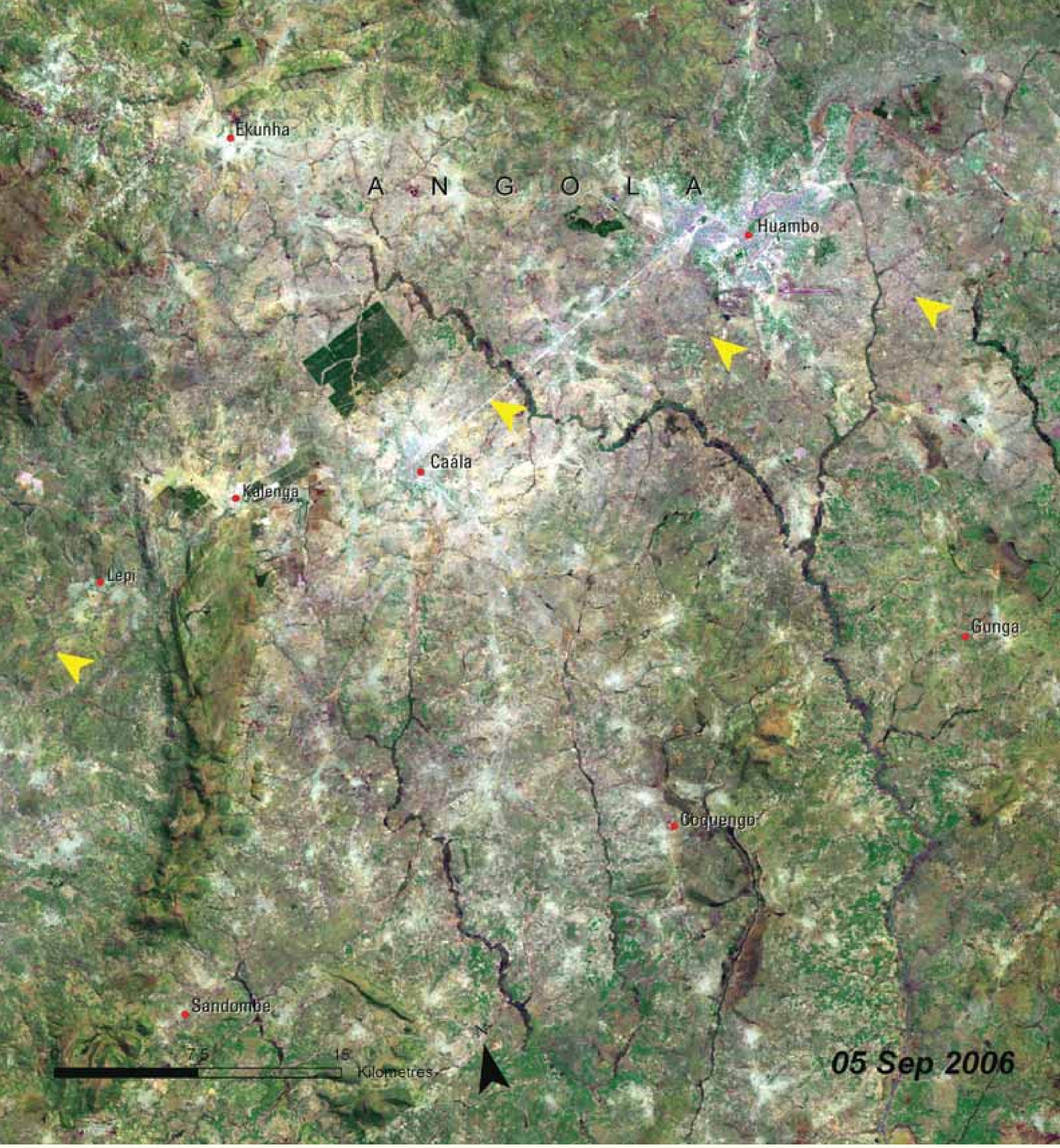
large-scale earth-moving operation—for each carat recovered, more than a tonne of material is moved. Diamond mining is also extremely water intensive, since water is used to wash the final gravels and separate the diamonds.

The Catoca Mine was built to minimize its environmental footprint. Its current extraction methods produce little toxic waste. The next stage of the project, however, will use dense media separation (DMS) for diamond recovery, a chemical process that exerts a far greater environmental impact.



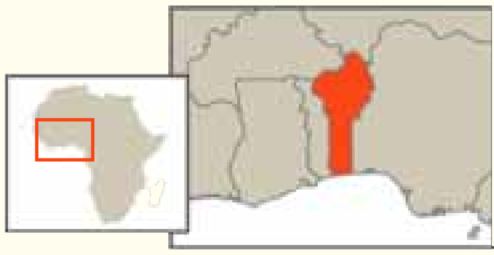
Land Degradation: Huambo Province , Angola

While Huambo province has been referred to as the “breadbasket of Angola,” its soils in reality are not ideal for agriculture. Many years of intensive cash crop agriculture on these marginal soils dating back to the 1920/1930s further diminished their agricultural capacity. During Angola’s civil war (1976-2002) many people who could not leave the region moved to the safer zones along the Benguela Railways corridor between Huambo and Caála. In the 2006 image this human activity shows as the lighter colours and loss of green throughout the centre of the



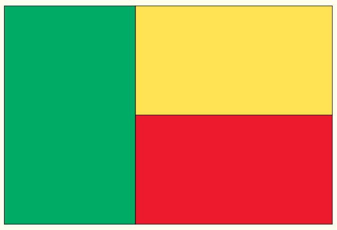
image, particularly surrounding the two cities and the rail line between them. This concentration of settlement and agriculture with minimal inputs further degraded soils in these areas.

Deforestation has also been found to be an important cause of land degradation and relocation in Huambo province. The loss of several forested areas, including some forest plantations, can be seen between the 1973 and 2006 images, where patches of dense green have been replaced by more reflective farmland and dense settlement (yellow arrows). At the end of the war, many of those returning to Huambo province found their land would no longer support them and were again displaced. In addition, returning refugees found that destruction of infrastructure, limited availability of inputs, and limited seed stock further reduced their prospects.



Republic of Benin

Total Surface Area: 112 622 km²
Estimated Population in 2006: 8 703 000



Credit: © Flagart.com

Benin's climate reflects a strong north-south gradient, with an equatorial coastline transitioning northward and inland to an increasingly arid continental zone. More than half of the population is concentrated in the south on only one-tenth of the country's land (CBD 2002). This region is characterised by coastal lagoons, marshes, and an area of fertile inland lowlands. The Niger River, one of the largest in Africa, forms a 120-kilometre-long border between northeast Benin and Niger.

Important Environmental Issues

- Deforestation
- Desertification
- Threats to Biodiversity

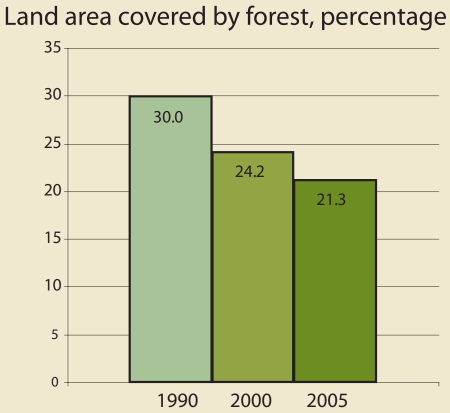
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

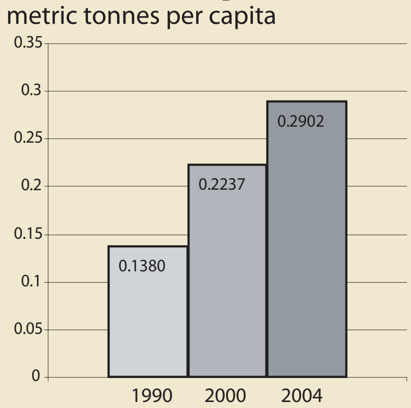
Gradual decrease in forested areas bears testament to the fact that Benin has little natural forest remaining. An estimated 59 per cent of Benin's forest loss is due to uncontrolled agricultural practices and fires. A recent study of three cities in Benin found that in two of them, the vast majority of the population lacked running water and basic sanitation, although the MDG graph shows small improvements in this area.

★ Indicates progress

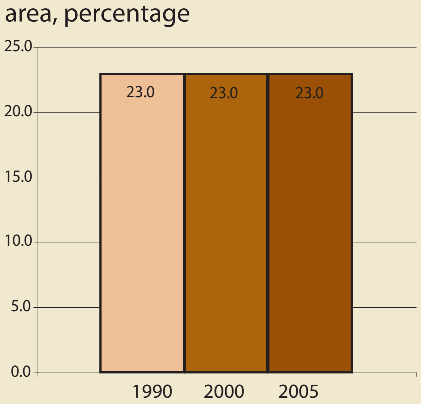
Land area covered by forest, percentage



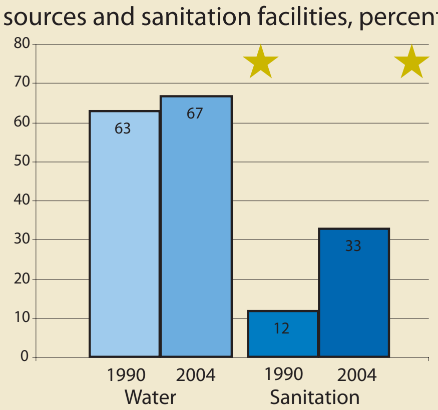
Carbon dioxide (CO_2) emissions, metric tonnes per capita



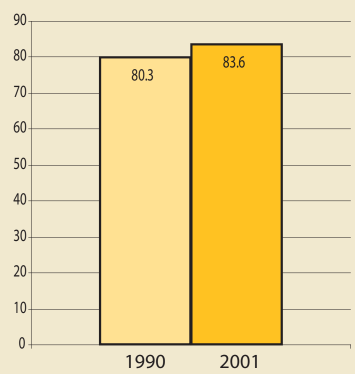
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

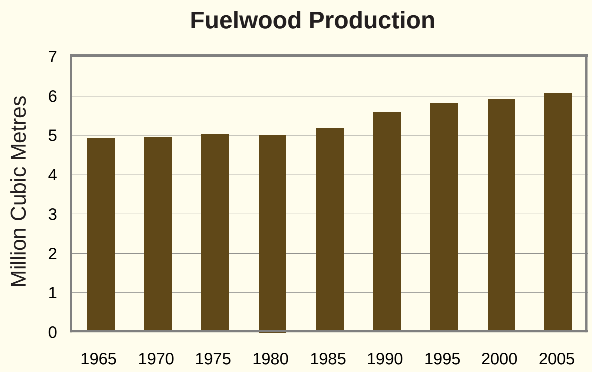


With more than 17 per cent of its surface area harvested for cotton production, Benin is the seventh largest producer of cotton in Africa.

faostat.fao.org (2008)

Deforestation

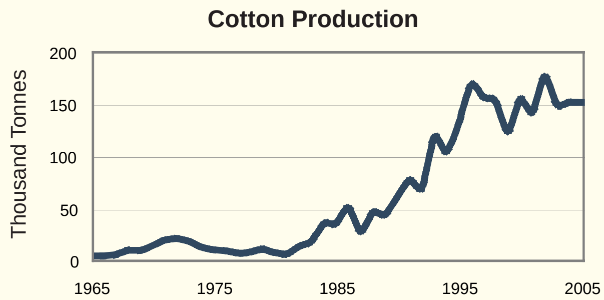
A dense tropical rain forest once covered much of the area north of the coast, but slash-and-burn agriculture and heavy dependence on fuelwood by 95 per cent of the population (WHO 2006) have driven rapid deforestation. Mangrove forests, on the other hand, are threatened most by fishing and salt production. Overall, Benin has lost nearly one-third of its forest cover since 1990, and the rate of forest loss between 2000 and 2005 was high at 2.4 per cent per year (UN 2007). Slash-and-burn agriculture is estimated to affect 160 000 hectares of forest per year.



Source: FAOSTAT database

Desertification

Benin's semi-arid northern territories are vulnerable to desertification, with an estimated 50 per cent of lands already affected. Although periodic drought is a natural driver of this trend, agriculture is the primary human cause due to its role in deforestation, soil erosion, and pollution. In particular, the relative profitability of cotton, which accounts for 80 per cent of all export revenues in Benin (Brottem 2005), has resulted in increasingly intensive farming practices. In the north, cotton production is directly linked to widespread deforestation, chemical pollution by pesticides and fertilizers, and reduced soil fertility.

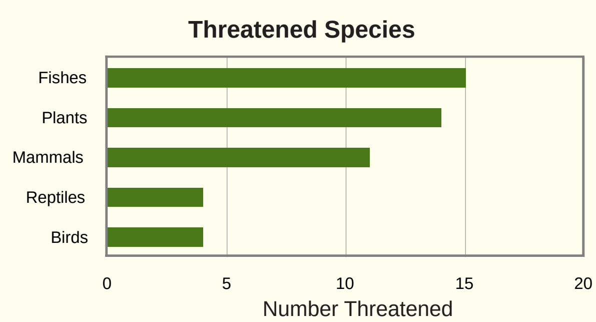


Source: FAOSTAT database

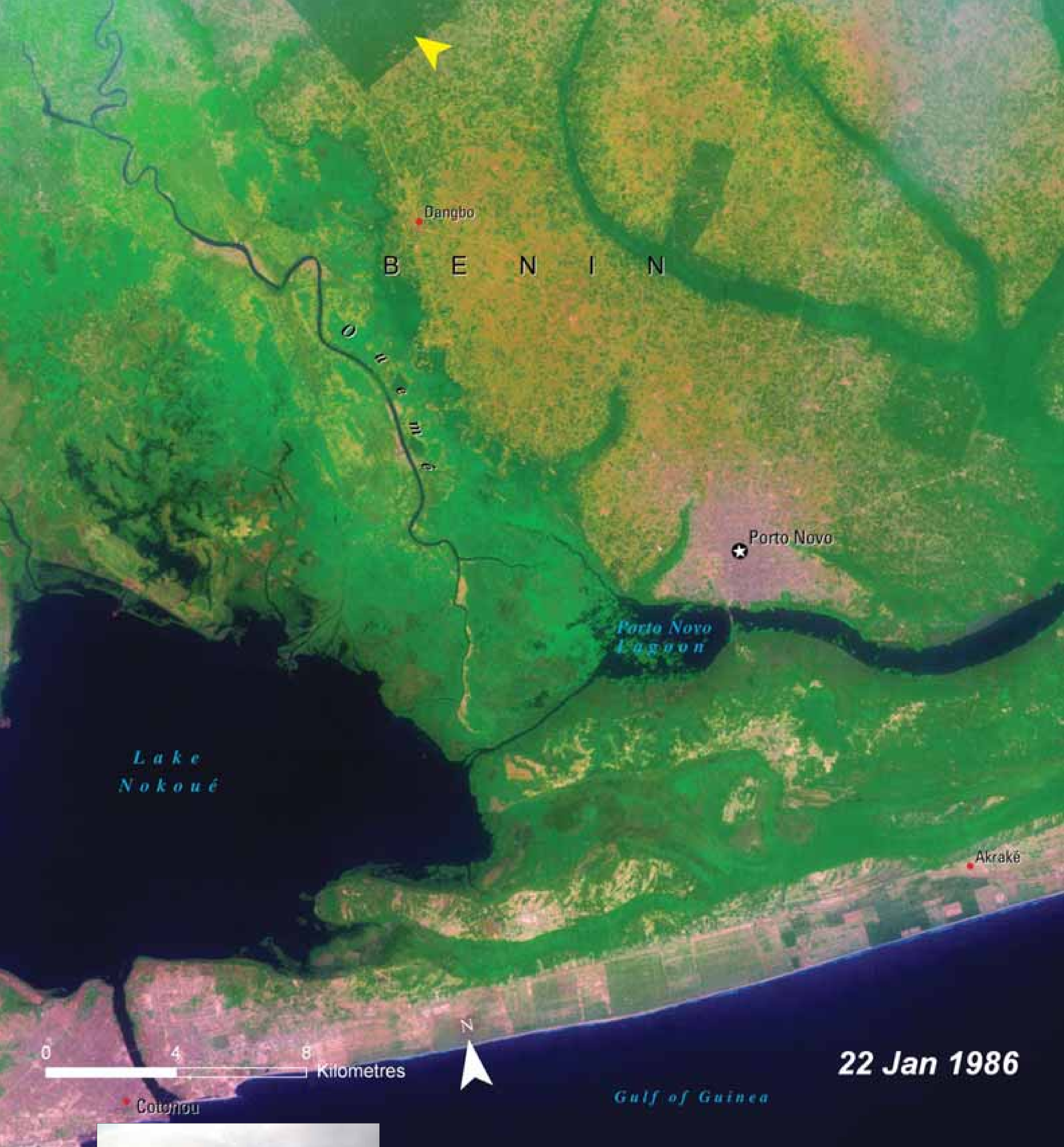
Threats to Biodiversity

Benin's diverse biological resources face a number of human threats, including agricultural expansion, uncontrolled use of bush fires for land clearing, and an increase in commercial poaching using automatic weapons. In the south, wetlands have been severely degraded and in the north, many large mammal species are endangered.

The "W" Biosphere Reserve, named after a double bend in the Niger River, is the first transboundary biosphere reserve in Africa, spanning Benin, Burkina Faso, and Niger. Covering more than one million hectares, the reserve is a buffer against advancing desertification from the north and hosts one of the largest populations of ungulates in West Africa. Endangered large mammal species in the reserve include cheetah, leopard, and spotted hyena.

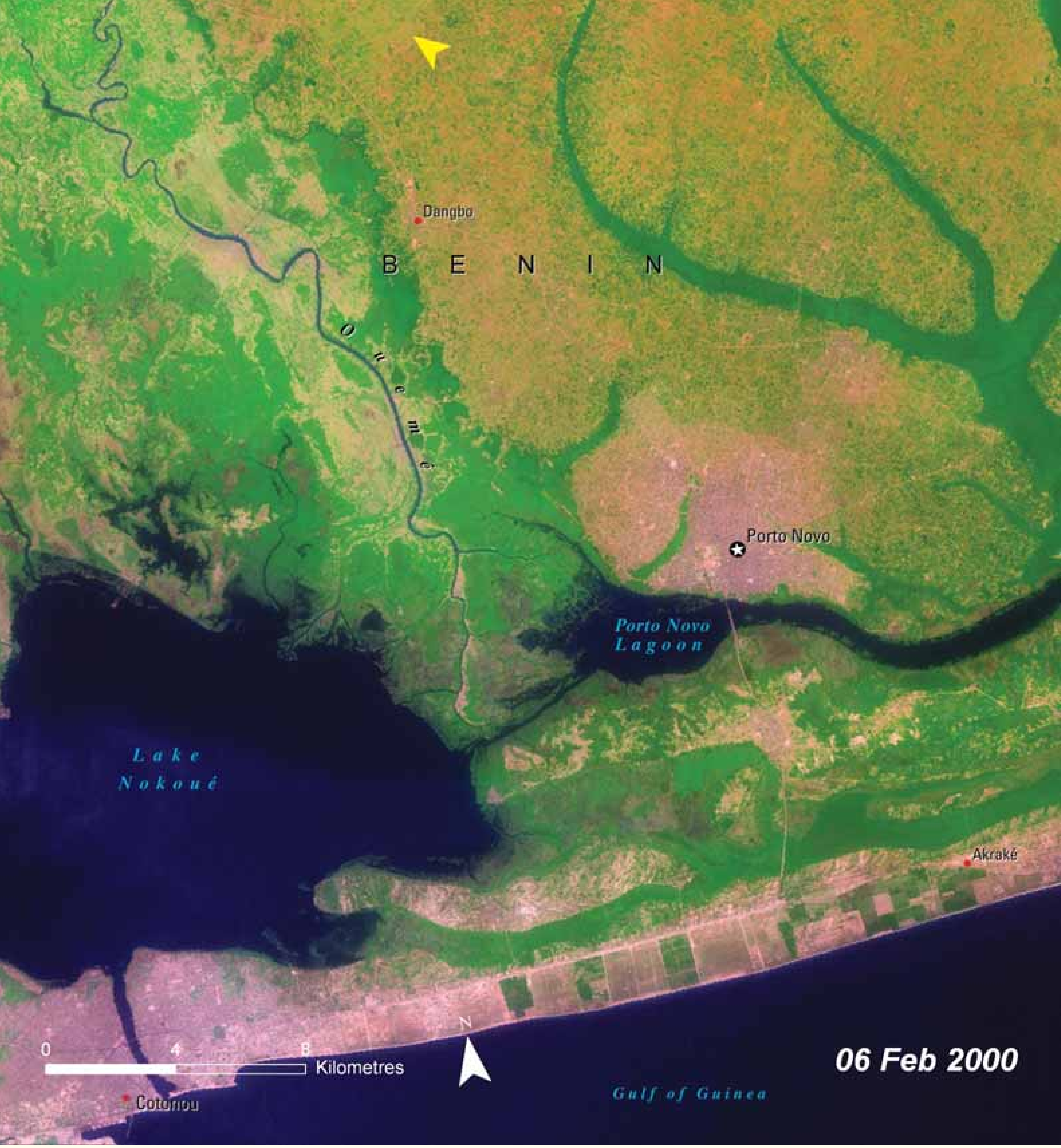


Source: IUCN Red List

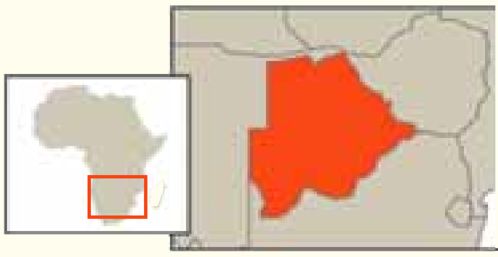


Deforestation: Ouemé Floodplain, Benin

Benin's capital city, Porto Novo, and its largest city, Cotonou, lie within the floodplain and watershed of the Ouemé River. They share this important water system with Lake Nokoué and Porto Novo lagoon. The Ouemé River is home to over 120 species of fish; the greatest concentration of the occurring in the lower reaches of the river basin. Almost all of them are used for human consumption. The wetlands in the system serve as important nursery and feeding grounds for many of these species. They are also important habitat for many of the 233 bird species found in Benin.

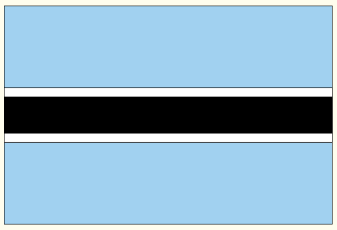


In addition to its biodiversity, the coastal zone plays a key role in the economy of Benin. Fishing, agriculture, and other economic activities within the coastal zone provide 70 per cent of the country's total GDP and livelihoods for much of Benin's population. Population pressure and the drive to boost the gross production from the coastal zone without proper environmental management threaten the integrity of the productive resource base and biodiversity resources. Illegal logging is a serious problem throughout the whole catchment. Between 1986 and 2000, dense forest in this area was reduced by more that 40 per cent. The 1986 image shows forested areas at the north-western edge of Lake Nokoué and north-eastern sections of the wetland system of Porto Novo lagoon. By 2000, some of the northern reserves had been decimated (yellow arrow).



Republic of Botswana

Total Surface Area: 581 730 km²
Estimated Population in 2006: 1 760 000


Credit: © Flagart.com

Botswana is a flat, landlocked country situated on the central plateau of southern Africa. The climate is generally semi-arid with variable rainfall and frequent droughts, particularly in the Kalahari (Kgalagadi) Desert in the western and central regions. Ninety-five per cent of Botswana's surface water resources are concentrated in the northwest corner of the country (FAO 2005) near the Okavango Delta, although the majority of the population lives in the east.

Important Environmental Issues

- Overgrazing and Desertification
- Water Scarcity and Urbanisation
- Wildlife of the Okavango Delta

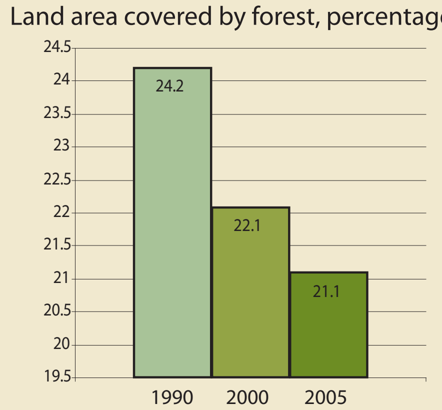
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

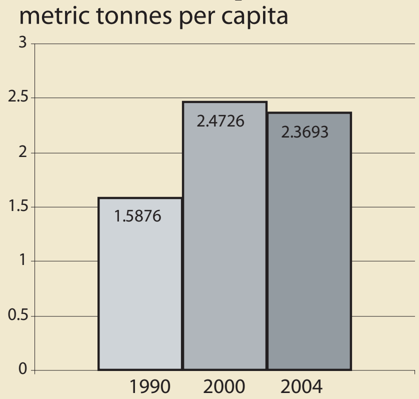
Nearly 68 per cent of the country is part of the Kalahari (Kgalagadi) Desert and periodic droughts exacerbate the water supply problem. About 90 per cent of Botswana is covered by some kind of savannah; however, overgrazing due to the rapid expansion of the cattle population is a continuing threat to vegetation and wildlife. While the country has a very limited water supply, Botswana shows a slight improvement in access to safe drinking water.

★ Indicates progress

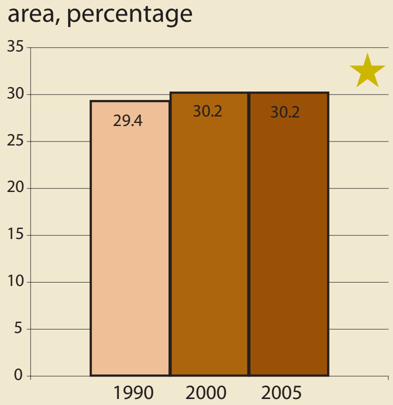
Land area covered by forest, percentage



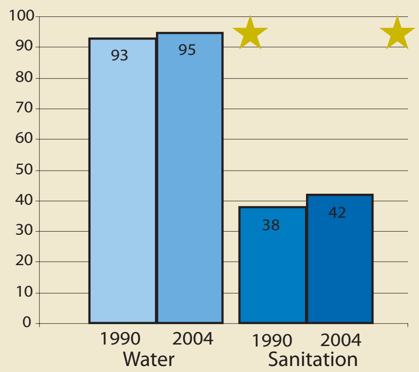
Carbon dioxide (CO_2) emissions, metric tonnes per capita



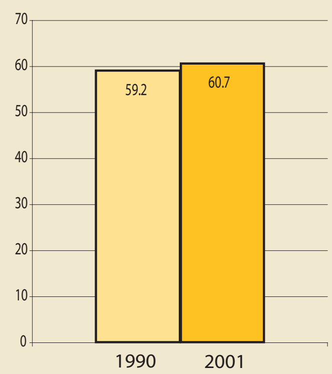
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

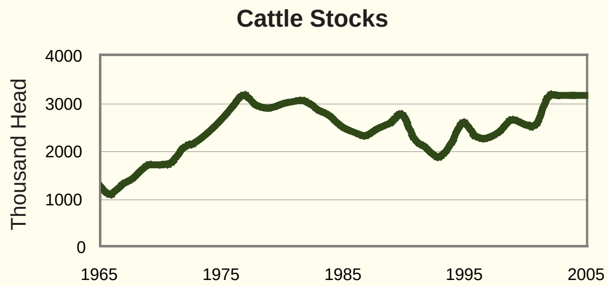


Botswana has the largest African elephant population in the world—estimated at over 133 829 in 2006. For every 14 people in Botswana, there is an elephant.

IUCN.org (n.d.); UN (2007)

Overgrazing and Desertification

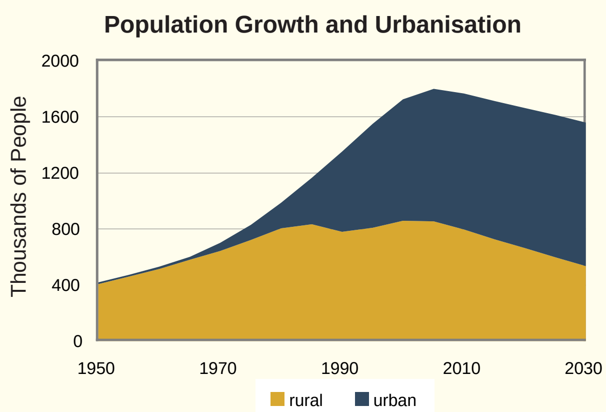
Due to naturally arid conditions and frequent droughts, Botswana is one of the countries in the Kalahari (Kgalagadi) region of southern Africa most at risk from desertification. Between 2000 and 2003, an estimated ten per cent of lands were already affected (UNCCD 2004). The major drivers of desertification are overgrazing and the creation of boreholes in semi-arid areas. Where water for livestock is limited, large numbers of cattle concentrate around boreholes, leading to localised overgrazing. In addition, significant growth in cattle stocks has forced pastoralists to expand westward into the Kalahari (Kgalagadi), leading to vegetation loss and erosion of marginal lands.



Source: FAOSTAT

Water Scarcity and Urbanisation

Botswana is poorly endowed with water resources and subject to frequent, severe drought, yet demand for water is increasing in all sectors. Groundwater accounts for two-thirds of all water consumption, but some underground aquifers are affected by natural salinity and others are threatened by pollution from livestock and human waste (FAO 2005). Water scarcity played a role in the decline of the agricultural sector from nearly 40 per cent of GDP in the 1960s to only 2.6 per cent in 2004 (FAO 2005). It is also a factor driving Botswana's rapid urbanisation. The proportion of people living in urban areas is expected to increase from 57 per cent in 2005 to over 70 per cent in 2030 (UNESA 2006).

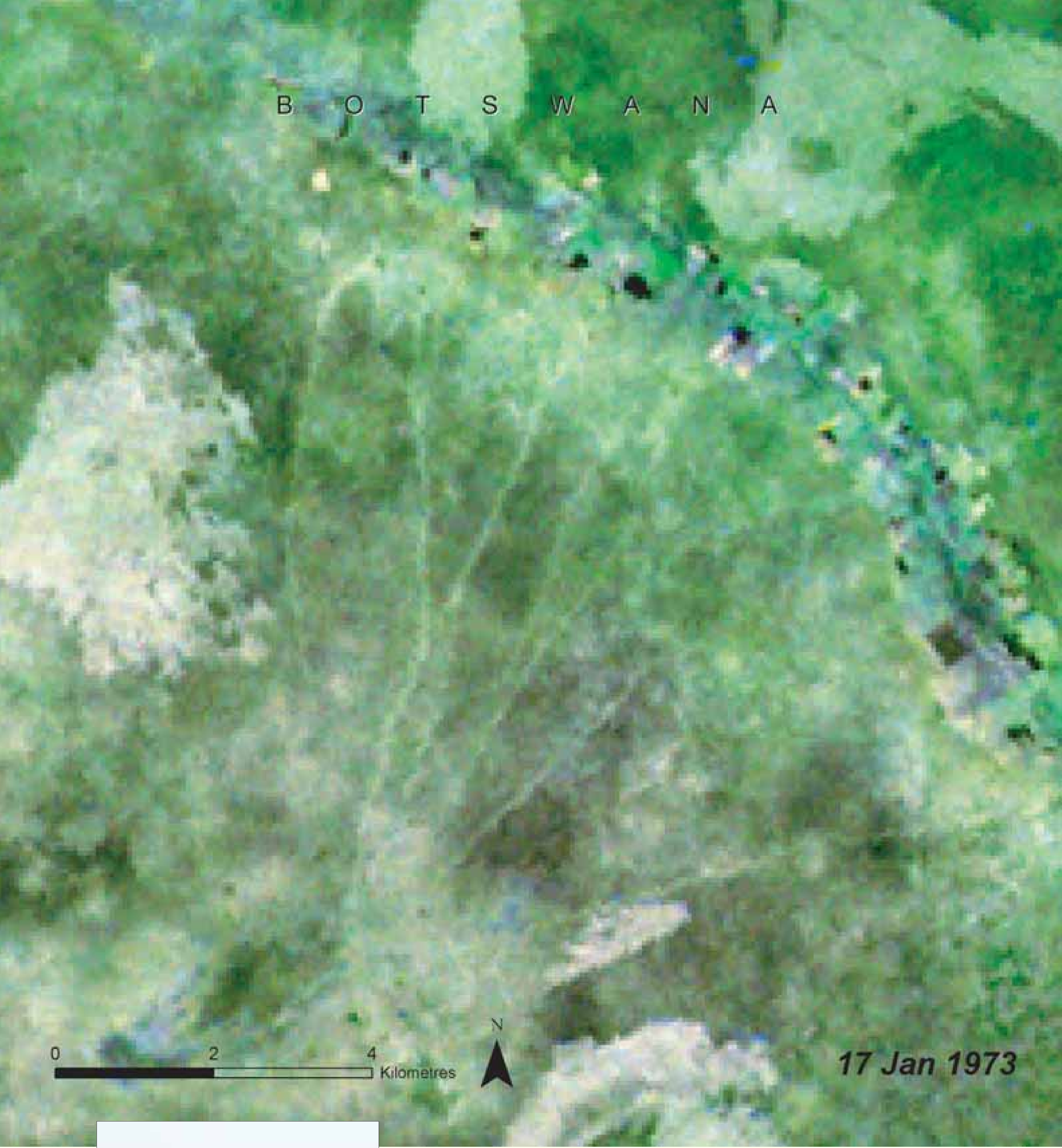


Source: UN Population Division, World Urbanization Prospects 2005 revision

Wildlife of the Okavango Delta

The Okavango Delta in northwest Botswana is one of the largest remaining inland wetland ecosystems in the world. It sustains over 2 000 plant species, 450 bird species, and 65 fish species associated with its 13-18 000 km² of permanent and seasonally inundated swampland (FAO 2005).

Land use conflict between wildlife and agriculture is a problem around the Delta and elsewhere in Botswana. Elephants, for example, now exceed 130 000 individuals and have surpassed the carrying capacity of their northern territory, especially along the Okavango Delta. This has resulted in the destruction of cropland and the depletion and degradation of resources that are important to rural livelihoods.



Flickr.com

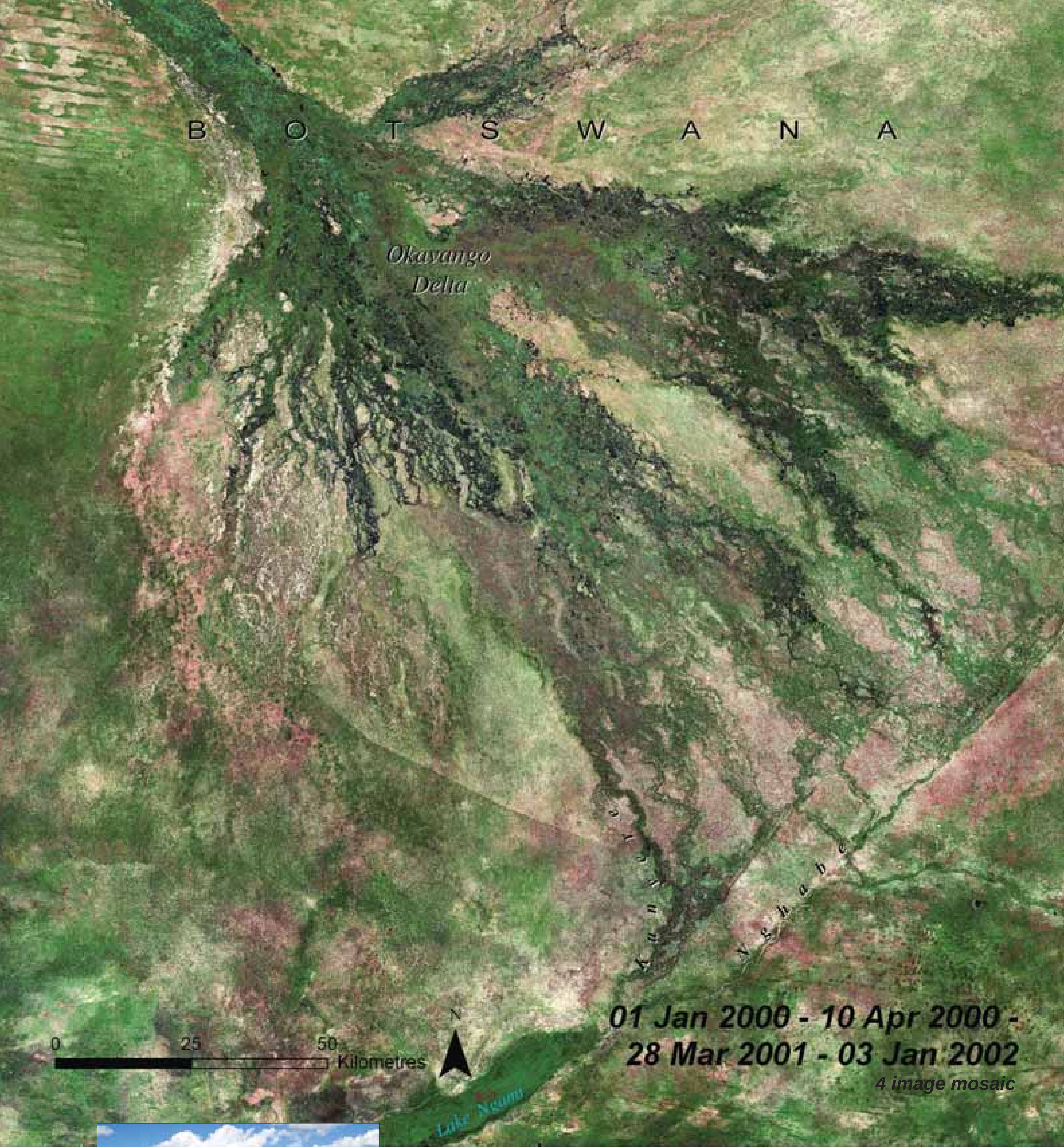
Jwaneng Diamond Mine: Botswana

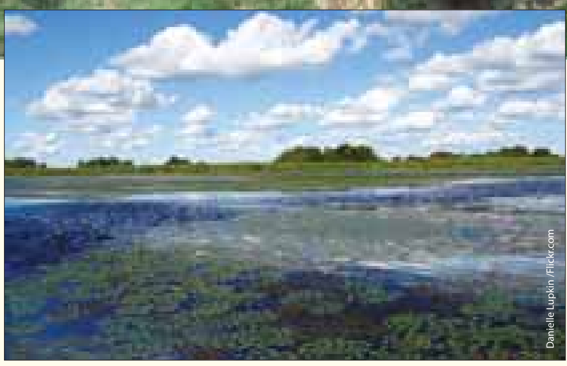
Botswana is the world's leading producer of gem-quality diamonds. The diamond industry accounts for 70 per cent of export earnings within the country. Diamond production in Botswana is dominated by Debswana, a joint venture company owned by De Beers Investments (50 per cent) and the Government of Botswana (50 per cent). The Jwaneng Diamond Mine is located in south-central Botswana about 170 km west of the city of Gaborone, in the Naledi River valley of the Kalahari (Kgalagedi).

Jwaneng is an open pit mine, dug over three kimberlite pipes (diamond-rich geological

formations) which converge near the surface, covering 520 000 m^2 at ground level. The mine annually produces 9.3 million metric tonnes of ore and an additional 37 million metric tonnes of waste rock. The high rate of diamond extraction, combined with high quality diamonds fetching top prices, make the Jwaneng Diamond Mine the richest diamond mine in the world by value of recovered diamonds.

Debswana has maintained a 5-star National Occupational Safety Association (NOSA) rating since 1986 and owns and operates a local hospital and airport. With over 2 100 employees, the Jwaneng mine is also the first Botswana company to receive International Standards Organization (ISO) 14001 certification in 2000, for environmental compliance. The 1973 image shows no signs of mining activity. The 2006 image shows the dramatic growth of the mine.

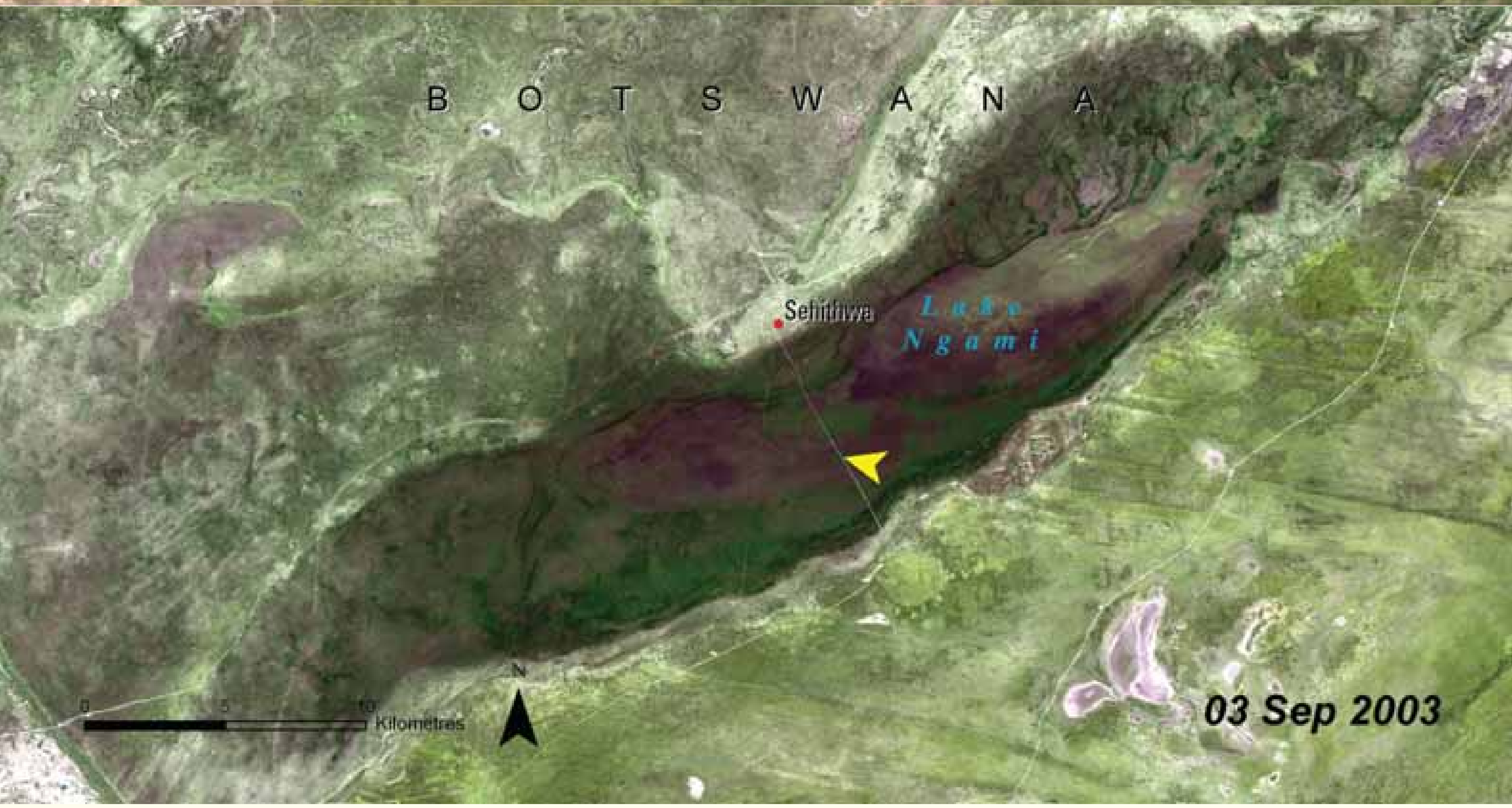




Threatened Waters: Okavango Delta, Botswana

The vast stretches of grassland, wetland, and open water of the Okavango Delta are home to a variety of wildlife and vegetation as well as several native tribes. Although the Okavango ecosystem is considered one of the wonders of the world and attracts tourists from all over the globe, it faces several significant threats.

Proposed upstream water projects are among these threats. The Okavango River originates in the highlands of east-central Angola and brings the flood waters and sediment necessary to maintain the dynamic flooding of the delta. Upstream dams could trap much of this



sediment, causing the river's channels to erode. These deeper channels would likely become established as the few permanent channels, thereby depriving vast areas of life-sustaining floods. Nevertheless, there is increasing pressure to divert water from the river for agriculture in Namibia and Angola.

At the southernmost tip of the Okavango Delta lies Lake Ngami, a significant breeding ground for birds. Historical records and recent satellite data suggest the lake has declined significantly over the past 150 years. For roughly the last century the lake has been fed primarily by flood waters that make it through the wetland into the Kunyere and Nghabe Rivers. Should flooding decrease or cease in the delta, the lake would likely dry up entirely. Decreasing water levels have already led to a paved road across a part of the lake which has been dry for several years (yellow arrow).

Burkina Faso

Total Surface Area: 274 000 km²
Estimated Population in 2006: 13 634 000

Credit: © Flagart.com

Burkina Faso is a landlocked country within the arid savannah belt of the Sahel, just south of the Sahara Desert. The tropical dry climate becomes increasingly arid to the north, with rainfall arriving during one wet season. Year to year, precipitation is highly variable, resulting in frequent droughts since the 1970s. Population density is relatively low, with the exception of the central plateau area, which is also the most agriculturally productive region.

Important Environmental Issues

- Water Scarcity
- Land Degradation and Desertification
- Deforestation

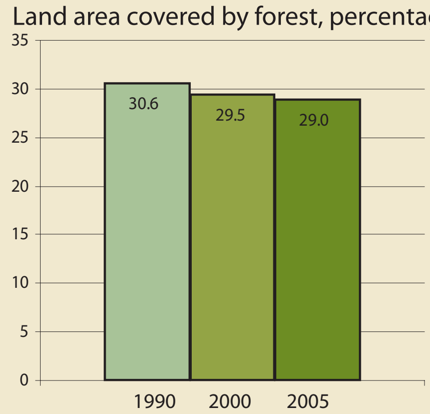
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

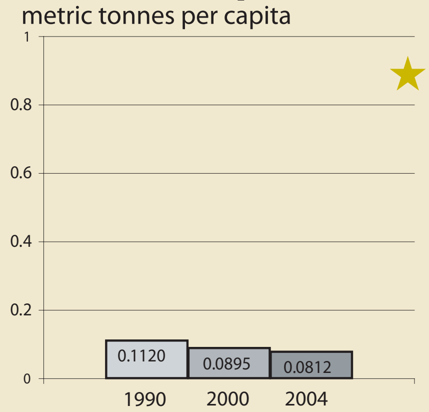
Major environmental problems facing Burkina Faso are recurrent drought, which contributes to the nation's water supply problems, and the advance of the northern desert into the savannah as a result of overgrazing of pasture, slash-and-burn agriculture, and overcutting of wood for fuel. Apart from a 1.6 per cent decrease in forested area between 1990 and 2005, all other environmental indicators of Burkina Faso show signs of improvement.

★ Indicates progress

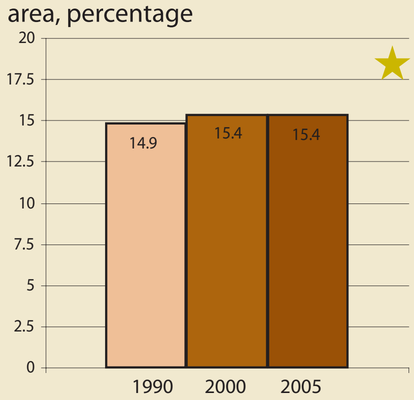
Land area covered by forest, percentage



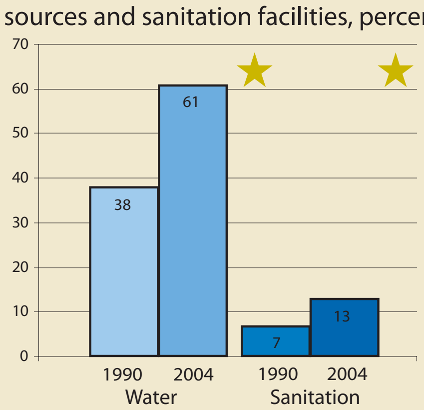
Carbon dioxide (CO_2) emissions, metric tonnes per capita



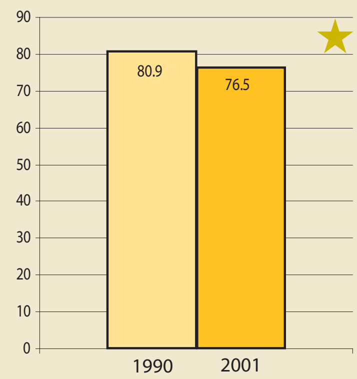
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



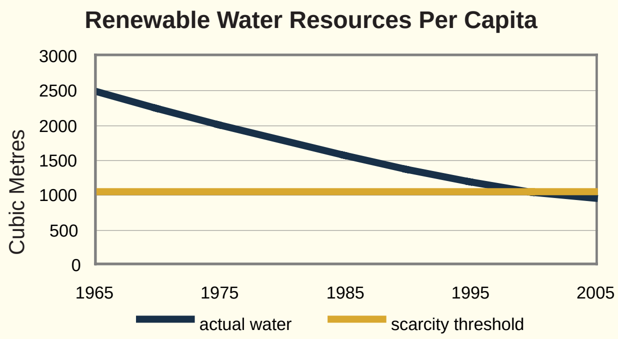
Burkina Faso's parks protect the largest elephant population in West Africa.

nationalgeographic.com (2008)

Water Scarcity

Burkina Faso is a water scarce country with only 906 m³ of freshwater available per person per year (FAO 2007). Seasonal variation in water availability is large and droughts frequently devastate rural areas. In 2003, the water supply in the capital city of Ouagadougou could only meet about 70 per cent of demand (UN 2003), yet the urban population continues to grow at five per cent per year.

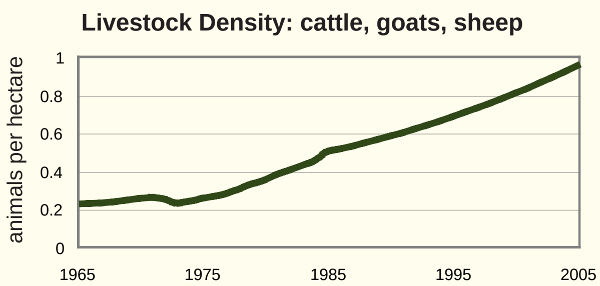
To manage its scarce water resources, Burkina Faso has a network of roughly 2 100 dams (International Small Hydro-Atlas n.d.) built mostly in rural areas to harvest rain water runoff. These dams provide important local protection against drought, extend the crop season, and create a year-round domestic water source. The Ziga Dam outside of Ougadougou, which was scheduled for completion in 2007, is expected to relieve some of the city's current water deficit (ADB 2006).



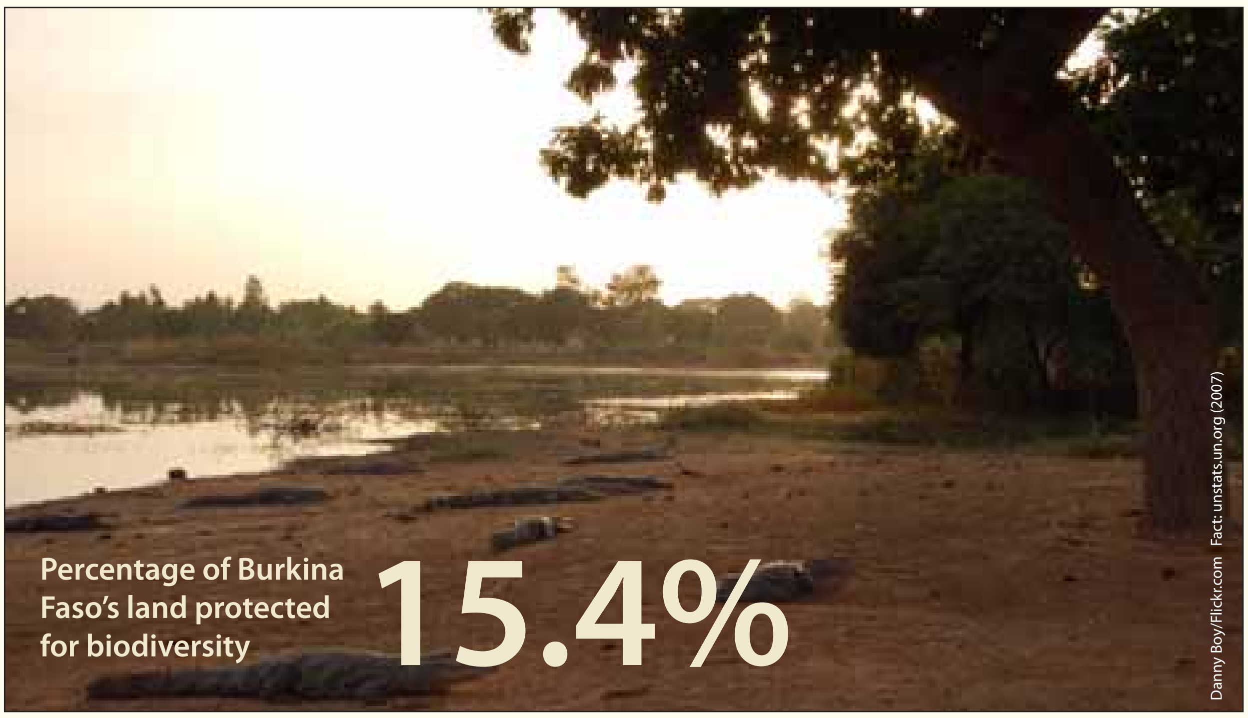
Source: AQUASTAT

Land Degradation and Desertification

Intensive cultivation and overgrazing in Burkina Faso threatens some of the country's most agriculturally productive regions with desertification; almost 90 per cent of lands are at risk (FAO AGL 2003). Agriculture accounts for 92 per cent of employment, which is the highest proportion in Africa, and approximately one-third of GDP (FAO 2005). Due to population growth, the cultivated area has more than doubled since 1961 at the expense of fallow, marginal, and previously unutilized areas, putting pressure on already fragile soils and limited water resources. Other drivers of desertification in Burkina Faso include bush fires, which ravage thousands of hectares of land each year, and recurrent drought.

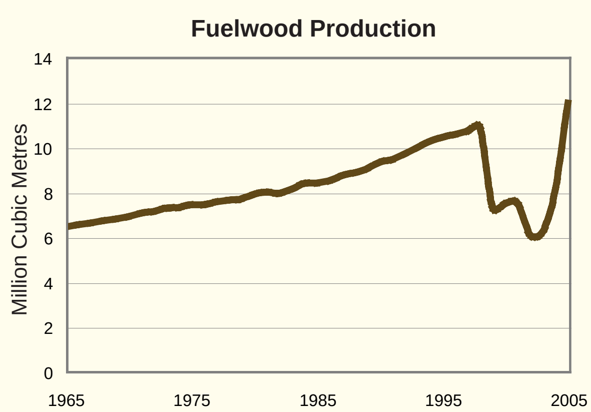


Source: FAOSTAT database



Deforestation

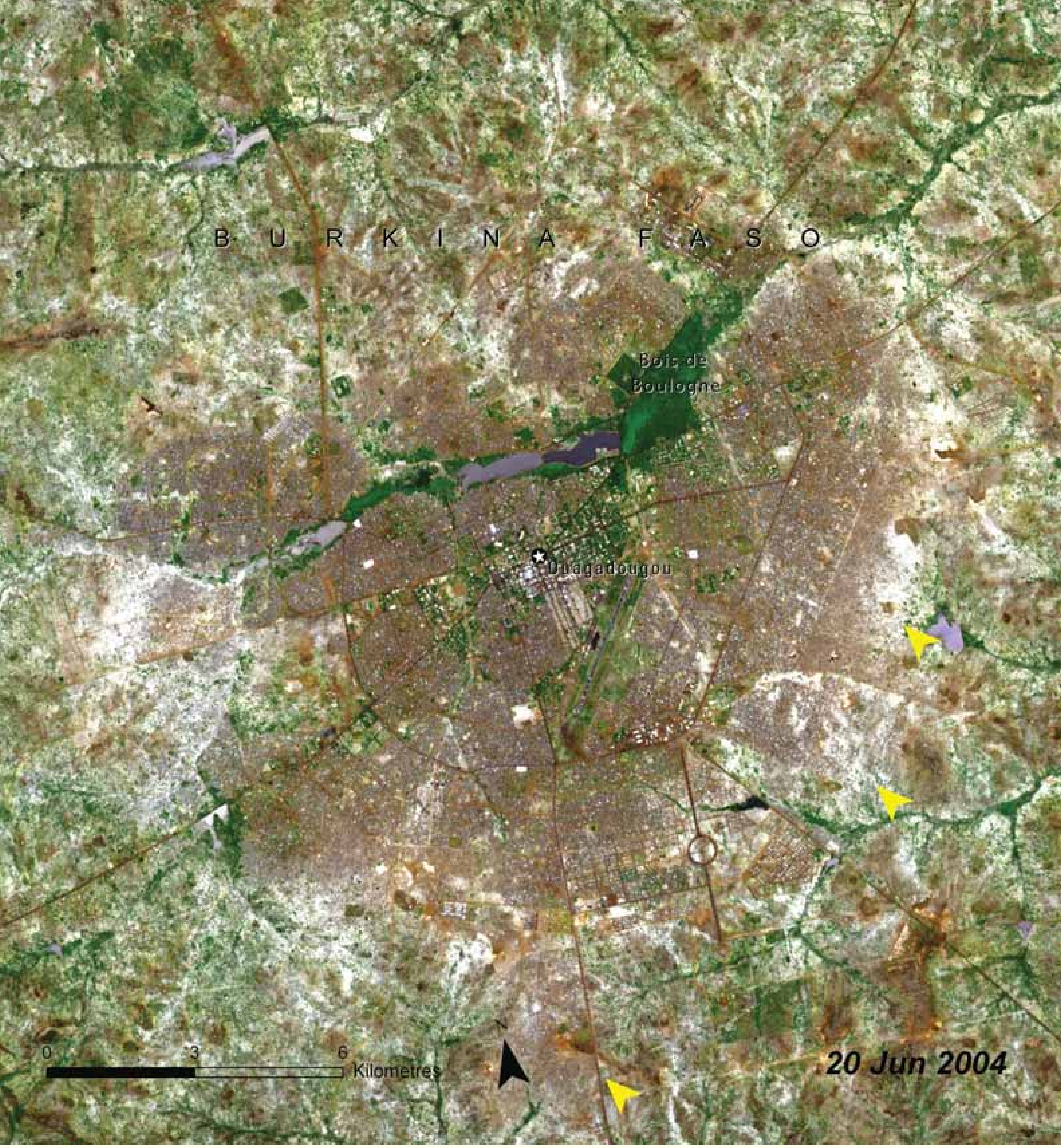
Forests cover nearly one-third of Burkina Faso's surface area and satisfy approximately 90 per cent of domestic energy needs (UNCCD 2000). Due to population growth, fuelwood harvesting has increased by almost 30 per cent since 1990 (FAO 2007), resulting in depletion of forest resources near population centres. In the capital city of Ougadougou, for example, fuelwood is now harvested from 150 km away (FAO 2003). However, overall forest cover has remained relatively stable, declining by less than two per cent between 1990 and 2005 (UN 2007). This is largely thanks to ambitious reforestation initiatives and the introduction of efficient fuelwood stoves.



Source: FAOSTAT database

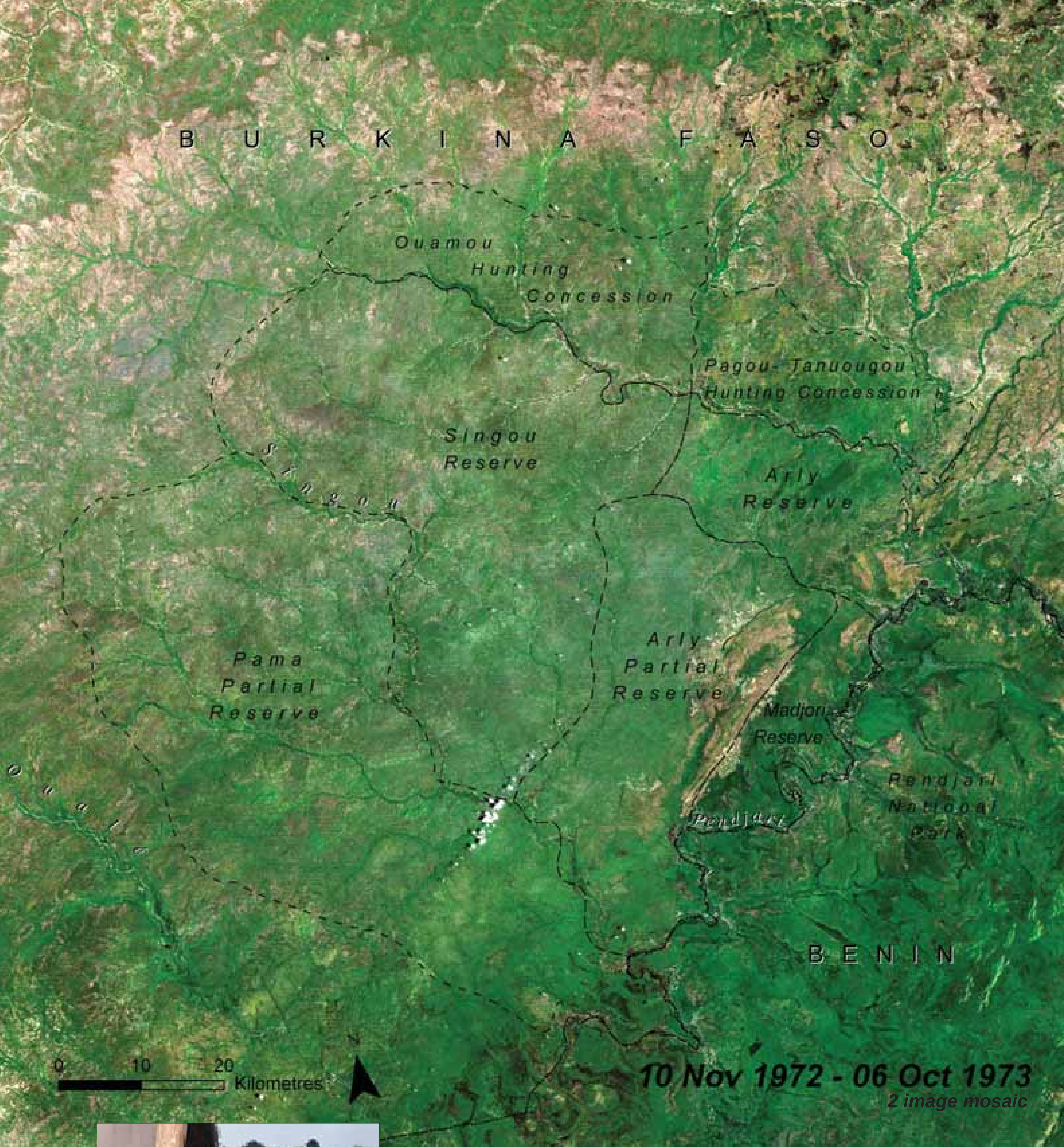
Unplanned Settlements: Ouagadougou, Burkina Faso

Urban population in Burkina Faso grew 200 per cent between 1975 and 2000 and is projected to continue expanding at a similar pace over the next quarter century. The capital, Ouagadougou, is home to approximately 40 per cent of Burkina Faso's rapidly growing urban population, with 1.2 million residents in 2003. In the 1980s, much of Ouagadougou's growth was the result of rural to urban migration of young people; however, by the mid-1990s natural growth had become the main factor.



In spite of government attempts to manage it, much of the residential growth in Ouagadougou has occurred in unplanned settlements at the periphery of the city. Because of the sprawling nature of these settlements, the city occupied 14 times more area in 1993 than it had only 33 years earlier. By the early 1980s, 60 per cent of the urban area was occupied by unplanned settlement. Much of this growth was concentrated in the south to southwest perimeter, a trend already apparent in the 1986 image (yellow arrows). The 2004 image shows more recent growth has been concentrated in the south and east (yellow arrows).

Unplanned settlements limit future possibilities for planned development and further complicate delivery of basic services. The problem of an insufficient water supply is already being heavily felt. In addition, space used for these settlements is lost to other uses, including agriculture and wildlife habitat.

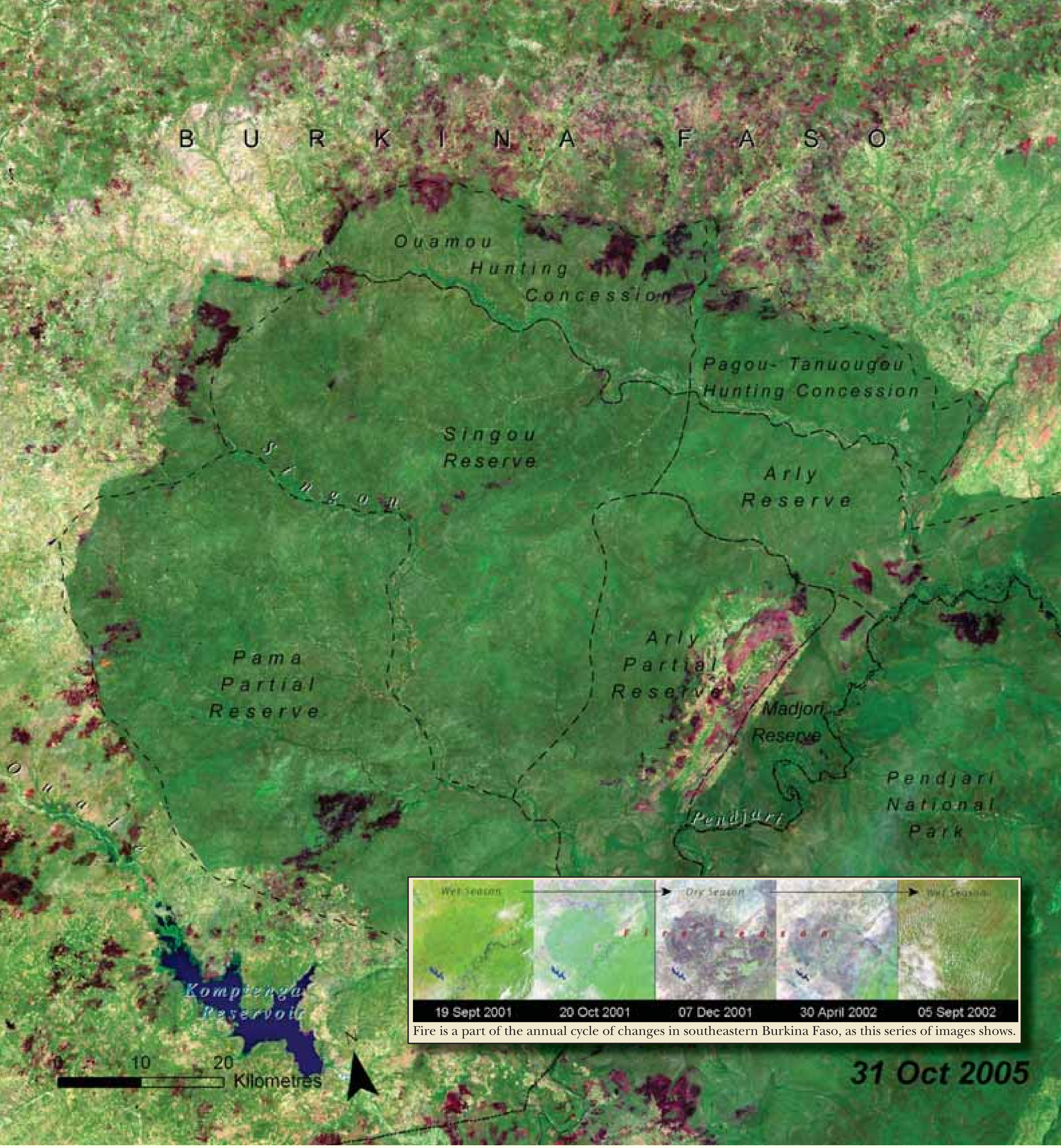



Permission Pending/Photoshare

Protection of W National Park: Burkina Faso

"W" National Park in Burkina Faso is part of the W-Arly-Pendjari Complex, a transboundary network of protected areas, which, taken together, are the largest and most important continuum of ecosystems in the West African savannah. The complex's varied habitat is home to approximately 544 different plant species, 360 bird species, and more than 50 species of mammals including elephants and hippopotamuses.

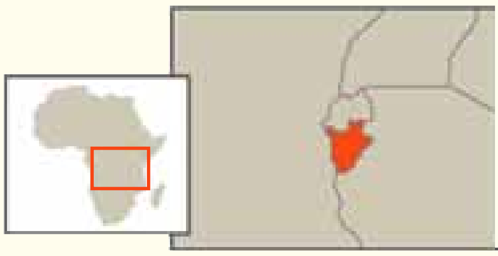
Partial eradication of the black and tsetse flies (carriers of river blindness and sleeping sickness), an influx of transhumant pastoralists due to Sahelian droughts, and government



Fire is a part of the annual cycle of changes in southeastern Burkina Faso, as this series of images shows.

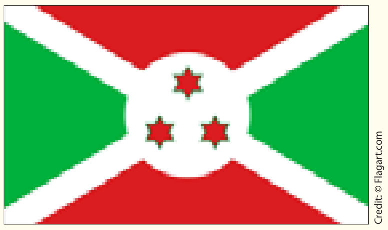
promotion of cotton growing, led to a regional population explosion in the late 1970s. Nevertheless, human population in and around the Park remains relatively low, which, along with its protected status, has kept it the most pristine of Burkina Faso's protected areas.

In the early 1970s image, the boundary of the Park and surrounding protected areas is indistinguishable from adjacent lands. By 2005, areas of contrasting land use are easily visible, as is the Kompienga Reservoir. Built in 1989, the dam is a source of water for irrigated agriculture as well as a fishery. Also visible in the 2005 image are scattered burn scars (dark reddish purple patches) as the dry season begins. Burning across most of the area is an annual occurrence.



Republic of Burundi

Total Surface Area: 27 834 km²
Estimated Population in 2006: 7 834 000



Burundi is one of Africa's smallest countries and has the second-highest population density on the continent. Its landscape is hilly and mountainous; differences in elevation lead to wide variations in rainfall and climate. The country is divided between the Nile and Congo Basins, which feed the Nile and Congo Rivers—the two longest rivers in Africa. Burundi has substantial surface water resources in the form of many rivers, lakes, and wetlands.

Important Environmental Issues

- Land Availability and Degradation
- Deforestation
- Lake Tanganyika Ecosystems and Fisheries

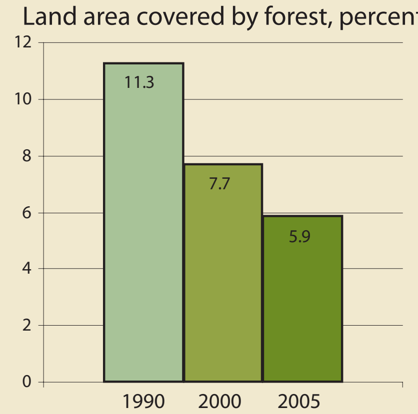
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

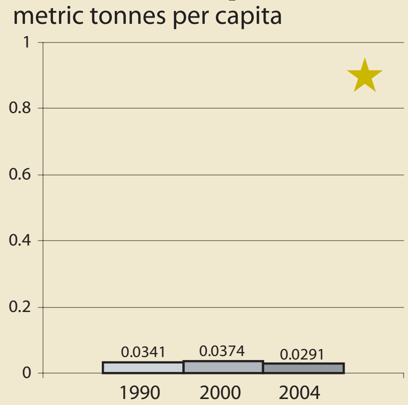
Burundi experienced an almost 50 per cent decrease in forested area from 1990-2005, which could have been the result of uncontrolled cutting of forests for fuel, despite legislation requiring permits. Burundi also has difficulty maintaining the purity of its water supply, a problem that contributes to deteriorating sanitation.


Indicates progress

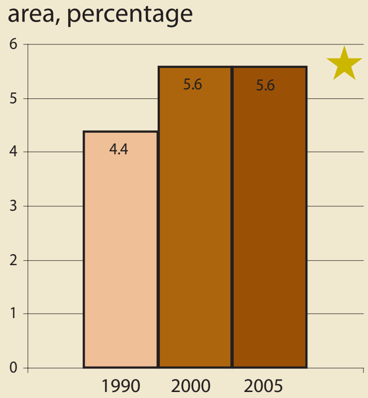
Land area covered by forest, percentage



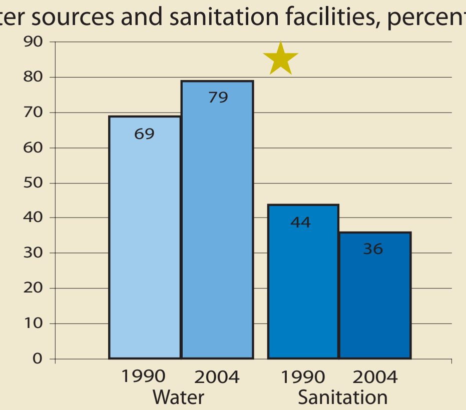
Carbon dioxide (CO_2) emissions, metric tonnes per capita



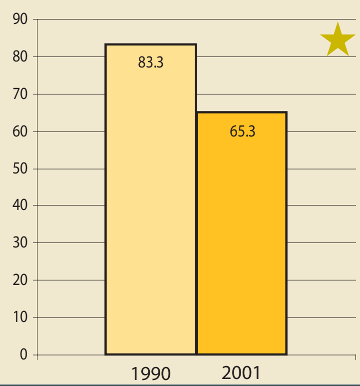
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



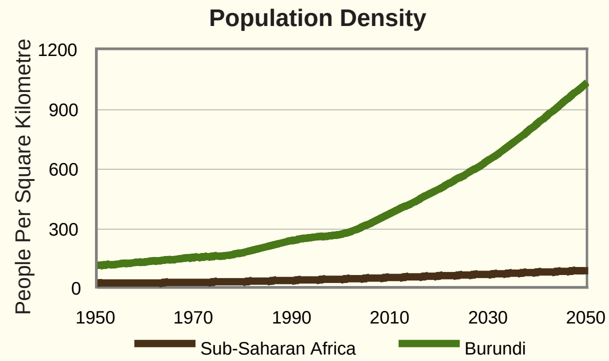
Lake Tanganyika, a remarkable 676 km long, is also the second deepest lake (after Lake Baikal) in the world at 1 471 m deep.

nps.gov (n.d)

Land Availability and Degradation

Burundi is densely populated with approximately 317 people per square kilometre, and the population continues to grow rapidly at three per cent per year (UNESA 2005). Over 90 per cent of the population resides in rural areas, making Burundi the least urbanised African country (UNESA 2006).

Despite low availability of arable land relative to other African countries, agriculture accounts for 90 per cent of the labour force (FAO 2006a) and 51 per cent of GDP (World Bank 2007). Roughly 91 per cent of the total land area is already being utilized for crops or livestock (FAO 2006b), and intensive cultivation has led to severe soil erosion on Burundi's naturally steep terrain. Seventy-six per cent of land is considered to be severely degraded (FAO AGL 2003).

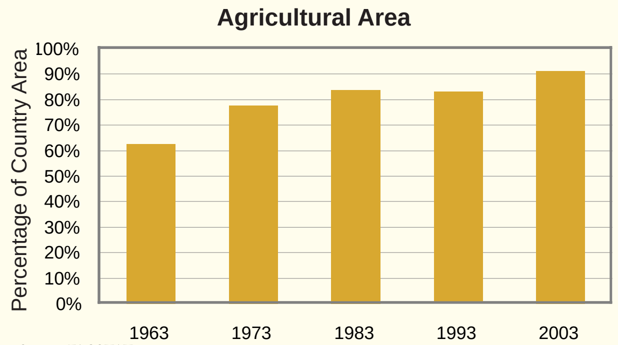


Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat

Deforestation

Burundi has the highest rate of deforestation in Africa, having lost 5.2 per cent of its forest cover annually between 2000 and 2005 (FAO 2005). Only six per cent of the country is now forested (UN 2007) a result of land conversion for crops and grazing and heavy reliance on wood for fuel; approximately 95 per cent of the population harvest fuelwood for their primary energy source (FAO AGL 2003).

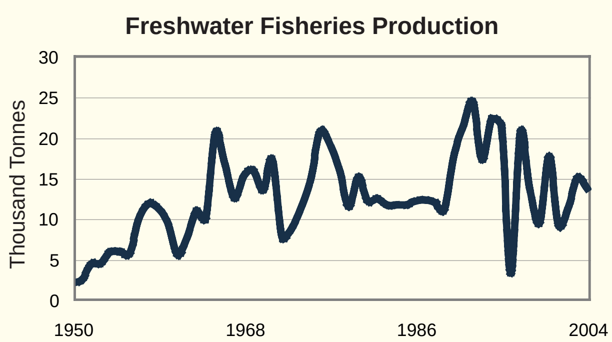
Deforestation has impacted Burundi's diverse biological resources and ecosystems, and has contributed to the extirpation of both gorillas and elephants. Soil erosion from deforestation has caused siltation of rivers, lakes, and wetlands, threatening both aquatic ecosystems and freshwater supplies.



Source: FAOSTAT

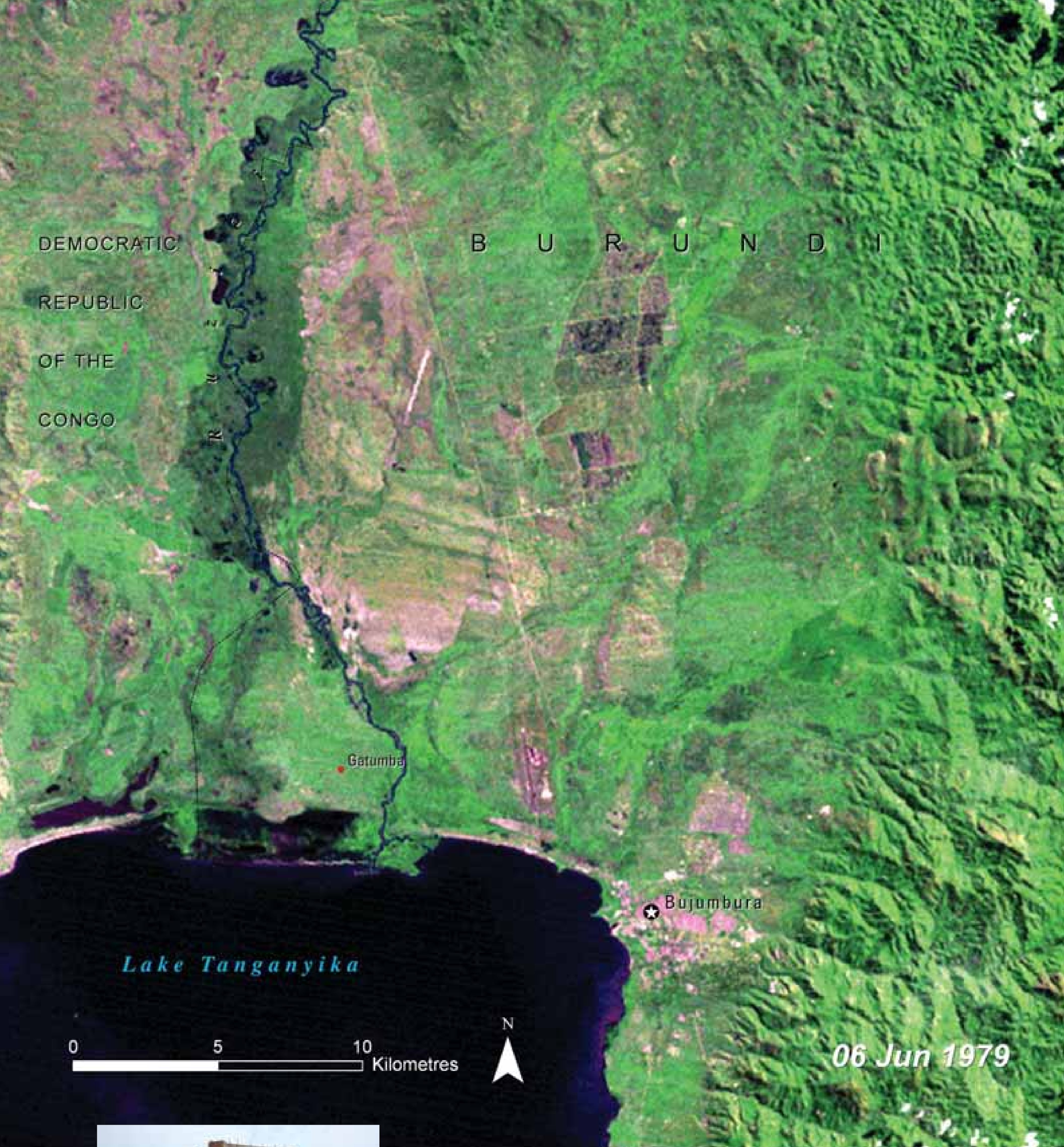
Lake Tanganyika Ecosystems and Fisheries

Burundi shares all three of its major lakes with neighboring countries. One of these is Lake Tanganyika, one of the oldest lakes in Africa's Rift Valley (Jorgensen and others 2005). Of 308 identified native fish species in the lake, 238 are endemic (FAO n.d.).



Source: FISHSTAT

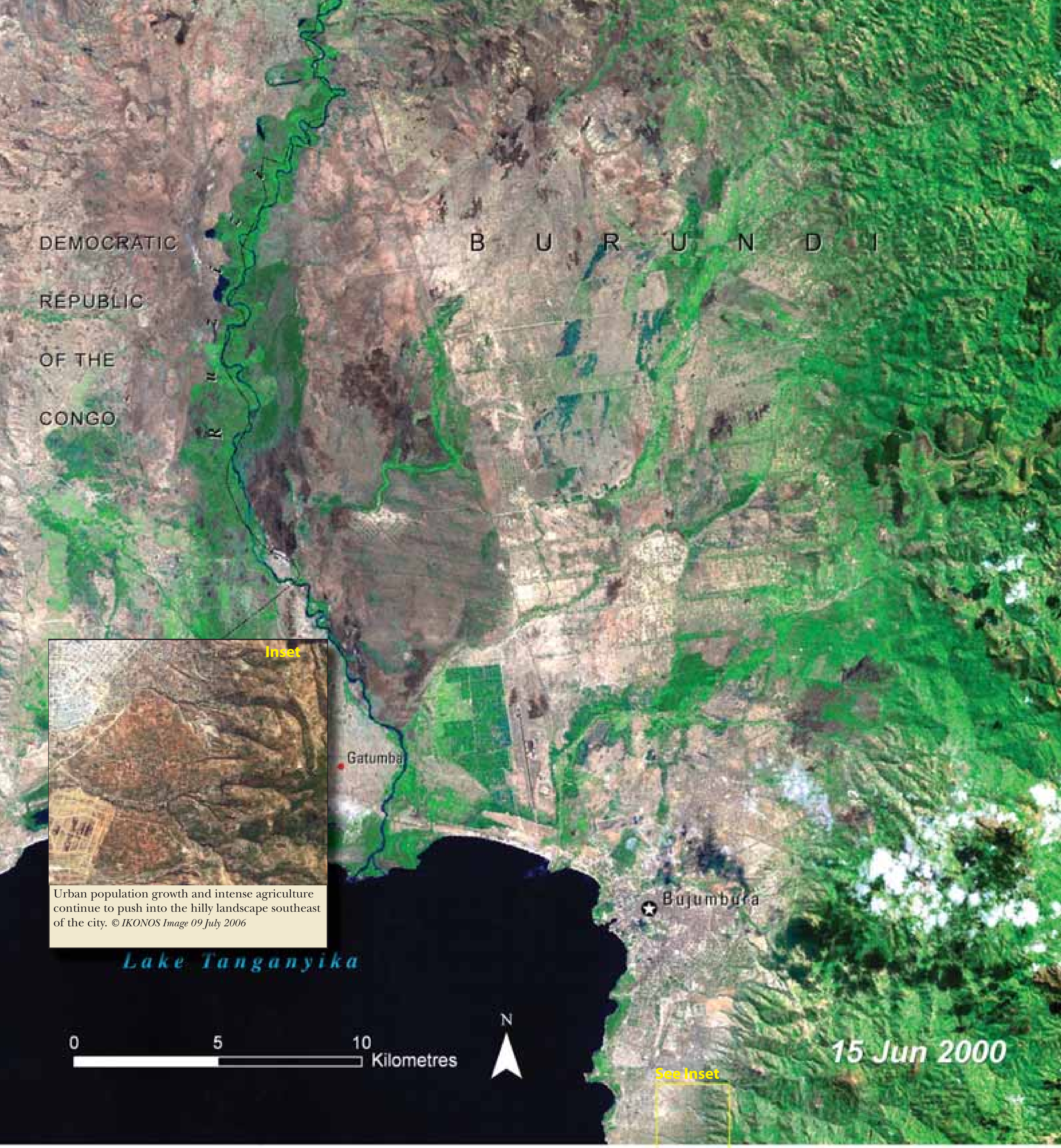
Lake Tanganyika is also the heart of Burundi's fishing industry, providing a vital source of income and protein for many people. However, fishing has intensified in recent decades, leading to a dramatic expansion of human settlements around the lake as well as concerns of over-fishing. Furthermore, deforestation in the region has accelerated siltation of lake waters, and waste discharge from the capital city of Bujumbura is a significant source of pollution.



Agriculture and Urban Expansion: Bujumbura, Burundi

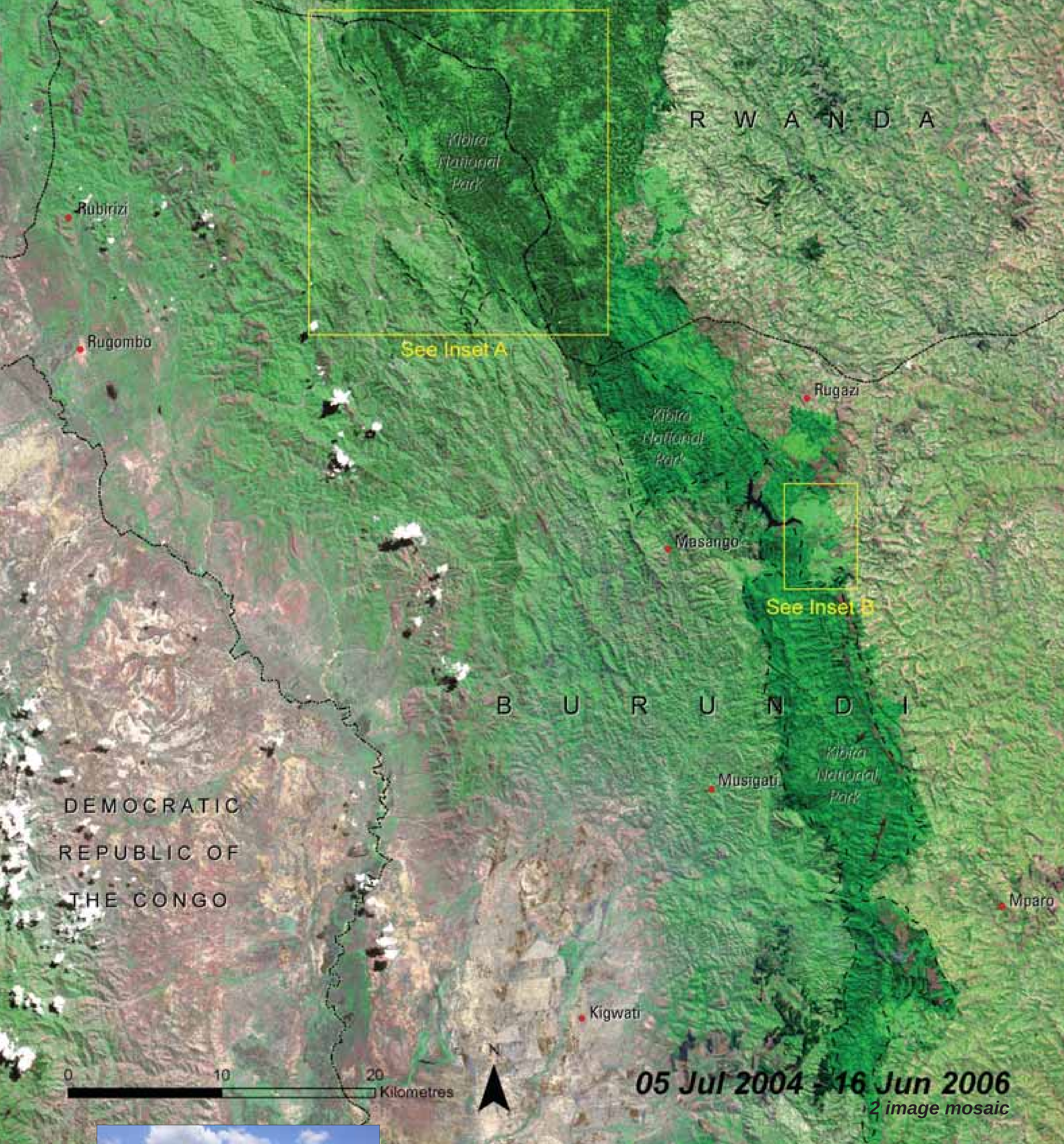
With 91 per cent of its people living in rural areas, Burundi is one of the most rural nations in Africa. It is also the second most densely populated. Approximately 90 per cent of the work force relies on agriculture, the vast majority being subsistence farmers. Some of the most intense agriculture in Burundi surrounds the growing capital of Bujumbura.

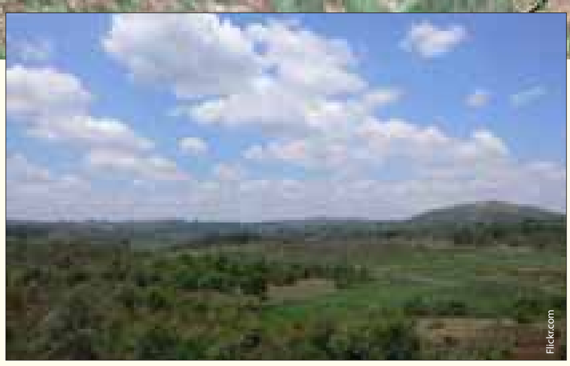
A comparison of 1979 and 2000 satellite images shows the expansion of agriculture around the capital. The high-resolution satellite image (inset) shows the interface between the southeast edge of the city and surrounding farms.



Urban population growth and intense agriculture continue to push into the hilly landscape southeast of the city. © *IKONOS Image 09 July 2006*

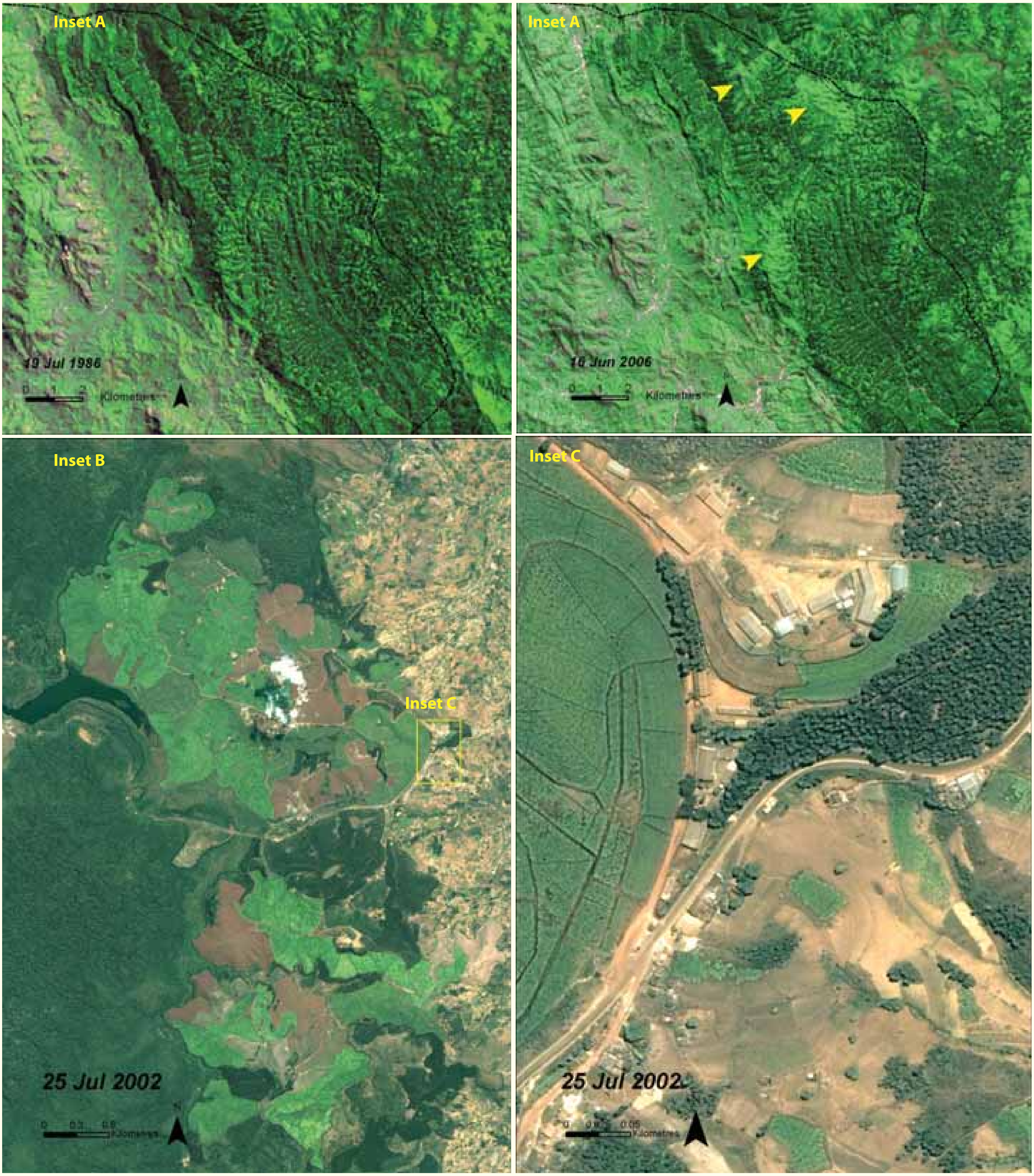
Adequate rainfall and good soils have historically made Burundi self-sufficient in food production. However, many areas in Burundi are considered unfit for cultivation. Scarcity of land will continue to put pressure on farmers to cultivate unsuitable lands. Burundi's domesticated land use has been measured at 86 per cent; a country is generally considered to be "land scarce" when 70 per cent or more of its land is used. Better agricultural practices could improve productivity and might relieve some of the pressure to convert additional unsuitable land to agriculture.



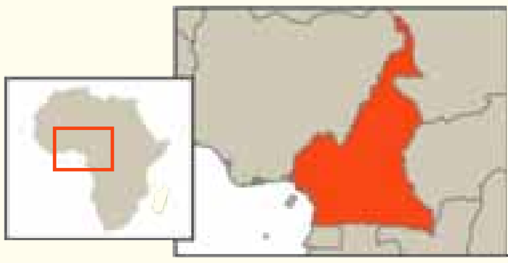


An Island of Biodiversity: Kibira Forest, Burundi

Uncontrolled cutting of trees for fuelwood coupled with land clearing for agriculture and grazing in Burundi has resulted in profound deforestation—as much as 47 per cent of the country's forest cover has disappeared since 1990. Along the mountains dividing the Congo and Nile River Basins is Kibira Forest, Burundi's only montane rain forest. This 40 000-hectare forest and national park is home to 644 plant species including the threatened African mahogany species, *Entandrophragma excelsum*, as well as 98 mammal and roughly 200 bird species. Kibira is also the source for 75 per cent of the water driving the country's largest hydroelectric dam.



The 2004/2006 image at left shows Kibira Forest as an island of green in a largely deforested landscape. The high-resolution images (lower right) show how agriculture—large and small—is closing in on the forest boundaries. While the forest is a national park, it faces continued pressure from legal and illegal cutting of trees, cutting of bamboo, fire, poaching, grazing, and agriculture. Light green patches in the enlarged 2006 image (top right, yellow arrows) show evidence of disturbance where the mature forest has most likely been lost to fire or tree-cutting. Limited legal forestry is allowed in the park; however inadequate capacity to enforce policy has led to considerable illegal logging and clearing for farms.



Republic of Cameroon

Total Surface Area: 475 442 km²
Estimated Population in 2006: 16 601 000

Cameroon is a medium-sized country whose nearly 17 million inhabitants are split fairly evenly between urban and rural areas. Its Atlantic coast is dominated by a wet, densely forested coastal plain, behind which is a large inland plateau of tropical rain forest. Further north are drier, less populated savannah plains extending to the northern border with Lake Chad. Cameroon is particularly well-endowed with timber resources, as well as petroleum, iron ore, and bauxite.

Important Environmental Issues

- Land Degradation and Deforestation
- Over-harvesting of Biological Resources
- Degradation of Coastal and Marine Ecosystems

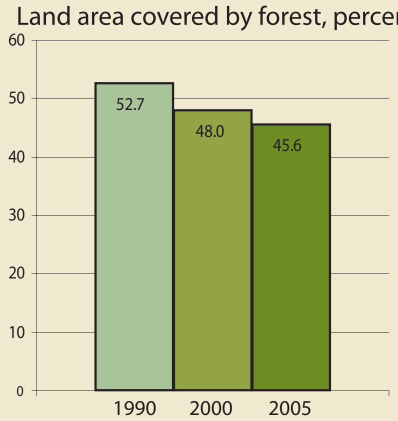
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

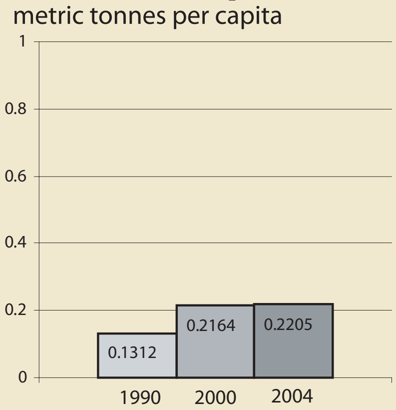
Fires and commercial exploitation of Cameroon's forests result in the clearing of 200 000 hectares per year. Currently, the forested area of 23.9 million hectares occupies almost 50 per cent of the land area. While forests are being destroyed even within reserved lands, Cameroon saw a gradual increase in the percentage of protected areas between 1990 and 2005.

★ Indicates progress

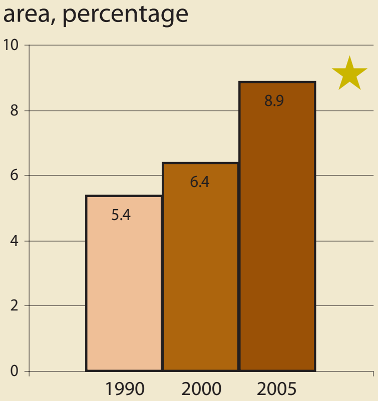
Land area covered by forest, percentage



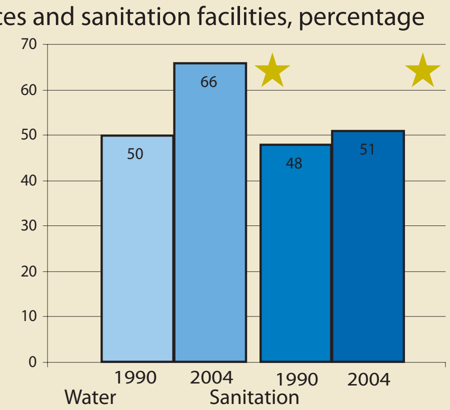
Carbon dioxide (CO_2) emissions, metric tonnes per capita



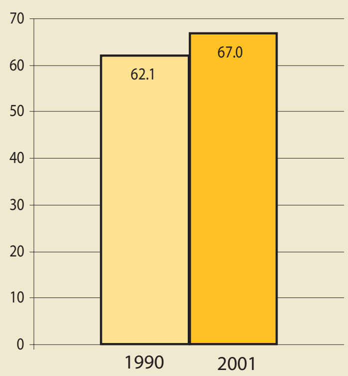
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



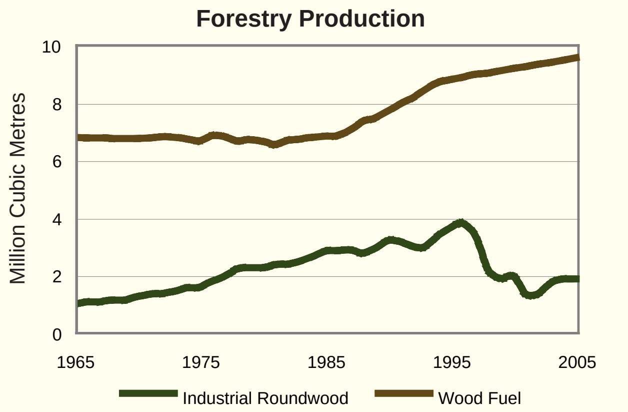
With 63 snake species, Mount Nlonako in Cameroon is the richest single locality in the world for snake species.

cres.sandiegozoo.org (2008)

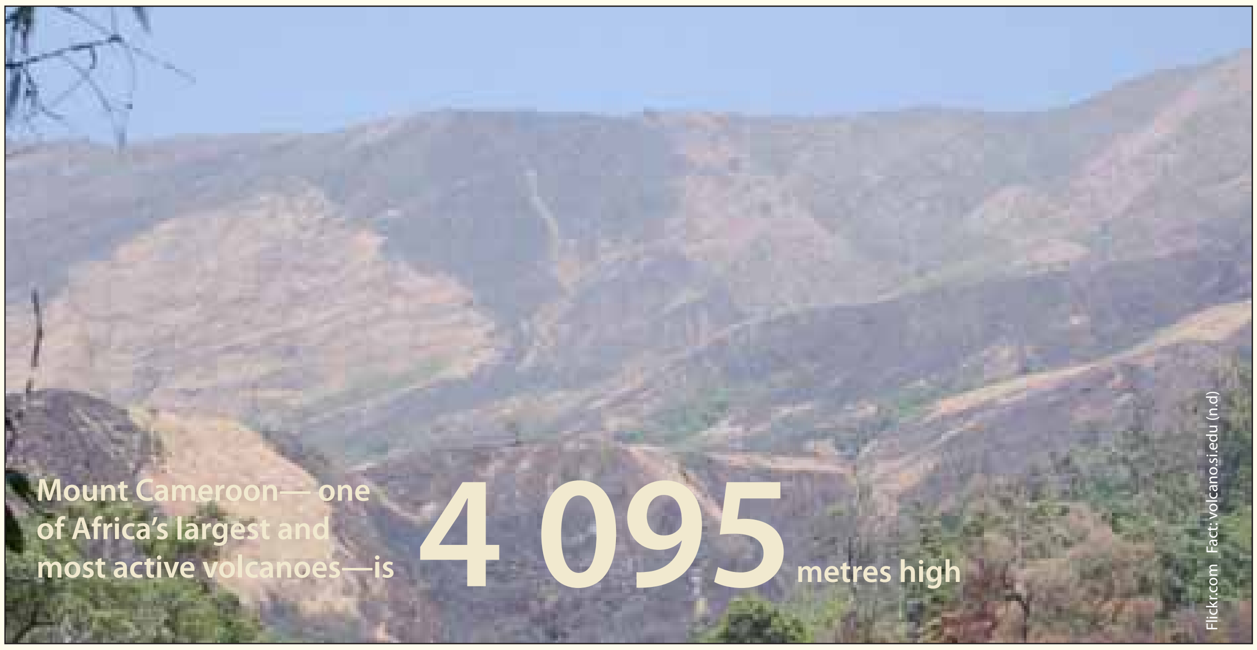
Land Degradation and Deforestation

Land degradation has long affected the drier regions of northern Cameroon, but it has also begun to affect the forested lands of the centre and south. Severely degraded land now covers 37 per cent of the country (FAO AGL 2003), driven by deforestation, intensive agriculture, and overgrazing, among other factors. The cattle population in Cameroon grew approximately 26 per cent between 1990 and 2004, reaching more than 5.9 million head (FAO 2007).

Forests cover nearly half of Cameroon, but they are being lost at an average rate of one per cent per year (UN 2007). This translates to over one million hectares of forest felled between 2000 and 2005, which is the second highest total in central Africa (FAO 2005). Commercial logging (both legal and illegal), demand for fuelwood, and agriculture are the principal drivers. A 1999 ban on raw timber exports designed to stimulate the domestic wood processing industry led to an initial drop in industrial roundwood production, but it is predicted that the industry will rebound as processing capacity grows (FAO 2003).



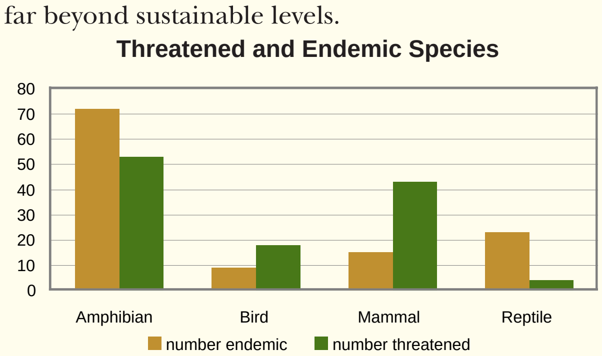
Source: FAOSTAT database



Over-harvesting of Biological Resources

Cameroon represents all of the major ecosystems on the African continent and ranks fifth among African countries for its level of biodiversity. Nearly 2 000 different animal species and 9 000 plant species, 156 of which are endemic, have been recorded (CBD 2007). This natural bounty is threatened by a combination of habitat loss and over-harvesting of biological resources.

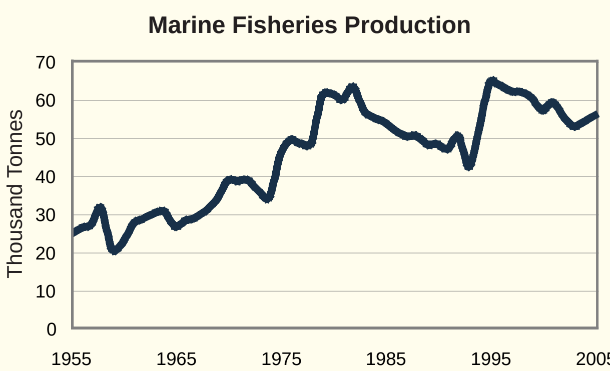
Among the rural poor in particular, biological resources such as medicinal plants and wildlife make up a significant portion of income and diet. One village-level study estimated that non-wood forest products contribute nearly half of household incomes (FAO 2003). Commercialised bush meat production is of particular concern for biodiversity, as increased demand has driven hunters to harvest far beyond sustainable levels.



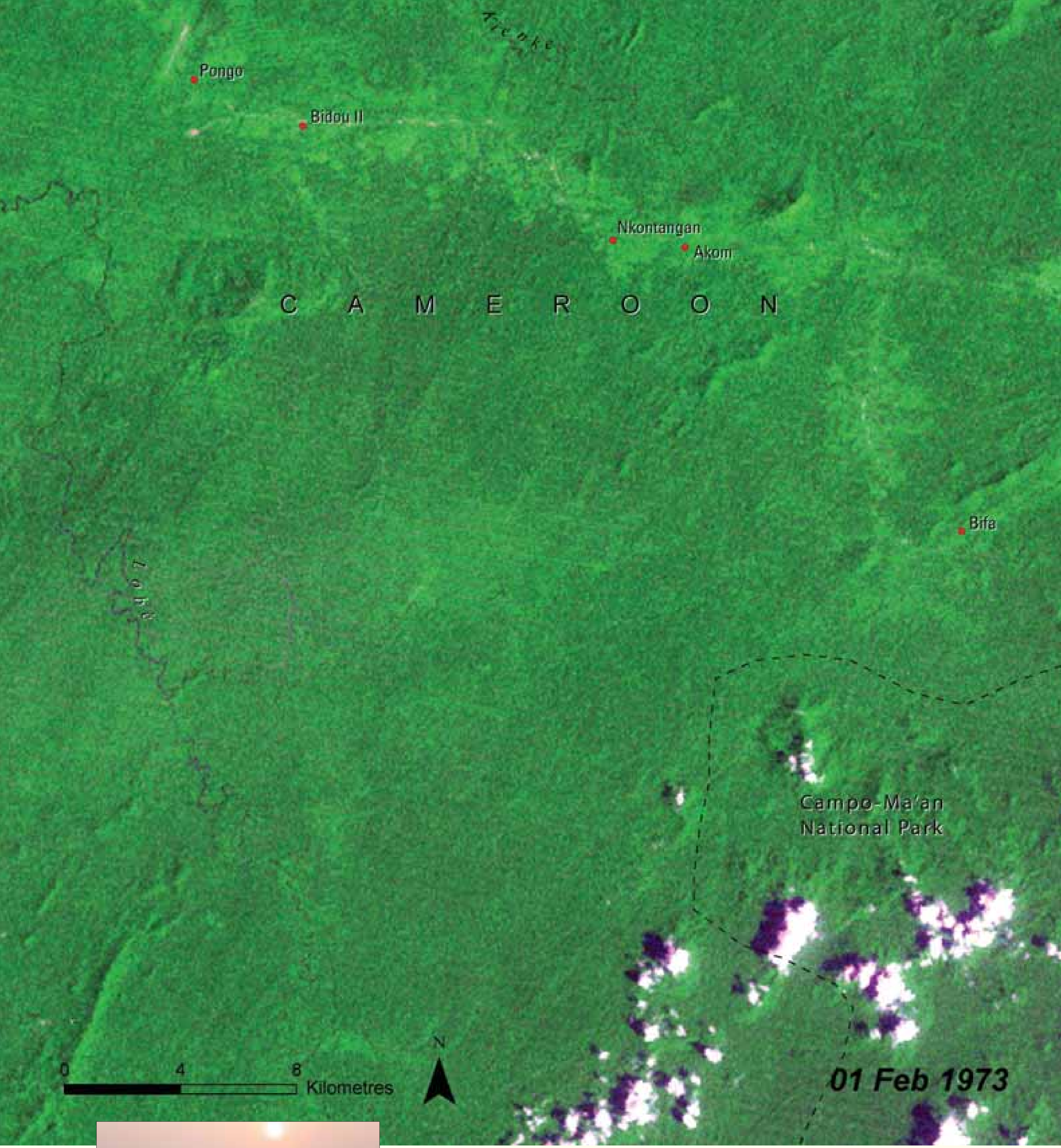
Source: IUCN

Degradation of Coastal and Marine Ecosystems

Cameroon has rich marine biodiversity, including 21 per cent of all African fish species and over 2 000 km^2 of coastal mangrove forest (CBD 1999). However, threats to these marine ecosystems are numerous. Approximately 70 per cent of industry is located near coastal ecosystems, contributing to substantial pollution (CBD 1999). Furthermore, overfishing and the use of small-mesh nets that capture young fish has reduced fish stocks and resulted in lower yields. Finally, demand for fuel and construction materials has driven rapid mangrove deforestation.

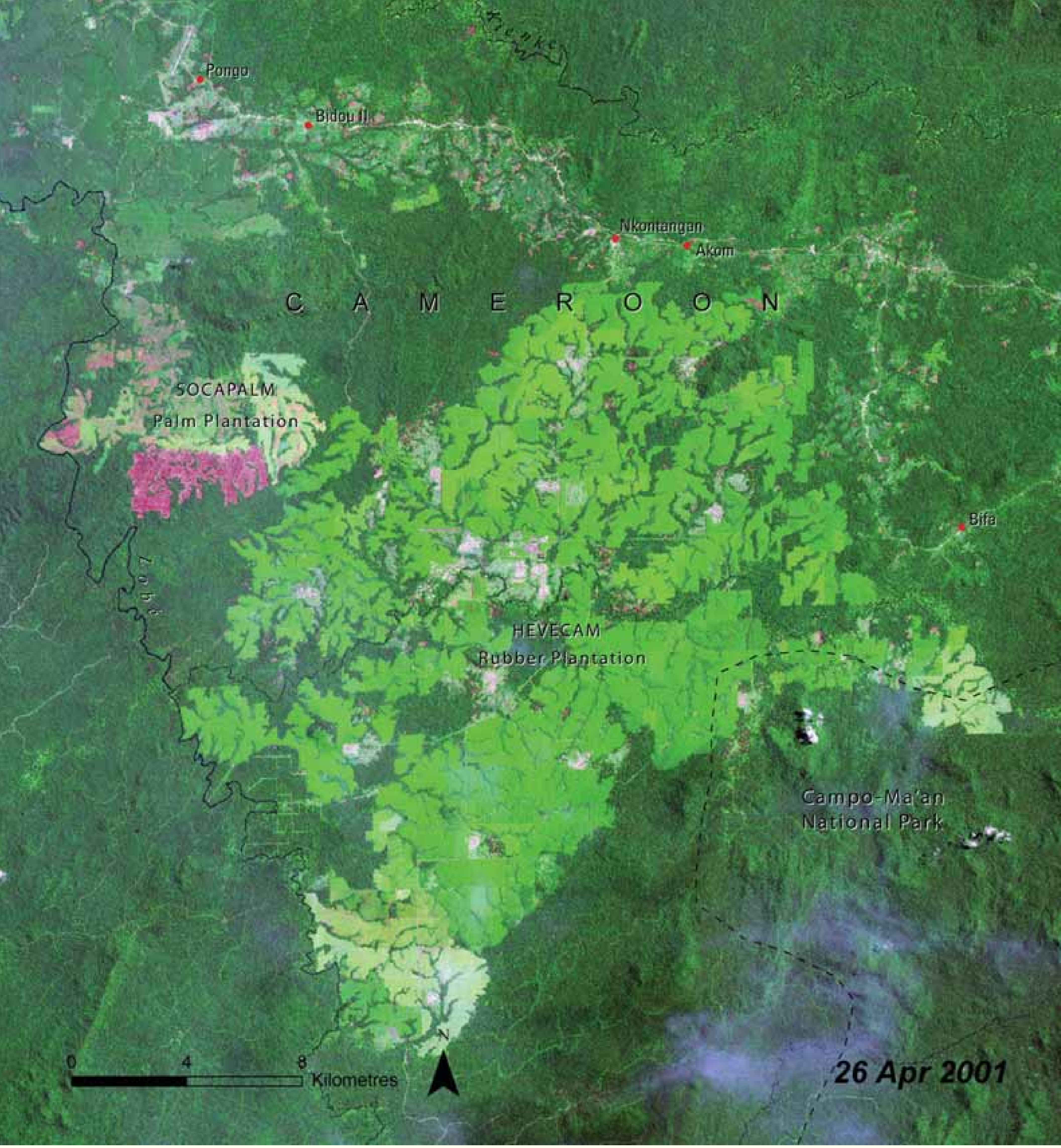


Source: FISHSTAT database



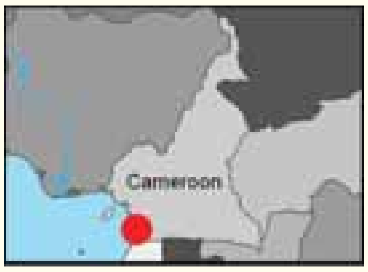
Plantations in Campo-Ma'an: Cameroon

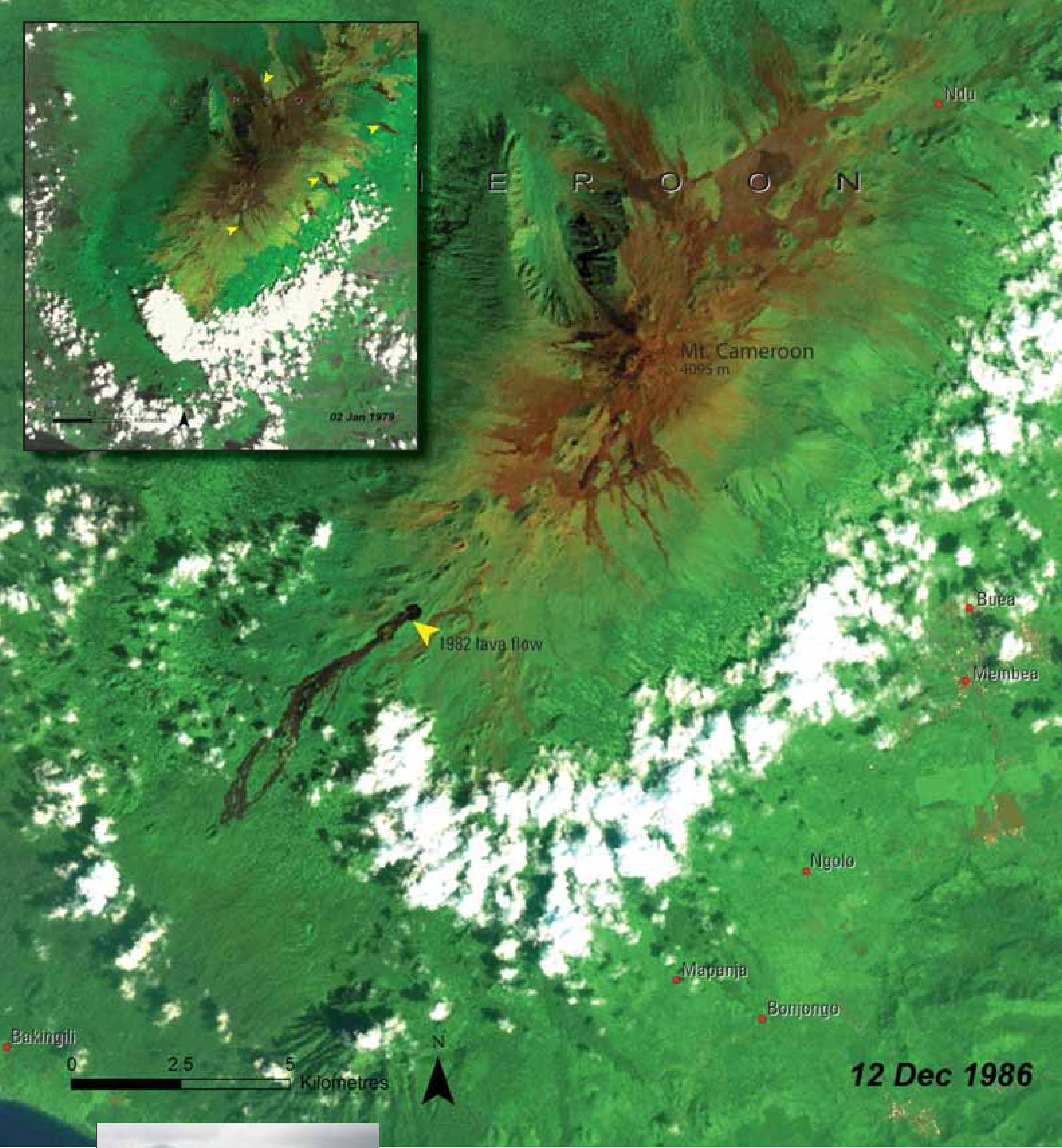
The Campo-Ma'an rain forest in southern Cameroon covers approximately 770 000 hectares of the Guineo-Congolian Regional Centre of Endemism—a species-rich area of rain forest with many species found nowhere else in the world. While the human population density is quite low, the area supports a host of economic activities, many of which threaten the area's ecosystems, including logging, shifting agriculture, and commercial agro-forestry. These forces contribute to the deforestation rate in southern Cameroon, which is among the highest in central Africa.



In the 1973 image the forest appears as largely intact. However, the impact of the agro-forestry industry, which is dominated by rubber and palm plantations, can be seen clearly in the centre of the 2001 image. Plantations, roads and cultivated areas dominate the landscape. These large-scale agro-industrial operations have replaced approximately 7.5 per cent of the area's forest cover.

Campo-Ma'an is an important focus of conservation efforts in Cameroon, and in 2000 the Campo-Ma'an National Park was created to protect its diverse flora and fauna. The park covers 26 400 hectares of diverse forests stretching from the coast to roughly 100 km inland.

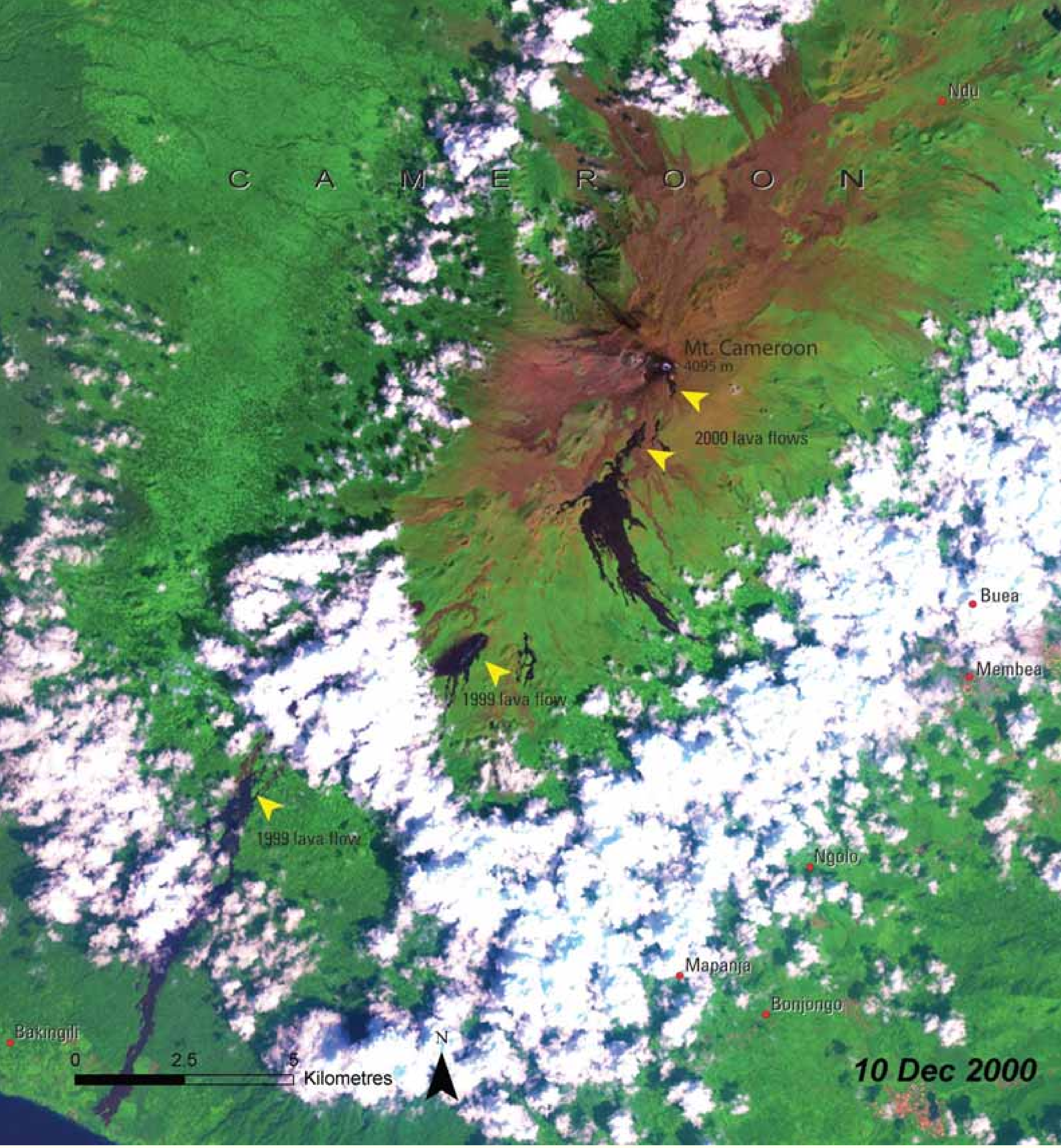


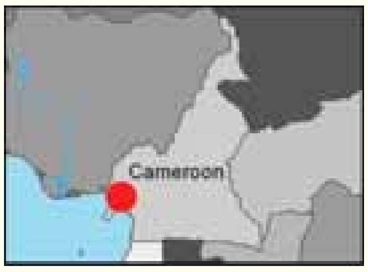


Recent Eruptions: Mount Cameroon, Cameroon

Mount Cameroon, in the country's southwest corner, is among the most active volcanoes in Africa. Rising 4 095 metres above the nearby Atlantic coast, it has erupted seven times in the last century, most recently in 1999 and 2000. The mountain is home to many rare birds and plants. In addition, there are several small communities near the volcano that are at risk from direct and indirect impact of volcanic activity.

In the 1979 satellite image, the tracks of several old lava flows (yellow arrows) can be seen although the volcano had not erupted since 23 January 1959. In the 1986 image, a lava flow is





visible on the southwest flank of the mountain (yellow arrow), the result of a 1982 eruption. The image from 2000 shows large lava flows left by the 1999 and 2000 eruptions (yellow arrows).

The principal vent of the 1999 eruption was at about 1 400 m elevation. It sent a voluminous lava flow estimated at about two kilometres wide and 30 m thick in a south-southwest direction. The flow eventually extended roughly seven kilometres, burning through dense rain forest, industrial palm plantations, and small subsistence farms, and flowing across the important Limbe-Idenau road. The village of Bakingili was evacuated over concerns that the hot lava entering the sea might pose a health threat. In 2000, Mount Cameroon erupted again, with two main lava flows moving down the volcano's southern flank.

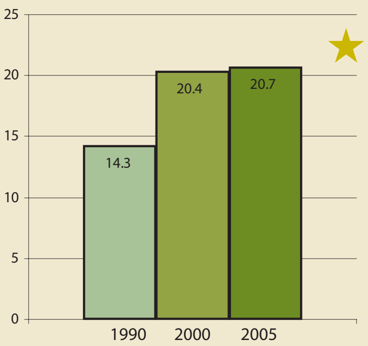
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goals 7 Indicators

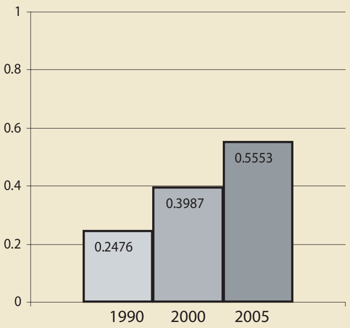
Demand for fuelwood in Cape Verde has resulted in deforestation and has led to the virtual elimination of native vegetation. The most widespread agricultural activity on the islands is raising crops such as corn, cassava, sweet potatoes, and bananas for domestic consumption.

★ Indicates progress

Land area covered by forest, percentage

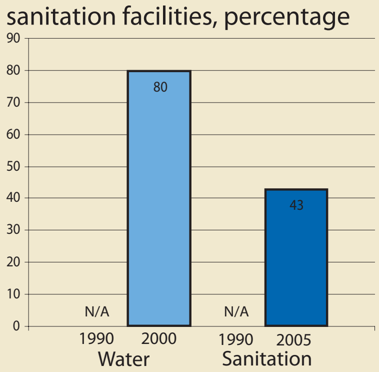


Carbon dioxide (CO_2) emissions, metric tonnes per capita

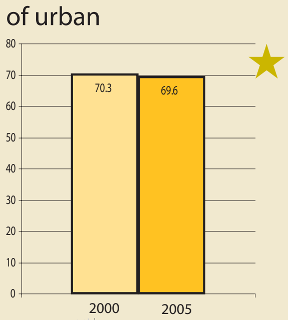


Protected area to total surface area, percentage

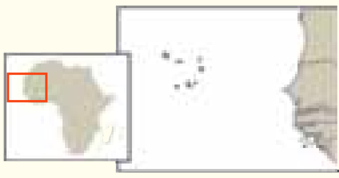
Proportion of total population using improved drinking water sources and sanitation facilities, percentage



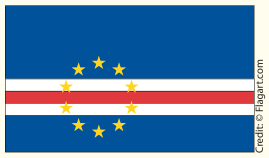
Slum population as percentage of urban



Republic of Cape Verde



Total Surface Area: 4 033 km²
Estimated Population in 2006: 519 000



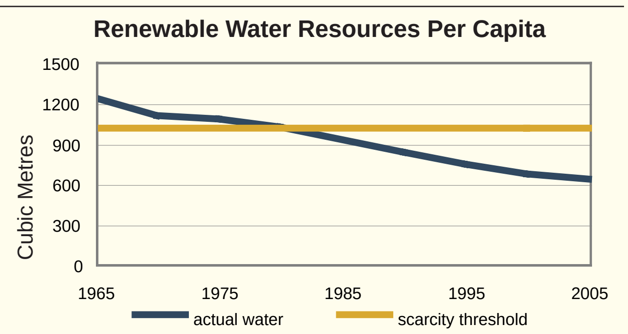
Located approximately 500 km from the West African coast, the Cape Verde archipelago consists of ten islands and eight islets. The climate is classified as tropical dry and rainfall is extremely erratic and insufficient, with an average of less than 300 mm per year (FAO 2005). In recent decades, the islands have experienced rapid urban migration and today nearly 60 per cent of the population resides in urban areas (UNESA 2006).

Important Environmental Issues

- Soil Erosion and Land Degradation
- Threats to Biodiversity

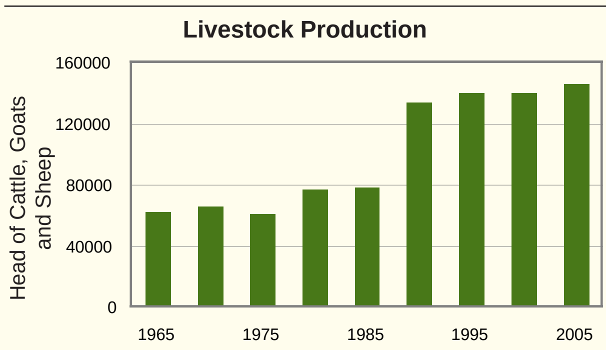
Soil Erosion and Land Degradation

Cape Verde is characterized by steep topography, infrequent but torrential rains, and underdeveloped volcanic soils, which make the country highly vulnerable to erosion. Since human settlement of the island, overgrazing, farming, and fuelwood collection have removed much of the natural vegetation, particularly at high altitudes. When combined with the impacts of occasional, severe droughts, these factors have contributed to widespread soil erosion and land degradation. Near the coast, overexploitation of groundwater aquifers has resulted in soil salinisation and saltwater intrusion of wells (FAO 2005).



Source: AQUASTAT

Threats to Biodiversity

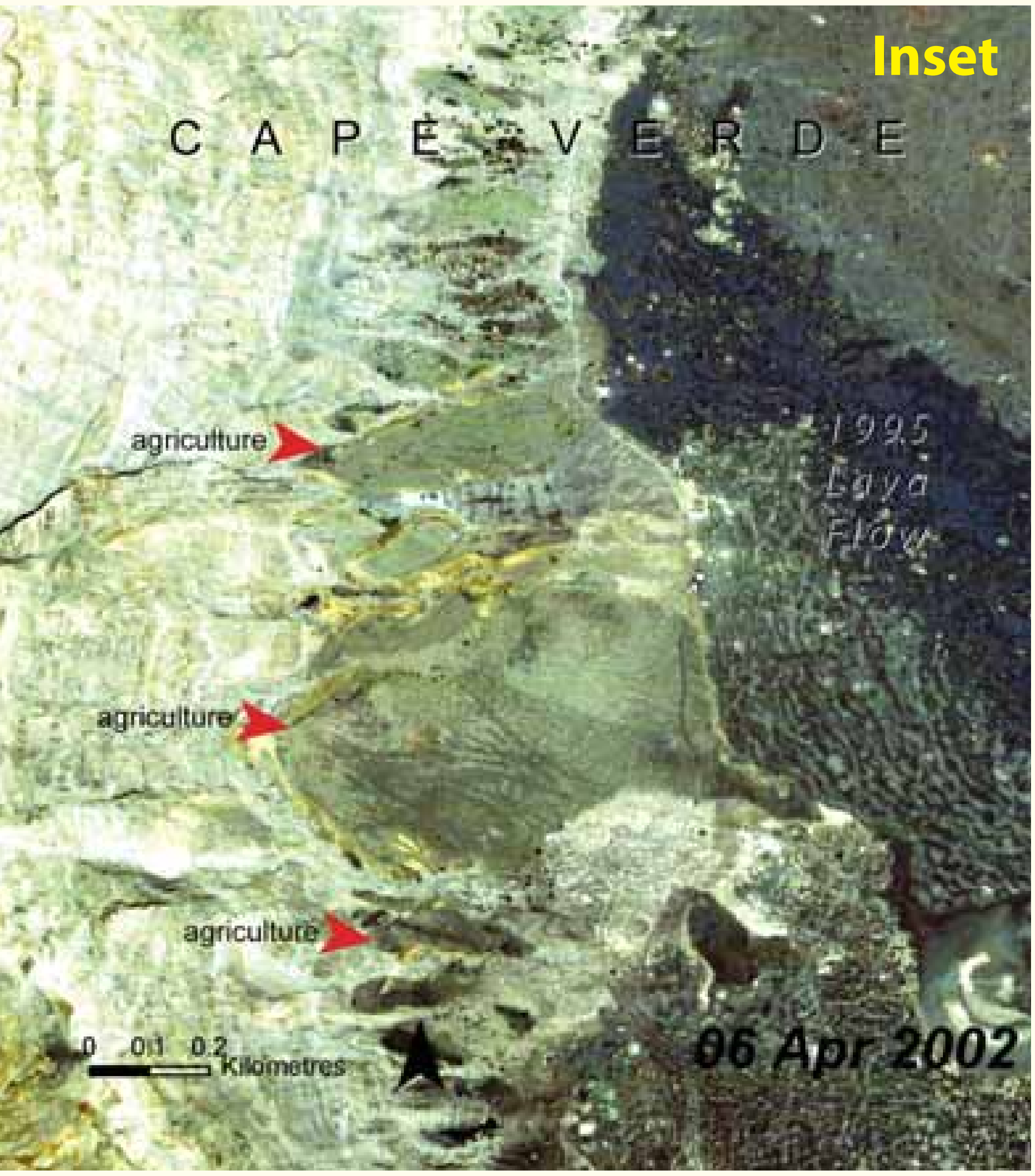


Source: FAOSTAT

The islands of Cape Verde support globally important biodiversity, but an estimated 47 per cent of birds and 25 per cent of reptiles are threatened with extinction (CBD 2007). Several bird species, including the Cape Verde swift and the Cape Verde sparrow, are endemic, as are a number of bird sub-species. The islands also provide important breeding and nesting grounds for rare seabirds such as Fea's petrel, which is found in only a few locations worldwide. Introduced predators, including rats and cats, the harvesting of eggs and nestlings for food, and habitat loss threaten all of the islands' birds.

The only native mammal of Cape Verde is the long eared bat (Plecotus austriacus).

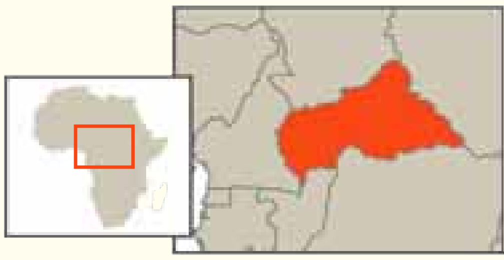
nationsencyclopedia.com (2007)



Volcanic Eruptions: Pico de Fogo, Cape Verde

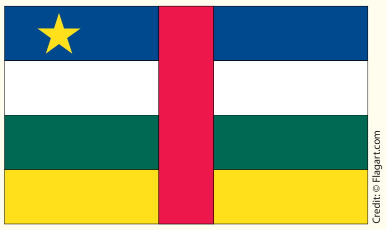
On 2 April 1995, residents on Fogo Island reported a red glow atop Pico de Fogo volcano. It was the beginning of volcanic eruptions that would continue for seven-and-a-half weeks, sending lava across the floor of Cha das Calderiras (Plain of Craters) that eventually covered 4.3 km^2 of farmland, destroyed the village of Boca de Fonte, and forced the evacuation of approximately 1 300 residents. Despite the danger, people live in the caldera and raise coffee, wine grapes, fruits, and other crops in the fertile volcanic soils (red arrows).

The 1995 eruption on the southwest slope sent lava flowing to the northwest across the main road through the caldera (yellow arrows). Studies are ongoing as to the stability of Pico de Fogo.



Central African Republic

Total Surface Area: 622 984 km²
Estimated Population in 2006: 4 093 000



Central African Republic (CAR) is a landlocked country situated in the centre of the African continent. The climate is generally tropical, and typical land cover includes dense tropical rain forests in the south, wooded savannahs in the centre, and grassland savannahs in the north. Central African Republic is rich in biological resources such as wildlife and timber, as well as valuable mineral deposits including diamonds, gold, and uranium.

Important Environmental Issues

- Subsistence and Commercial Poaching
- Deforestation and Land Degradation
- Diamond Mining and Pollution

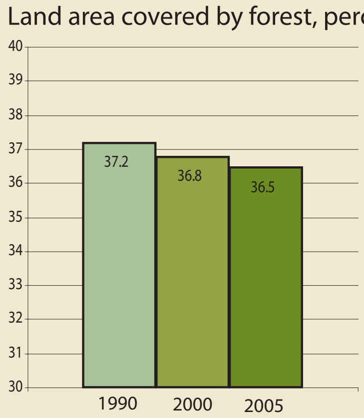
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

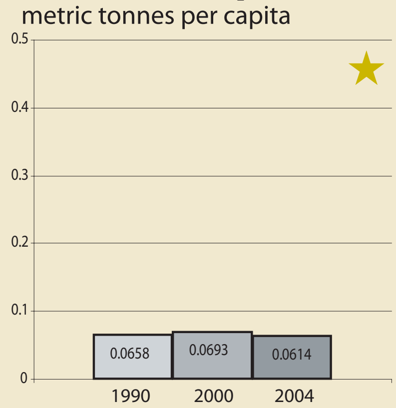
With forest covering 36 per cent of the total land area, deforestation and degradation are the primary environmental issues. The country once had the third-largest area of rain forest in Africa. Today, most of this has been degraded by logging. About 16 per cent of the country's land is some form of protected area, home to about 3 600 species of plants, 663 birds, 131 mammals, 187 reptiles, and 29 amphibians.

★ Indicates progress

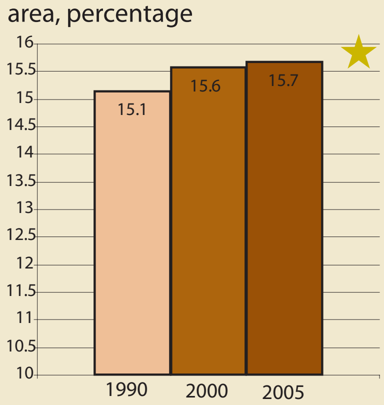
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

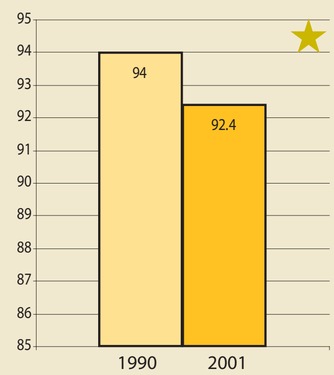


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban



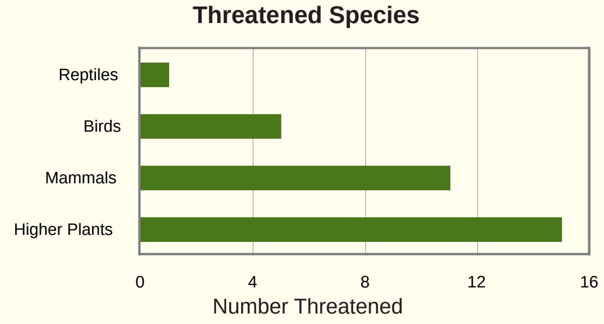
Tropical forests cover 36 per cent of the Central African Republic, and the rain forests in the southwest contain some trees reaching a height of 46 metres.

rainforests.mongabay.com (2007)

Subsistence and Commercial Poaching

Poaching is one of the biggest threats to the Central African Republic's wildlife, which includes forest elephants, gorillas, chimpanzees, lions, and hippopotamuses. The country has a long history of subsistence hunting and the practice is perpetuated by widespread and severe poverty. More recently, a growing transnational market for bushmeat, hides, and ivory has led to a new poaching boom.

Poaching decimated the country's last remaining rhinos in the 1980s, while the savannah elephant population in the north was reduced by 75 per cent. Today, approximately 1 800 elephants remain, including the northern savannah elephants and two forest elephant populations in the south (Blanc and others 2007). The elephants' range once covered over one-third of the country, but it is now largely confined to a few protected areas, which have some of the highest densities of forest elephants in Africa.

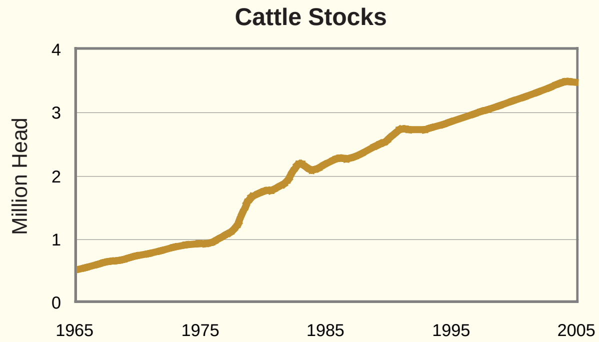


Source: IUCN Red List

Deforestation and Land Degradation

Land degradation, manifested as widespread soil erosion and localized desertification in the far north, is a growing problem in Central African Republic. Poor agricultural practices and overgrazing—cattle stocks have increased almost four-fold in the last three decades (FAO 2007)—are significant contributors.

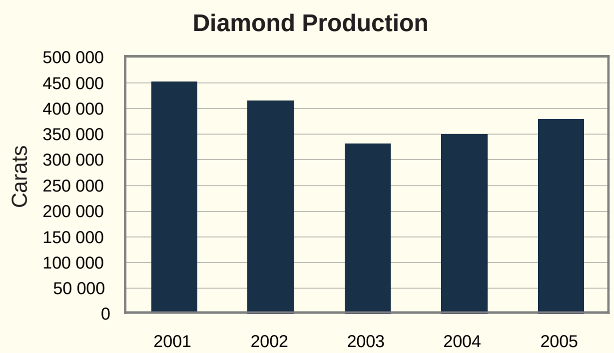
However, deforestation and forest degradation are the biggest land degradation problems. Between 1990 and 2005, CAR lost roughly 450 000 hectares of forest (FAO 2005), leaving roughly 37 per cent of the country deforested (UN 2007). The expansion of logging and mining roads into previously remote forests has facilitated degradation by people seeking commercial timber and fuelwood.



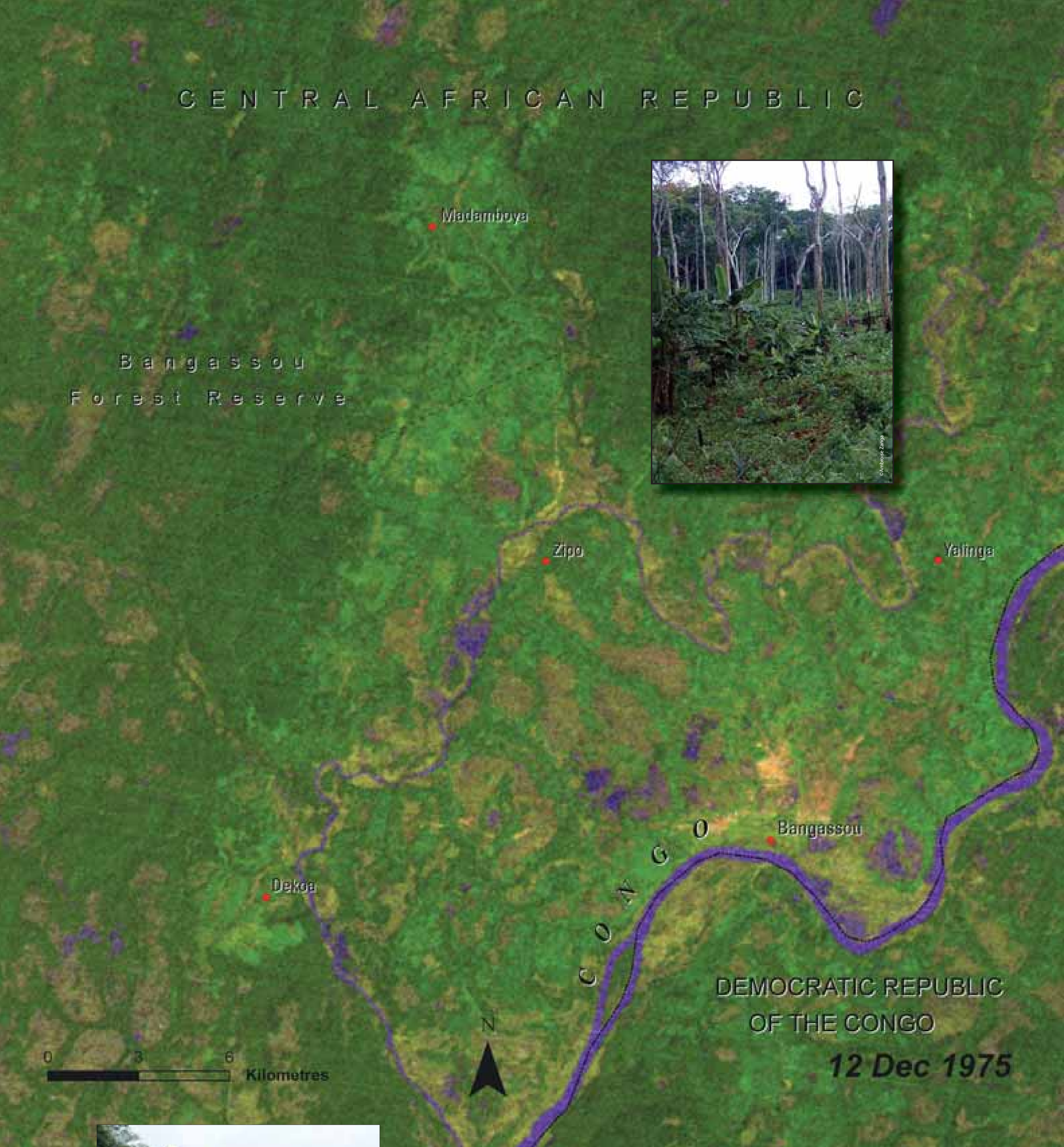
Source: FAOSTAT database

Diamond Mining and Pollution

Diamond mining in Central African Republic is mostly artisanal in nature, but it is still the most important extractive industry in the country, accounting for 60 per cent of export earnings in 2004 (Bermudez-Lugo 2005). The mining is typically conducted in and around streams, which causes localised destruction of riverine ecosystems as well as more dispersed impacts such as waterway sedimentation and pollution. Furthermore, there is typically increased bushmeat hunting and deforestation near mining camps (CARPE 2005).

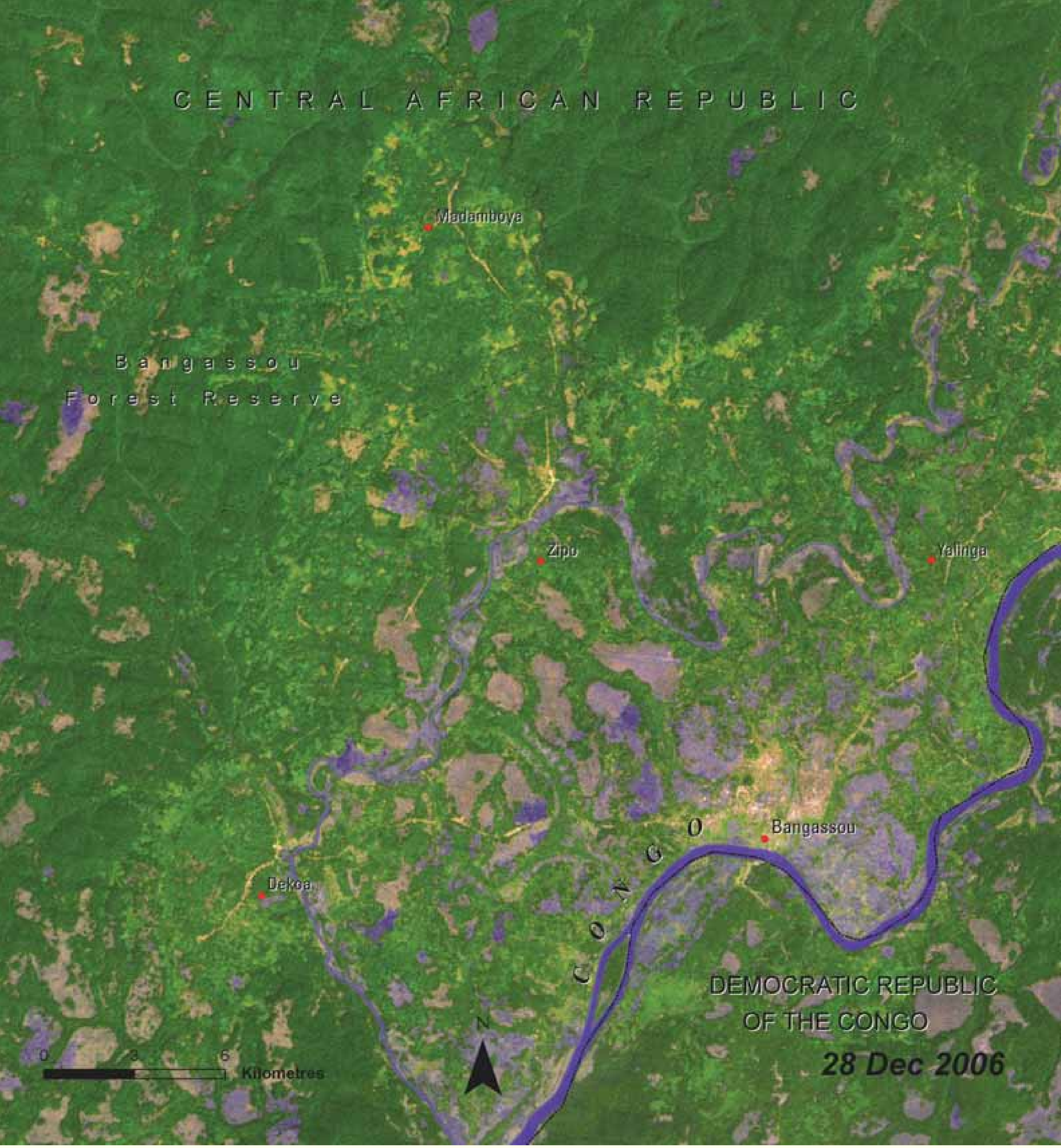


Source: USGS Mineral yearbook 2005



Biodiversity of Bangassou: Central African Republic

The Bangassou Forest is a mosaic of lowland rain forest and secondary grasslands in southeastern Central African Republic covering an estimated 1.2 to 1.5 million hectares. This region is very isolated; little is known about its forests and there has been no commercial exploitation of the forest products in this area. While this is not a protected area, there has been oversight from the regional Office of Water and Forests and a community conservation project. The Bangassou Forest is an area with high biodiversity and a wide range of habitats.



Only about 20 000 people live in the forest itself; however, the city of Bangassou has a population of over 24 000. The growth of Bangassou and the apparently increasing gaps in the forest canopy between 1975 and 2006 (light coloured areas, particularly between Zipo and Madamboya) suggest that pressure on the forest may be increasing.

The Bangassou Forest is one of only two areas in Central African Republic where elephants still live. Estimates of the elephant population have declined from 2 640 in 1989 and 1 600 in 1995 to perhaps as few as 500 to 1 000 in 2004. This is widely believed to be the result of poaching which appears unlikely to decrease under current circumstances.

Republic of Chad

Total Surface Area: 1 284 000 km²
Estimated Population in 2006: 10 032 000

Chad, named after the shallow lake on its southwestern border, is a large, sparsely inhabited country in the heart of Africa. The Lake Chad Basin forms a vast plain covering over 80 per cent of the country (FAO 1997), connecting the northern Sahara Desert region to the tropical zones of the south. Nearly half of the population lives in the southern one-fifth of the country, where water resources are most abundant.

Important Environmental Issues

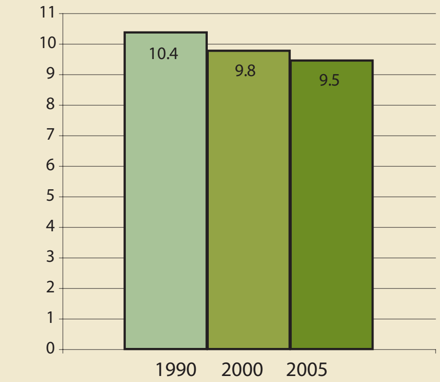
- Drought
- Desertification and Land Degradation
- Access to Water and Sanitation

Progress Towards Environmental Sustainability

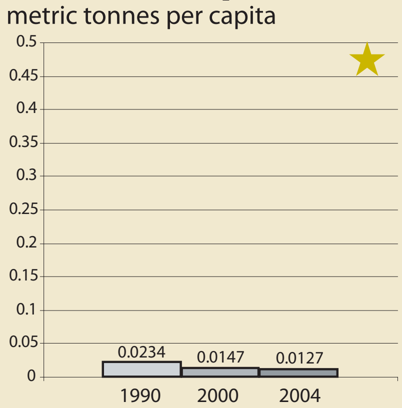
As defined by the United Nations Millennium Development Goal 7 Indicators

The main environmental problem in Chad is increasing desertification after a decade marked by below-average rainfall and periodic droughts. Linked to this major problem is that of Lake Chad, one of the most striking symbols of Africa's deteriorating environment. The lake is very responsive to changes in rainfall. In less than 30 years, Lake Chad has shrunk from 25 000 km² to a current 2 000 km².

Land area covered by forest, percentage

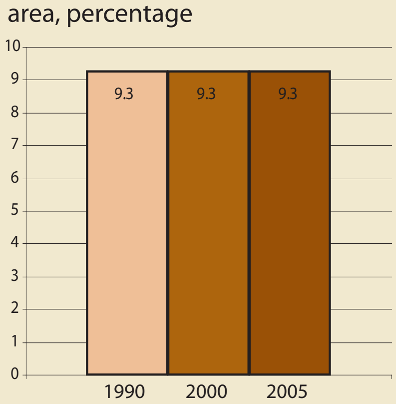


Carbon dioxide (CO_2) emissions, metric tonnes per capita



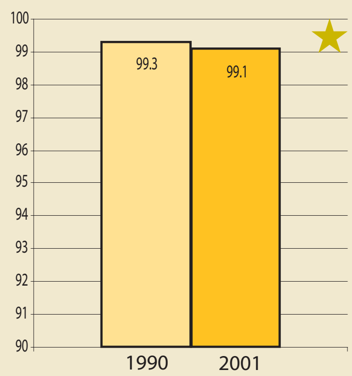
★ Indicates progress

Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban



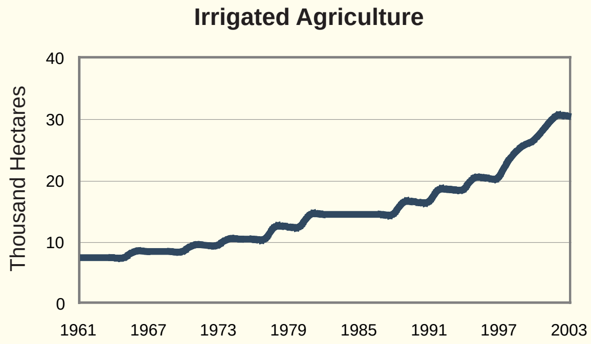
Lake Chad is the most significant water body in the Sahel.

worldlakes.org (2008)

Drought

Lake Chad is the fourth-largest lake in Africa (in terms of surface area) and the largest wetland in the Sahel region. In recent decades, the lake has shrunk dramatically, now measuring only one-twentieth of its 1963 size. Increased water extraction for irrigation is estimated to be responsible for at least 50 per cent of this decrease, although repeated severe drought is also to blame (Coe and Foley 2001).

Since 1910, Chad has experienced at least seven major droughts impacting over 1.5 million people (EM-DAT 2007) and an unknown number of species of flora and fauna. Severe droughts in the late 1960s, early 1970s, and mid-1980s have contributed to unprecedented levels of desertification, wetland degradation, and water scarcity.

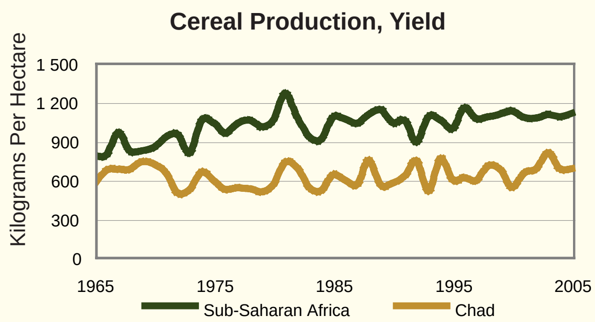


Source: FAOSTAT database

Desertification and Land Degradation

Chad is more susceptible to desertification than any other Sahelian country—an estimated 58 per cent of its land is already classified as desert and another 30 per cent is highly vulnerable (UNEP 2006). The flood plains and wetlands surrounding Lake Chad and its tributaries, which support close to 20 million inhabitants, are particularly prone to degradation resulting from deforestation, bush burning, and unsustainable agricultural practices. These human factors, in combination with natural aridity, have reduced the fertility of soils that are already known to produce some of the lowest crop yields in sub-Saharan Africa.

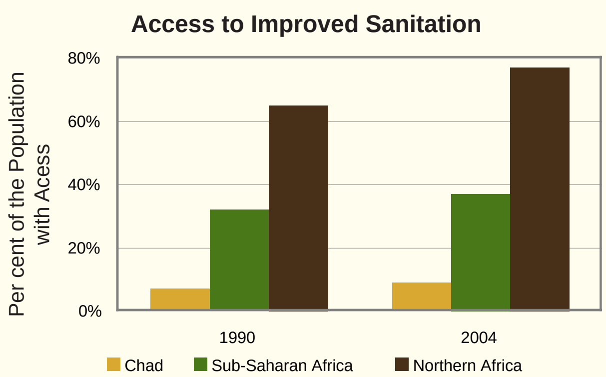
A possible increase in pollution from oil drilling presents yet another threat to land resources. Oil exploration began in 2000, and by 2004, a pipeline to Cameroon's Atlantic coast was generating significant export revenue. As of January 2006, proven oil reserves were estimated at 1 500 million barrels (EIA 2007).



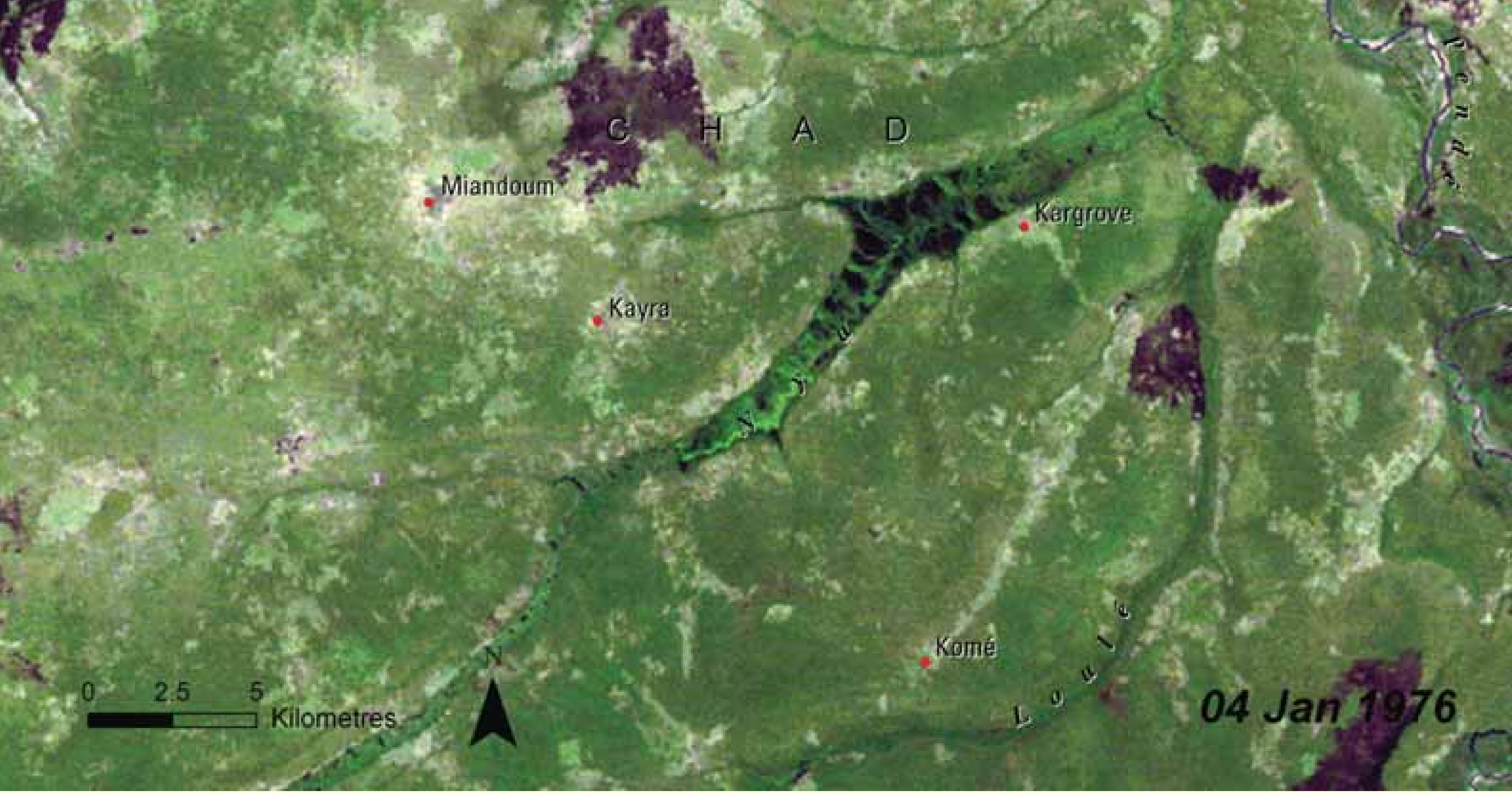
Source: FAOSTAT database

Access to Water and Sanitation

Chad has the third-lowest level of access to safe water and the lowest level of access to adequate sanitation in all of Africa. Water infrastructure is largely undeveloped and surface water resources are limited, so people are forced to walk long distances to fetch fresh water for domestic use and livestock. The arrival of thousands of Sudanese refugees in recent years has worsened the problem in eastern Chad. Lack of access to adequate water and sanitation has had pronounced impacts on human health: approximately one out of every five children dies before reaching the age of five (UNICEF 2006), primarily due to water-related diseases.



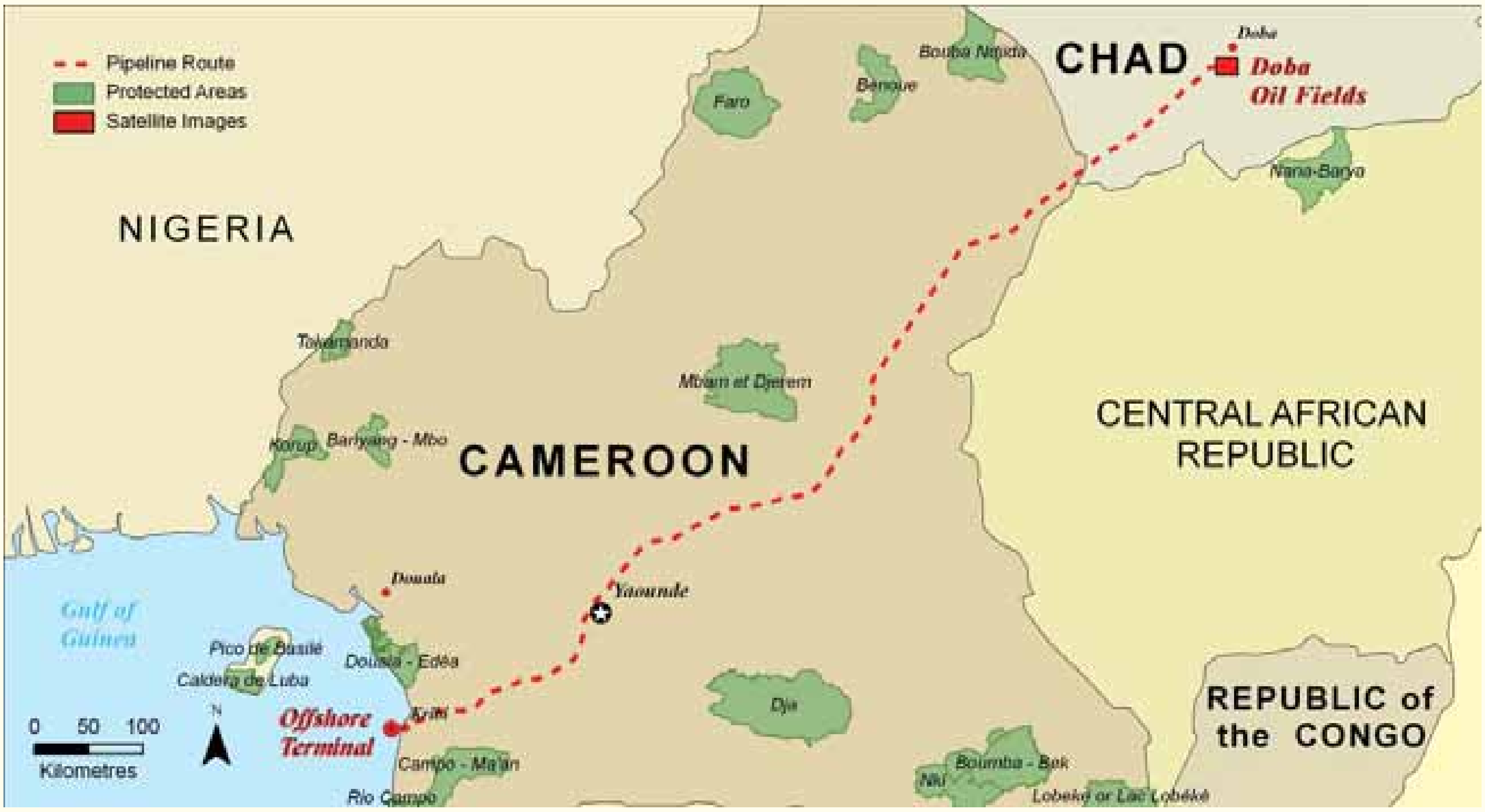
Source: MDG Indicators



Massive Oil Development: Doba, Chad

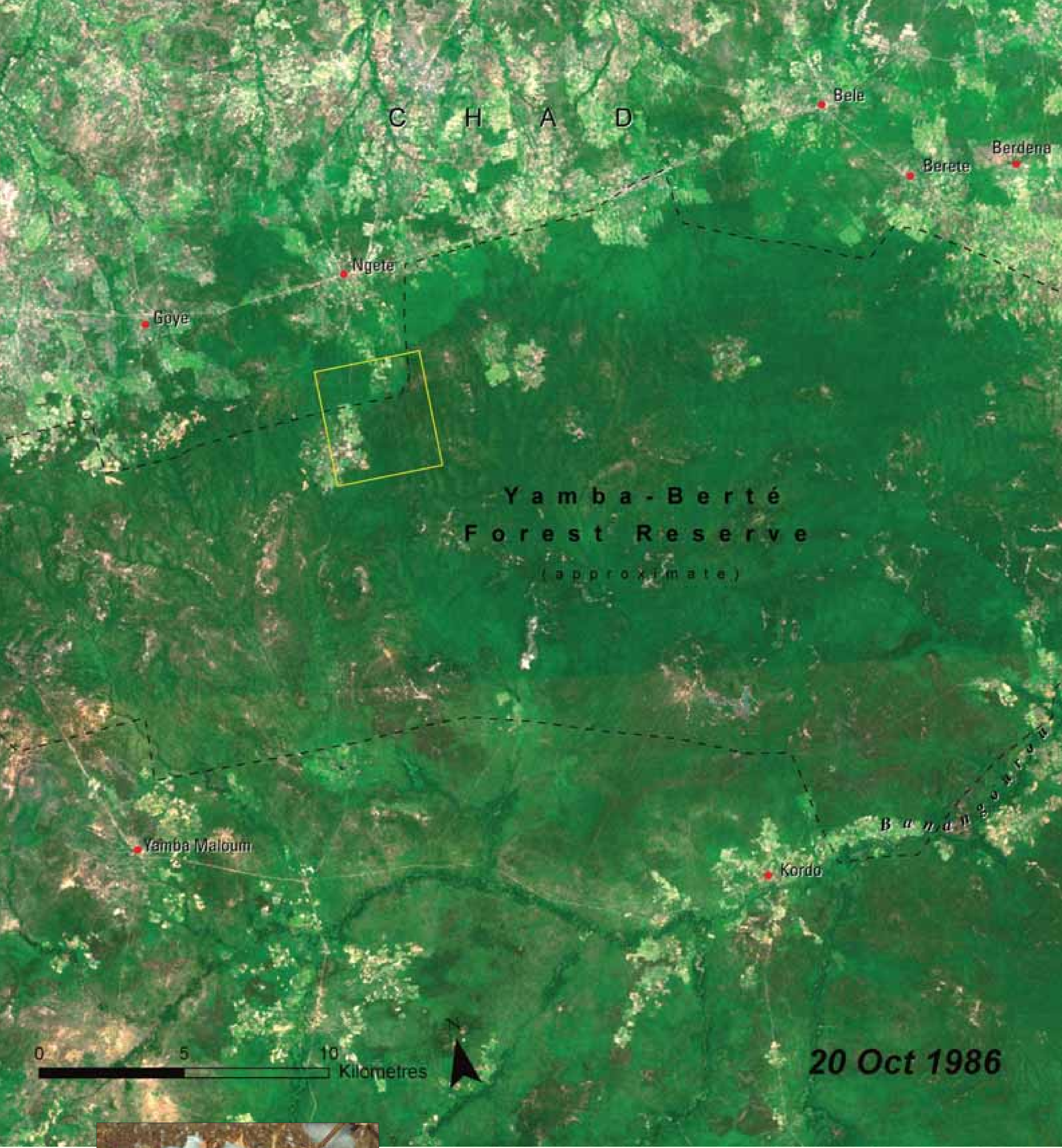
The Chad Export Project brought an investment of approximately US$3 500 million to one of the poorest countries in the world. Among the stated goals was to "provide additional resources to alleviate poverty through social sector and infrastructure development." Concerns were voiced by non-governmental organizations at the outset; these concerns included displacement of people from traditional land and livelihoods, environmental degradation, opportunity for corruption, and inadequate capacity to enforce environmental regulations.

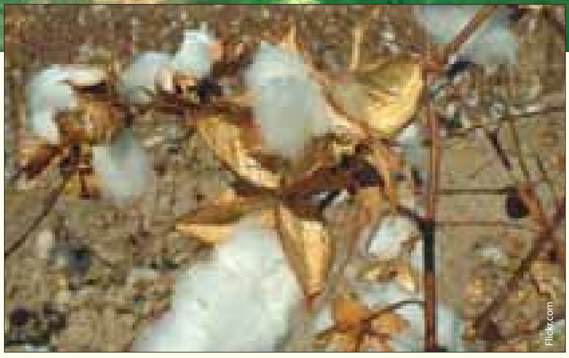
Kome Oil Field is the largest of the three clusters of oil wells at Doba.



The project included drilling 300 oil wells in farmland surrounding Doba and construction of a 1 050-km pipeline across Cameroon to Kribi on the Atlantic Coast. Small patches of light green in the 1976 satellite image show agriculture already present in the area. By 2007, the intensity of agriculture had increased greatly and three clusters of oil wells, concentrated over three oil fields, can be seen. The fields of well pads show as light coloured squares at the end of access roads (yellow arrows).

While the project has brought an influx of revenue, it remains to be seen if this translates to a better life for the people living in the vicinity of the oil fields or in Chad as a whole. World Bank documents rate the project's performance in this regard as "moderately satisfactory." Other reports have taken a less favourable view.

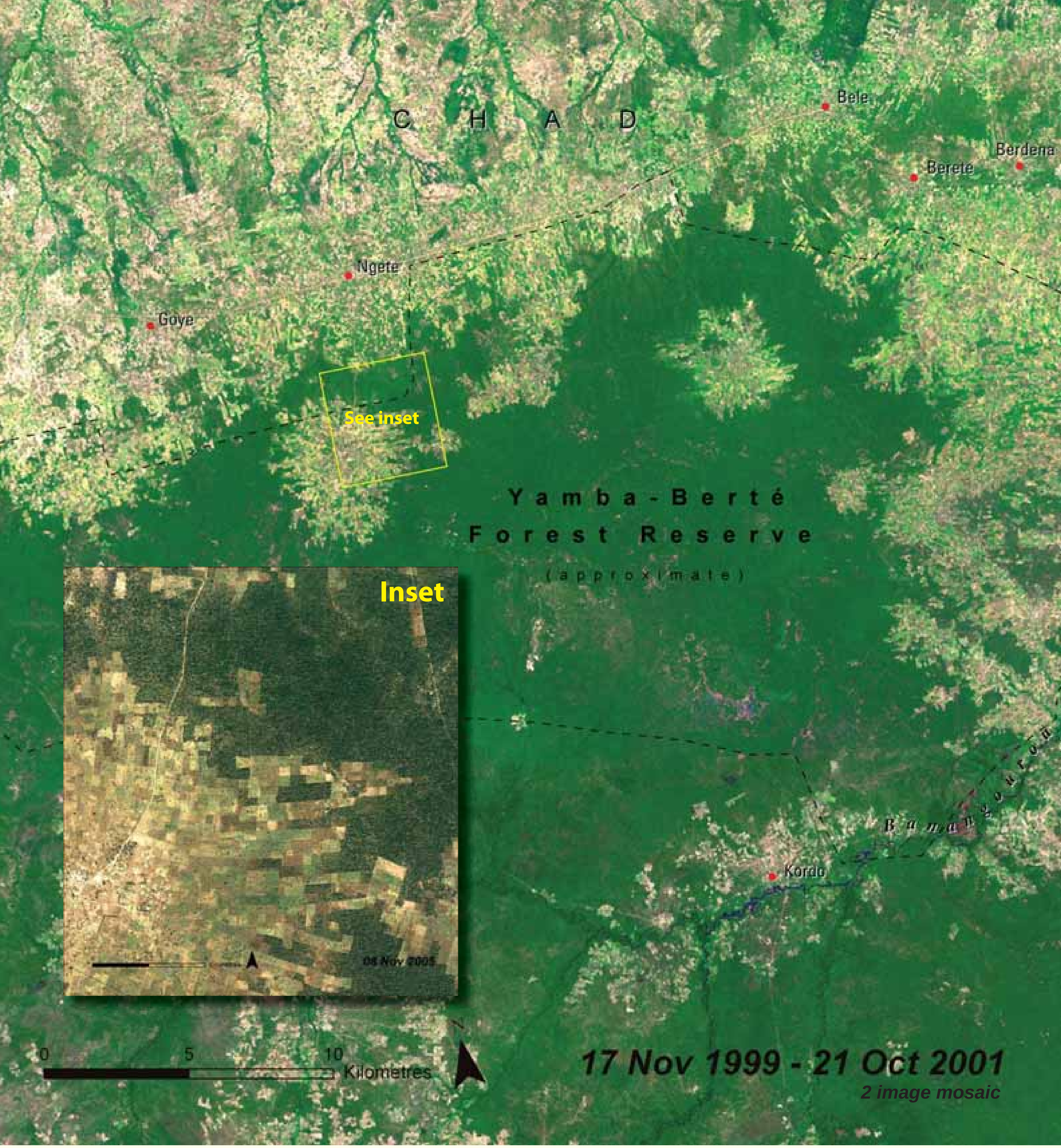




Agriculture in the Yamba Berté Forest Reserve: Chad

The Yamba Berté Forest Reserve in southwestern Chad is made up of critical gallery forests, pristine woodlands, and a network of small lakes and swamps. The dense forest includes trees that can grow as tall as 35 m. The reserve is important habitat for gazelles, monkeys, warthogs, giraffe, elephants, and the rare giant eland (*Taurotragus derbianus*).

Yamba Berté is located in a zone of savannah woodland that stretches across southern Chad and also supports a dense human population and most of the country's agriculture. The introduction of cotton in the 1930s and draft animals in the 1950s supported a large increase in



agriculture. During the drought years (1968, 1972-1973, 1983-1984) large numbers of people migrated to the area because of its higher rainfall and the economic opportunity of its larger cities. In addition to subsistence crops such as maize, millet, and sorghum, the area is ideal for growing cotton and groundnuts, which are the two primary cash crops.

The 1986 image shows agriculture around Yamba Berté, including some encroachment on the reserve area. The second image, captured 15 years later, shows dramatically increased agriculture around the reserve and several areas where the reserve boundary has been breeched. The high-resolution image (inset) shows the detail in one area of encroachment.

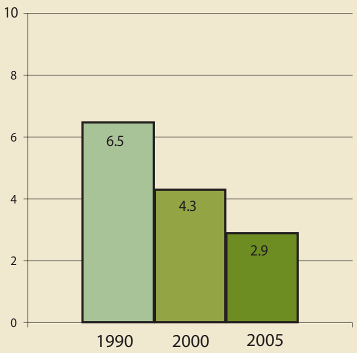
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goals 7 Indicators

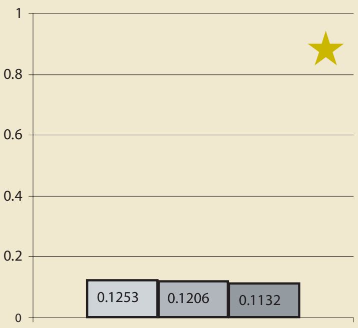
Deforestation and decreasing access to sources of clean water are environmental concerns in Comoros. Population growth has increased the demand for firewood, threatening the remaining forest areas.

★ Indicates progress

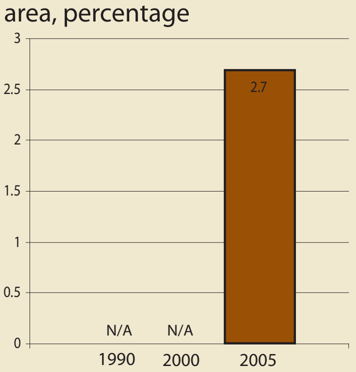
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

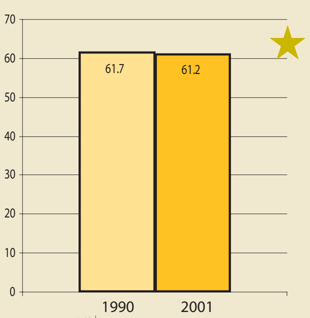


Protected area to total surface area, percentage

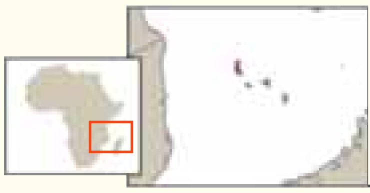


Proportion of total population using improved drinking water sources and sanitation facilities, percentage

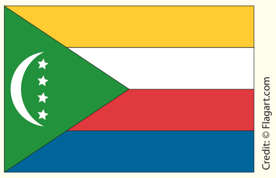
Slum population as percentage of urban



Union of the Comoros



Total Surface Area: 2 235 km²
Estimated Population in 2006: 798 000



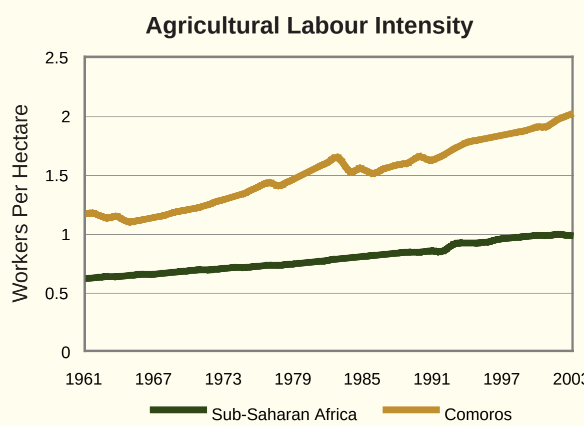
The Union of the Comoros comprises four islands located at the entrance to the ocean channel separating Madagascar from the eastern African coast. The islands are of volcanic origin and the largest of the four, la Grande Comore, has an active volcano known as la Karthala. The climate is generally tropical with two distinct seasons and an average of 900 mm of rainfall per year. With 377 inhabitants per square kilometre, it is one of the most densely populated countries in Africa (UNESA 2006, FAO 2007).

Important Environmental Issues

- Deforestation and Soil Erosion
- Threats to Coastal Ecosystems

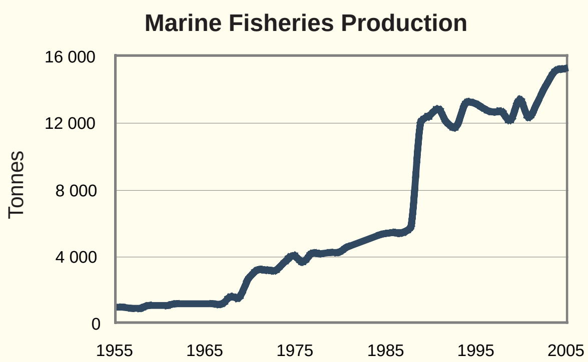
Deforestation and Soil Erosion

Between 2000 and 2005, Comoros experienced the highest rate of deforestation in Africa: 7.4 per cent per year (UN 2007). Once heavily forested, Comoros' denuded slopes and fragile soils are now prone to severe soil erosion and desertification. Charcoal production and slash-and-burn agriculture are major threats, particularly in light of rapid population growth measured at over 2.5 per cent per year (UNESA 2005). All potentially arable land is already in use, meaning that additional agricultural land is created at the expense of remaining forests (CBD 2007). In 2004, agriculture accounted for nearly three-quarters of employment and over 40 per cent of GDP (FAO 2007).



Source: FAOSTAT

Threats to Coastal Ecosystems

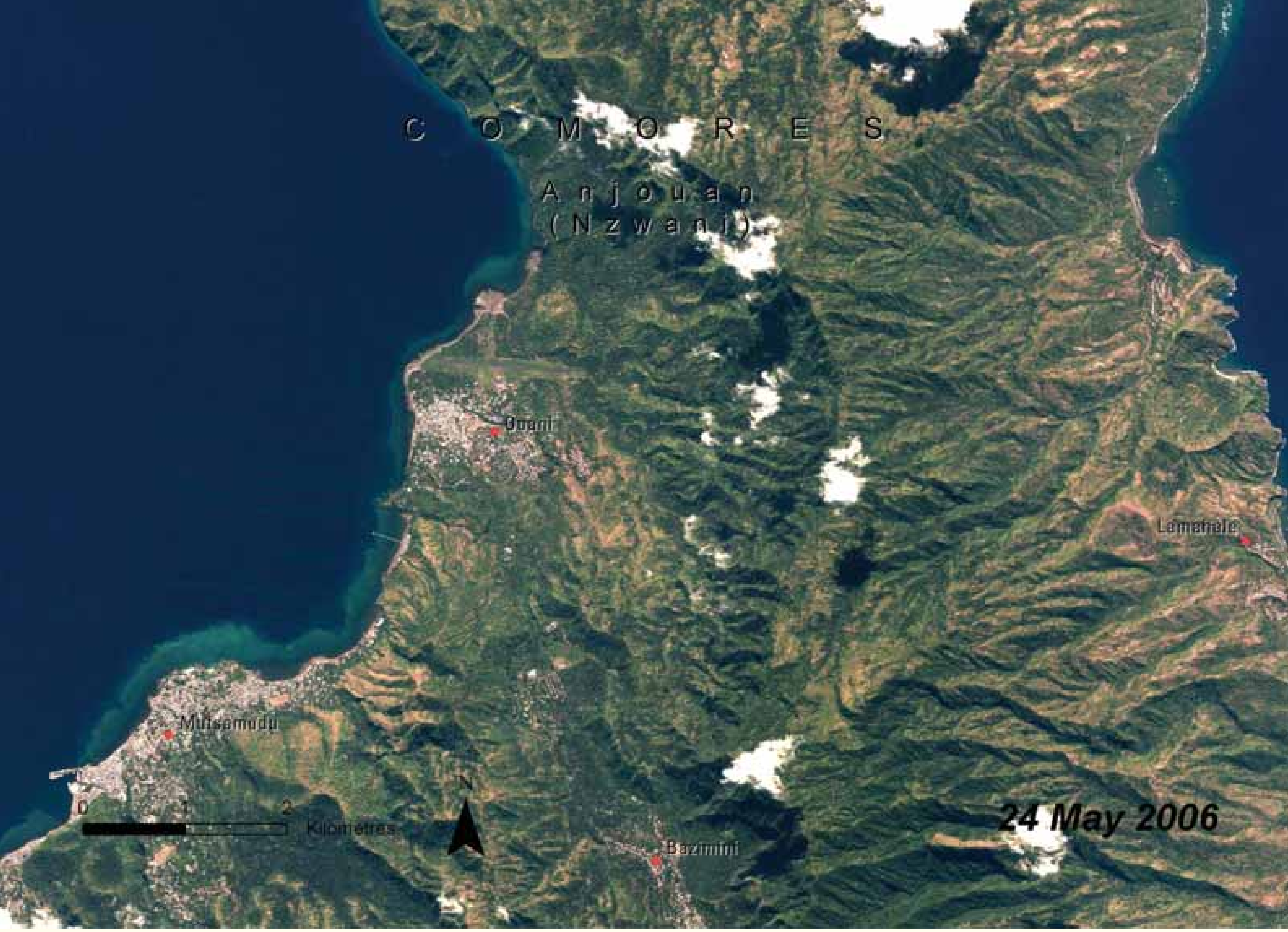


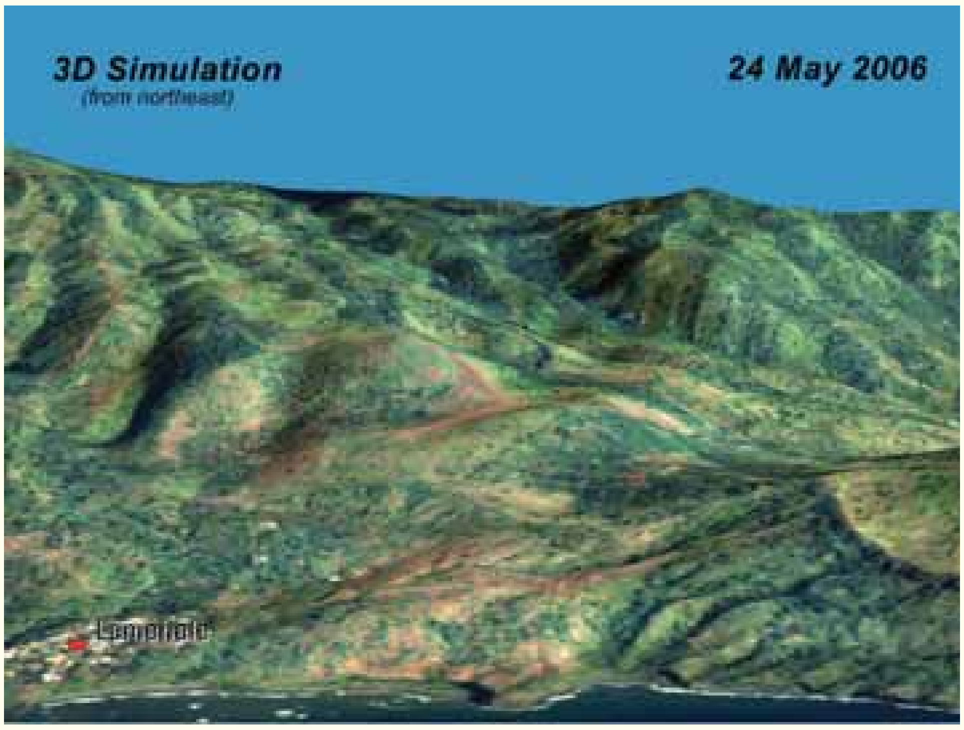
Source: FISHSTAT

Comoros possesses 430 km² of coral reef (UNEP-WCMC 2001), an area equivalent to one-fifth of the nation's total land area. Fishing directly employs over 8 000 people (FAO 2000-2007) and is an important economic and subsistence activity, but it is almost entirely artisanal in nature. The use of dynamite, poison, and other destructive fishing techniques has caused some reef degradation, but corals are also threatened by increased siltation resulting from coastal erosion. Due to the near-shore concentration of fishing activities, localised over-harvesting of Comoros' limited fisheries is also a problem (FAO 2000-2007).

Comorian waters harbour the coelacanth, a rare, primitive fish once thought to have been extinct for 65 million years.

nationsencyclopedia.com (2007)

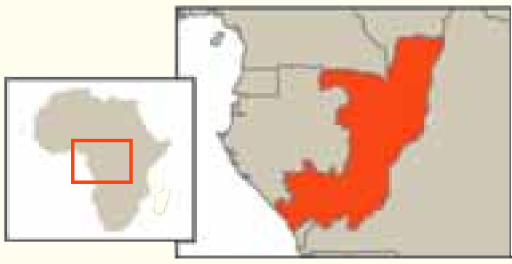




Agriculture and Erosion: Anjouan Island, Comoros

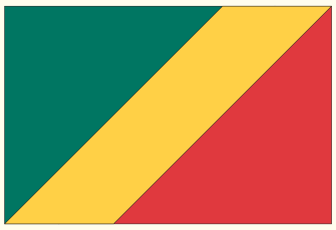
Comoros' population quadrupled between 1950 and 2000. On Anjouan Island, where population density of is 446 people/km², agricultural land is in short supply and many areas of steep terrain not suitable for agriculture have nevertheless been cultivated. Traditional agriculture leaves many trees in the fields, which help control soil erosion. However, pressure for food production is leading to more open field agriculture and some monoculture farming on the island of Anjouan. These more intense methods of agriculture encourage soil erosion.

The large image above shows Anjouan's fragmented forest. The reddish yellow areas on the simulated 3-D images show agricultural lands on Anjouan's slopes. As a whole, Comoros lost about 60 per cent of its forest cover between 1950 and 1985.



Republic of the Congo

Total Surface Area: 342 000 km²
Estimated Population in 2006: 4 117 000



Credit: © Flagart.com

Republic of the Congo is a tropical country with ample precipitation, receiving an average of 1 600 mm of rain per year. Nearly three-quarters of the country lies within the Congo River basin, where ground and surface water resources are some of the most abundant in Africa. Approximately 70 per cent of Republic of the Congo's 4.1 million inhabitants live in its two main cities, Brazzaville and Pointe-Noire, and in the towns and villages along the railroad connecting them.

Important Environmental Issues

- Wildlife Poaching
- Threats to Coastal Ecosystems and Inland Wetlands
- Deforestation

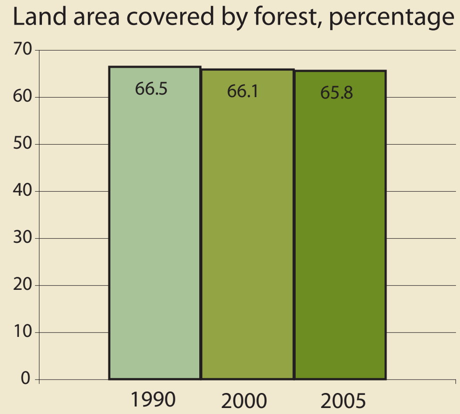
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

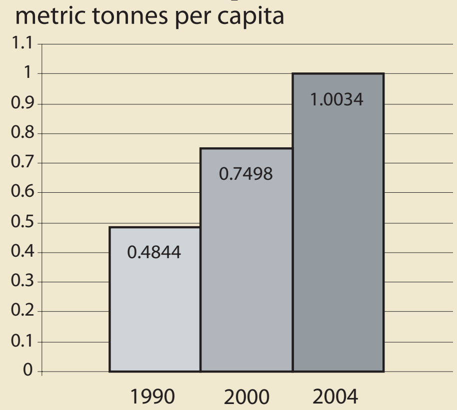
The most significant environmental problems in Republic of the Congo are deforestation of Africa's second-largest block of tropical rain forest, increasing slum populations, and the lack of protection for wildlife (which for the period of 1990-2005 has shown signs of improvement). The country enjoys remarkable biodiversity for its size—it is home to 597 species of birds, 166 mammals, 58 amphibians, 149 reptiles, and more than 6 000 species of plants.

★ Indicates progress

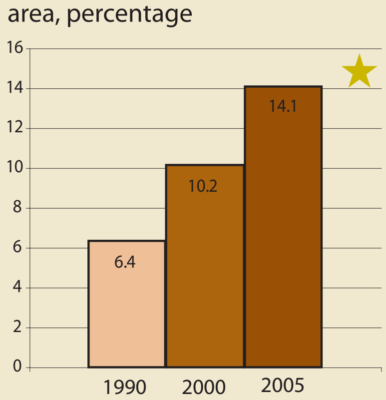
Land area covered by forest, percentage



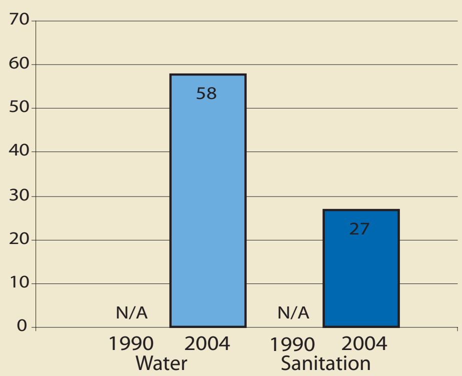
Carbon dioxide (CO_2) emissions, metric tonnes per capita



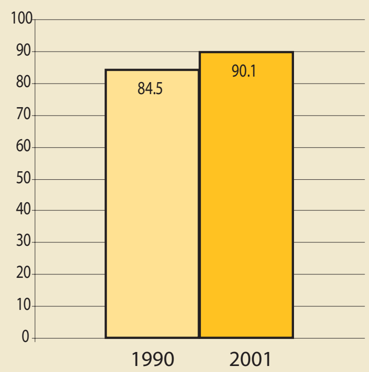
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



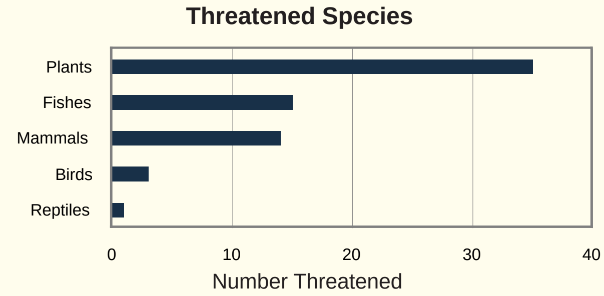
Republic of the Congo is second only to Democratic Republic of the Congo in terms of tropical rain forest coverage among African countries.

rainforests.mongabay.com (2007)

Wildlife Poaching

To conserve its unique and endangered wildlife, which include elephants, chimpanzees, and alligators, Republic of the Congo has designated 14 per cent of its land as protected areas. However, illegal poaching for bushmeat and ivory, driven by both domestic and international demand, remains an enormous threat to wildlife.

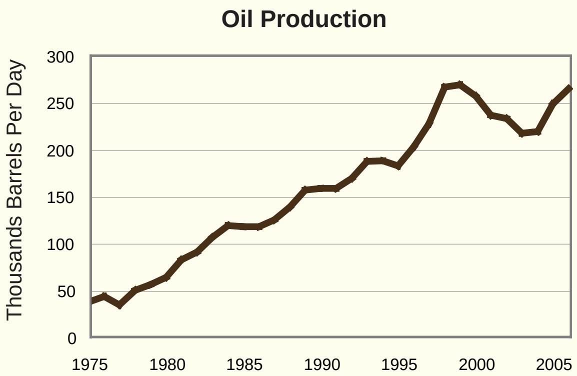
Poaching is facilitated by the expansion of logging roads into previously remote forests. Some 6 000 km of new logging roads have been constructed during the last 30 years (Laporte and others 2007), threatening the country's estimated 17 000 forest elephants, which constitute one of the largest elephant populations left in Central Africa (Blanc and others 2007).



Source: IUCN Red List

Threats to Coastal Ecosystems and Inland Wetlands

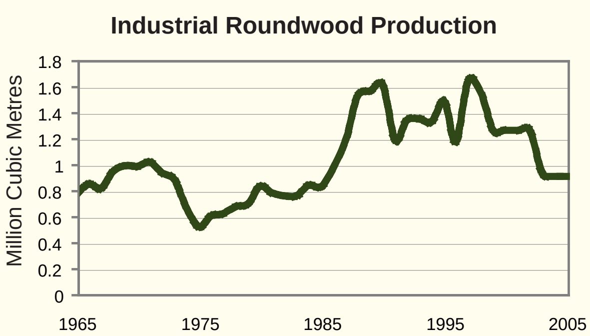
Wetlands and seasonally flooded areas cover approximately one-fifth of Republic of the Congo's surface area, serving as important stores of floral and faunal biodiversity and regulating river flow (FAO 2005). Inland, these regions include swampy forests and large savannah floodplains, which are threatened by logging, mining, and agricultural activities. On the coast, wetland resources include mangroves and brackish lagoons. Pollution from off-shore oil production is a significant threat to coastal ecosystems. The country is sub-Saharan Africa's fifth-largest oil producer with proven reserves of 1 500 million barrels (EIA 2007).



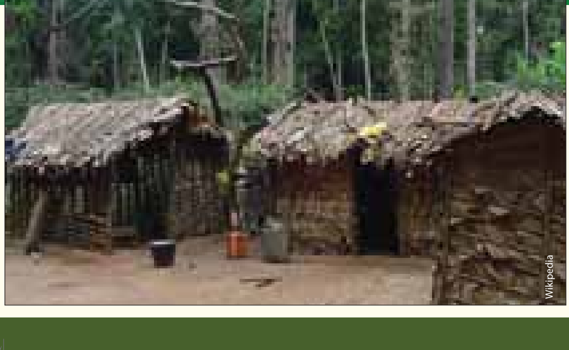
Source: BP Statistical Review of World Energy 2007

Deforestation

The Republic of the Congo is one of the most heavily forested countries in Africa, with forests covering roughly two-thirds of its land. Over half of this area has been opened to logging through timber concessions (CARPE 2006). While the majority of logging occurs as selective harvests that target only the most valuable species, the industry still contributes to forest degradation and loss of biodiversity (FAO 2003). Fuelwood harvesting and slash-and-burn agriculture also drive deforestation.

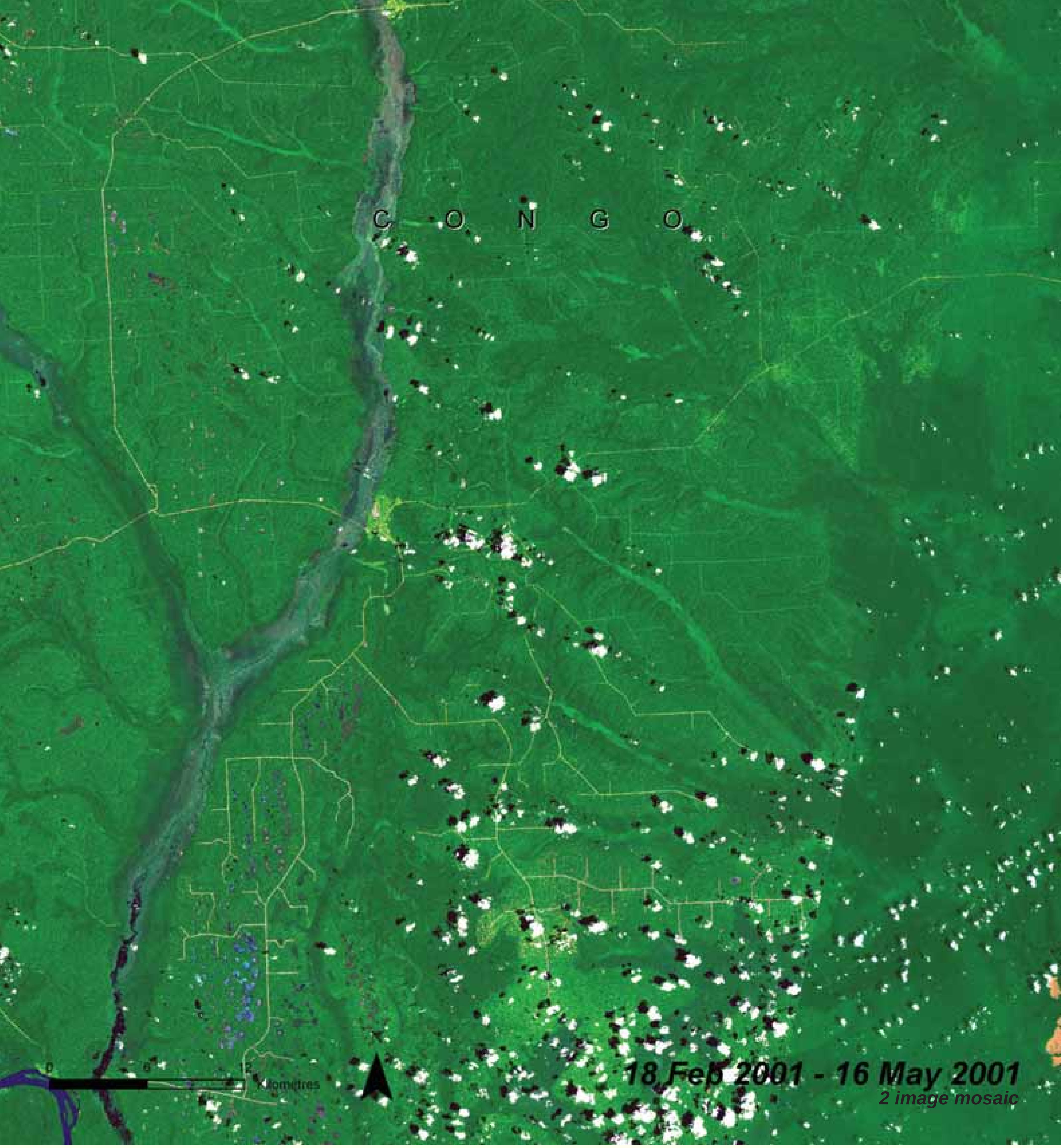


Source: FAOSTAT



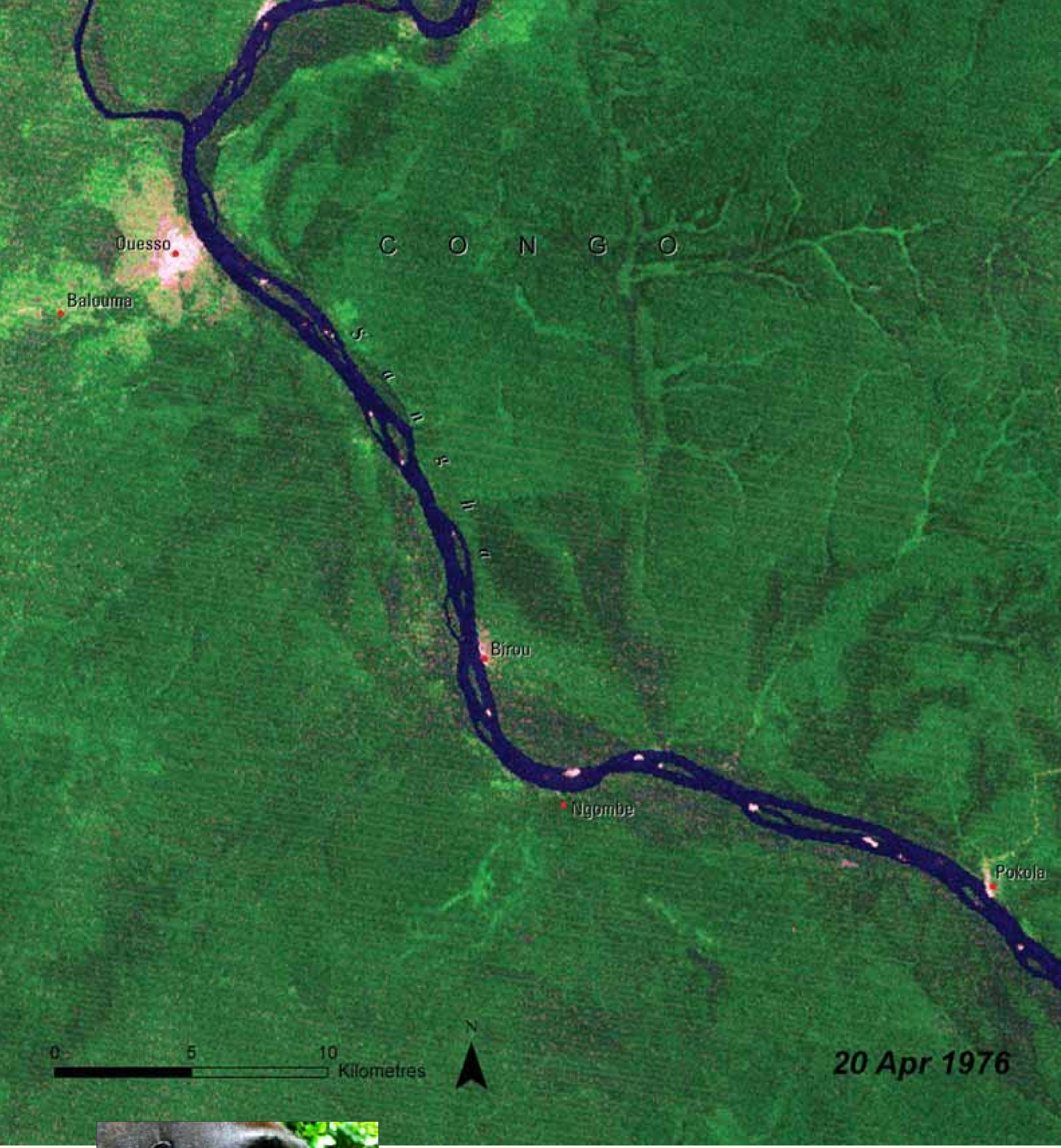
Logging Roads in the Rain Forest: Congo

In the dense tropical rainforest of sparsely populated northeastern Republic of the Congo, large tracts of relatively intact forest support a high concentration of biodiversity—including several large mammal species, approximately 1 700 plant species, 428 bird species, and many fish species. These forests play an important role in regulating local rainfall and climate. Tropical rain forests also absorb large amounts of carbon dioxide, a major greenhouse gas.



The 1976 image shows a large intact tract of humid tropical forest. By contrast, the 2001 image shows an extensive network of logging roads. The associated felling and removal of logs are causing considerable damage to the forest. The roads also provide access for bushmeat hunters and farmers into previously remote, intact forest. This has led to extreme over-hunting of vulnerable species including western lowland gorillas, elephants, and leopards.

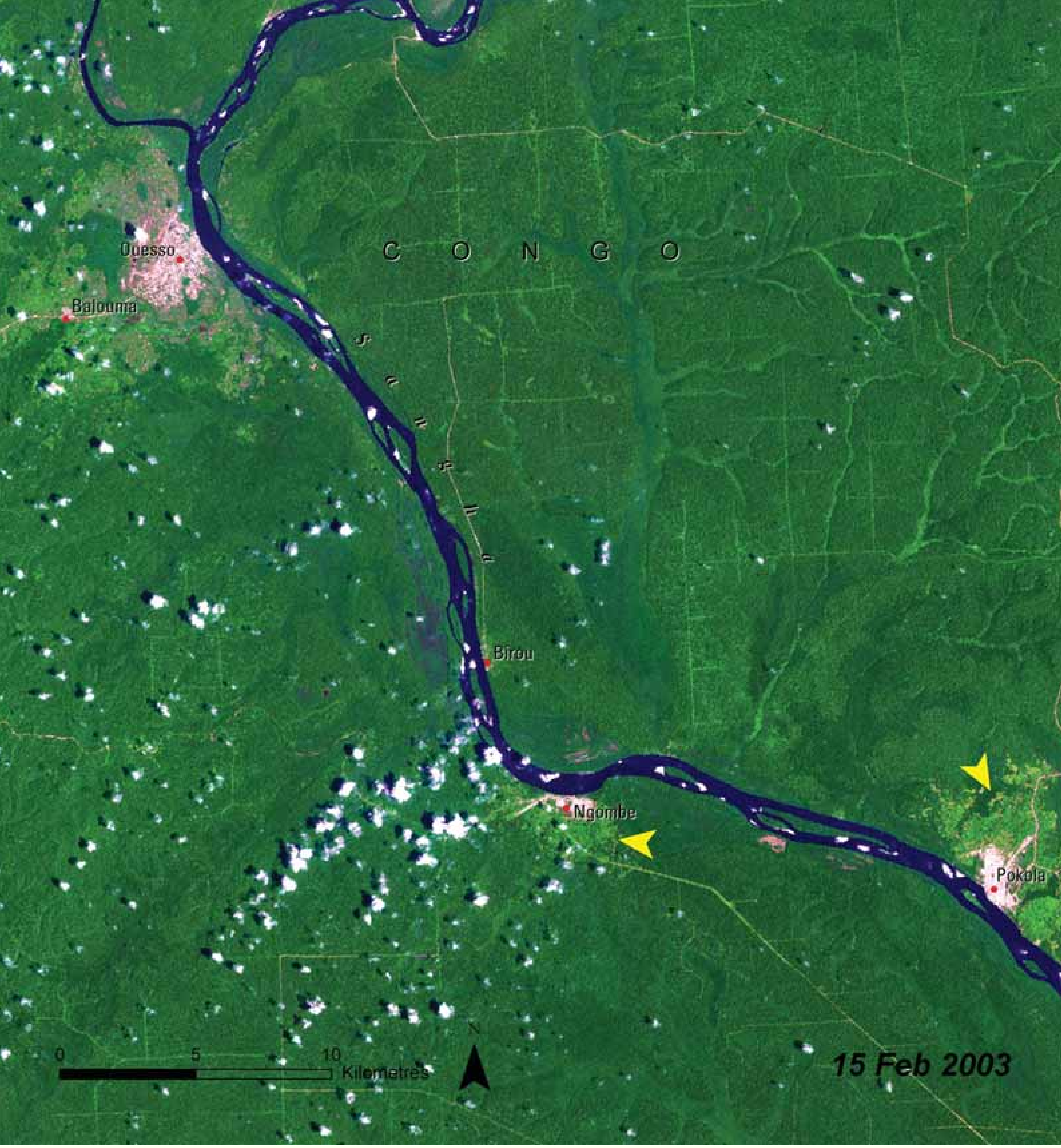
Global demand for timber is expected to encourage substantial deforestation in the long term. If this deforestation triggers a landscape-scale transition from forest to woodland or savannah, the consequences for biodiversity and climate would be catastrophic.



Bushmeat on the Roads: Ouesso, Congo

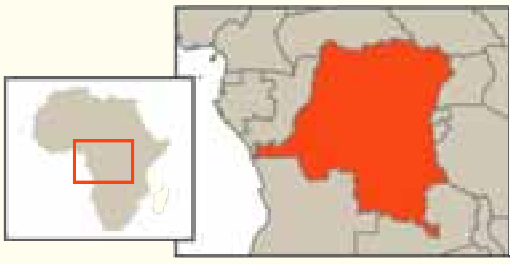
Ouesso, the largest town in northern Republic of the Congo with roughly 25 000 people, is surrounded by relatively intact tropical rain forests with a range of fauna including elephants, gorillas, chimpanzees, and bongos. Bushmeat accounts for the vast majority of protein in the diet of local people. Hunters largely ignore laws governing the taking of wild game; the harvest is only limited by accessibility and technology.

Inaccessibility of the area around Ouesso has also limited timber exploitation. Of seven companies logging in the area in the 1990s, four went bankrupt under the burden of high



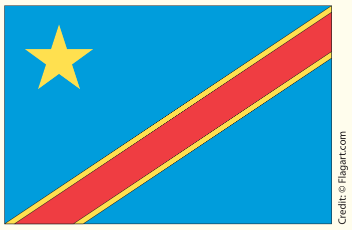
transportation costs. However, the area's inaccessibility appears to be changing. In the 1976 image few roads are visible and towns in the area are quite small, with little visibly disturbed forest surrounding them. By 2003, roads have penetrated throughout the area, towns have grown significantly, and, particularly near Pokola, the area of disturbed forest has grown (yellow arrows).

Logging roads, vehicles, and increased job opportunities have been shown to dramatically increase the range in which bushmeat hunting takes place. It also changes hunting from a subsistence activity to a commercial activity with meat being transported as far away as Brazzaville. There is a proposal to build an Ouesso-Brazzaville rail line. Improved transportation at lower cost would likely bring more roads, increased logging, and further increase in the bushmeat trade.



Democratic Republic of the Congo

Total Surface Area: 2 344 858 km²
Estimated Population in 2006: 59 320 000



Democratic Republic of the Congo (DRC) is the third-largest country in Africa. Dense tropical forests and sweeping savannahs each cover approximately one-half of this biologically rich nation. The DRC contains roughly 30 large rivers—including the entire length of the Congo River—which is the second-longest river in Africa, and has the second-largest flow of any waterway in the world. High, glaciated peaks are found along the ridges of the Great Rift Valley in the extreme eastern zone.

Important Environmental Issues

- Wildlife Poaching
- Deforestation
- Mining and Ecosystem Degradation

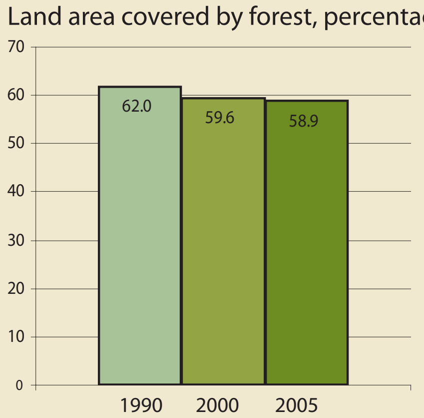
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

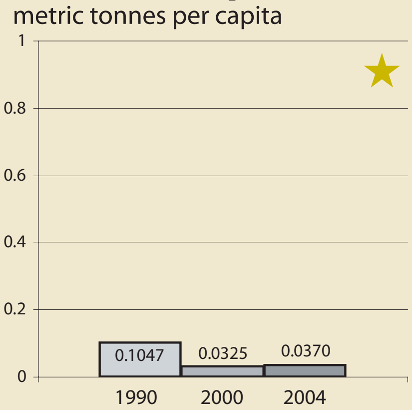
About 45 per cent of the DRC is covered by primary rain forest, which provides a refuge for several large mammal species driven to extinction in other African countries. Overall, the country is known to have more than 11 000 species of plants, 450 mammals, 1 150 birds, 300 reptiles, and 200 amphibians. Home to the greatest extent of tropical rain forest in Africa, deforestation caused by agricultural activity and the national dependence on fuelwood is evident.

★ Indicates progress

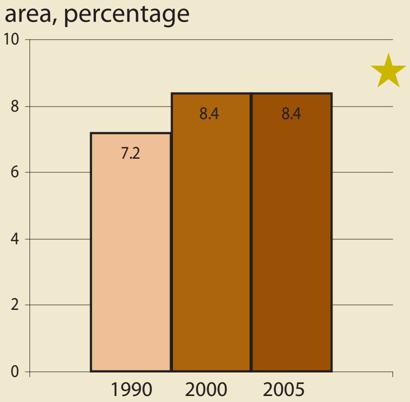
Land area covered by forest, percentage



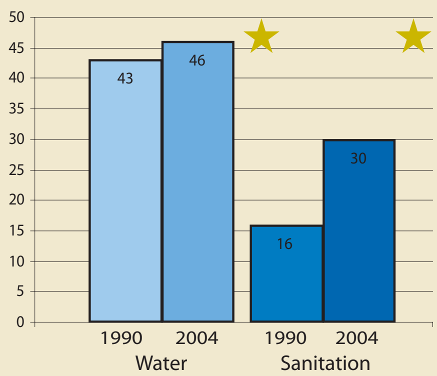
Carbon dioxide (CO_2) emissions, metric tonnes per capita



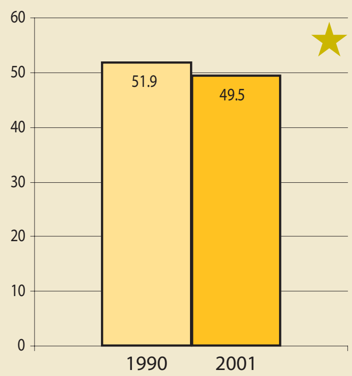
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



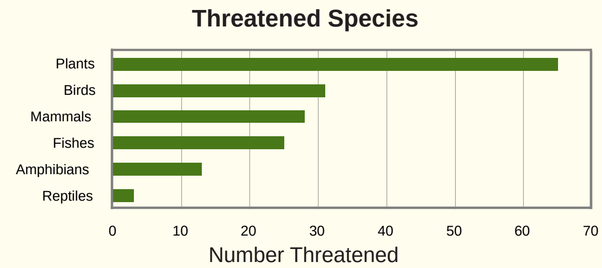
Salonga National Park, Africa's largest tropical rainforest reserve, is home to the bonobo (Pan paniscus), a small chimpanzee-like ape which is found only in Democratic Republic of the Congo.

whc.unesco.org (2008)

Wildlife Poaching

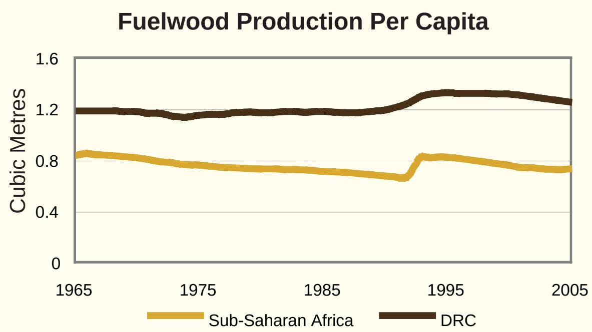
The forests and savannahs of Democratic Republic of the Congo support abundant and rare wildlife (UNEP-WCMC 2004). The DRC is home to more types of great apes than any other country on Earth, including the critically endangered lowland eastern gorilla and the bonobo.

Poaching is an issue throughout Central Africa, although the situation is perhaps most severe in the DRC, where armed conflict, widespread poverty, and illegal mining all contribute to the problem. In Virunga National Park, hippopotami have been poached almost to local extirpation, even though their numbers were estimated at 30 000 only three decades ago (Owen 2006).



Source: IUCN Red List

Deforestation

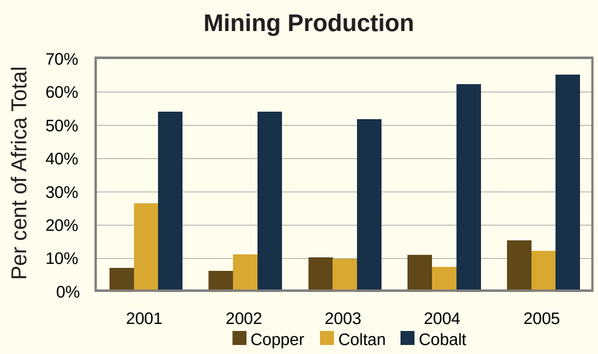


Source: FAOSTAT database

Democratic Republic of the Congo is nearly 60 per cent forested and alone accounts for one-fifth of Africa's total forest area (FAO 2003). Much of this forest is relatively undisturbed, making it an ecosystem of global importance. But many areas are threatened by fuelwood collection, agriculture, and logging. As a result of these activities, the DRC has lost nearly two million hectares of forest since 2000, which is the fifth-highest total in Africa (FAO 2005).

Mining and Ecosystem Degradation

The DRC possesses substantial mineral resources, including diamonds, gold, copper, and columbite-tantalite, or coltan, a valuable metal used in electronics. Mining of these various deposits increases human activity in forest interiors, causing substantial degradation to surrounding ecosystems and increasing exploitation of forest resources such as wildlife and timber. Coltan mining in Kahuzi-Biega National Park, for example, has been implicated in the precipitous decline of the lowland gorilla population, which now numbers less than 1 000 (Ecologist 2004).



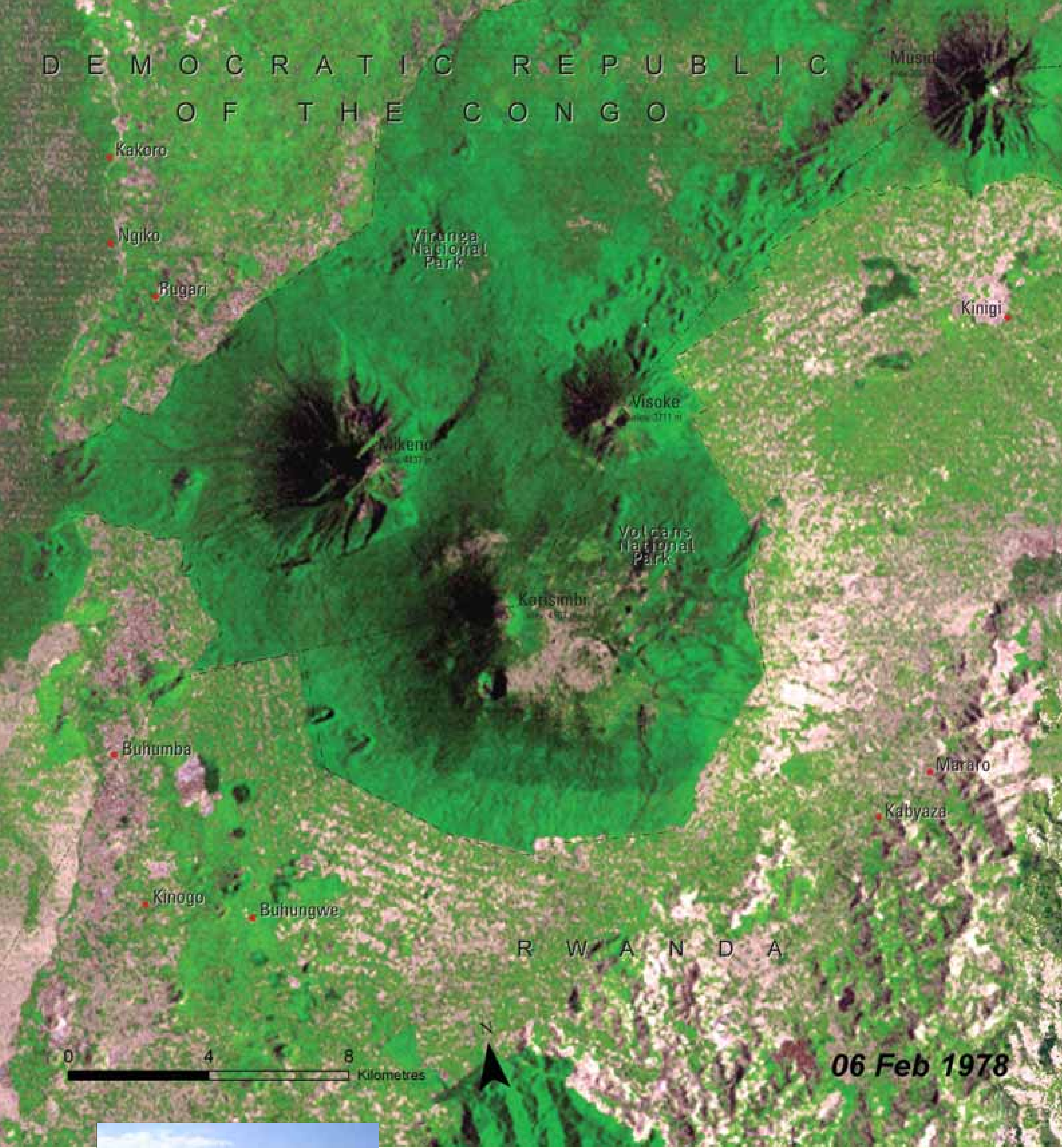
Source: USGS Mineral Summaries

Deforestation Surrounding Bumba: DRC

A pattern of deforestation concentrated along the local roads in the Nord-Ubangi and Mongala provinces of the DRC can be seen clearly in the 1975 image as loops of light green through the otherwise dense rain forest. In the 2003 image, these deforested corridors have widened, almost to the point of joining. Most of this deforestation is the result of agricultural conversion, fuelwood collection, settlement, and artisanal logging. Networks of logging roads can also be seen within two of the patches of largely intact forest in the lower right corner of the 2003 image.

While industrial logging has had a relatively small impact in the DRC in the past, it has recently become the most extensive form of land use in Central Africa. More than half of the area visible in these images is under logging concession. The selective logging practised by commercial logging companies has been shown to have long-lasting impacts on forest composition. Logging roads have been shown to significantly increase bushmeat hunting.

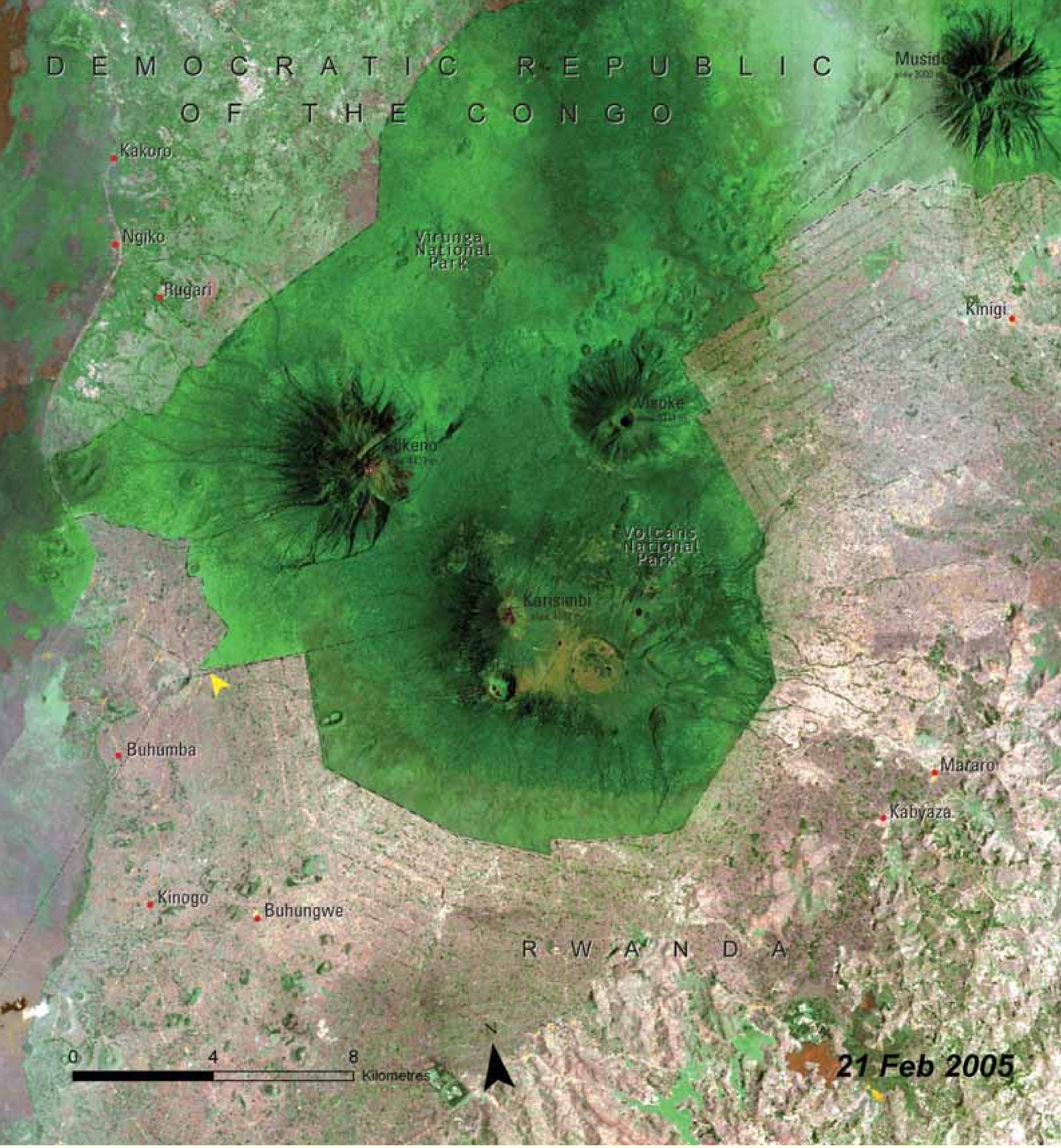
In addition to local and logging roads, a recent study for the World Bank suggests the road from Bangui, CAR, to Kisangani, DRC, be improved as part of a continental road network. The study shows that the network would increase trade on this route enormously. It also acknowledges concern that parts of the road network that would experience the greatest increase in trade correspond to areas with the highest biodiversity.



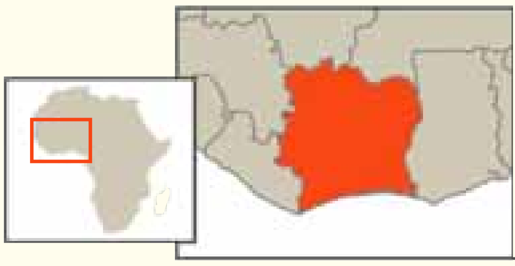
The Gorillas of Virunga National Park: DRC

The Virunga Park area is home to over half of the world's 700 surviving mountain gorillas (*Gorilla beringei beringei*). In an area approximately 40 km by 12 km with an elevation ranging from 2 300 to 4 507 metres there are a variety of ideal gorilla habitats including bamboo and montane forests.

The area includes Mgahinga National Park in Uganda, Volcans National Park in Rwanda and the Mikeno (Gorilla) sector of Virunga National Park in DRC. Surrounding these protected areas, however, are some of the densest human populations in Africa. In addition to population pressure, armed conflict in the region has made habitat and species protection very difficult.

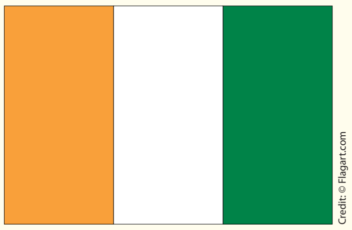


In the 1978 image, a line between the protected areas and the populated agricultural areas surrounding the parks is already apparent. While the boundary of the parks has remained largely intact since the mid-1970s, during the 1990s and early 2000s, large numbers of people moved into the area surrounding the parks, many of them refugees from armed conflict. A report by the Institut Congolais pour la Conservation de la Nature documented a large coordinated influx of people from outside the area in May and June of 2004. The report estimated that 15 km^2 of land at the west edge of the Park (yellow arrow) were deforested during this time. The decline in areas of green outside the protected areas suggests that few fallow fields and little natural vegetation remain—a sign of the agricultural intensity in this area.



Republic of Côte d’Ivoire

Total Surface Area: 322 463 km²
Estimated Population in 2006: 18 454 000



Côte d’Ivoire is the western-most country bordering the Gulf of Guinea, with 515 km of coastline fringed by a network of large lagoons. A dense tropical rain forest in the south, once the largest in West Africa, covers over 30 per cent of the country. Soils are particularly fertile and agriculturally productive, even in the semi-arid savannahs to the north. Approximately 65 per cent of the country’s land is suitable for cultivation (FAO 2005).

Important Environmental Issues

- Deforestation
- Threats to Biodiversity
- Threats to Coastal Ecosystems

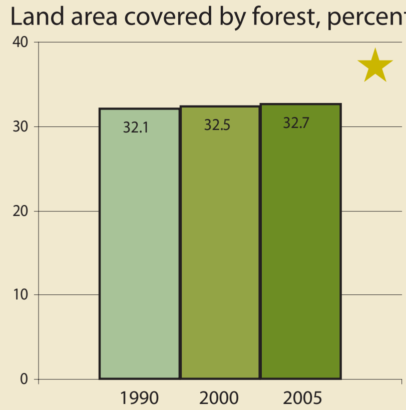
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

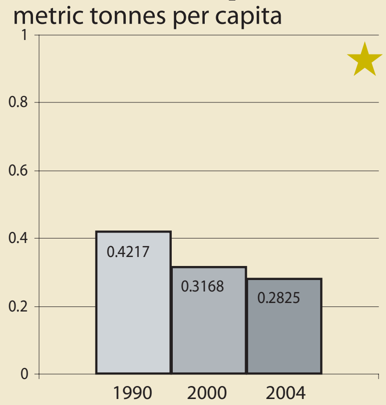
Water pollution is still a significant environmental problem in Côte d’Ivoire due to chemical waste from agricultural, industrial, and mining sources. Other than water pollution and an increase in the percentage of slum population, Côte d’Ivoire seems to be faring well in all other environmental indicators. Most of Côte d’Ivoire’s biodiversity occurs in the rugged interior region and not in the coastal regions as is the case in other parts of West Africa.

★ Indicates progress

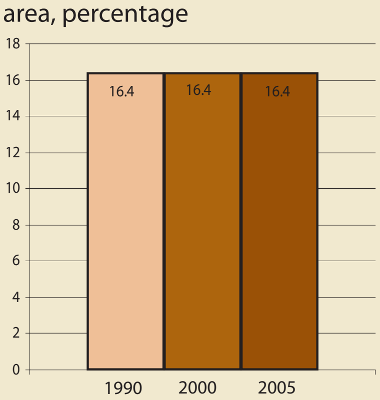
Land area covered by forest, percentage



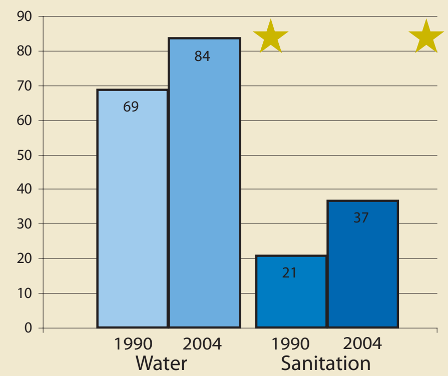
Carbon dioxide (CO_2) emissions, metric tonnes per capita



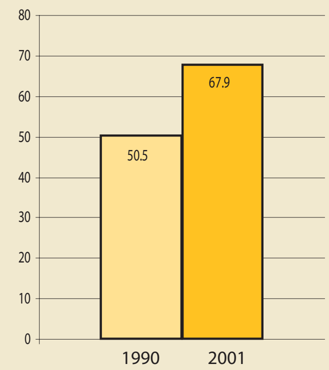
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



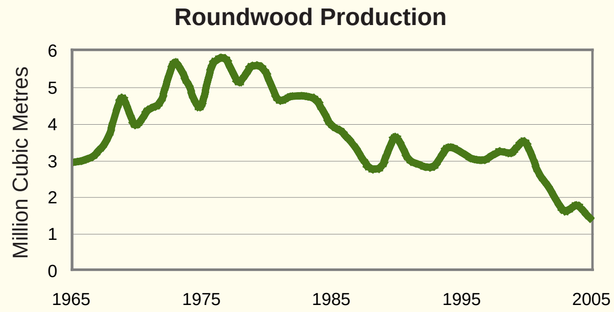
With over 1 200 animal species and 4 700 plant species, Cote d’Ivoire has the highest biodiversity of any West African country.

rainforests.mongabay.com (2007)

Deforestation

Since achieving independence in 1960, Côte d'Ivoire has lost roughly 40 per cent of its forest cover (Mongabay 2006). Although government policies have dramatically slowed the rate of deforestation since 1980, agricultural expansion and illegal logging for valuable tropical hardwoods continue to pressure the remaining primary forests, which account for only six per cent of the total forest area (Mongabay 2006).

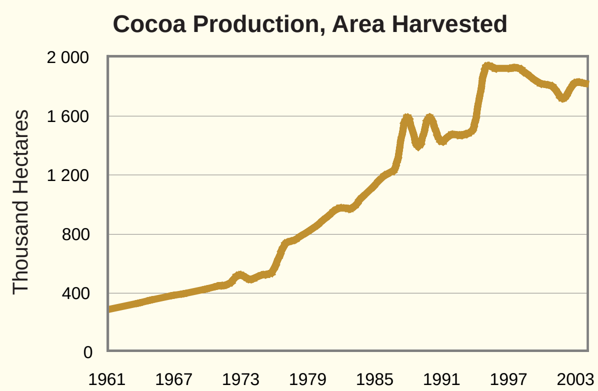
Côte d'Ivoire's Tai National Park is the single largest tract of undisturbed tropical rain forest in West Africa. The park contains some 1 300 species of higher plants, 150 of which are endemic to the Tai region, and several endangered primate species (UNEP-WCMC 1989). Primary threats include illegal poaching, logging, farming, and gold mining.



Source: FAOSTAT

Threats to Biodiversity

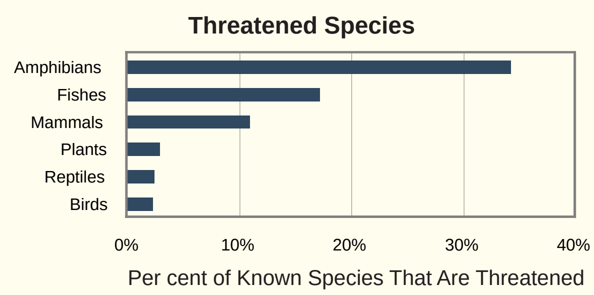
Côte d'Ivoire has the highest level of biodiversity in western Africa with over 1 200 animal species and 4 700 plant species. A total of 178 plant and animal species are currently threatened with extinction (IUCN 2007) due to deforestation, poaching, and destruction of natural habitats. In particular, cocoa farming has played a significant role in altering the natural landscapes that are important for the maintenance of biodiversity. High population growth and immigration have spurred farmers to increase use of fertilizers and pesticides and illegally expand plots into protected rain forests, where cocoa trees thrive in the hot, humid conditions.



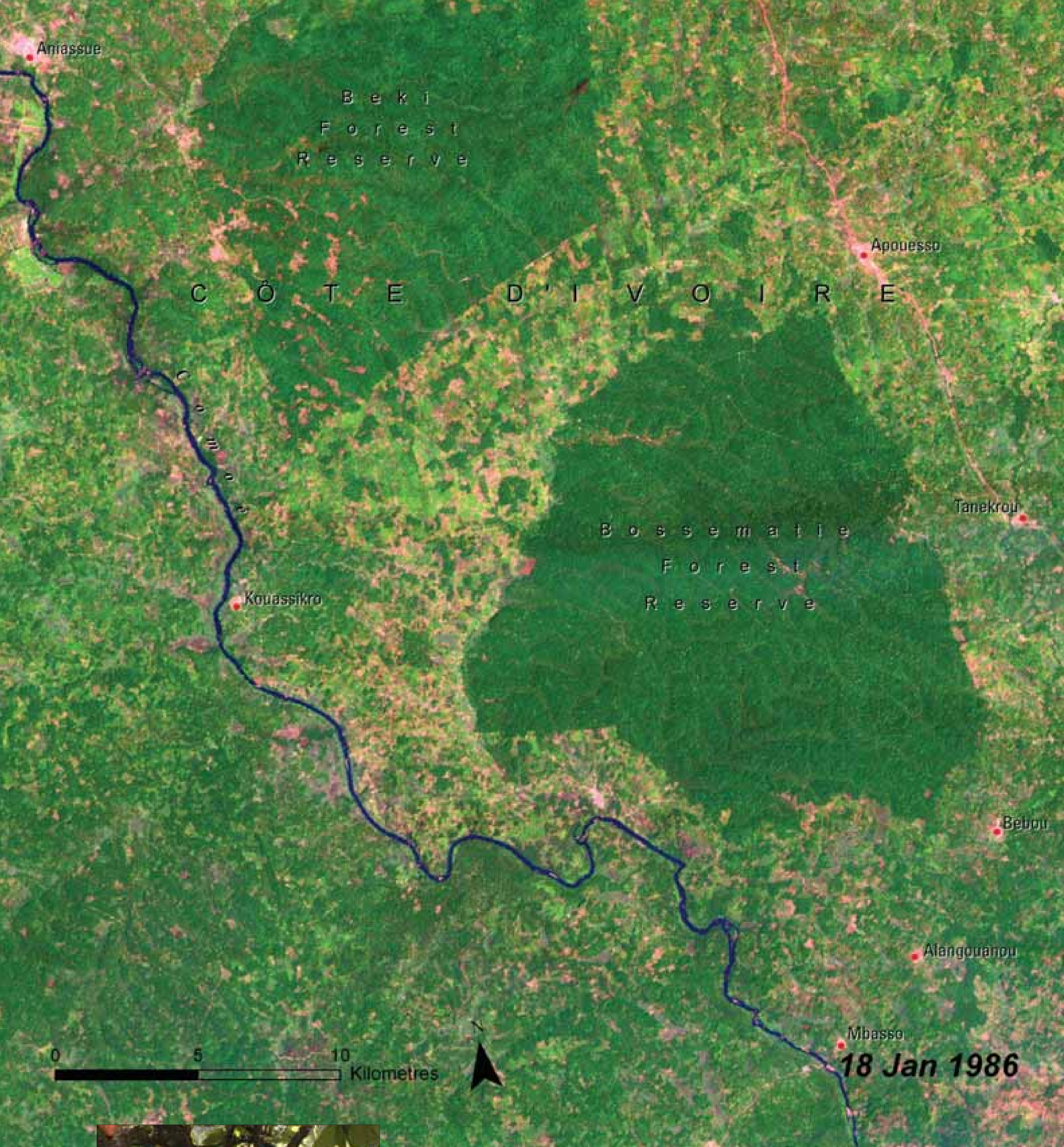
Source: FAOSTAT

Threats to Coastal Ecosystems

Côte d'Ivoire's coast has an impressive six sites designated as Ramsar Wetlands of International Importance, totaling 127 344 hectares (Ramsar 2005). The protected areas include large mangrove forests and are biologically noteworthy for wildlife, including chimpanzee, forest elephant, pygmy hippo, manatee, and five species of turtle. However, roughly 40 per cent of the country's population lives within 100 km of the coast (CIESIN 2000), where increasing pollution from sewage and industrial effluent is degrading aquatic ecosystems and development is leading to coastal erosion. The situation is particularly severe in the southwest near the major city of Abidjan.



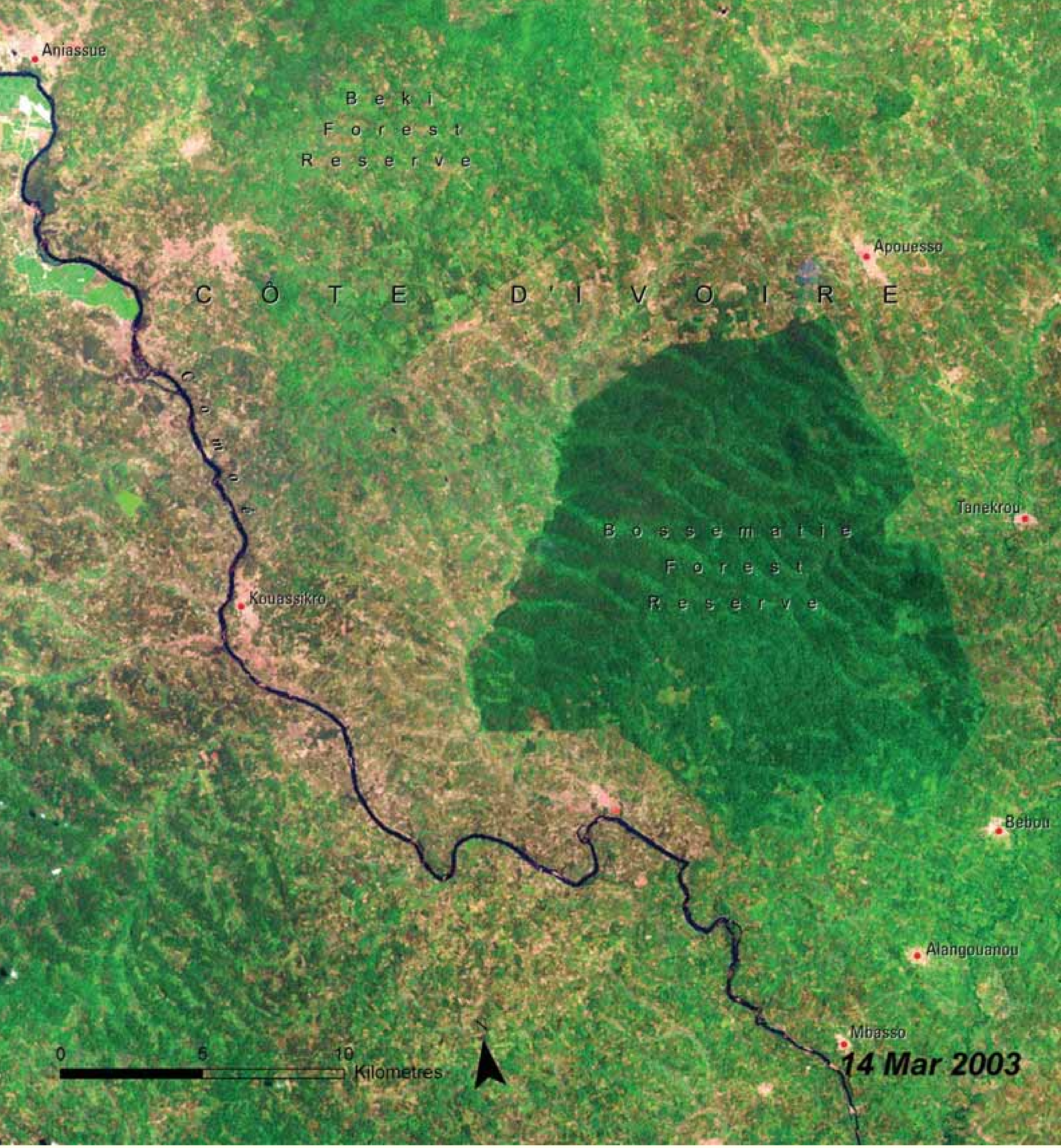
Source UNEP-WCMC 2004; IUCN Red List



The Loss of Beki Forest Reserve: Côte d'Ivoire

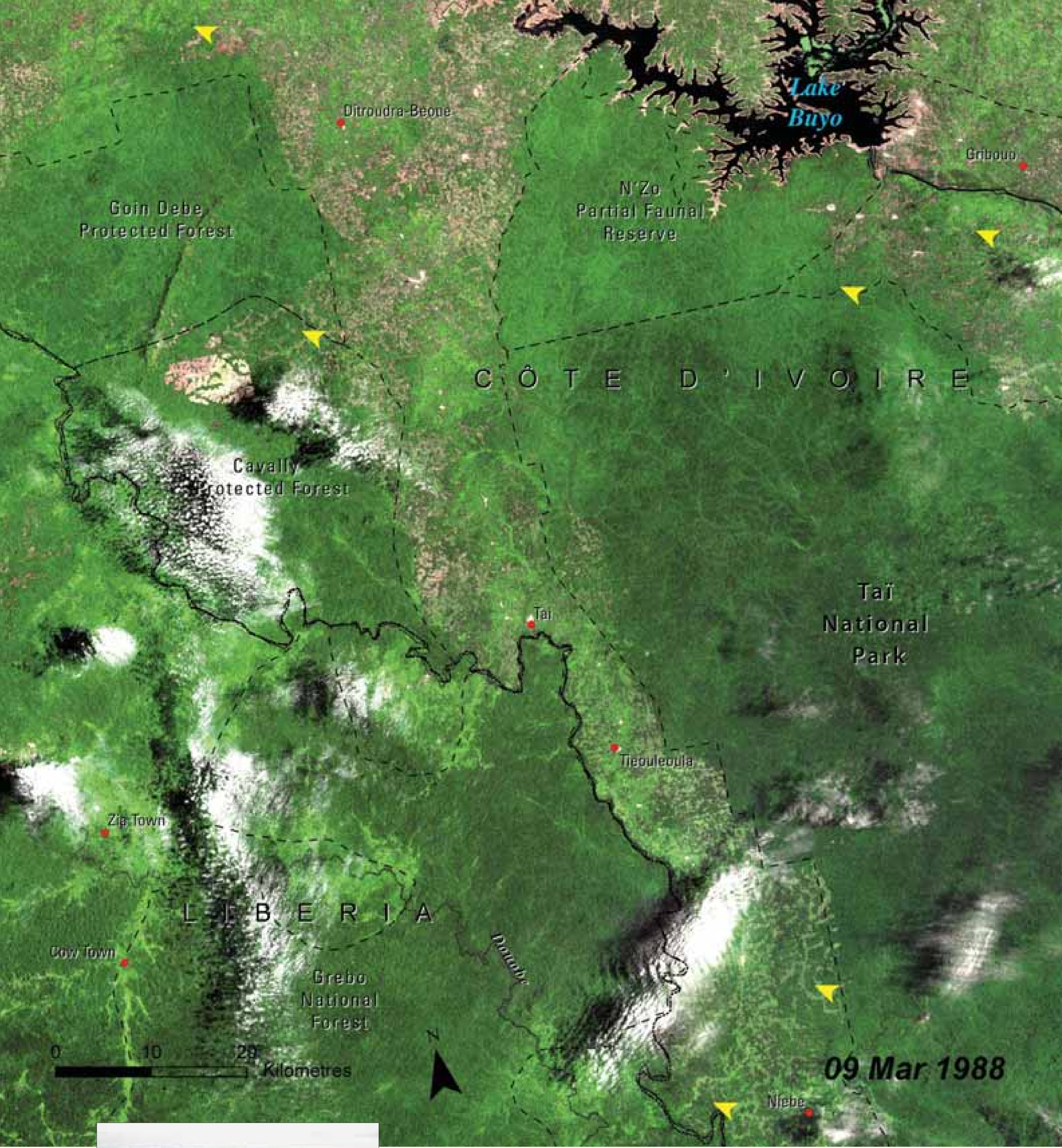
Located in southeastern Côte d'Ivoire, Beki Forest Reserve was one of 230 forest reserves established in the country in 1965. In 1971, Beki Forest Reserve covered 16 764 hectares. By 1986 its forested area had decreased by about one-fifth to 12 816 hectares. In 1995, less than one-third of the 1971 extent remained, representing an annual rate of loss around 4.5 per cent.

Much of this deforestation began in the 1980s when the government resettled two villages away from the Comoé River and adjacent to the Beki Forest Reserve. The villages had been afflicted with an outbreak of onchocerciasis (river blindness) carried by blackflies that live near



fast flowing water. To facilitate the village resettlements, authorities allowed the villagers to exploit land within the Reserve. Unfortunately, no limits were set on this authorized exploitation, and by the mid-1990s cultivation of cocoa and coffee covered much of the original forest area. In the images above, decimation of Beki Forest Reserve is apparent between 1986 and 2003, in contrast to the Bossematie Forest Reserve to the southeast.

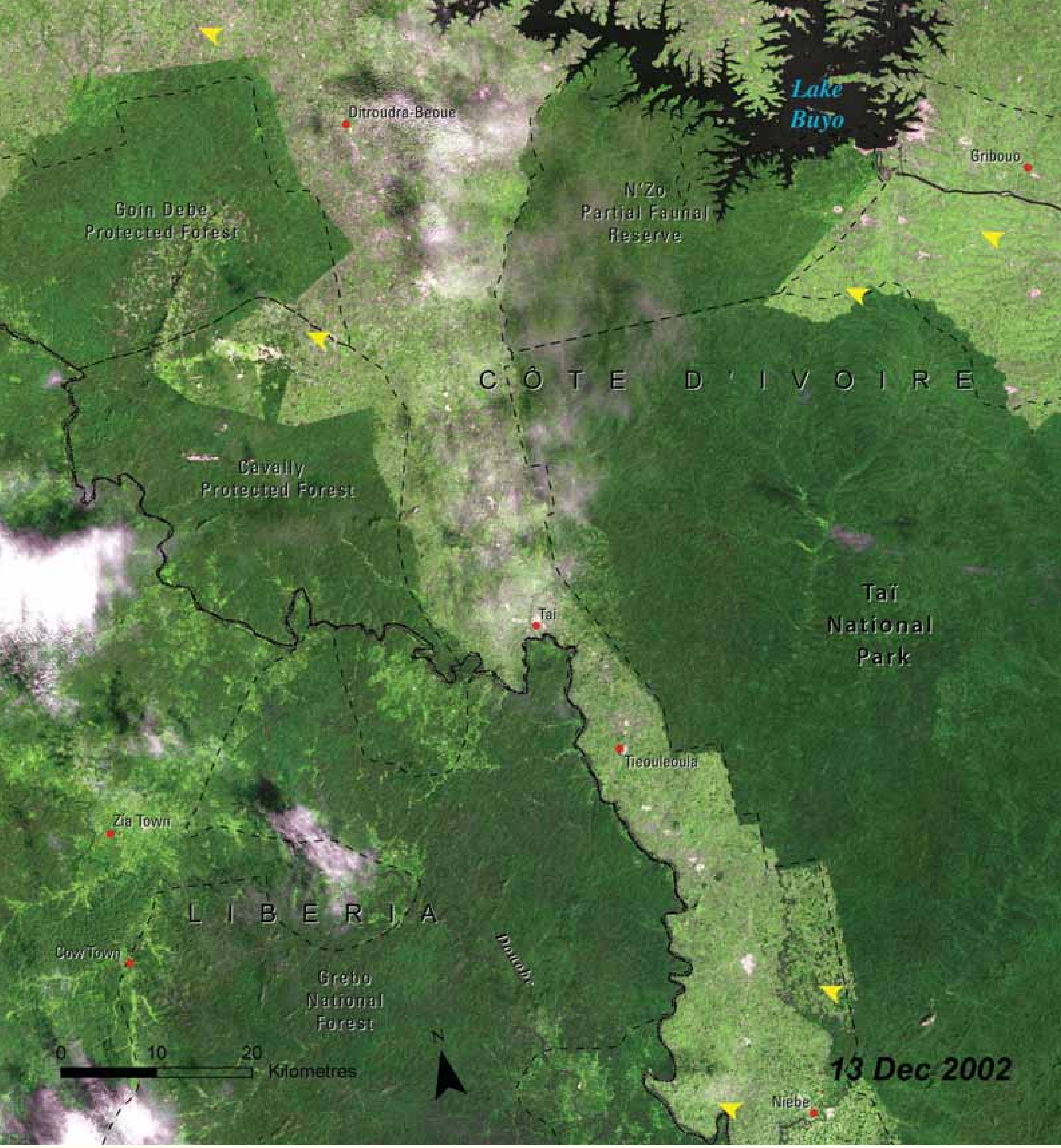
In Côte d'Ivoire, cocoa plantations currently cover two million hectares, and have caused the loss of a significant portion of the country's natural forests. Côte d'Ivoire produced 1.275 million metric tonnes of cocoa in 2004/2005. Coffee and cocoa generate 50 per cent of the country's total export revenues and one-third of the population depends on cocoa cultivation.



The Survival of Taï National Park: Cote d'Ivoire

Taï National Park, N'Zo Partial Faunal Reserve, and the Goin-Débé and Cavally Forest Reserves, are remnants of tropical rain forests that at one time stretched from Ghana to Sierra Leone. Taï National Park, the most pristine and heavily protected of these, contains some 1 300 plant species, over half of which are unique to the region's rain forests. Taï is also home to most of the large mammals that occur in the area, including the leopard (*Panthera pardus*), which is critically endangered.

The park was declared a forest and wildlife refuge in 1926 and more recently a National Park, a UNESCO Biosphere Reserve, and a World Heritage Site. This area was historically remote and



sparsely populated; however, roads built in the late 1960s brought periods of population influx. That population has converted most of the forest outside the protected areas to agricultural land, leaving only scattered fragments of forest. Much of this deforestation had already occurred before these images were taken; however several further areas of forest loss can be seen between 1988 and 2002 (yellow arrows).

While deforestation continues outside the protected areas, the Government of Côte d'Ivoire has maintained the Taï National Park's integrity and its core area remains in relatively good condition. The current concern within the park is commercial poaching, putting at risk all fauna, but duikers and primates in particular. Also, as these images make clear, the boundaries of the park are under increasing pressure from a growing population that is running out of unprotected land to farm.

Republic of Djibouti

Total Surface Area: 23 200 km²
Estimated Population in 2006: 807 000

Djibouti is the third-smallest country on the African continent. It has 443 km of coastline (Earth Trend 2007) at the junction of the Red Sea and the Gulf of Aden, which represents an important international shipping lane and a unique tropical marine ecosystem. The climate is mostly hot, dry desert—over 90 per cent of the country is classified as hyper-arid desert (FAO AGL 2003), and average temperatures range between 25 °C in winter and 35 °C in summer. Natural resources include geothermal energy and limited deposits of gypsum, copper, and other ores, which are currently not exploited.

Important Environmental Issues

- Water Scarcity
- Land Availability and Desertification
- Marine Resources and Pollution

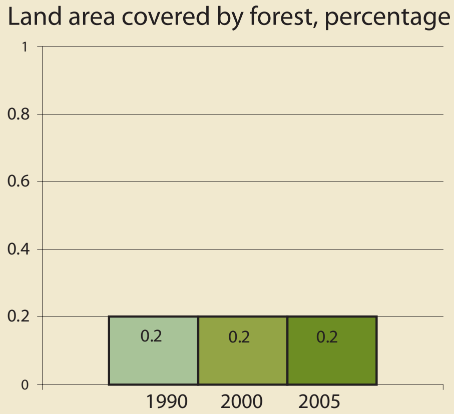
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

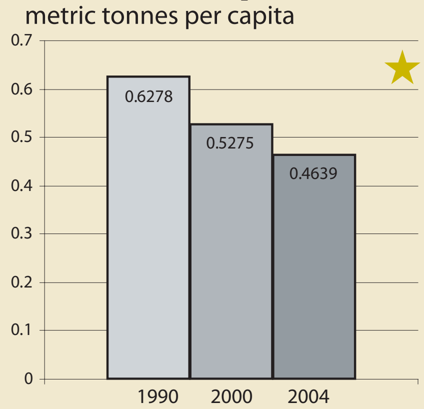
Less than one per cent of the country's total land area is forested. Djibouti's most significant environmental problems are inadequate supplies of potable water, limited arable land, and desertification. The climate is torrid, and rainfall is sparse and erratic; the limited water supply is further threatened by increasing salinity.

★ Indicates progress

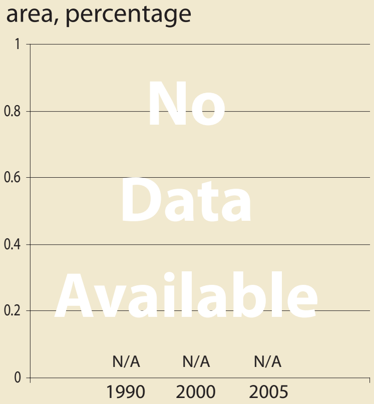
Land area covered by forest, percentage



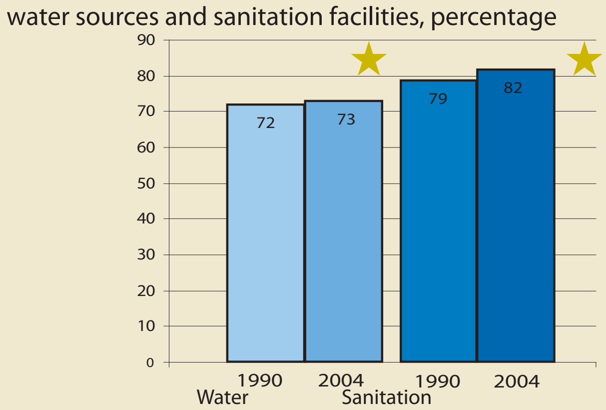
Carbon dioxide (CO_2) emissions, metric tonnes per capita



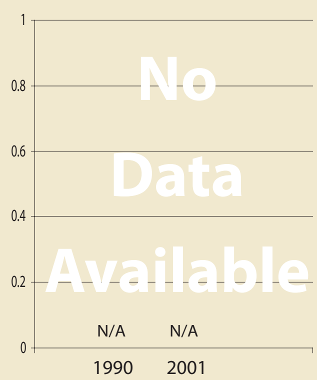
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

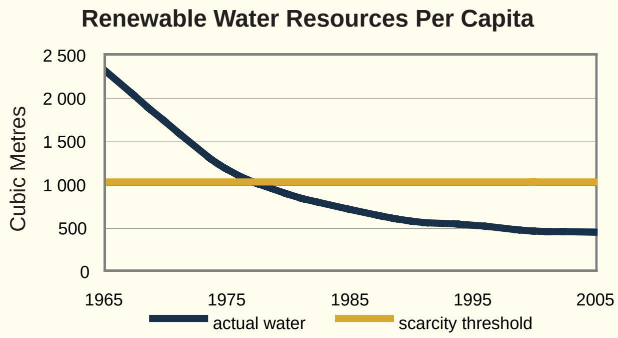


Djibouti's Lake Assal, at 156 m below sea level, is both the saltiest body of water and the lowest point in Africa.

Water Scarcity

Djibouti is well below the international water scarcity threshold with only 416 m^3 available per person per year (FAO 2007a). Erratic rainfall leads to frequent droughts and floods that regularly threaten food security and rural livelihoods. There are no permanent rivers or streams in the country, so groundwater is the primary water source. However, overexploitation is increasing groundwater salinity; a 2000 survey found that over half of the country's wells contain high salt concentrations (FAO 2005) due to the intrusion of sea water.

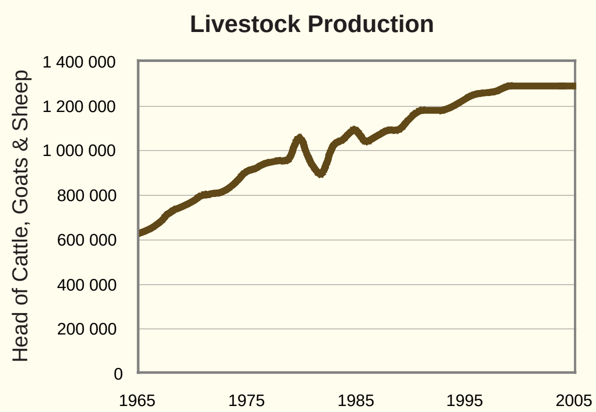
Population growth, measured at 1.61 per cent annually (UNESA 2005), exerts the greatest pressure on scarce water resources. Domestic water use accounts for 86 per cent of total withdrawals (FAO 2007a), which is the largest proportion of any African country.



Source: AQUASTAT

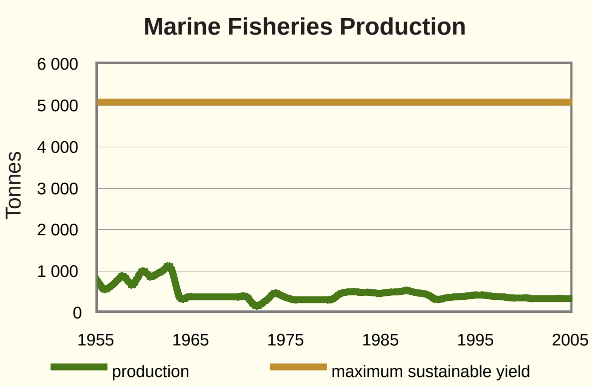
Land Availability and Desertification

Less than one per cent of land in Djibouti is arable due to poor soils and low rainfall. Over 50 per cent of land is permanent pasture (FAO 2007b), where water availability is the greatest constraint on livestock production and overgrazing contributes to land degradation and desertification. Pastoralists constitute 75 per cent of the total labour force (FAO 2007b), yet account for less than four per cent of GDP (World Bank 2006), reflecting the prevalence of rural poverty. Urban poverty is also pervasive; 83 per cent of the population lives in the country's capital and only urban area, Djibouti (UN 2006), where unemployment is over 50 per cent (USAID 2006).



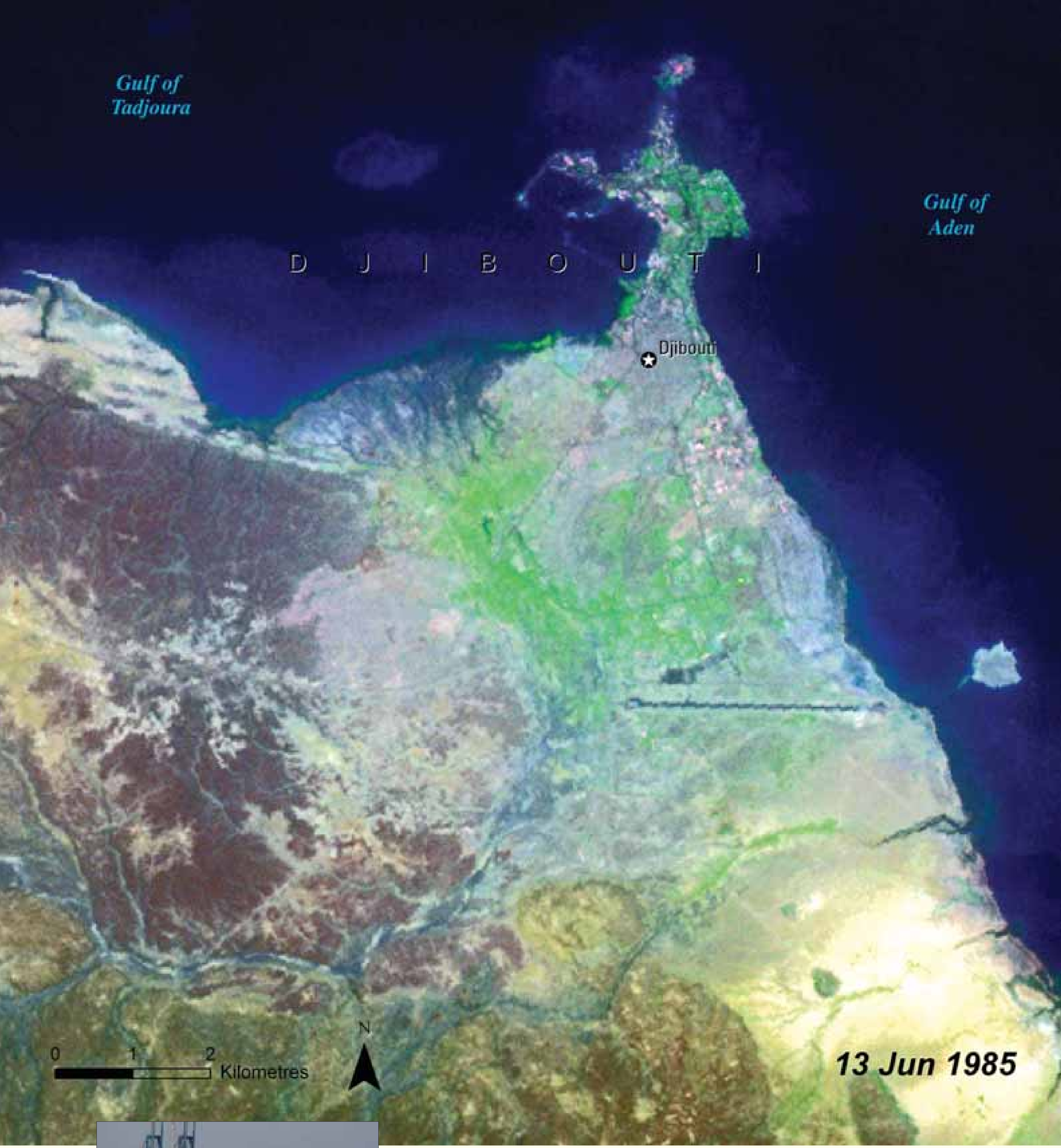
Source: FAOSTAT

Marine Resources and Pollution



Source: FISHSTAT

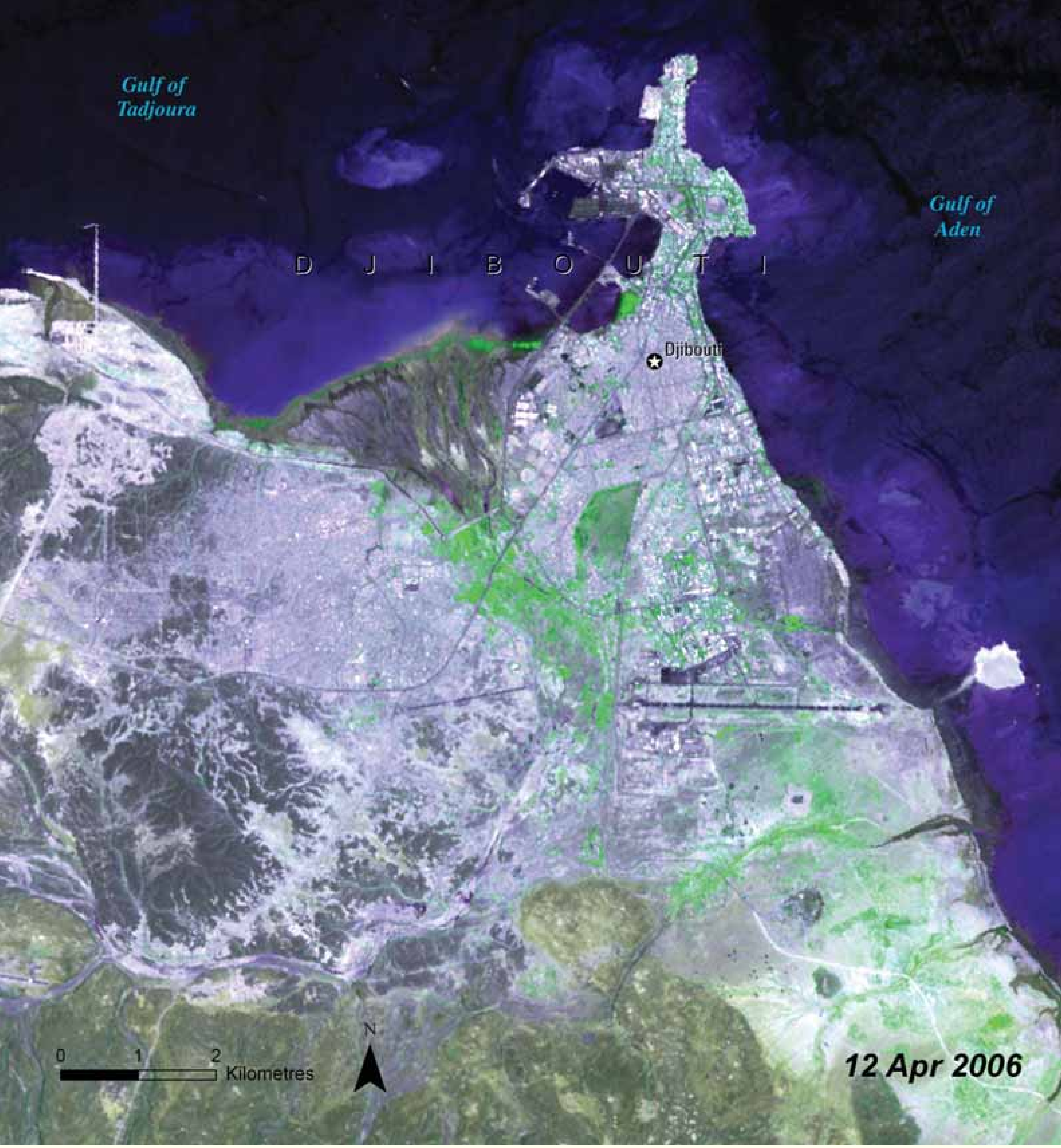
There are no large-scale fisheries in Djibouti, and most fishing occurs at the subsistence level. The maximum sustainable yield has been estimated at 5 000 metric tonnes of fish annually, although total catch remains at 350 metric tonnes per year (FAO n.d.). Although overfishing is currently not a threat to marine resources, coastal development, municipal waste discharge, and oil pollution from petroleum development and transport have degraded coastal ecosystems. Djibouti has designated two small marine protected areas to preserve its valuable coral reefs and coastal mangrove forests.



Rapid Population Growth: Djibouti, Djibouti

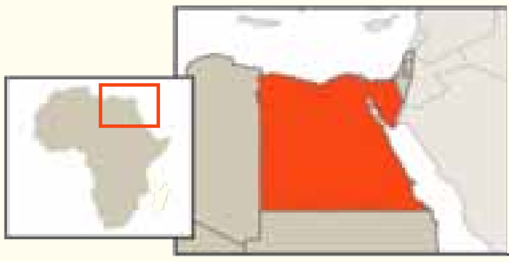
Nearly 85 per cent of Djibouti's population is urban, with the vast majority of urban dwellers living in the capital city, Djibouti. The city's population grew 10-fold between 1950 and 2002 and is projected to grow another 25 per cent, to 800 000 people by 2025. The city is poor by international standards, but its relative prosperity for the area has attracted migrants from rural Djibouti and surrounding countries.

The country of Djibouti has little arable land, little rainfall, and limited possibilities for irrigation. Because of this it imports 80 per cent of its food, mostly through the port of the



capital city. Droughts during recent decades and desertification exacerbated by overgrazing have reduced the viability of pastoral life. This, along with high rural water insecurity, has helped to drive many rural residents to villages and cities—many of them settling in the capital.

Water availability in the capital is better than in rural areas, but supply and sanitation are problems there as well; the rapidly growing population will make the supply issue worse. Improving access to water in the rural areas is a way to address poverty and health issues in the countryside and at the same time reduce the rural-to-urban migration that is straining the capital city's infrastructure. A recent partnership between the European Union, UNICEF, and Djibouti's Ministry of Agriculture should bring clean, safe water to 25 000 of Djibouti's poorest rural residents.



Arab Republic of
Egypt

Total Surface Area: 1 001 449 km²
Estimated Population in 2006: 75 437 000

Credit: © Flagart.com

Egypt consists of a large desert plateau, interrupted only by the Nile River Valley and Delta, which constitute less than five per cent of the nation's territory. Approximately 97 per cent of the population occupies these latter lands, reaching population densities of nearly 1 200 inhabitants per square kilometre (FAO 2005). Located strategically in the northeastern corner of Africa, Egyptian coasts border both the Mediterranean Sea and the Red Sea.

Important Environmental Issues

- Urbanisation and Pollution
- Soil Erosion and Land Degradation
- Threats to Biodiversity

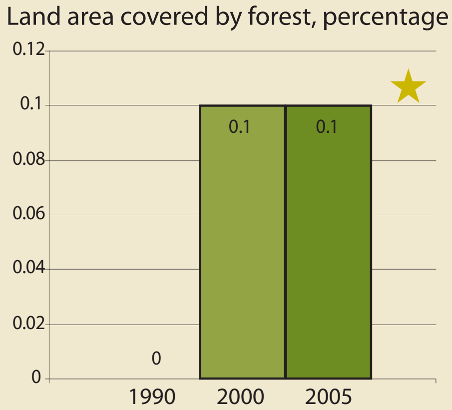
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

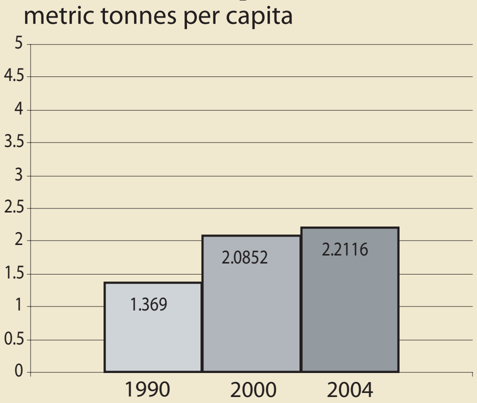
Egypt is primarily a desert country where aridity is a major problem. Soil fertility has declined because of over-cultivation and agricultural land has been lost to urbanisation and desert winds. However, Egypt has some positive environmental changes, including an increase in protected areas, access to improved water sources and sanitation, and a decrease in slum population percentage in urban areas.

★ Indicates progress

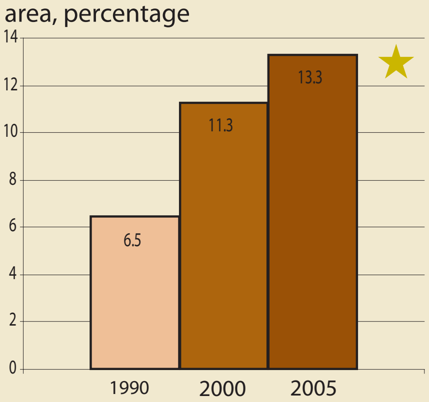
Land area covered by forest, percentage



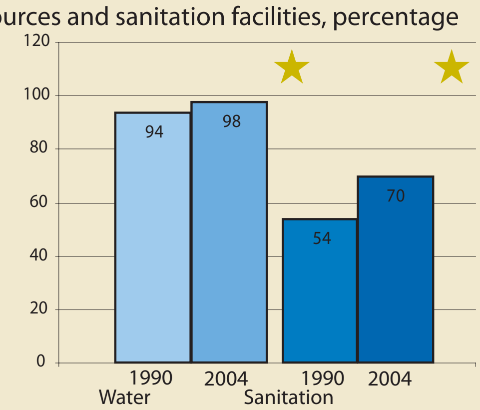
Carbon dioxide (CO_2) emissions, metric tonnes per capita



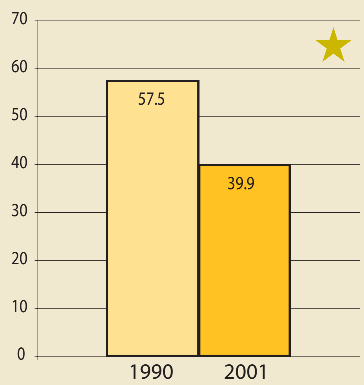
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

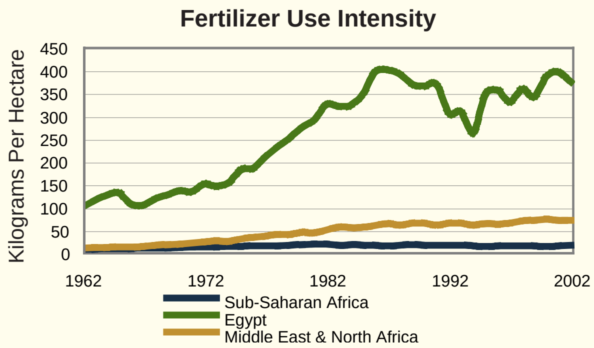


Egypt is the driest country in Africa with an annual precipitation of 51 mm/year on average and has hardly any forest area.

fao.org (2008)

Urbanisation and Pollution

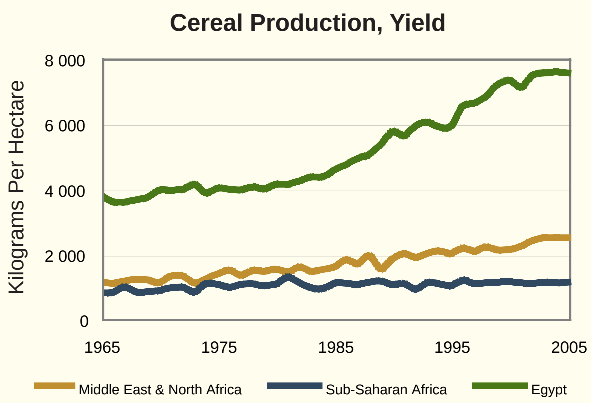
Cairo is one of the most populous cities in the world with 11.1 million residents in 2005 (UN 2006). With increasing population growth and industrialisation, pollution has become a growing problem in Egypt's urban areas. Vehicle emissions and solid municipal waste burning are the largest contributors to air pollution, and the number of vehicles is continuing to increase by ten per cent each year (SoE 2006). Water pollution is predominantly a result of agricultural runoff, although industrial waste water effluent is also a problem. Egypt uses more fertilizer and pesticides per hectare of cropland than any other African country (FAO 2005), forcing the government to advocate organic farming and mechanised weed control to reduce pollution.



Source: Earth Trends (from FAOSTAT)

Soil Erosion and Land Degradation

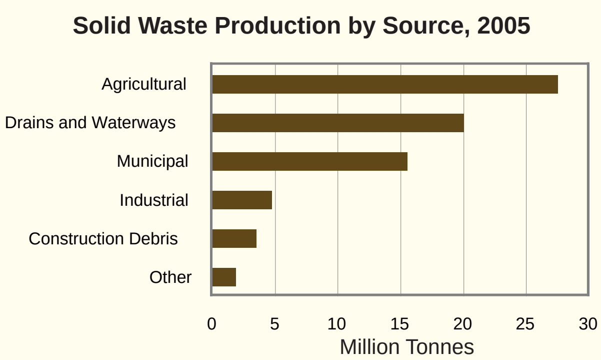
Consisting mostly of hyper-arid lands that are highly vulnerable to desertification, Egypt cultivates a very small percentage of its land (SoE 2006). Virtually 100 per cent of this cropland is irrigated (FAO 2007), contributing to annual cereal yields that are the highest in Africa (FAO 2005). However, pressures on agricultural land, including urban encroachment, waterlogging and soil salinity, pollution, and erosion from intensive farming have contributed to degradation and exacerbated the land scarcity problem. In some areas north and northeast of the Nile Delta, production losses from land degradation are estimated at eight per cent (SoE 2006).



Source: FAOSTAT

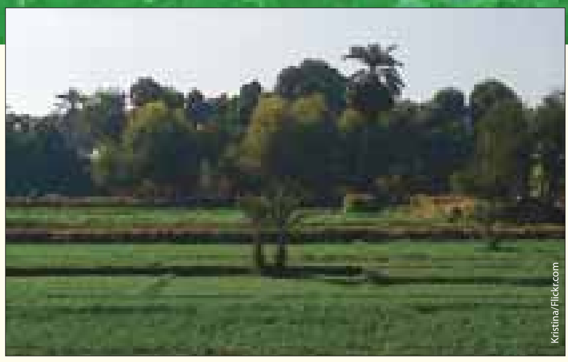
Threats to Biodiversity

Much of Egypt's biodiversity is associated with the oases, marshes, mangroves, and other wetlands of the Nile River system. Habitat loss due to high population density in these areas is the primary threat to wildlife, but escalating levels of land, air, and water pollution are also problems. Nearly 38 per cent of mammal species are critically endangered or vulnerable (SoE 2006).



Source: Egypt State of the Environment Report 2005

Egypt's coral reefs are the largest in Africa and account for 1.34 per cent of global reef area (Spalding and others 2001), attracting millions of international tourists to the region. However, coastal ecosystems are threatened by pollution from solid waste and chemical residues from agricultural, industrial, and urban development. The Egyptian government has declared five marine protectorates, including several areas along the Sinai Peninsula and the Red Sea coast (SoE 2006).



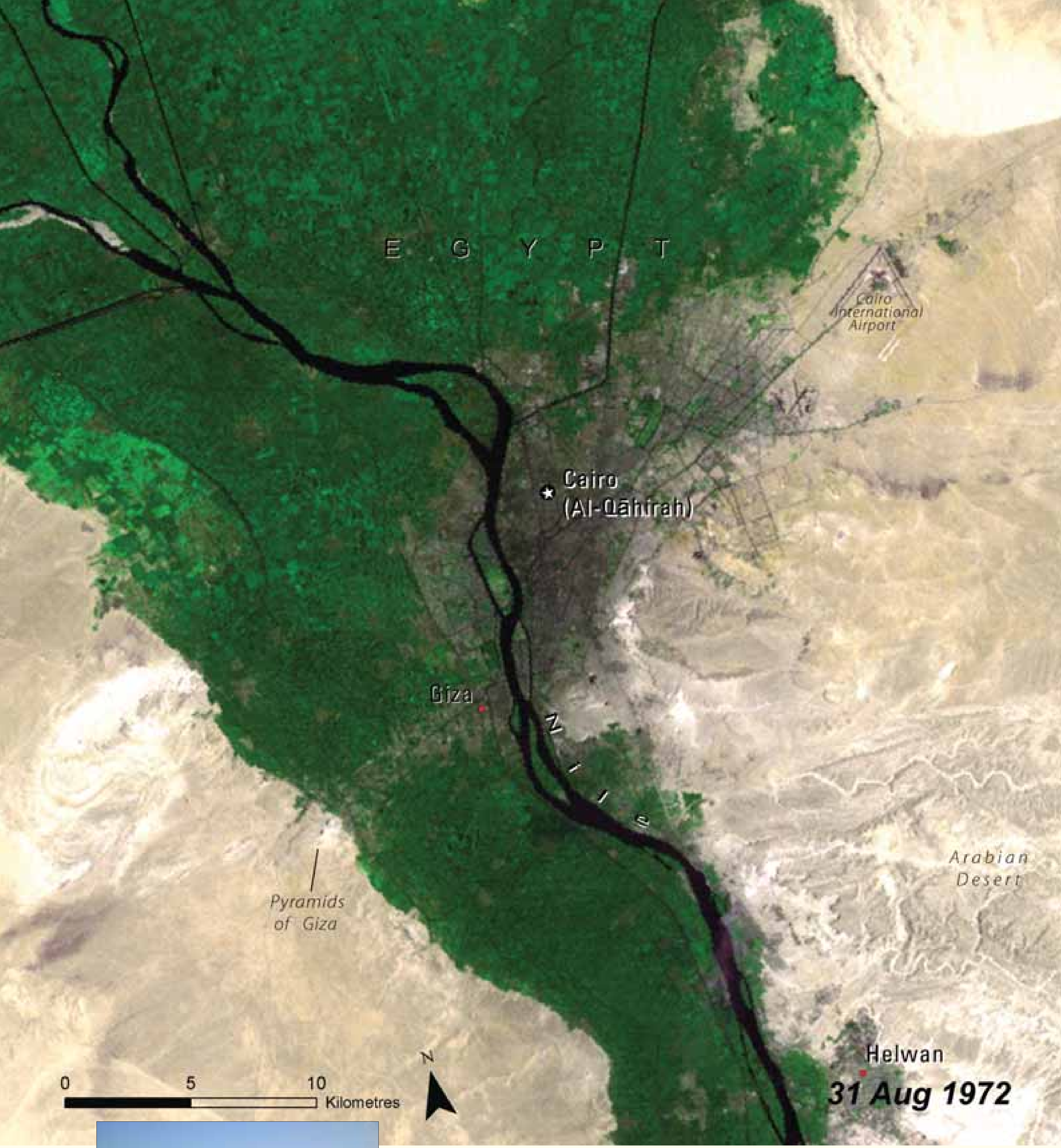
The Disappearing Damietta Promontory: Egypt

The Nile Delta is built of sands carried to Egypt's Mediterranean coast by the Nile River, primarily since the end of the last ice age. Dams along the river and entrapment of sediment in a vast network of irrigation canals have led to a dramatic decrease in the flow of water and sediment to the delta's edge. Closing of the Aswan High Dam in 1964 shifted the balance between sedimentation and erosion in favour of erosion.

At several points along the coast, the delta is now receding. Damietta Promontory has eroded dramatically as waves and currents have stripped its sands faster than the river can replenish

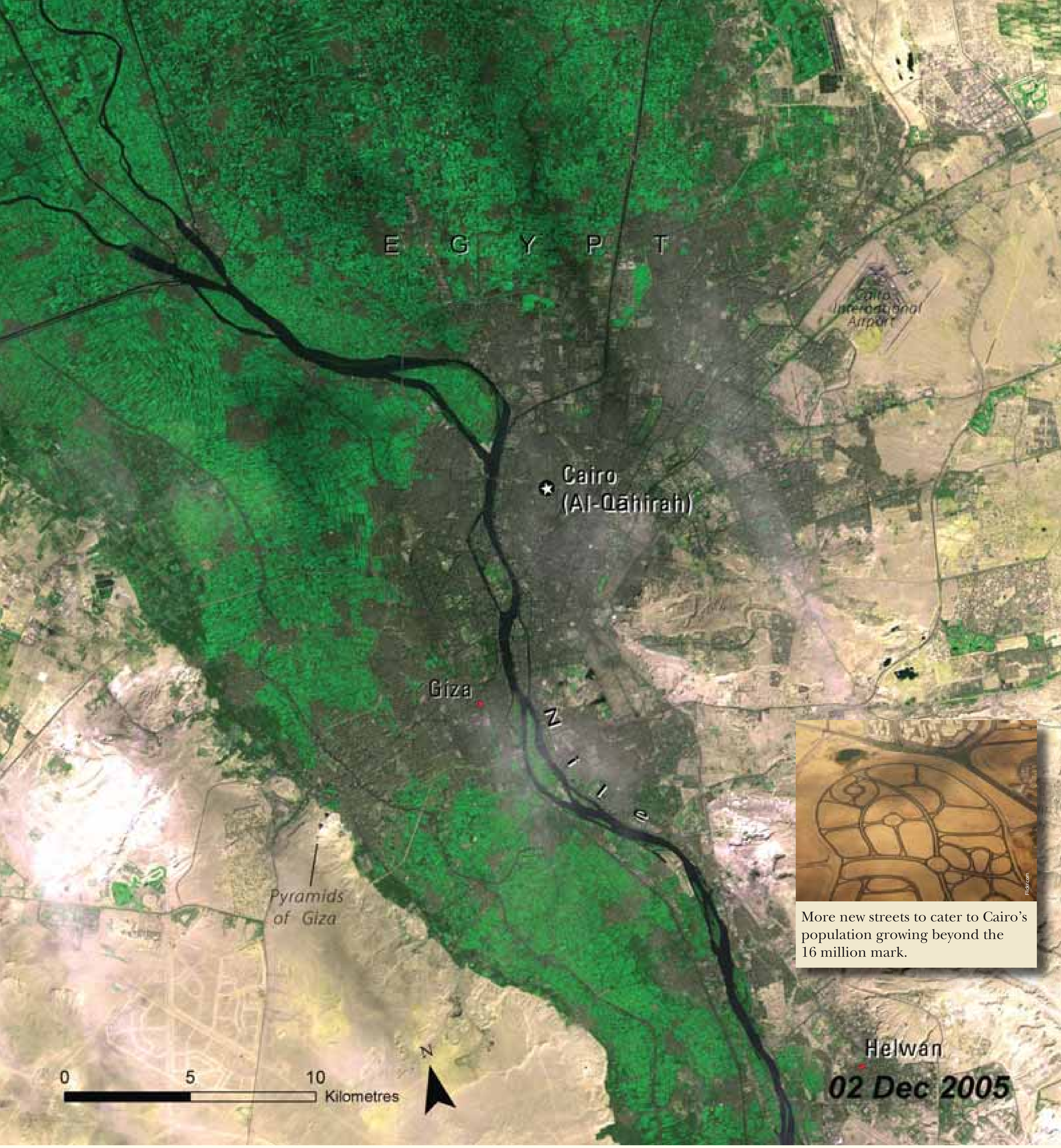
them (yellow arrow). While there are local areas of accretion such as the Damietta Spit (red arrow), on balance the delta is shrinking.

Prior to the construction of the Aswan High Dam, fresh water from annual floods influenced salinity and circulation patterns up to 80 km offshore from the delta. In contrast, current discharge patterns allow salt water from the Mediterranean to reach dams up to 26 km inland. Diminished freshwater and sediment delivery to the delta also affects the ecology of coastal lagoons, soil fertility, and salinisation of irrigated land. Coastal protection structures, regulation of irrigation, and increased groundwater exploitation may mitigate the delta's decline, but the current rate of population growth threatens to outstrip these measures.



Megacity Growing in the Desert: Cairo, Egypt

Cairo is the largest city in Africa, ranked by urban population, and Egypt is the third most populous country. In 1850, Cairo's population was only 250 000; 80 years later it had reached one million. Growing continuously, the population of the Cairo metropolitan area increased from less than six million in 1965 to more than ten million in 1998. Estimates of the city's current population vary widely, with some reaching as high as 16 million people.



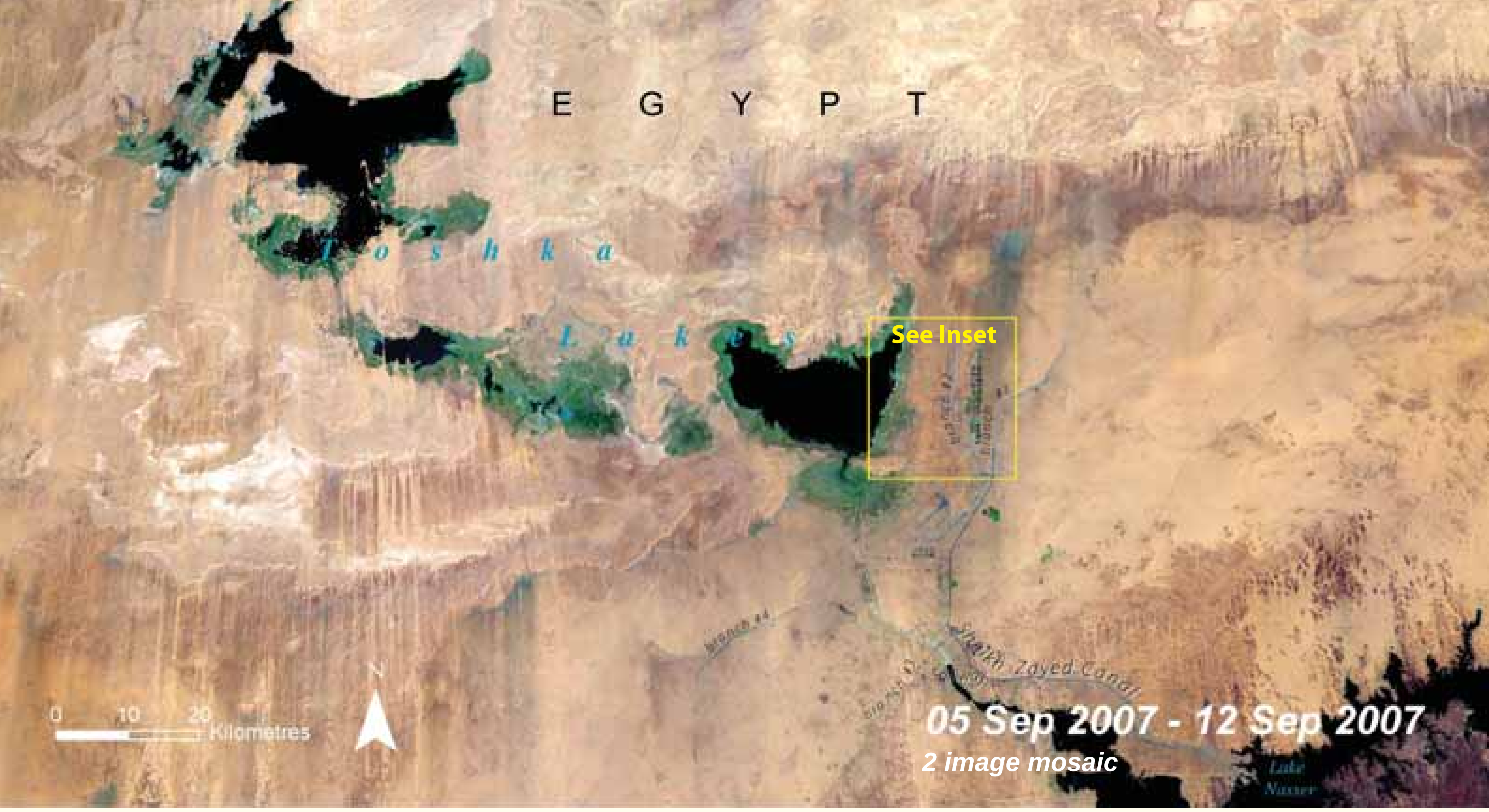
More new streets to cater to Cairo's population growing beyond the 16 million mark.

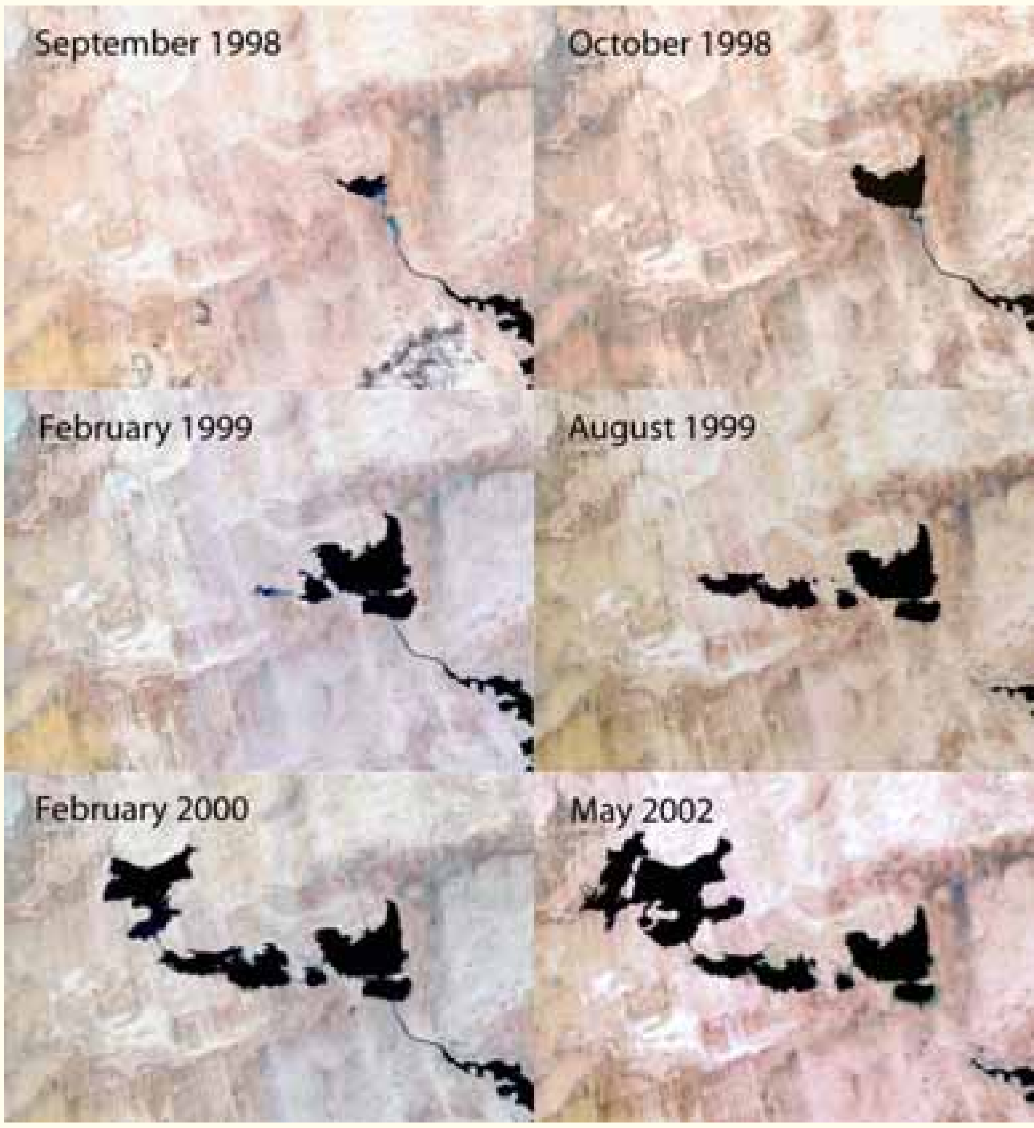
The Nile River is the lifeblood of Egypt as it is the main source of freshwater for household use and irrigation, a source of power from the hydroelectric facility at Aswan, and a means of transportation for people and goods. The only arable regions in Egypt are the green floodplains that line the Nile River.

Phenomenal population growth in the 20th century has resulted in the loss of much of the critically needed arable land around Cairo to urban development. The urban extent of Cairo (gray areas) expands dramatically between the 1972 and 2005 images, both into the Arabian Desert to the east and into the lush agricultural areas (green) surrounding the Nile. Most of Cairo's physical growth, particularly its unplanned or informal settlements, has been concentrated on agricultural land.

Nile Waters in the Desert: Toshka Lakes, Egypt

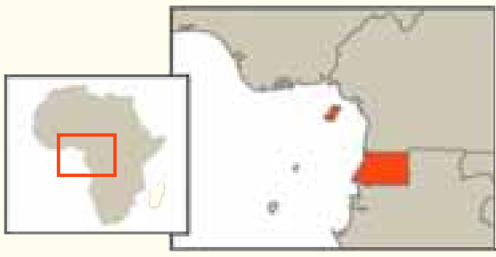
In the mid 1990s, water levels in Lake Nasser on the Nile River approached the reservoir's storage capacity of 183 m above sea level. Excess water was released through a spillway, which flowed into the Toshka Depression in the Western Desert. Over the next several years, continued overflow created a series of lakes on some of Egypt's most arid land. After peaking in 1998, reservoir levels declined and flow through the spillway stopped in 2001. Since that time, water levels in the Toshka Lakes have been declining as well, primarily by evaporation and to a lesser degree by infiltration.





In January 1997, the Egyptian government began construction on a network of canals to continue carrying Lake Nasser water to Toshka with the goal of irrigating 3 360 km^2 of land in the Western Desert. The project, called the New Valley Project, is intended to relieve overcrowding within the densely populated Nile Valley and provide economic development.

The project is an enormous undertaking with a cost over US$1 000 million. Critics of the project are concerned that the anticipated withdrawal of 5 000 million m^3 of water per year will reduce water available to farmers on the delta, leave Egypt more economically vulnerable to drought, and reduce resources available for other development opportunities. Much of the needed infrastructure is already in place and crops are already being produced on irrigated land including fruits and wheat (green around the lakes, 2007 image).



Republic of Equatorial Guinea

Total Surface Area: 28 051 km²
Estimated Population in 2006: 515 000

Equatorial Guinea is one of the smallest countries in Africa in terms of both area and population. It consists of a small continental territory known as Rio Muni and seven islands of volcanic origin. The largest island, Bioko, contains the highest population densities in the country and is characterized by mountainous and heavily forested terrain. The climate is tropical and humid, and average annual precipitation levels are among the highest in Africa at over 2 000 mm of rain per year (FAO 2007).

Important Environmental Issues

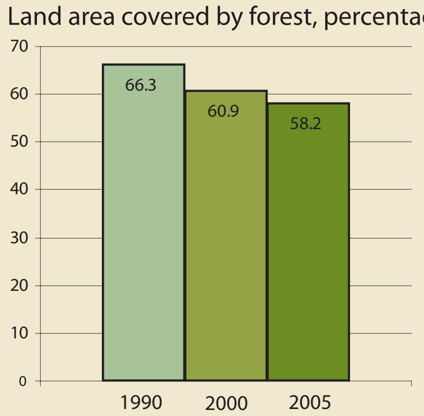
- Oil Production and Coastal Degradation
- Deforestation
- Bushmeat and Hunting on Bioko Island

Progress Towards Environmental Sustainability

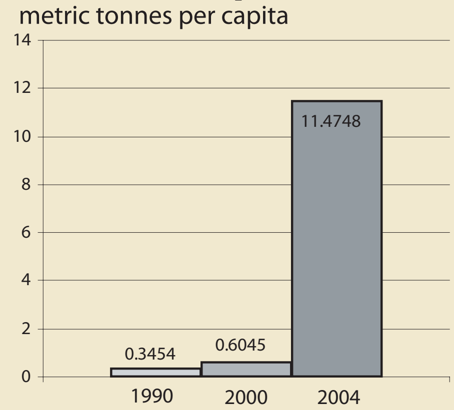
As defined by the United Nations Millennium Development Goal 7 Indicators

The country's oil production increased from 81 000 barrels per day (bbl/d) in 1998 to more than 300 000 bbl/d by 2004 and an estimated 420 000 bbl/d in 2005. This increase may explain the sharp increase in carbon dioxide emissions. Other problems include deforestation, water pollution, desertification, and wildlife loss. Agriculture is the main economic activity, involving about 71 per cent of the economically active population.

Land area covered by forest, percentage

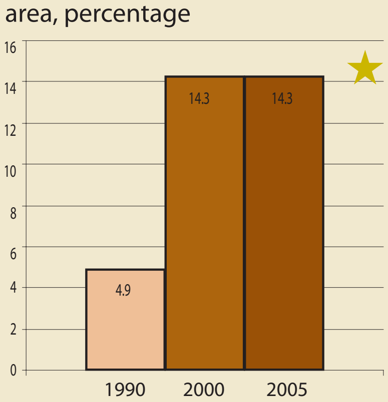


Carbon dioxide (CO_2) emissions, metric tonnes per capita

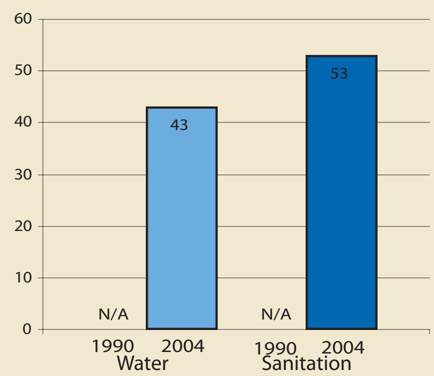


★ Indicates progress

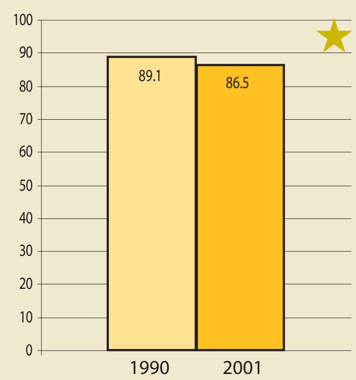
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



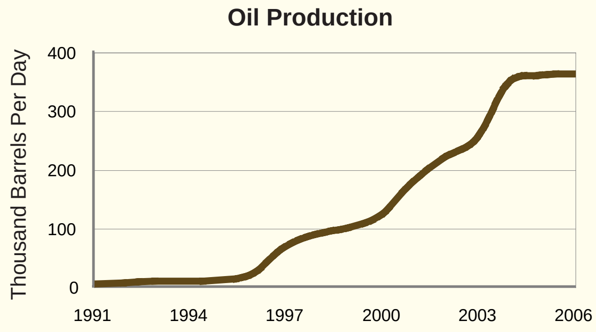
Bioko Island has several endemic sub-species of primates, including the drill (Mandrillus leucophaeus poensis) and the red-eared monkey (Cercopithecus erythrotis).

Sunderland and Tako (1999)

Oil Production and Coastal Degradation

Since the early 1990s, oil production has propelled rapid economic growth in Equatorial Guinea, which is now the third-largest oil exporter in sub-Saharan Africa, after Nigeria and Angola (EIA 2007a). In 1999, gross domestic product increased by over 40 per cent, which was the highest growth rate recorded by any country in the world (World Bank 2007).

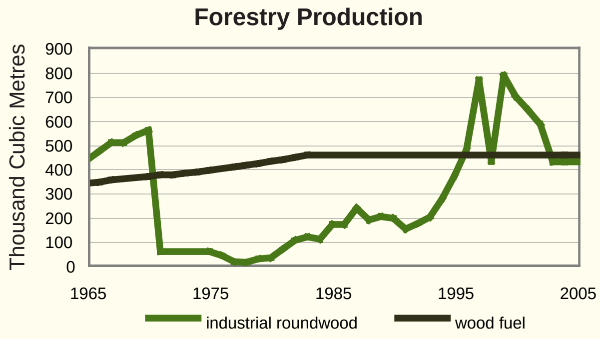
The social and environmental consequences of this economic transformation include rapid urbanisation, increased coastal development, and localized pollution. The urban growth rate is now twice the overall population growth rate (UNESA 2006), thanks to rural-to-urban migration and immigration of foreign oil workers. This has created a construction boom in the city of Malabo and in other oil towns, resulting in increased coastal degradation and pollution.



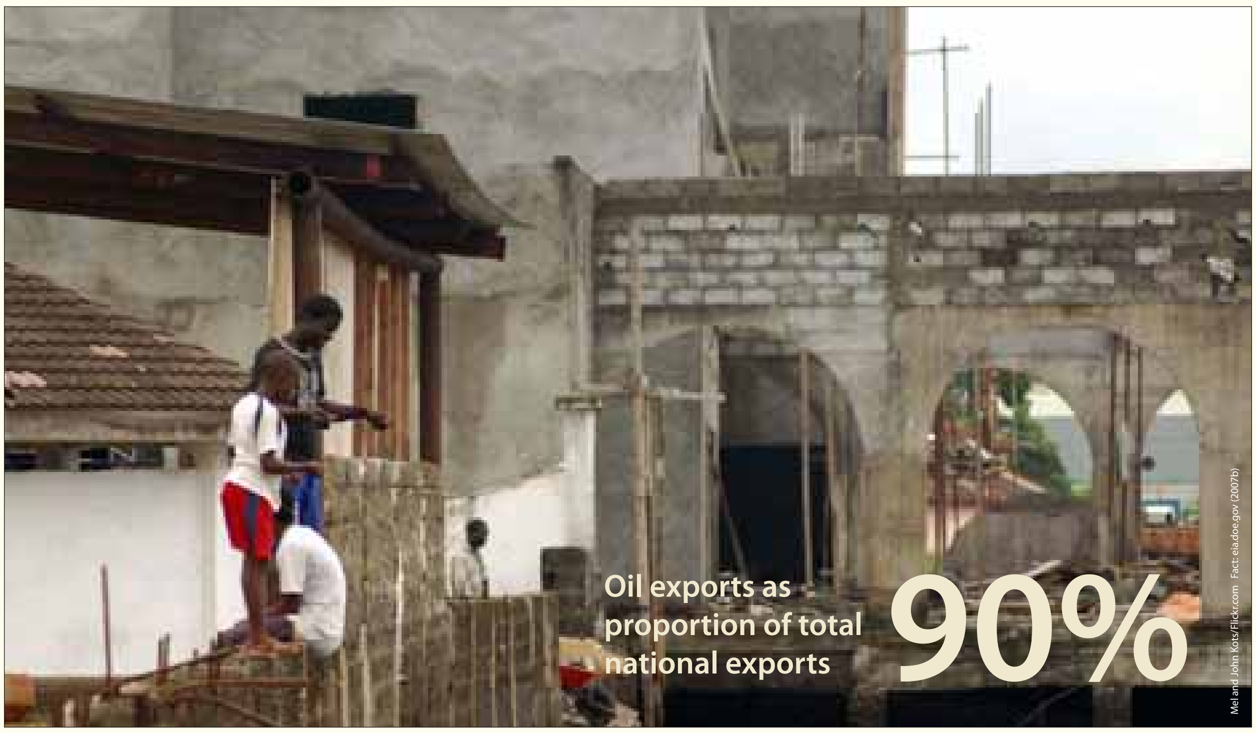
Source: BP Statistical Review of World Energy 2007

Deforestation

The forestry sector is second only to oil in terms of importance to the national economy in Equatorial Guinea. As of 2005, 58 per cent of the country was forested, which reflects a 12 per cent decrease in forest cover since 1990 (UN 2007). Agriculture and timber harvesting are the major drivers of deforestation, with fuelwood accounting for approximately one-third of all roundwood consumption (FAO 2003). Coastal regions have been hit hardest by this trend, whereas the more inaccessible continental interior and mountainous islands have been spared to some extent.

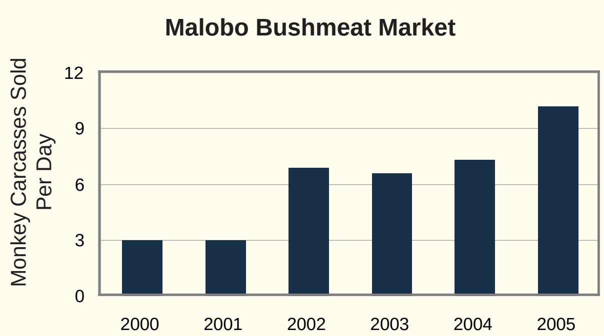


Source: FAOSTAT



Bushmeat and Hunting on Bioko Island

Located 51 km off the coast of Cameroon, Bioko Island is a haven for several rare primate species, four of which are subspecies found nowhere else in the world. Its mountainous interior includes the Gran Caldera, a volcanic crater whose high ridges have created a natural wildlife refuge, and Pico Basile, a peak rising over 3 000 m above sea level. In recent decades, the growing commercial bushmeat market in the city of Malabo—encouraged by increased prosperity brought by offshore oil fields—has severely threatened the island's wildlife. Hunters have completely extirpated large forest mammals in the easily accessible lowland areas, and primate populations have been reduced by as much as 60 per cent since 1986, even in the more isolated wildlife reserves (BIOKO 2006).

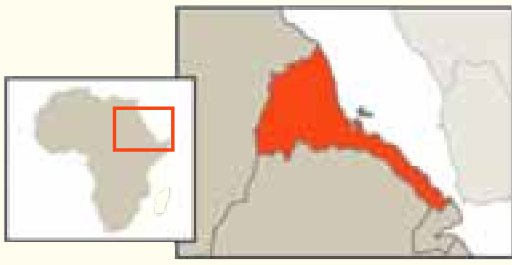


Source: Bioko Biodiversity Protection Program

Oil and Gas: Punta Europa, Equatorial Guinea

Petroleum and natural gas are key to Equatorial Guinea's rapid development and growing GDP. The Alba gas field located 19 km north of Bioko Island is the country's largest natural gas field, with 37 000 million m^3 of proven reserves. The above images show massive infrastructural development of the gas and the hydrocarbon facility at Punta Europa on Bioko, between 2000 and 2007.

The Punta Europa plant flares natural gas and associated byproducts—initially at a rate of approximately 2.5 million m^3 per day to the current volume of about 3.5 million m^3. To reduce the economic and environmental damage associated with this flaring, the Atlantic Methanol Production Company completed construction of a methanol plant at Punta Europa in May 2001. The plant consumes around 3.5 million m^3 per day of quality gas to produce 19 000 barrels per day of methanol used in a variety of industries. Similarly, Marathon Oil and its partners are nearing completion of a liquefied natural gas plant at Punta Europa. These two facilities will eliminate the need to flare gas at Punta Europa. The projected greenhouse gas reduction from the methanol plant alone is 2.85 million metric tonnes of carbon dioxide equivalent per year for each year of the project.



Eritrea

Total Surface Area: 117 600 km²
Estimated Population in 2006: 4 560 000

Eritrea consists of diverse climates and landscapes, from a hot and dry Red Sea coastal plain to temperate central highlands. Dividing the country between semi-arid lowlands to the east and west, the highlands range between 1 500 and 2 000 m in altitude and are among the oldest areas cultivated by humans in the world. Sixty-five per cent of the population lives in the highlands, although the highlands account for only 19 per cent of the total land surface (FAO 2005a).

Important Environmental Issues

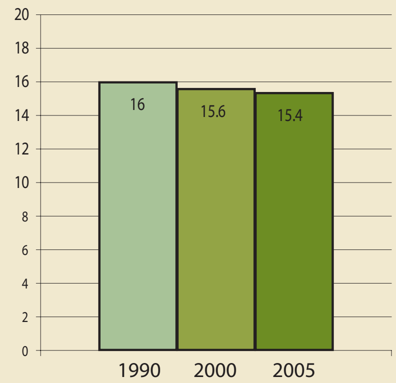
- Water Stress
- Land Availability and Land Degradation
- Deforestation and Threats to Biodiversity

Progress Towards Environmental Sustainability

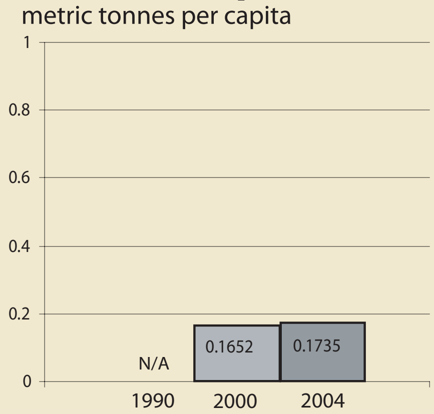
As defined by the United Nations Millennium Development Goal 7 Indicators

Eritrea has 391 000 hectares of arable land and 2 000 hectares under permanent cultivation. Three-quarters of Eritrea's people are subsistence farmers dependent on unreliable rainfall to feed families that average seven children. Eritrea's forested area covers 1 585 000 hectares of the total land area. When Eritrea became independent from Ethiopia, it gained about 1 011 km of Red Sea coast.

Land area covered by forest, percentage

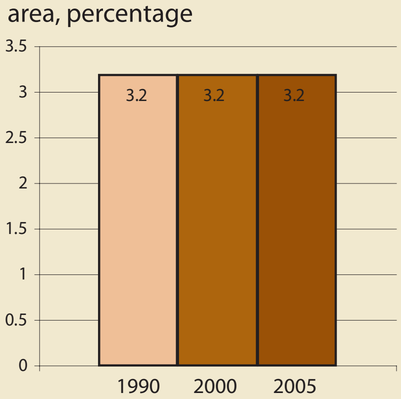


Carbon dioxide (CO_2) emissions, metric tonnes per capita

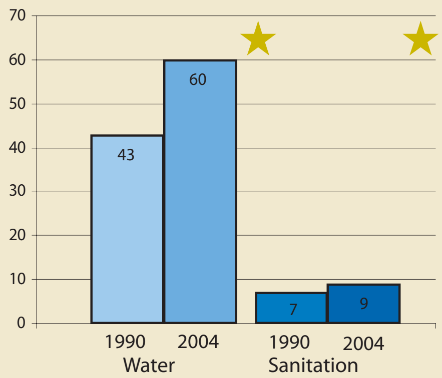


★ Indicates progress

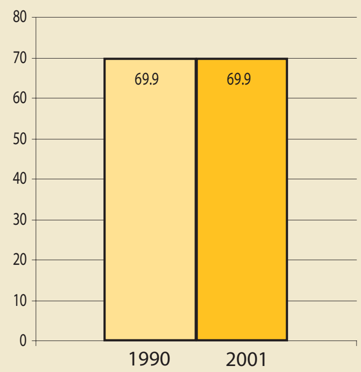
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

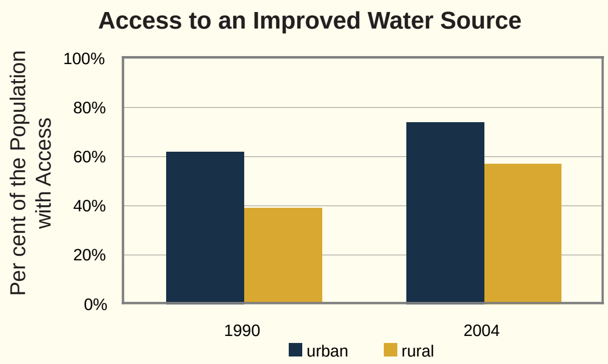


In 2006, Eritrea announced it would become the first country in the world to turn its entire coastline into an environmentally protected zone.

World Ocean Observatory

Water Stress

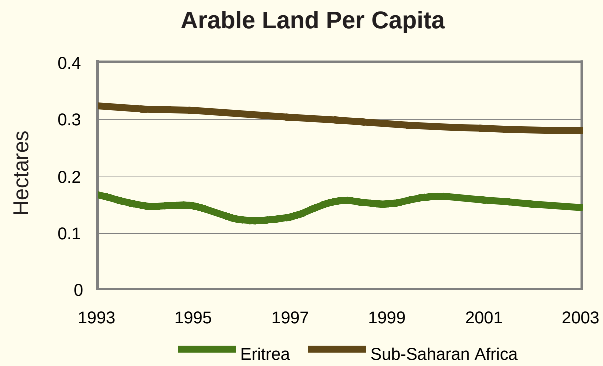
With only one perennial river and no natural fresh surface water bodies, Eritrea depends on groundwater resources that are regionally limited in both quantity and quality. The country is below the international threshold for water stress with only 1 338 m^3 available per person per year (Earth Trends 2007 and UNESA 2005). Agriculture accounts for 95 per cent of all water withdrawals (FAO 2005b), although only four per cent of cropland is irrigated. It is estimated that demand for water is ten times greater than the national supply, indicating a 3 500 million cubic metre water gap (UNDP 2006).



Source: MDG Indicators

Land Availability and Land Degradation

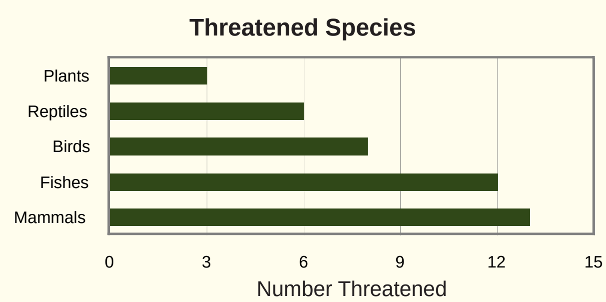
Eritrea is at extremely high risk of desertification due to its arid climate and heavy reliance upon agriculture despite limited availability of arable land. Only 6.3 per cent of land is suitable for cultivation and most of this potential has already been exploited (UNEP 2006). But continued population growth has forced expansion onto marginal lands and steep slopes. Livestock grazing, which is concentrated predominantly in the semi-arid western lowlands, has also exposed soils to water and wind erosion. Overall, 63 per cent of land is considered to be severely degraded (FAO AGL 2003).



Source: FAOSTAT

Deforestation and Threats to Biodiversity

Forests account for only 15 per cent of land in Eritrea (UN 2007b), although original forest cover is estimated to have been twice that amount (FAO 2001). Deforestation is driven by agricultural expansion, deliberately set forest fires, and demand for fuelwood. Deforested terrain is particularly vulnerable to soil erosion due to torrential and erratic rainfall. Furthermore, deforestation removes valuable habitat for threatened species, including elephant, wild ass, greater kudu, and civet, all of which are in danger of national extirpation.

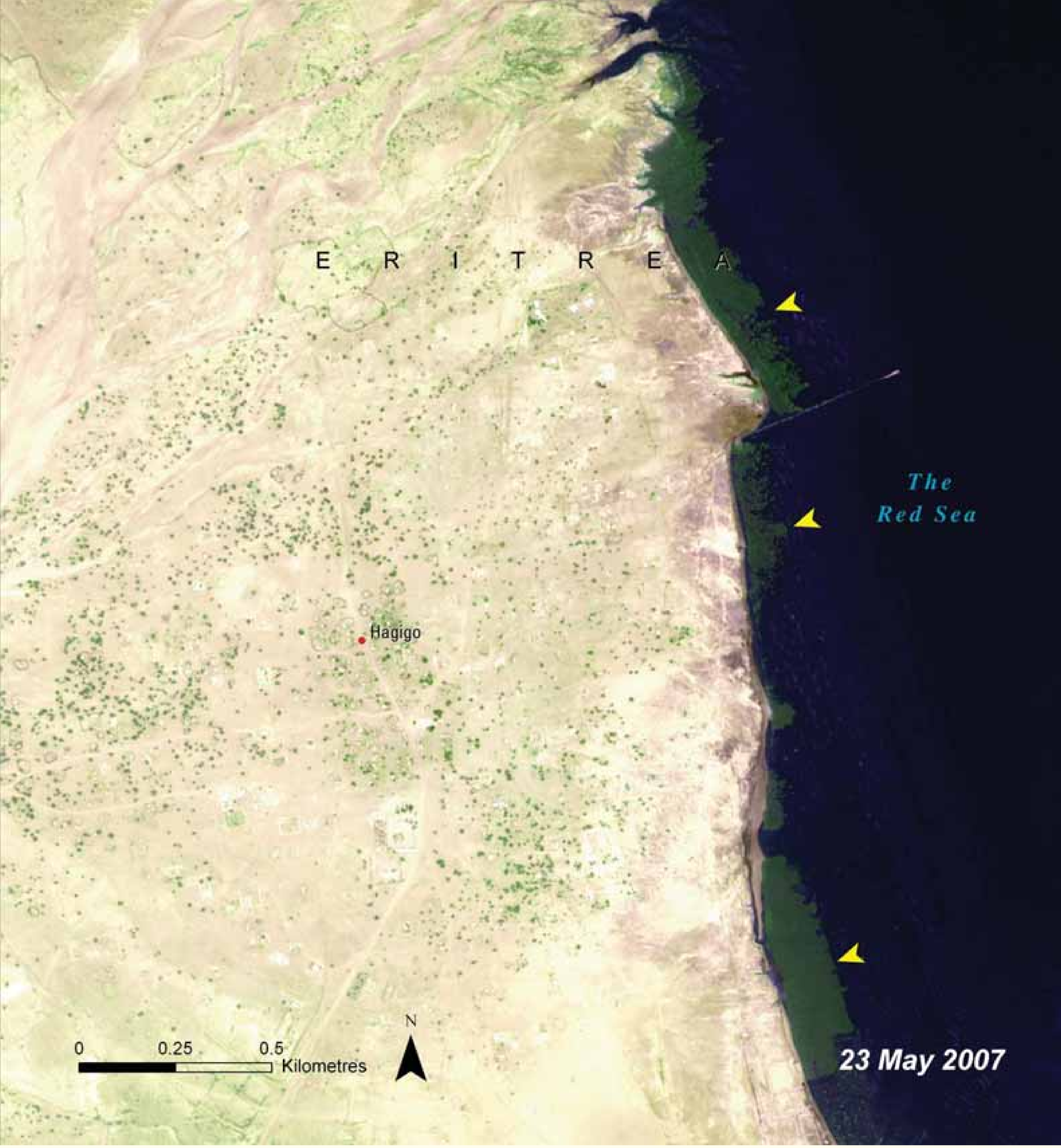


Source: IUCN Red List

Unlike Eritrea's interior, its long coast is sparsely inhabited, resulting in a relatively pristine coastal and marine environment. The Red Sea coast and the 350 islands of the Dahlak Archipelago support fertile fishing grounds, with over 1 000 species of fish, 220 species of corals (FAO n.d.), and 851 km^2 of mangrove forest (Spalding and others n.d.). In 2006, Eritrea announced its intention to become the first country in the world to turn its entire coastl into a marine protected area.

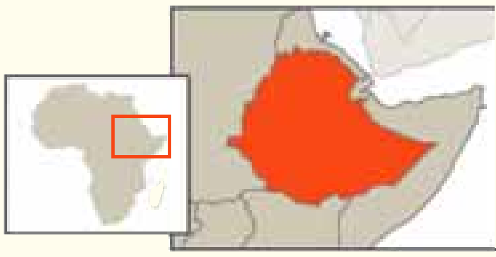
Cultivating Mangroves: Hagigo, Eritrea

Along 15 per cent of Eritrea's coast there are stretches of green that contrast with the arid environment surrounding them. They are mangroves—stands of salt tolerant trees and plants that can get their water from the sea. Dr. Gordon Sato, a retired molecular biologist, wondered why they occur only intermittently rather than along the entire coast. He discovered that streams flowing into the Red Sea during seasonal rains provide nutrients that the mangroves need to grow. He devised a simple means of delivering these missing nutrients, allowing mangroves to be grown on otherwise barren shoreline.



More than 700 000 mangrove seedlings have been planted along the Eritrean coast since 2001, (yellow arrows). These mangroves flourish with low cost applications of fertilizer. The 2001 and 2007 images of the coast near Hagigo, Eritrea, show how quickly the seedlings are growing into stands of mangrove trees (yellow arrows). The mangrove's leaves provide fodder for sheep, which in turn are a source of food for the Eritrean population.

The so-called Manzanar Project aims to develop self-sufficiency in Eritrea, village by village. Coupled with aquaculture, the mangroves provide both a land- and sea- based economy that might eventually be developed for the specialty seafood export market.



Federal Democratic Republic of Ethiopia

Total Surface Area: 1 104 300 km²
Estimated Population in 2006: 79 289 000

Credit: © Flagart.com

Ethiopia is the tenth-largest and second most populous country in Africa. Most of the population occupies the plateau and central mountain range of the rugged Ethiopian Highlands, which are divided diagonally by the Great Rift Valley and surrounded to the east and west by lowland deserts. The highlands, which account for roughly half of the country's area (Woldeyes n.d.), are also the source of the Blue Nile, which originates in Lake Tana in the northwest and contributes two-thirds of the Nile River's water.

Important Environmental Issues

- Water Availability and Access to a Safe Source
- Livestock, Soil Erosion, and Land Degradation
- Threats to Biodiversity and Endemism

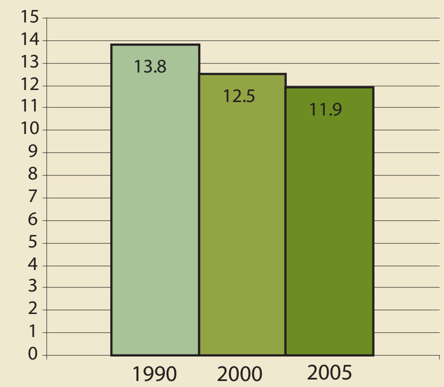
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

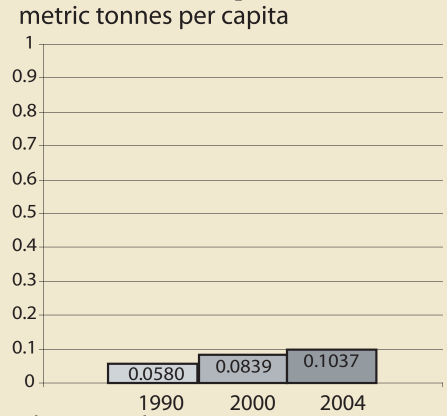
Availability of clean water and sanitation in Ethiopia is among the lowest in the world and, in the case of water, the situation is deteriorating. An estimated three-quarters of children's health problems and communicable diseases have an environmental cause. Ethiopia's land area under protection remains fairly constant. Nearly 70 per cent is arable yet only 11 per cent is under cultivation with permanent crops; almost 12 per cent is forested.

★ Indicates progress

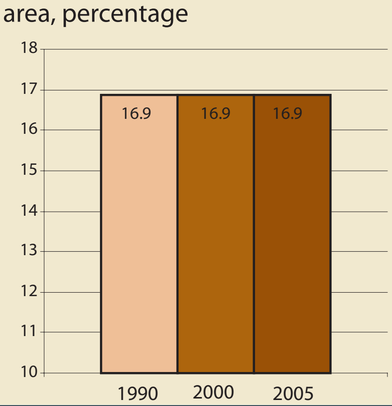
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

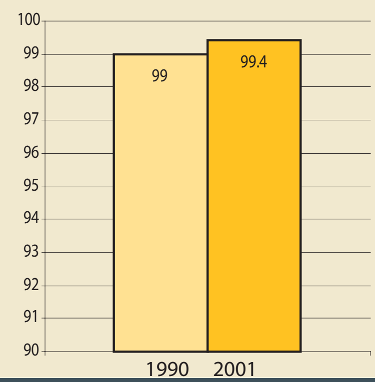


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban

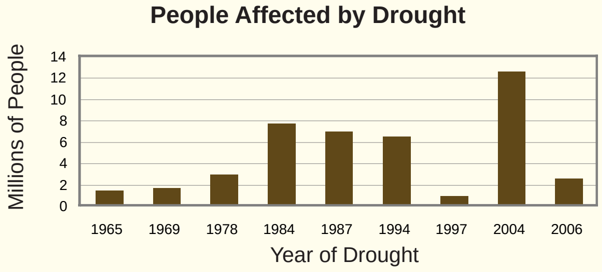


In 2005 scientists watched a 60 kilometre fissure develop in the Afar Desert of Ethiopia. The fissure created an eight metre wide rift at its centre which may be the beginning of a "future ocean."

nerc.ac.uk (2006)

Water Availability and Access to a Safe Source

Although surface water resources are relatively abundant, they are largely undeveloped and unevenly distributed. Approximately 70 per cent of runoff is obtained between June and August (FAO 2005), and recurring droughts and erratic rainfall are frequently responsible for widespread food insecurity and significant loss of livestock and crops. During a severe drought in 2003, for example, over ten million people required food aid and the gross domestic product declined by 3.3 per cent (CIA 2007).

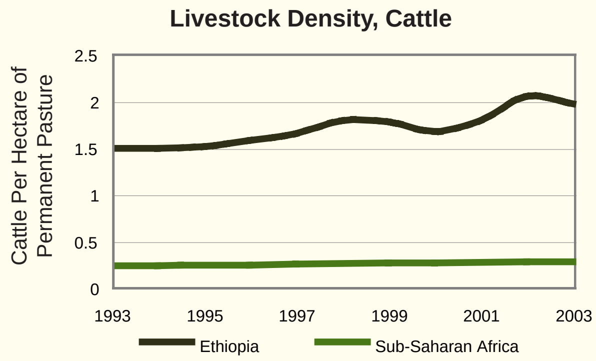


Source: EM-DAT disaster database

As a consequence of both natural and economic circumstances, only 22 per cent of the population has access to an improved water source, the lowest proportion in Africa (UN 2007). The situation is acute in both rural areas, where 84 per cent of the population resides (UNESA 2006), and in urban areas, where over 99 per cent of inhabitants are slum-dwellers (UN 2007).

Livestock, Soil Erosion, and Land Degradation

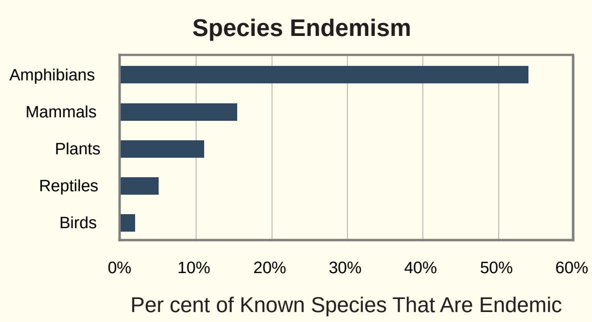
Desertification and soil erosion are widespread in Ethiopia, particularly in the highlands where the terrain is very steep, and where the majority of agricultural production occurs. Ethiopia has the seventh-largest cattle stock in the world (FAO 2007), and overgrazing coupled with heavy dependence on dung for fuel is a significant driver of land degradation. Other factors include deforestation and poor farming practices. Overall, 85 per cent of the land is classified as moderately to very severely degraded (FAO AGL 2003) and 70 per cent is affected by desertification (UNCCD 2002).



Source: Earth Trends (from FAOSTAT Resource STAT, Land data)

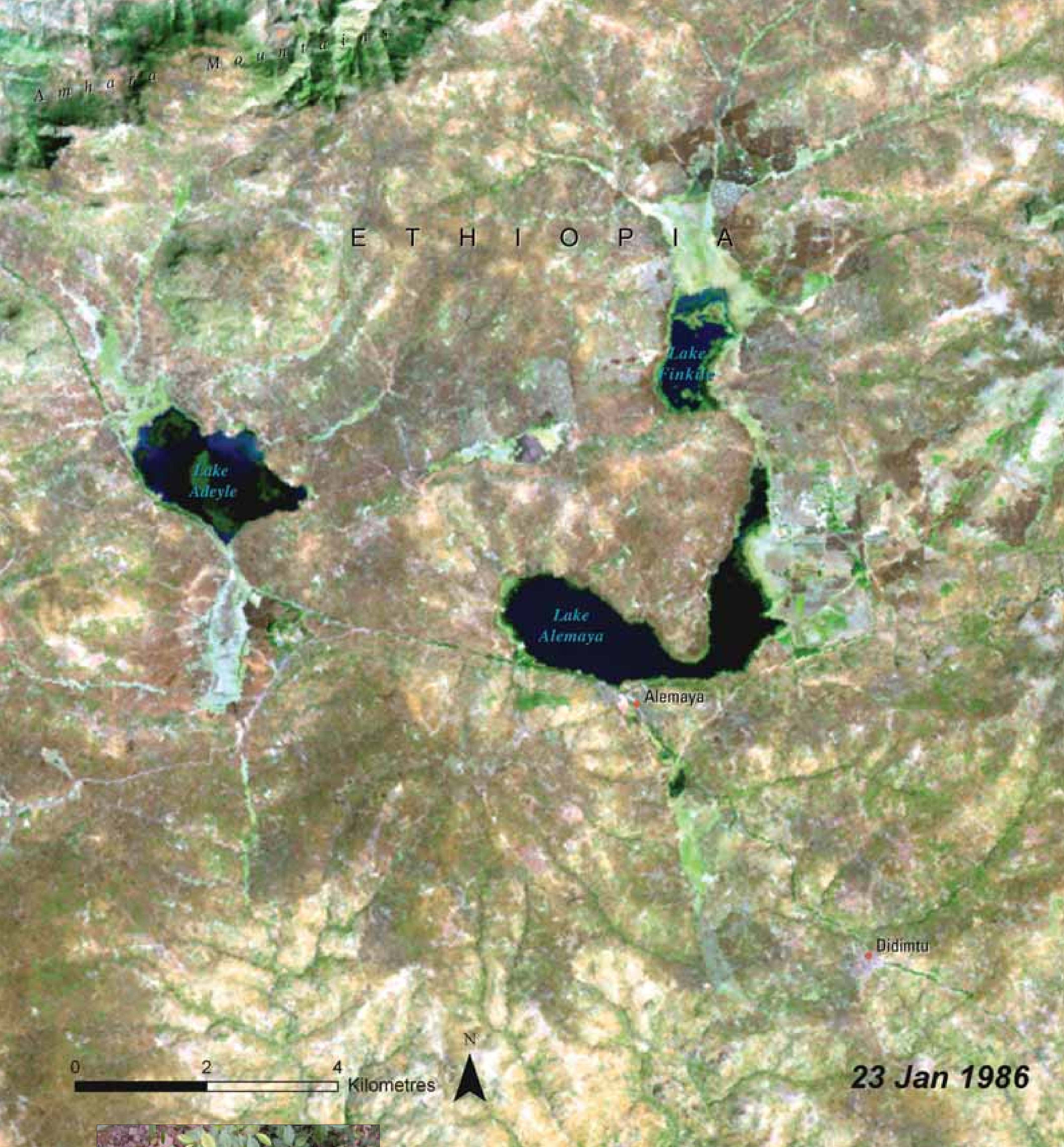
Threats to Biodiversity and Endemism

Wide variation in climate and topography contribute to Ethiopia's rich biological resources—of approximately 7 900 identified plant and animal species, over ten per cent are endemic. Threats to biodiversity include overexploitation, conversion of habitats for agriculture, and deforestation. It is estimated that forest cover now constitutes less than four per cent of the original forest extent (CBD 2005).



Source: Earth Trends (from Ethiopia's Third National Report to the CBD)

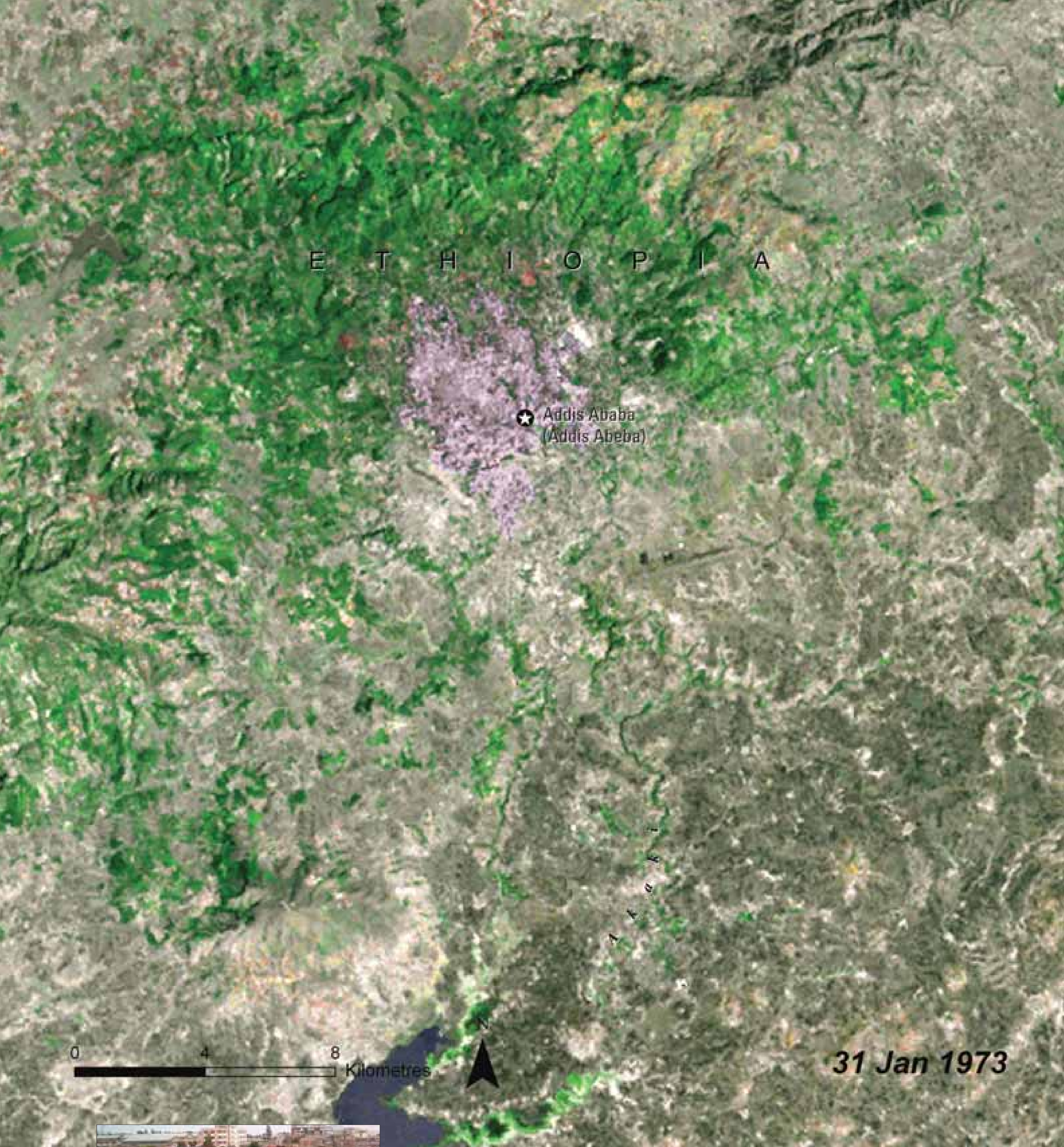
Ethiopia's Simien National Park was one of the first sites added to the UNESCO World Heritage list in 1978. Located in the north, the park contains spectacular landscapes of jagged mountain peaks and deep valleys, and it provides refuge for rare species such as the Simien fox and Walia ibex, a goat that is found only in this area.



Shrinking Water Resources: Lake Alemaya, Ethiopia

Lake Alemaya in the Ethiopian Highlands has historically provided the surrounding area with water for domestic use, irrigation, and livestock and has served as a local fishery. As recently as the mid-1980s its maximum depth was around eight metres and it covered 4.72 km^2. Since then Alemaya's water level and surface area have declined considerably, as is evident in these images. In recent years, low water levels have interrupted the water supply in Harar, a nearby town of over 100 000.

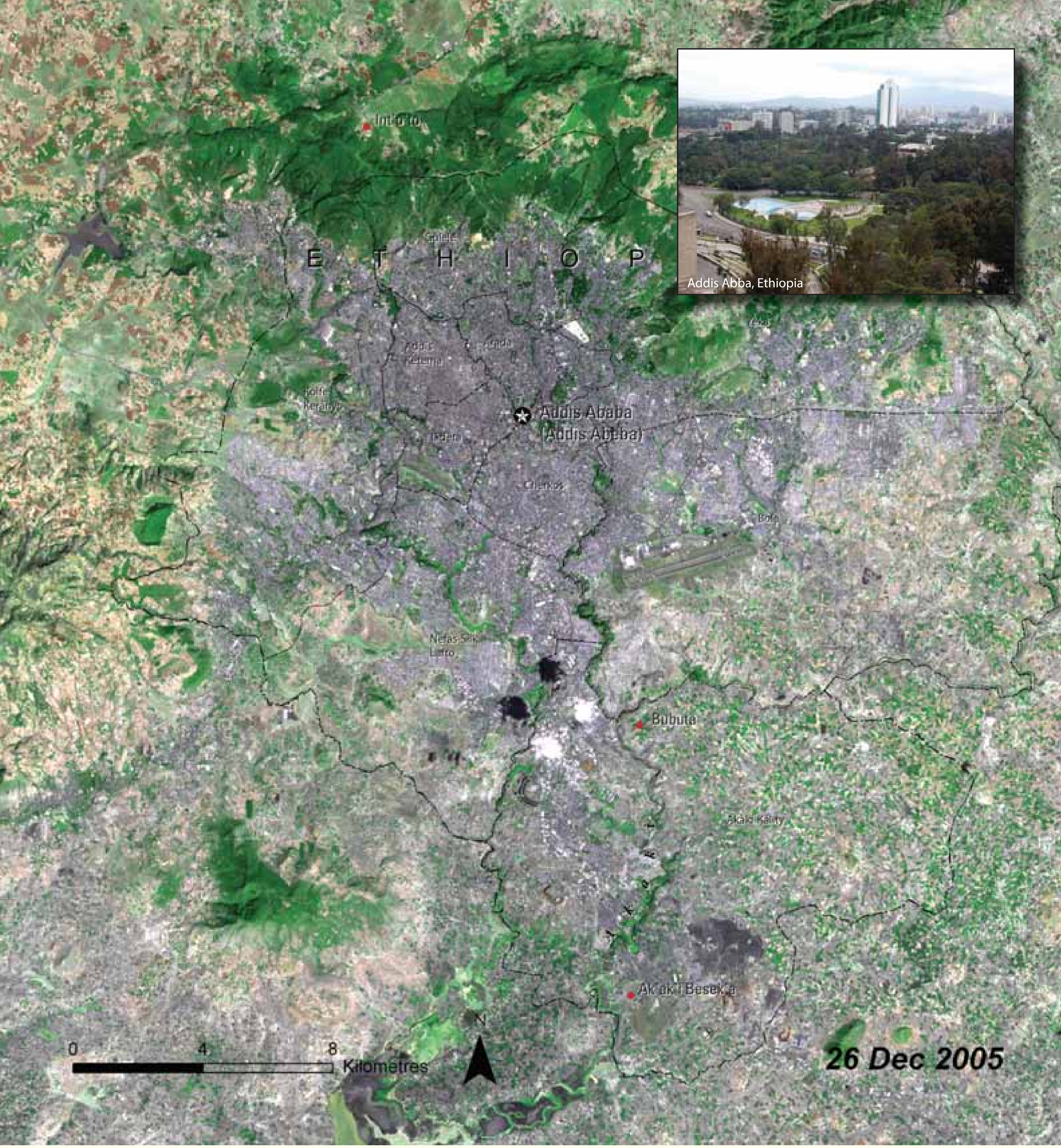
Increasing irrigation and domestic water use, change in the local climate, and changes in the surrounding land cover are believed to be the causes of Alemaya's demise. Agriculture expanded dramatically starting in the mid-1970s due to improved infrastructure, increased population, and changes in government policies toward production and marketing. Among the crops grown is khat, a psychoactive leaf consumed heavily in northeastern Africa. Khat has become an exported cash crop in recent decades and irrigation has increased as a result. In addition, siltation caused by the deforestation of the Alemaya watershed has reduced the capacity of the shallow lake. A trend of warmer temperatures since the mid-1980s may also have increased the rate of evaporation from the lake.



Urban Sprawl in Addis Ababa: Ethiopia

Addis Ababa, the capital of Ethiopia, was established in 1889. Major urban migration into the city began in the mid-1970s, driven mainly by unemployment, poverty, and declining agricultural productivity in rural areas. The population of Addis Ababa is currently 2.9 million, and is projected to grow to 5.1 million by 2015.

Ethiopia as a whole has an annual population growth of 2.8 per cent. Twenty-seven per cent of Ethiopia's urban population lives in Addis Ababa and this has created substantial pressure



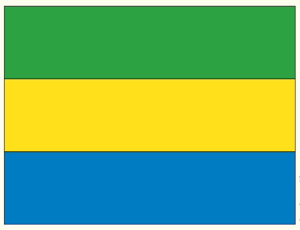
Addis Abba, Ethiopia

on the city's infrastructure, housing, and urban services. These satellite images taken in 1973 and 2005 show the development of Addis Ababa's massive urban sprawl.

In 1996, the city had only 238 000 residential housing units. That same year, the total number of households was estimated to be 460 000, leaving 220 000 households or nearly 1 000 000 residents without suitable housing. This situation led to illegal housing construction and uncontrolled settlements, some of which are encroaching on protected forest and reserve lands at the edges of the city.

Gabonese Republic

Total Surface Area: 267 668 km²
Estimated Population in 2006: 1 406 000



Credit: © Flagart.com

Gabonese Republic, or Gabon, is one of the least densely populated countries in Africa with less than two inhabitants per square kilometre (Earth Trends 2006 and FAO 2005). A narrow coastal plain characterized by many lagoons and estuaries runs along the country's 800 kilometre-long Atlantic coast, giving rise to a hilly, forested interior and savannah plains to the east and south. The climate is generally hot and humid all year round, with two rainy seasons and two dry seasons.

Important Environmental Issues

- Threats to Biodiversity
- Coastal Degradation and Industrial Pollution
- Lack of Sanitation and the Urban Environment

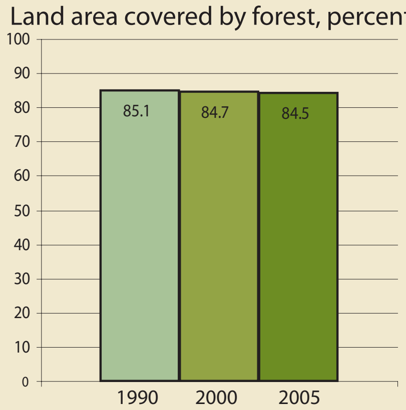
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

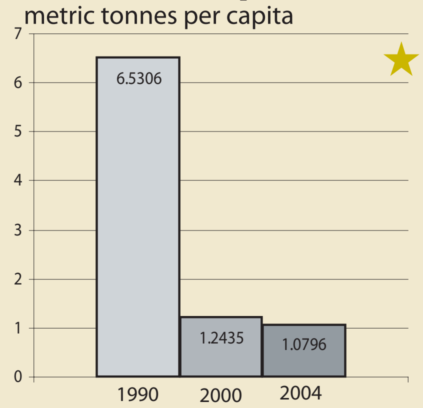
Gabon's growing urban centres and slum population increases industrial and domestic contaminants, thus polluting the nation's water supply. Gabon is one of the few places where primary tropical rain forest still extends all the way to the beach. Even though Gabon's coastal forests are slowly being depleted, a reforestation program has been successful in retaining most of the interior dense forest cover and in increasing the percentage of protected areas.

★ Indicates progress

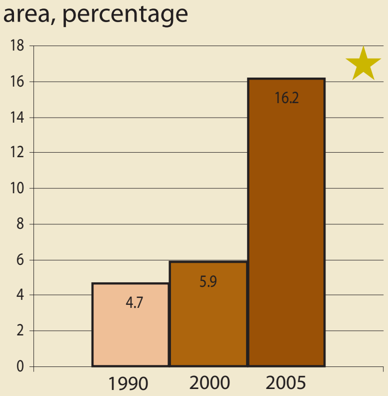
Land area covered by forest, percentage



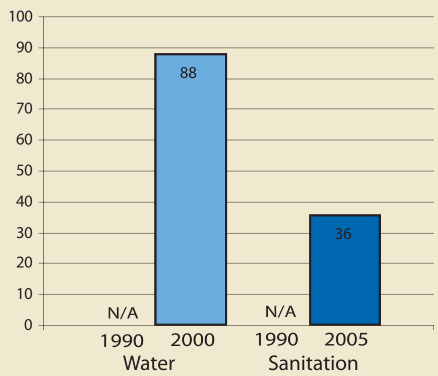
Carbon dioxide (CO_2) emissions, metric tonnes per capita



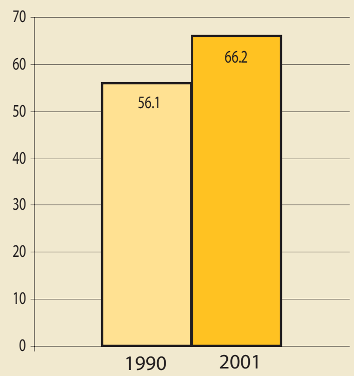
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



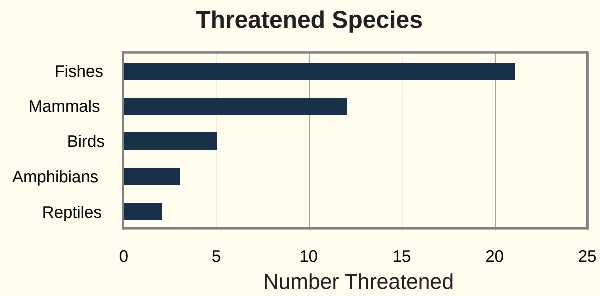
Gabon has more than 8 000 species of plants, 20 per cent of which are endemic.

rainforests.mongabay.com (2007)

Threats to Biodiversity

Forests cover 85 per cent of Gabon's surface area, which is the highest proportion of any mainland African country (UN 2007). These forests are home to approximately 8 000 plant species, of which 20 per cent are endemic (CBD 2007). Although total forest cover has remained stable over recent decades due to the declining rural population, selective logging for valuable tree species is a growing threat to forest biodiversity—nearly half of Gabon's forests were affected as of 1998 (CBD 1999).

Gabon's forests also shelter several endangered mammal species, including chimpanzees, gorillas, and elephants. The commercial bushmeat trade, driven by both domestic and international markets, is a growing threat to wildlife populations. Hunting as well as recent outbreaks of the deadly Ebola virus are estimated to have reduced the great ape population by over 50 per cent between 1983 and 2002 (Walsh and Others 2003).

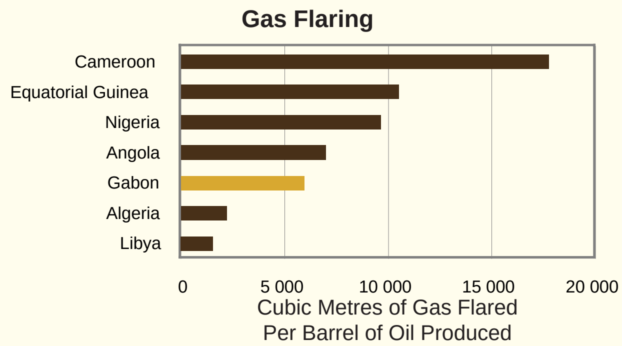


Source: IUCN Red List

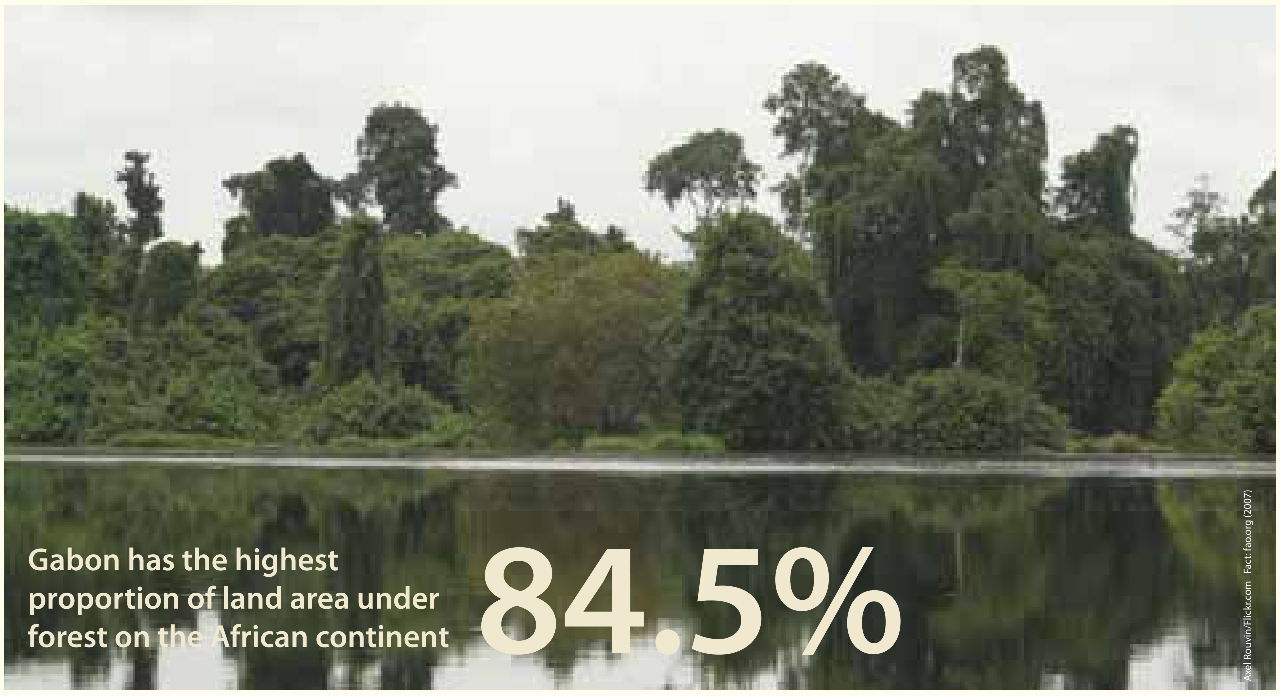
Coastal Degradation and Industrial Pollution

Nearly two-thirds of Gabon's approximately 1.5 million inhabitants live within 100 km of the coast (CIESIN 2000), resulting in significant localised environmental degradation. Clearing of mangrove forests, for example, has led to intense coastal erosion, which is particularly troubling in light of climate change and potential sea-level rise (UNEP 2002).

Pollution from industrial sectors, including timber and oil, has also degraded the coastal environment. Oil production, which is the principal economic activity in the country accounting for nearly one-half of gross domestic product (CIA 2007), has contaminated coastal waters and generated air pollution through gas flaring.

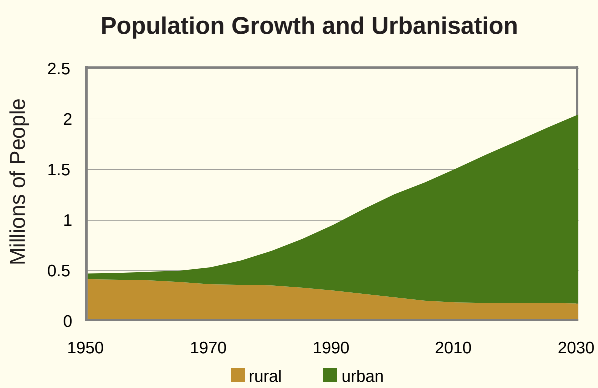


Source: Earth Trends (from World Bank and BP Statistical Review of the World Energy 2007)

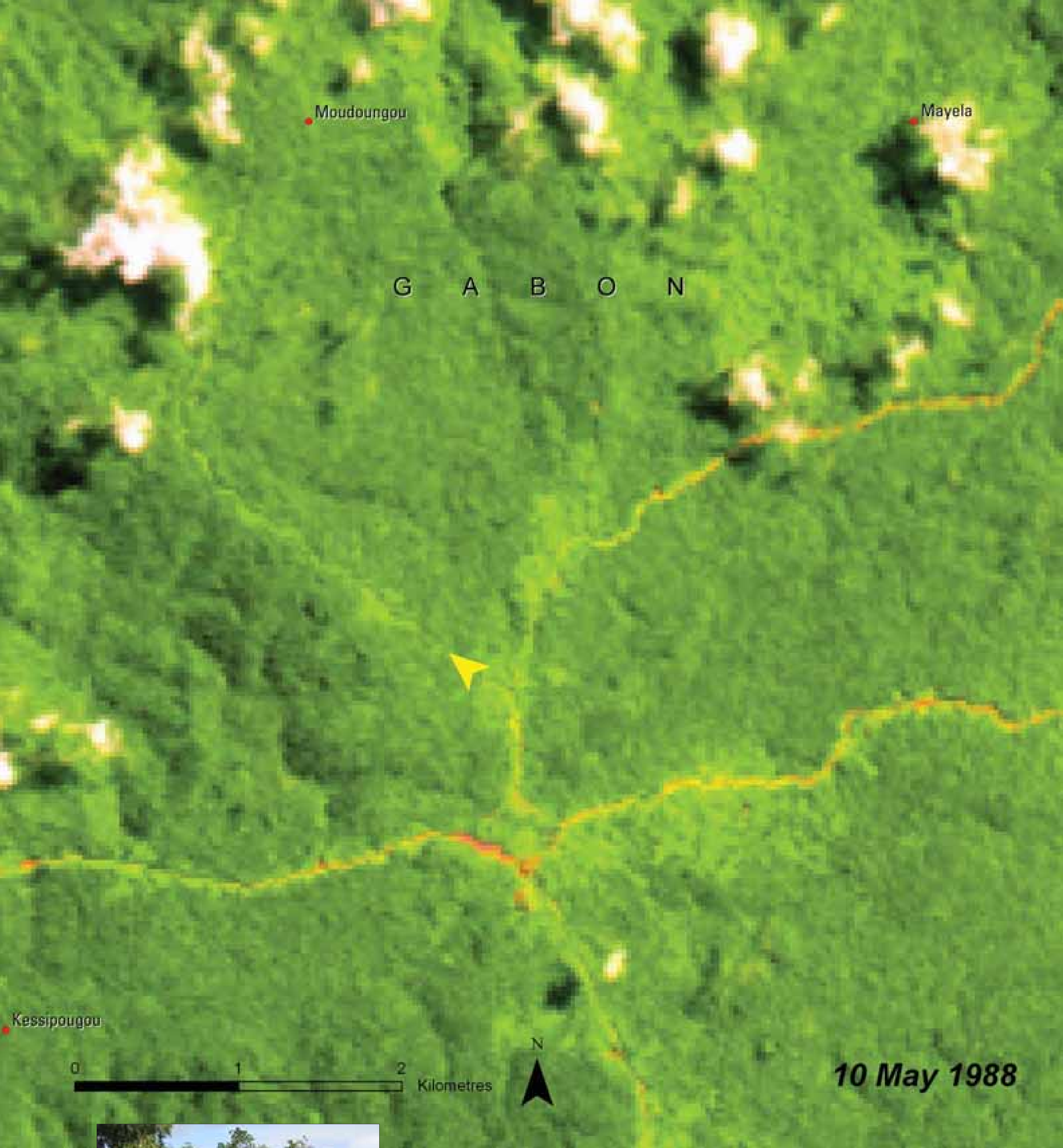


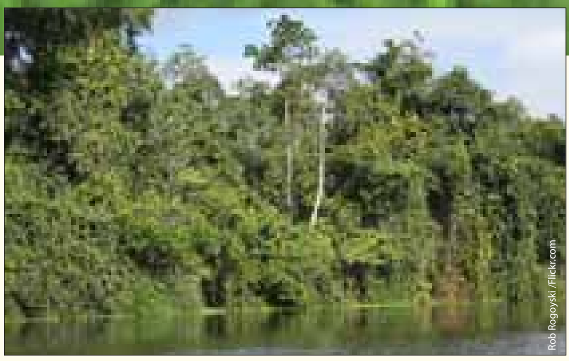
Lack of Sanitation and the Urban Environment

Roughly 84 per cent of Gabon's population resides in urban areas, especially in the capital city of Libreville. The urban population continues to grow by 2.4 per cent per year while the rural population declines by 1.6 per cent per year (UNESA 2006), resulting in a proliferation of urban slums and inadequate housing (approximately two-thirds of city residents are slum-dwellers (CBD 2007). Municipal pollution is on the rise as a result of improper household waste disposal, affecting nearby rivers, streams, and marine ecosystems and taking a toll on human health. Only 37 per cent of urban residents have access to an adequate sanitation facility (CBD 2007).



Source: UN Population Division, World Urbanization Prospects

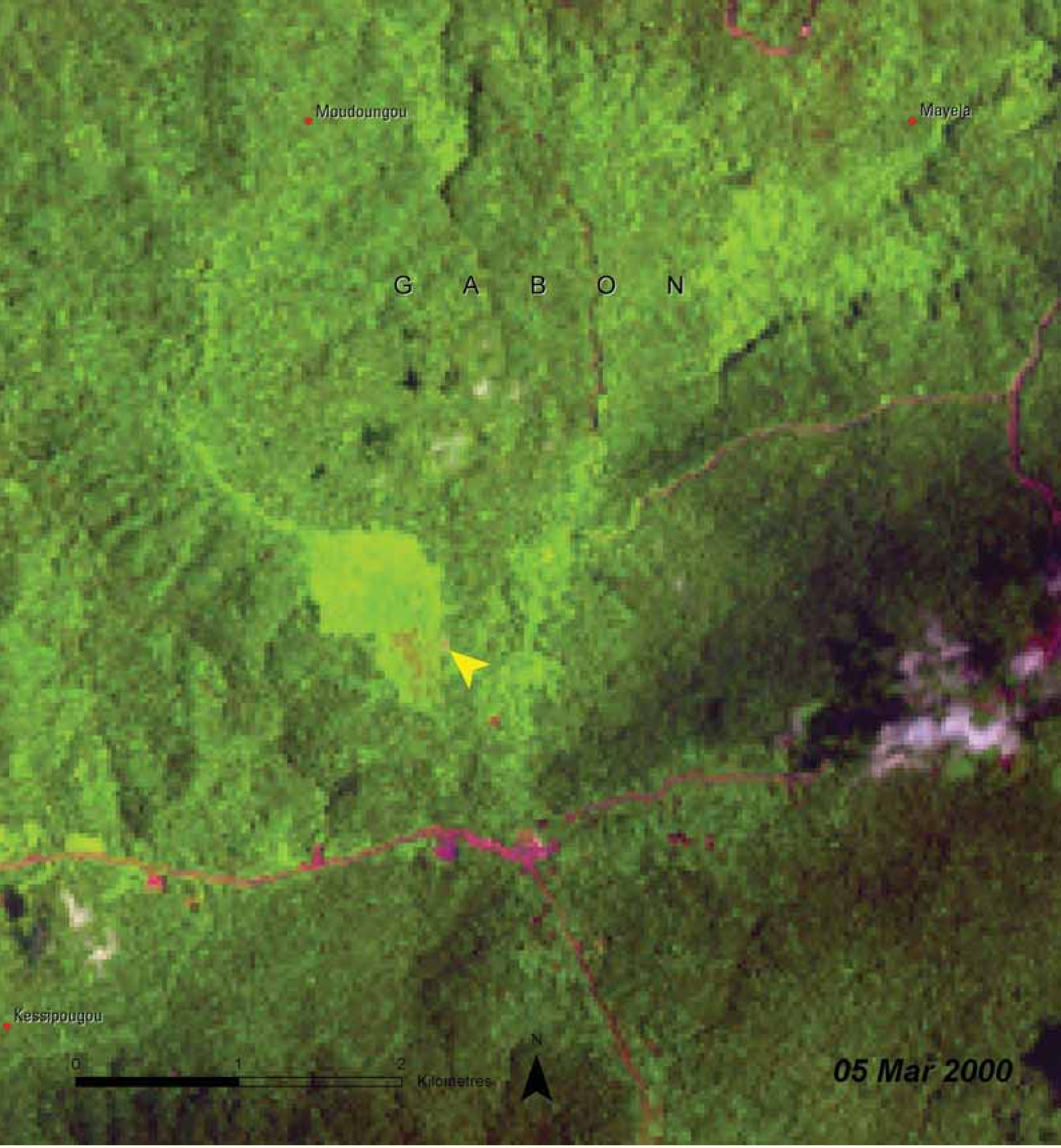




Forestry in the Guineo-Congolese Forest: Gabon

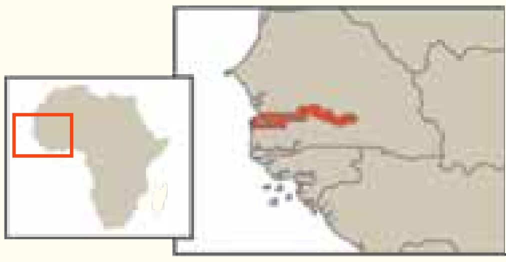
Various sources estimate Gabon's forest cover at between 17 and 20 million hectares, comprising the majority of the Guineo-Congolese forest. Guineo-Congolese forest is a tropical rain forest ecosystem known for its high species richness and endemism. This forest is an invaluable resource to Gabon locally and is also important globally as a source of biodiversity and a carbon sink, which influences the global climate.

Over the past 40 years, the area of forest allocated to logging concessions has grown from less than 10 per cent to over 50 per cent with most of this increase occurring in the last decade.



Okoume, a valuable African hardwood, accounts for over 70 per cent of Gabon's timber harvest. It is selectively harvested by clear-cutting patches of Okoume, leaving a few trees to encourage regrowth. During the first six months of 2005, production of logs of all species in Gabon rose 4.7 per cent over the previous year

The 2000 image shows a clear cut patch in the centre of the image at a regrowth stage. This is in contrast to the 1988 image, in which only slight disturbance of the forest cover is visible (yellow arrow). The least densely populated country in Central Africa, Gabon has less pressure than many of its neighbours to convert forests to agricultural land. With good forest management practices, the immense value of Gabon's Guineo-Congolese forest can be sustainably utilized for many generations.



Republic of the Gambia

Total Surface Area: 11 295 km²
Estimated Population in 2006: 1 556 000

The Gambia is the smallest and third most densely populated country on the African continent. It extends roughly 300 km east from the Atlantic Ocean along the banks of the River Gambia, which divides the country into two narrow strips of land each, no more than 25 to 50 km wide. The landscape is dominated by two major topographical units, the lowland river floodplains and the upland plateaus. Climate is characterized by one rainy season followed by a long dry season between November and May.

Important Environmental Issues

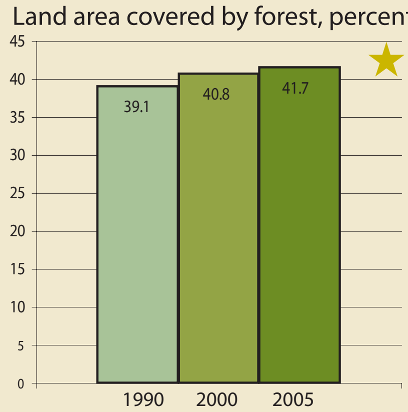
- Drought and Agricultural Productivity
- Threats to Forest and Wetland Ecosystems
- Overfishing and Coastal Erosion

Progress Towards Environmental Sustainability

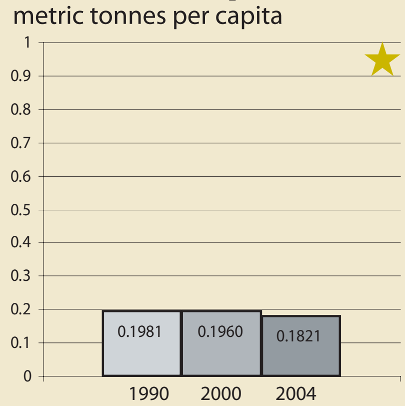
As defined by the United Nations Millennium Development Goal 7 Indicators

Only nine per cent of the Gambia's existing forests survived the expansion of agricultural land and the use of trees for fuel. With 30 per cent decrease in rainfall over the last 30 years, the desertification rate for agricultural lands has accelerated. According to the United Nation's Food and Agriculture Organization, in the past five years the Gambia has seen a net increase in forest cover, likely resulting from increased plantations.

Land area covered by forest, percentage

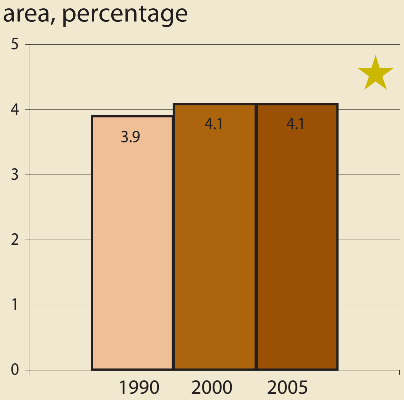


Carbon dioxide (CO_2) emissions, metric tonnes per capita

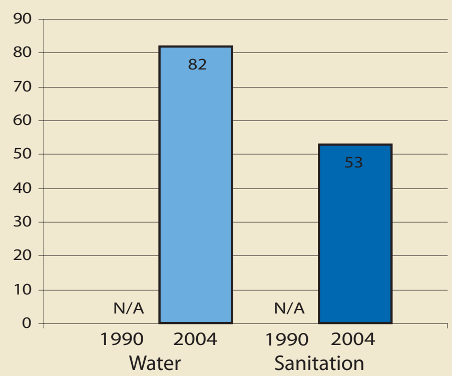


★ Indicates progress

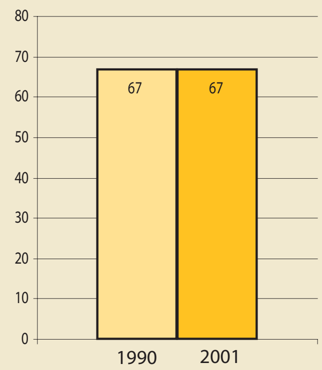
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

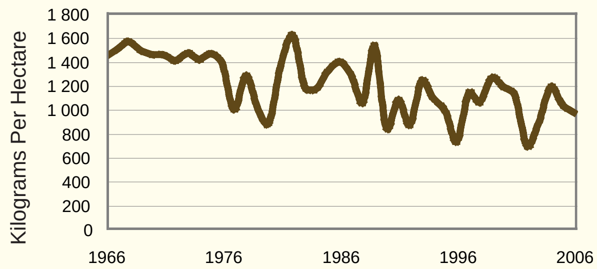


The Gambia is the smallest of the mainland African states.

Drought and Agricultural Productivity

In 2003, agriculture employed nearly 80 per cent of the Gambia's labour force and contributed nearly one-third to its gross domestic product (FAO 2005), despite generally poor soil quality in the country. Most farmers are poor, cultivate small areas of land, and use minimal inputs of fertilizer and pesticides. Decreasing average rainfall over the past three decades (CIA 2007), has created challenges for agriculture and increased saltwater intrusion. During the dry season, saltwater can be detected up to 250 km inland from the coast (FAO 1997), contaminating soil and freshwater wells. The consequences of drought, including soil erosion and degradation, have been particularly acute in the upland areas where groundnuts are the primary crop.

Groundnut Production, Yield



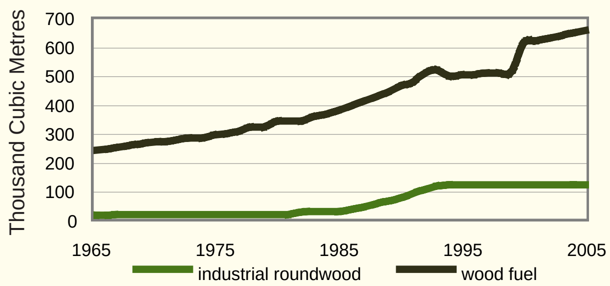
Source: FAOSTAT

Threats to Forest and Wetland Ecosystems

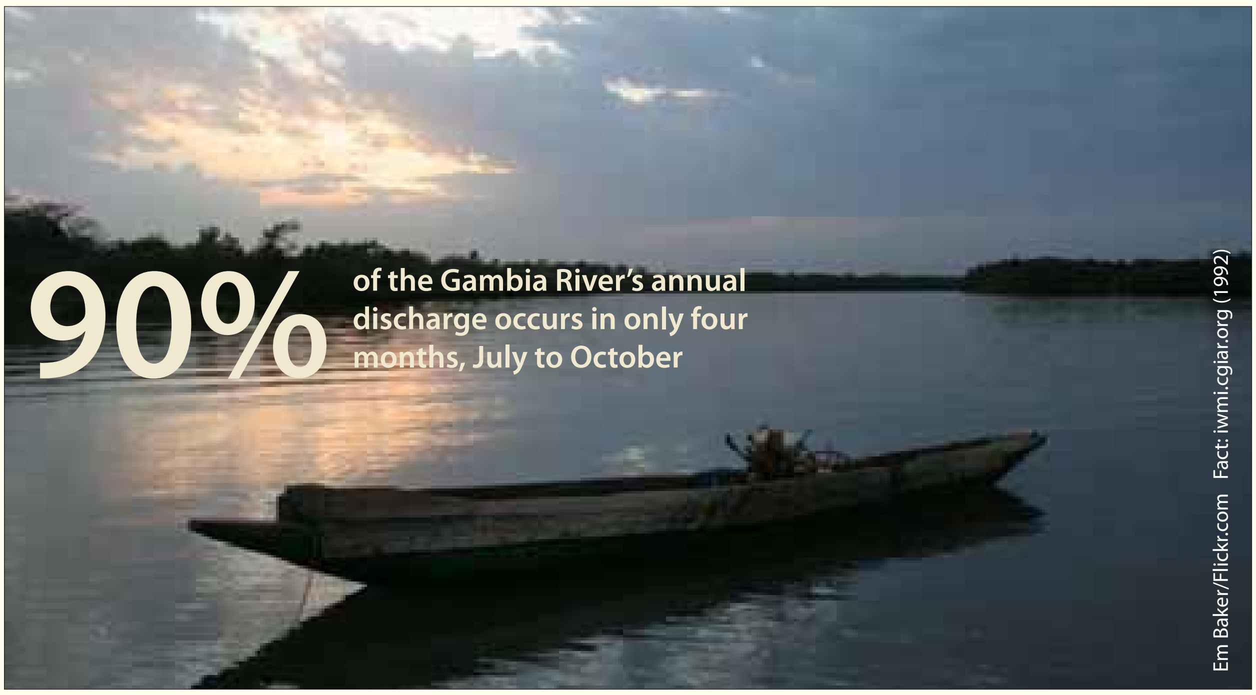
The Gambia is heavily forested compared to other Sahelian countries, with forests accounting for 42 per cent of land cover (UN 2007). Although the net rate of forest change has been positive since 1990, the proportion of closed woodland forest has decreased substantially in favour of less dense savannah forest. Population growth, measured at 2.4 per cent per year (UNESA 2005), coupled with heavy reliance on fuelwood, bush fires, and agricultural expansion are the primary drivers of forest degradation.

The mangroves and wetlands associated with the Gambia River account for one-fifth of the country's total land area (FAO 2005) and provide important habitat for much of the Gambia's floral and faunal diversity. Wetlands are threatened by rice production and dry season livestock grazing; almost one-third of swamps have been cultivated (The Gambia Department of Parks and Wildlife Management 2006).

Forestry Production



Source: FAOSTAT

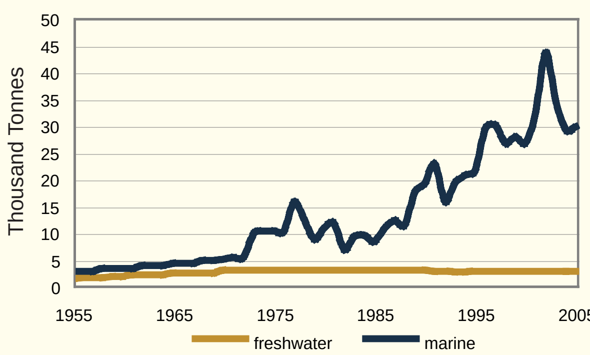


Overfishing and Coastal Erosion

The Gambia's marine fisheries are particularly productive due to the freshwater flow from the Gambia River estuary, which attracts both feeding and breeding fish. Recent studies show that demersal (near-shore) species are suffering from excessive fishing pressure, whereas pelagic (off-shore) species are vastly underexploited (FAO 2000-2007).

Intensive development of the Gambia's short coast has resulted in severe coastal erosion. In some areas, the shoreline is receding by one to two metres per year (UNESCO 2002), threatening nearly three-quarters of a million people, or 45 per cent of the country's population, who live on the coast.

Fisheries Production

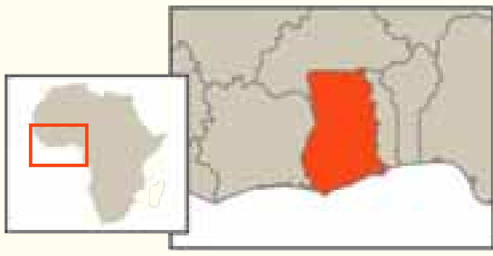


Source: FISHSTAT

Urban Sprawl: Greater Banjul Area, the Gambia

The Gambia's capital city, Banjul, is located at the end of a peninsula referred to as Banjul Island or St. Mary's Island. Banjul grew rapidly until the early 1980s, when commuter services from the surrounding area were developed. Easy access to Banjul led to dramatic population growth in the nearby Kanifing District, from less than 12 000 in 1963 to over 332 000 in 2003. The pattern repeated itself as the Kanifing District became crowded in the mid-1990s and services and amenities were made available in the areas south of Kanifing, inducing many people to move there.

The sprawl of greater Banjul has led to the loss of forest cover and arable land. It is also putting increasing pressure on the Tanbi Wetland Complex, a mangrove forest located between Banjul and Kanifing District. Tanbi was recently designated a Ramsar Wetland of International Importance. These images show the dramatic increase in urban development in the Banjul area between 1973 and 2006, particularly in the Kanifing District. Some forest blocks (deep green patches) have survived; most of them are designated forest reserves. The Abuko Nature Reserve, immediately southwest of the Tanbi Wetland Complex, increasingly contrasts with the developed areas around it. The Reserve was set aside in 1916 to protect a water catchment and was made a nature reserve in 1968.

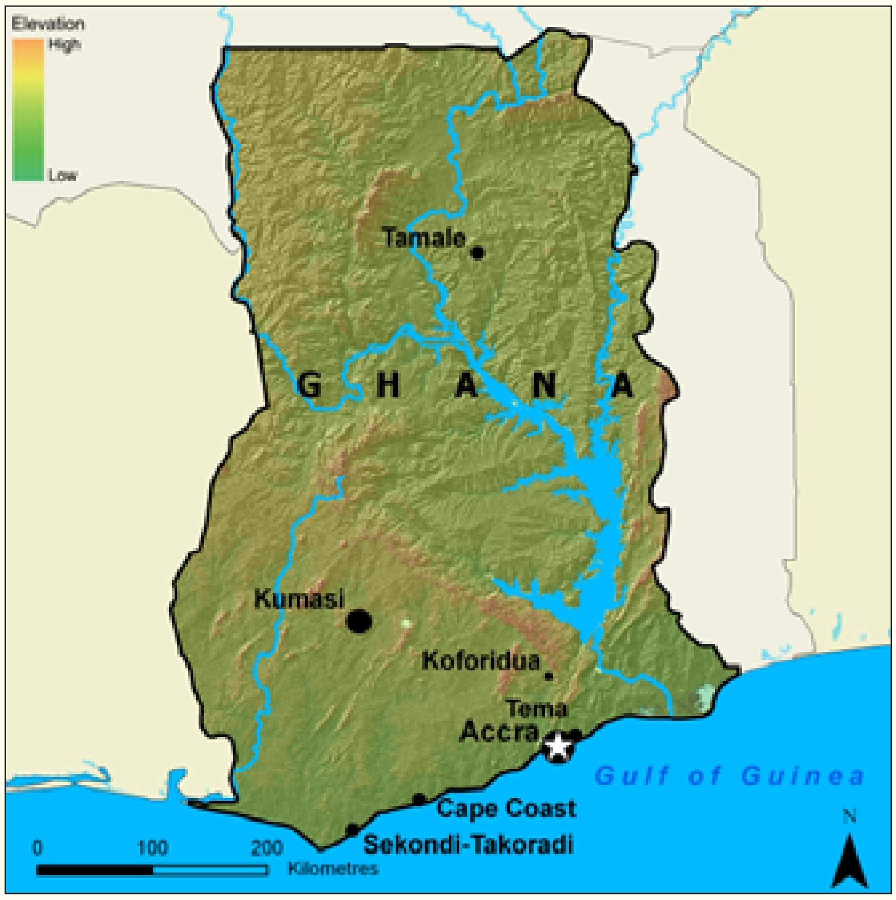


Republic of Ghana

Total Surface Area: 238 553 km²
Estimated Population in 2006: 22 556 000

Credit: © Flagart.com

Ghana is relatively well-endowed with natural resources, including fertile soils, forests, and mineral deposits of gold, diamonds, manganese, and bauxite. The climate is generally tropical and warm, with aridity increasing from south to north. Occupying central Ghana, the Volta River Basin drains nearly half of the country. While the coastal zone represents only 6.5 per cent of the total land area, it supports one-quarter of the population and most of the country's industries (Amlalo 2006).



Important Environmental Issues

- Deforestation
- Land Degradation and Coastal Erosion
- Overfishing and Reduced Water Volume in Lake Volta

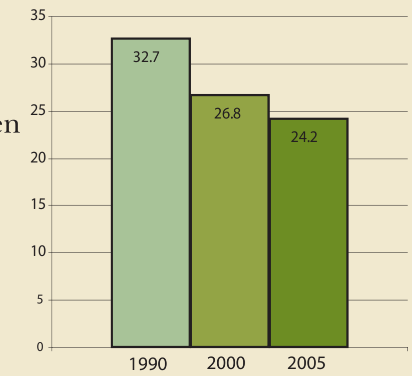
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

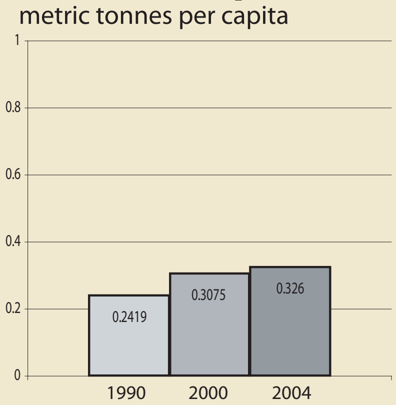
In less than 50 years, Ghana's primary rain forest has been reduced by 90 per cent, and between 1990 and 2005, the country lost 26 per cent of its forest cover. Overgrazing, heavy logging, overcutting of firewood, and mining have all taken a toll on forests and woodlands. About one-third of the land area is threatened by desertification, caused mainly by slash-and-burn agriculture and overcultivation of cleared land, resulting in widespread soil erosion and degradation.

★ Indicates progress

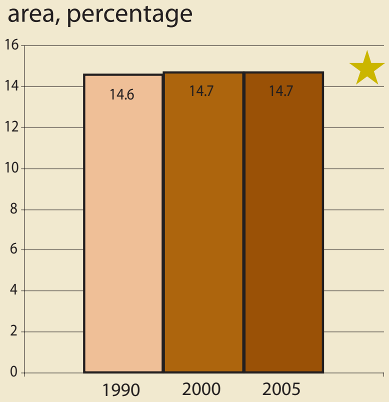
Land area covered by forest, percentage



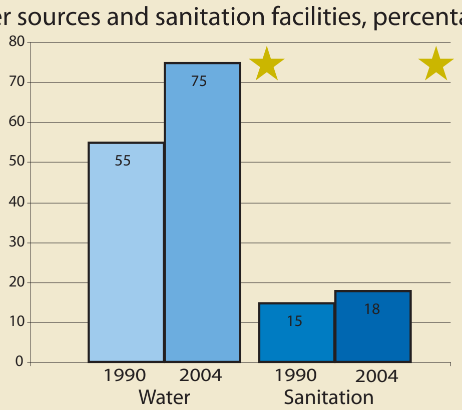
Carbon dioxide (CO_2) emissions, metric tonnes per capita



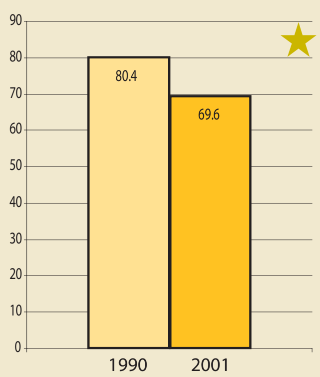
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



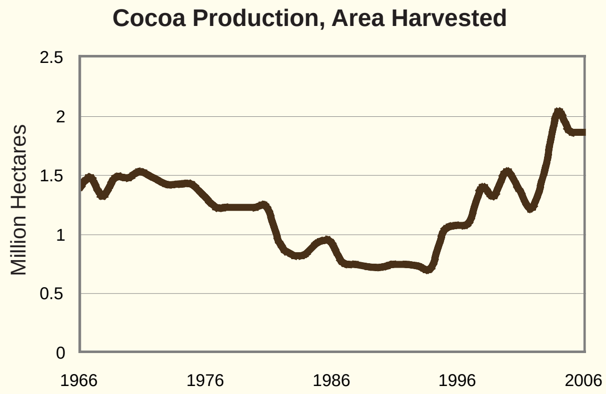
The closing of Akosombo Dam in the early 1960s flooded four per cent of Ghana's land and created the largest reservoir in the world by surface area, Lake Volta.

internationalrivers.org (2007); Tanaka and others (2002)

Deforestation

Ghana is the world's second-largest producer of cocoa beans (FAO 2007), and large tracts of tropical forest have been cleared to support increasing cocoa cultivation. When world cocoa prices are low, Ghana's foreign exchange earnings are significantly affected; this is often compensated for by increasing timber and mineral exports. Thus, cocoa farming is both a direct and indirect driver of deforestation.

Ghana has one of the highest deforestation rates in Africa at—two per cent annually (UN 2007). Timber harvesting and slash-and-burn agriculture are the greatest threats, but wildfires, mining, and rising demand for fuelwood are also important contributors.



Source: FAOSTAT

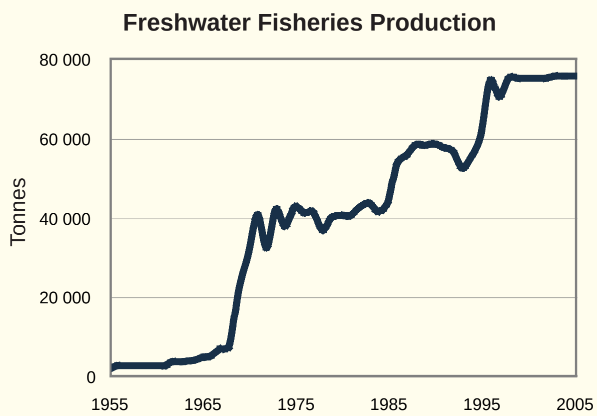
Land Degradation and Coastal Erosion

Despite relatively flat topography, nearly three-quarters of Ghana suffers from sheet and gully erosion (FAO 2005) and one-third of its land is affected by desertification (UNCCD 2002). Lowered water tables, siltation of rivers, and increased flooding are evidence of increasing aridity. Rapid deforestation and poor cultivation practices are largely responsible, although occasional droughts and wildfires intensify the problem. Furthermore, mining is a significant source of localised land degradation; the use of cyanide and other poisonous chemicals has contaminated surface and groundwater resources and rendered much land unusable for agriculture or forestry. Although most mining is controlled by international corporations, small-scale, illegal mining is pervasive.

On the coast, land degradation is a consequence of the heavy concentration of people and industries. Overexploitation of mangroves and rapid development are driving coastal erosion at an average rate of two to three metres per year (ACOPS n.d.).

Overfishing and Reduced Water Volume in Lake Volta

In the mid-1960s, the Akosombo Dam was constructed on the Volta River creating Lake Volta, one of the largest artificial water bodies in the world. With roughly 140 identified fish species, Lake Volta is the site of the most important inland fishery in Ghana. However, the maximum sustainable yield has been exceeded annually since 1995, causing fish catch to stagnate (FAO 2000-2007). Furthermore, the lake's water volume recently dropped to record low levels, affecting the dam's electricity-generating capacity. This is likely both a consequence of natural factors such as climate variability as well has human-induced problems such as soil erosion.

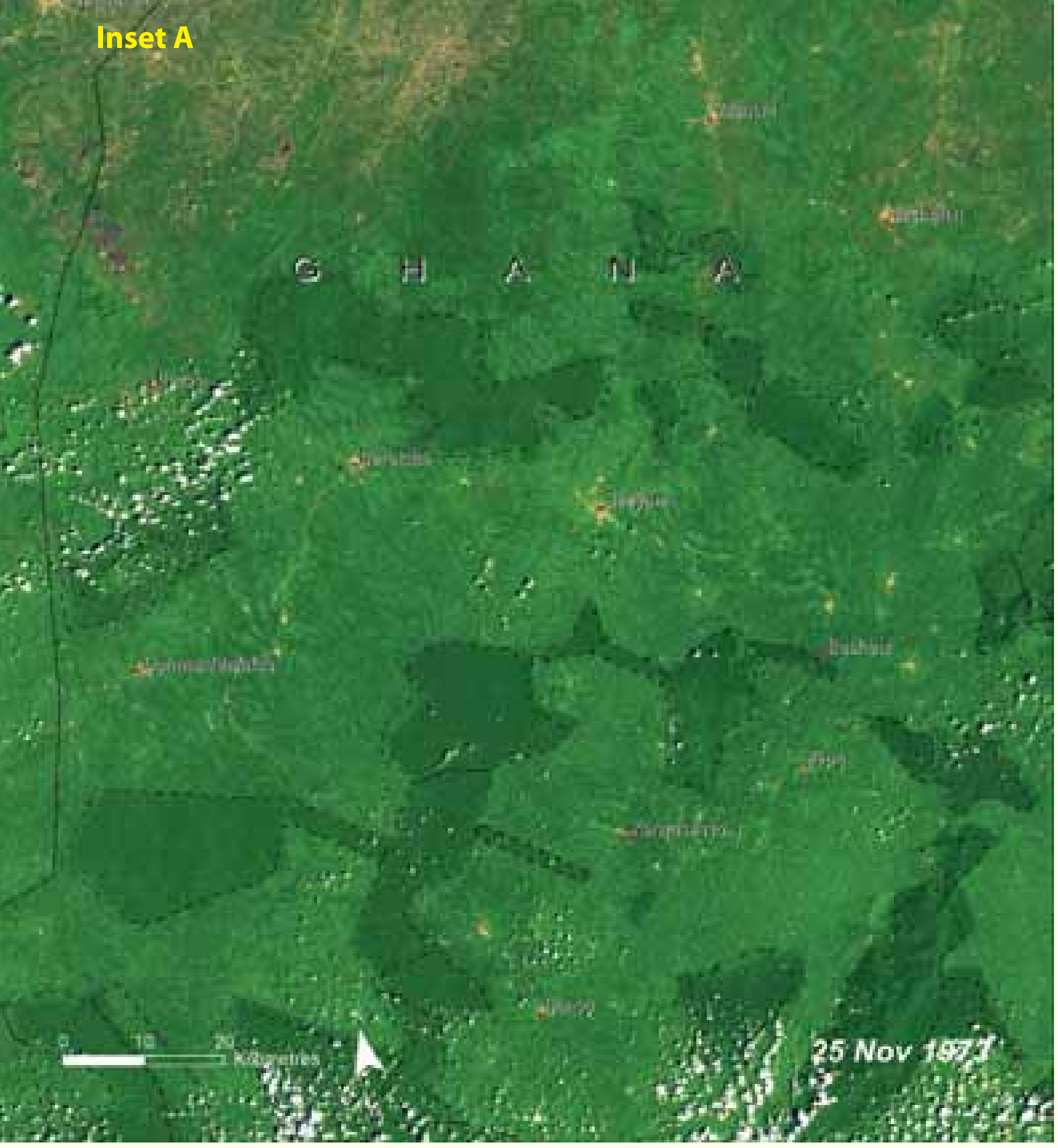


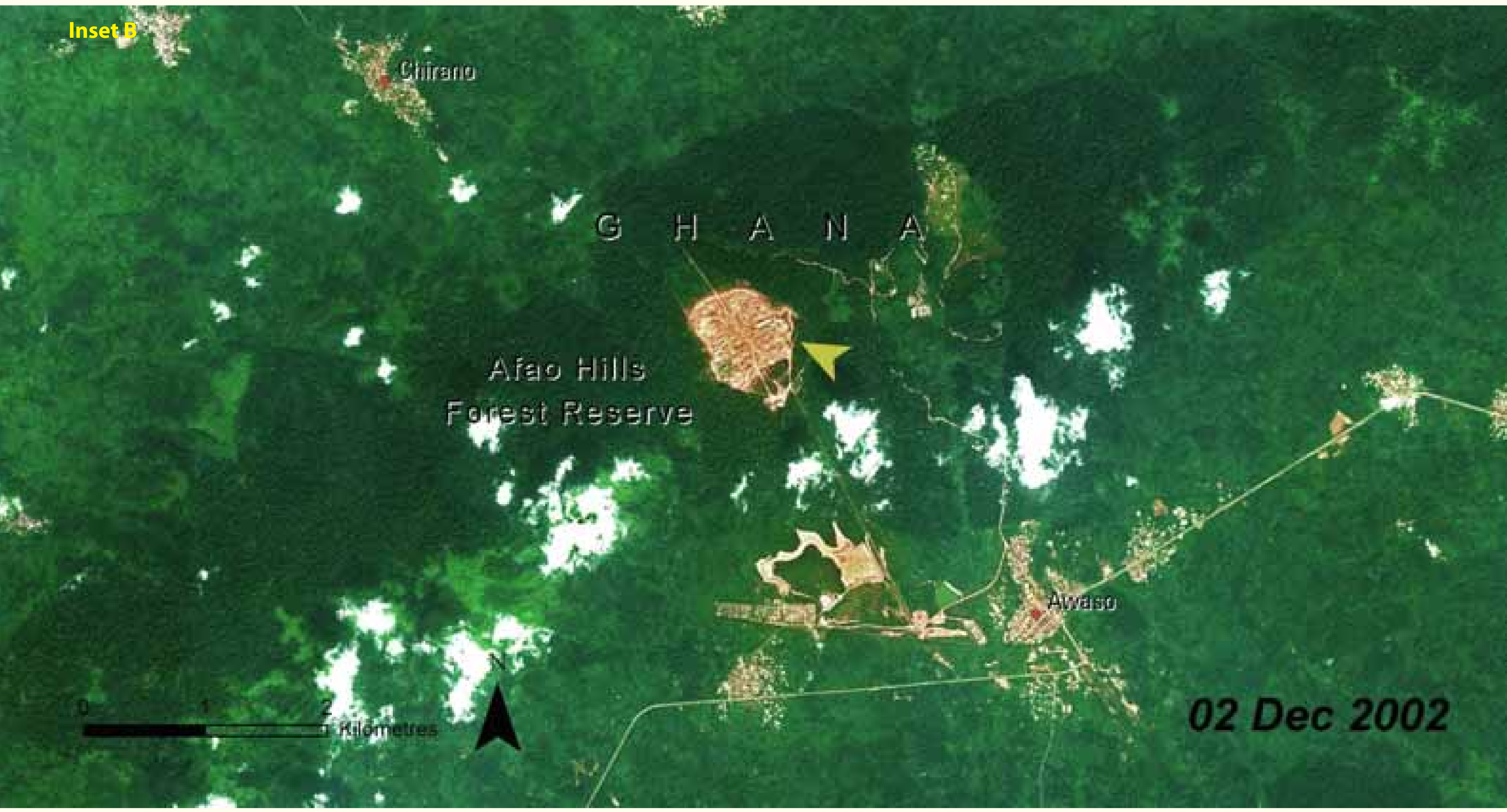
Source: FISHSTAT

Forest Reserves Under Pressure: Ghana

The fragmented tropical forest of southwestern Ghana creates a fascinating pattern from space. The dark green patches seen above are reserves set aside early in the 20th century; they are the only significant blocks of forest remaining in the country. Recognizing this priceless ecological heritage, the Ghanaian government has developed policies for sustainable forest management.

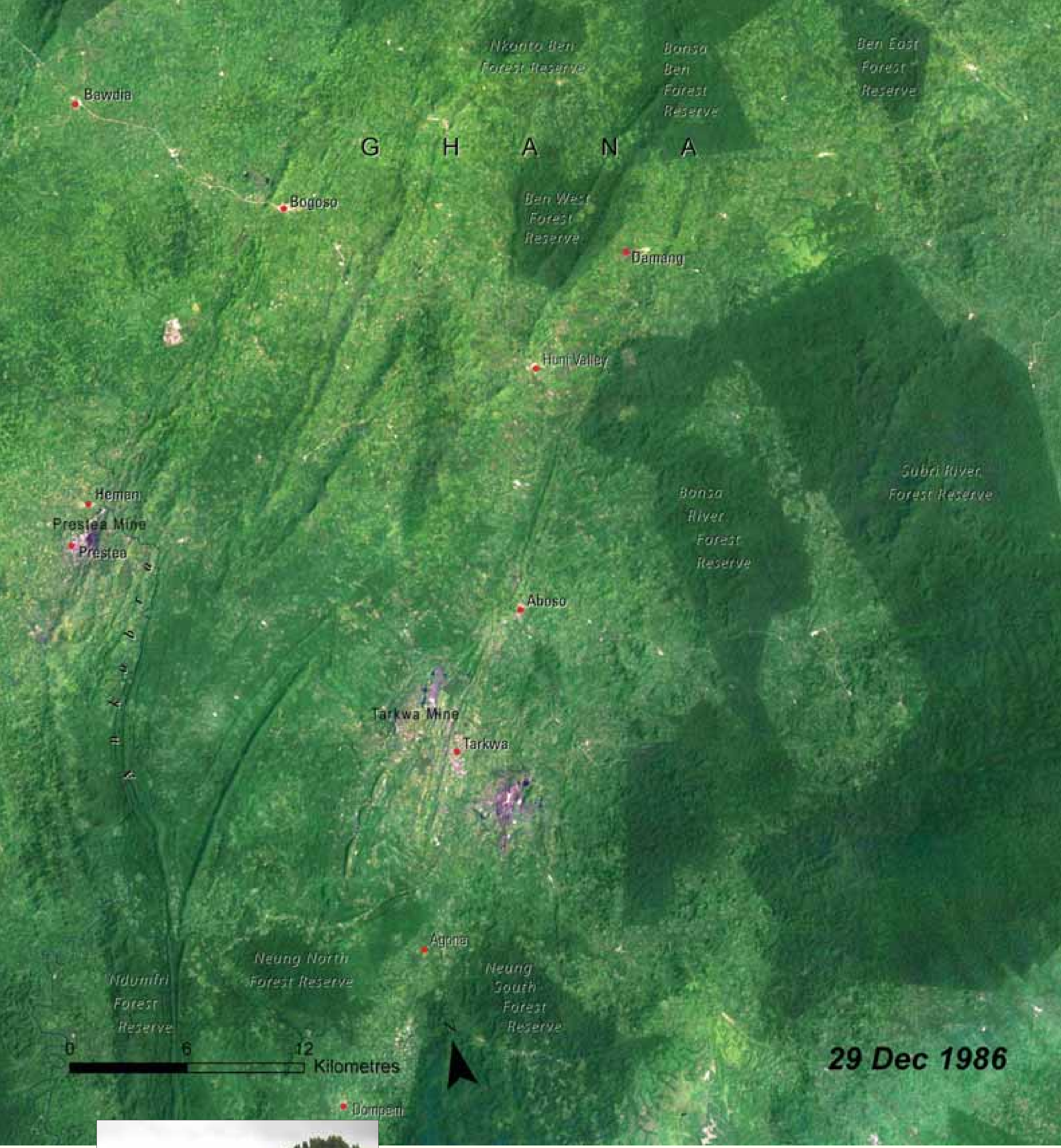
In spite of the enormous ecological benefits of the forest and the government's effort to sustainably manage the reserves, shifting cultivation, uncontrolled logging, surface mining,





charcoal production, and increasing population place enormous pressure on these remnants of Ghana's tropical forests. In the 1973 image (top left) the vegetation inside and outside the protected areas appears green and robust. In the 2002/2003 (top right), dramatic change is apparent; some of the northern reserves have been decimated and the northern edge of the forest zone has moved south.

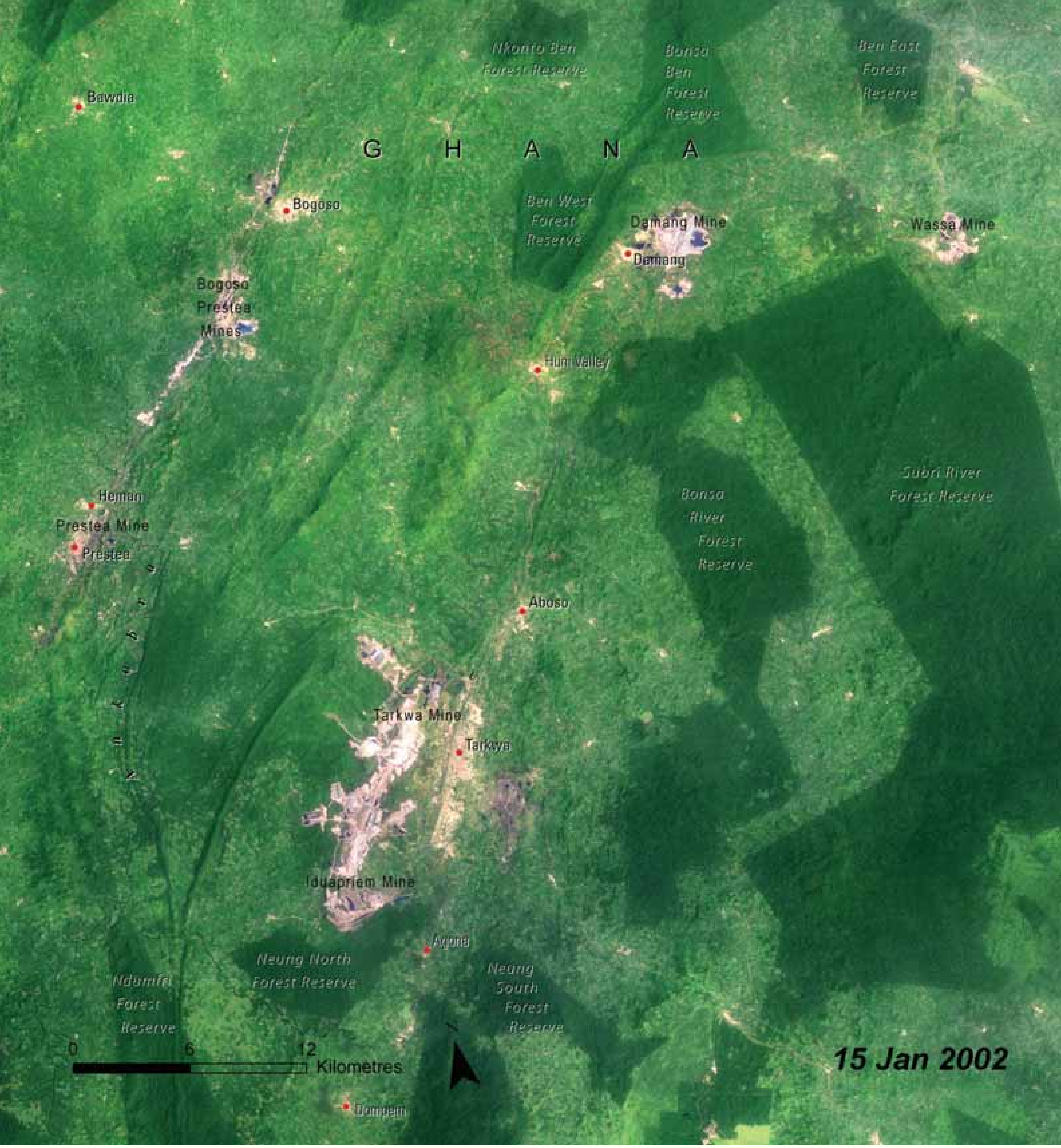
Recently, mines have been permitted within some of Ghana's forest reserves. On the advice of the International Monetary Fund (IMF), Ghana relaxed mining and logging regulations and nurtured investment by the mining and forestry industries through generous incentives during the 1980s and 1990s. Mines like the one within the Afao Hills Forest Reserve (yellow arrow on the bottom image) pose a serious threat to Ghana's remaining forests.




Luke and Kate Bosman/Flickr.com

Gold Mining in Wassa West District: Ghana

With the encouragement and support of the World Bank, Ghana revised its mining laws in the 1980s, privatising the industry and liberalising regulation. This resulted in several hundreds of millions of dollars of foreign investments in Ghana's mining industry. While this brought gold production to new highs, replacing cocoa as Ghana's most valuable commodity, it also resulted in social and environmental impacts that are proving to be unpopular locally and internationally.

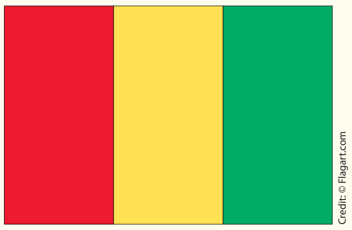


Over 60 per cent of the Wassa West District in western Ghana is now under concession to large-scale gold mining companies, the greatest concentration of mining in a single district in Africa. The large footprints of these open-pit mines directly result in significant forest loss. In addition, related infrastructure and associated population growth indirectly drive even greater land cover conversion. Significant portions of Wasa West's tropical rainforest have been degraded by or lost to this gold mining boom since the 1980s.

The mines in Wassa West have been kept out of the forest reserves, which can be seen as dark green areas with clear straight boundaries in both the 1986 and 2002 images. However, the 2002 image shows that the footprints of mining operations in the district have grown dramatically since 1986.

Republic of Guinea

Total Surface Area: 245 857 km²
Estimated Population in 2006: 9 603 000



Guinea is a relatively small country with diverse geographic regions including a coastal plain, gently rolling savannahs, a mountainous plateau, and forested highlands. It is known as the "water tower of western Africa" due to the 22 major rivers originating within the country, which include the Niger and Senegal Rivers. The climate is tropical with one rainy season and one dry season. Precipitation is generally high and varies from roughly 1 200 mm per year in upper Guinea to 4 200 mm per year in lower Guinea (FAO 2005).

Important Environmental Issues

- Deforestation and Refugees
- Overfishing and Destruction of Mangrove Forests
- Land Degradation

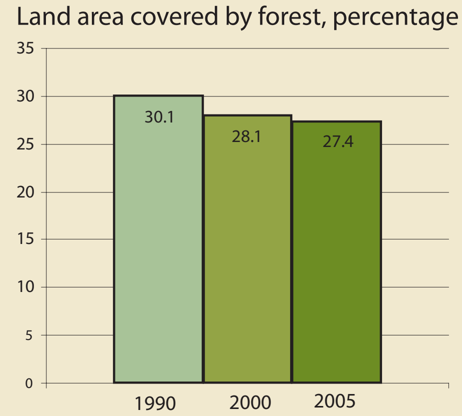
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

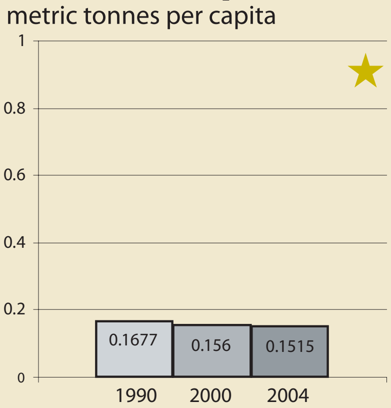
In Guinea, centuries of slash-and-burn agriculture have caused forested areas to be replaced by savannah woodland, grassland, or brush. Mining, the expansion of hydroelectric facilities, and pollution contribute to the erosion of the country's soils and desertification. Dense mangrove forests grow along the mouths of Guinea's major rivers, but the ecosystems are overexploited and are rapidly being lost.

★ Indicates progress

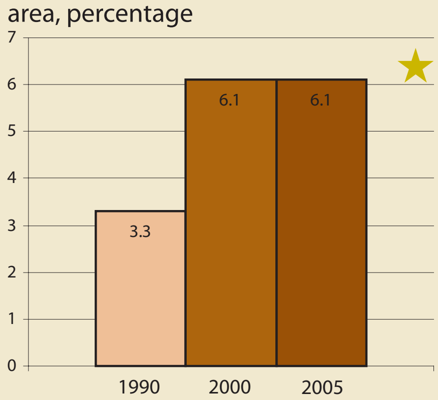
Land area covered by forest, percentage



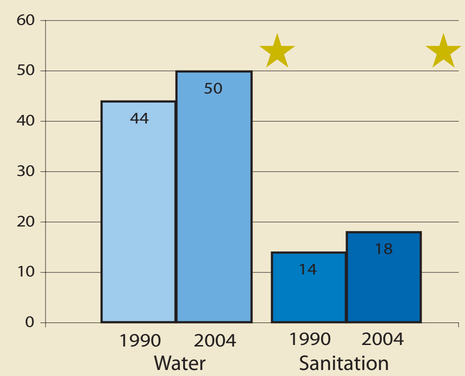
Carbon dioxide (CO_2) emissions, metric tonnes per capita



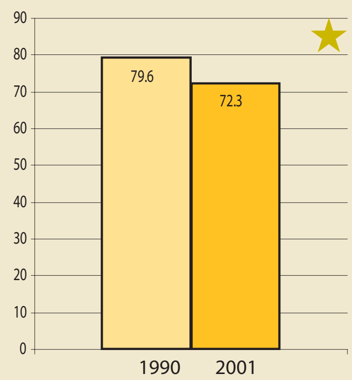
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

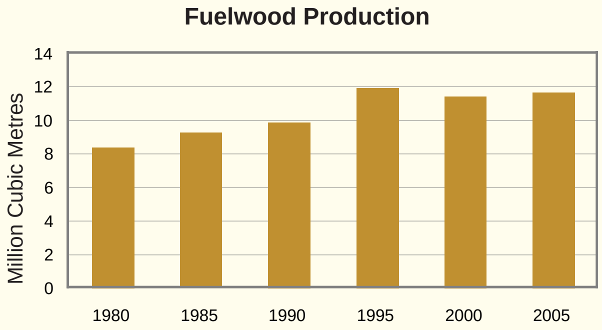


Guinea has the world's largest bauxite reserves and is the world's number one exporter of bauxite ore.

minerals.usgs.gov (2008)

Deforestation and Refugees

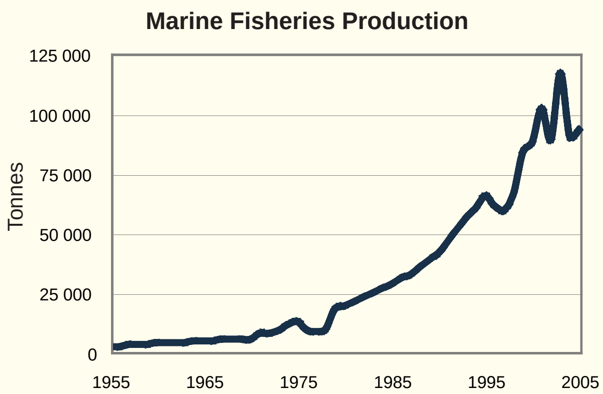
Less than one-third of Guinea is now forested, reflecting many decades of uncontrolled deforestation. The primary drivers include growing demand for agricultural land and dependence on wood and charcoal for 90 per cent of all energy needs. The humid tropical forests of southeast Guinea have been reduced to less than five per cent of their original extent (CBD 2002). This is in part due to an influx of at least 600 000 refugees from Sierra Leone, Liberia, and Côte d'Ivoire during the past 15 years, which has placed increased demand on forest resources. Refugees have expanded the local populations by as much as 40 per cent in some areas, resulting in local population densities close to 400 people per square kilometre (CBD 2002).



Source: FAOSTAT

Overfishing and Destruction of Mangrove Forests

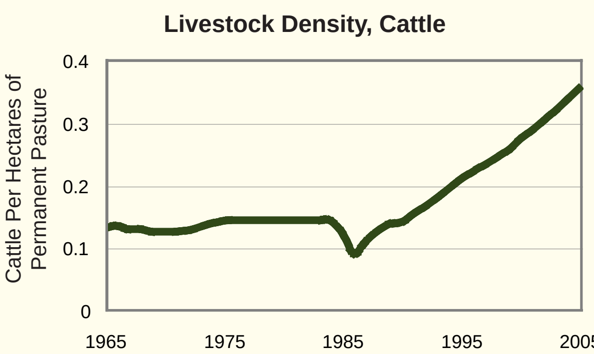
Guinea's marine fisheries sector has grown dramatically in recent decades, resulting in the overexploitation of certain commercial species and declining stocks. Those species traded internationally and exploited by foreign trawlers are particularly threatened. Fish populations are also endangered by the loss of coastal mangrove forests, which provide important shelter and breeding habitat. Since 1965, mangroves have been lost at an average rate of 4.2 per cent per year (CBD 2002). Salt production reached 30 000 metric tonnes per year in 2002, requiring 93 000 metric tonnes of fire wood from mangrove forests to fuel the process (CBD 2002).



Source: FISHSTAT

Land Degradation

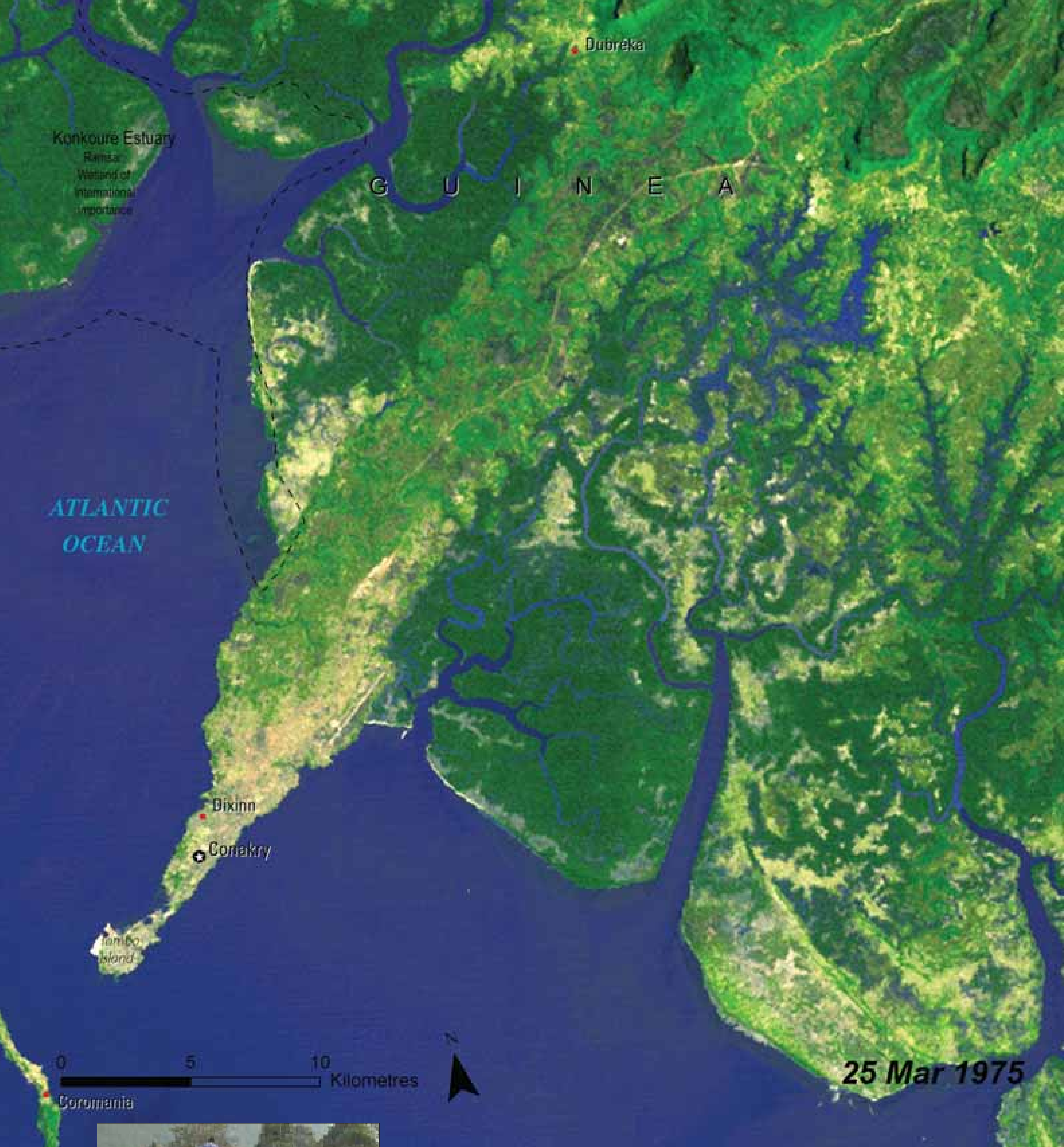
Agriculture employs 82 per cent of the population in Guinea (FAO 2005) and is a leading cause of land degradation. Cropped area has expanded significantly in recent decades, although most cultivation is characterized by low availability of inputs and mechanization, resulting in reduced soil fertility and low yields. Similarly, cattle stocks have increased nearly three-fold since 1961, thereby increasing grazing intensity.

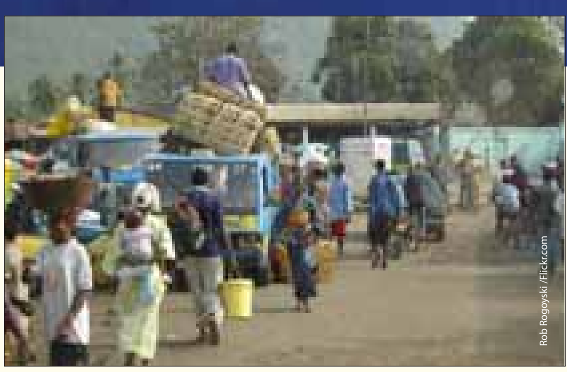


Source: FAOSTAT

Mining, which accounts for over three-quarters of export earnings in Guinea, is also responsible for substantial land degradation. Due to insufficient regulation, many open-pit mines have been abandoned without rehabilitation and wastes have been left to pollute the soil and water. One estimate suggests that 1 118 hectares of land had been affected as of 1994 (Campbell 1997).

Rob Rogoyski/Flickr.com





A City Between the Mangroves: Conakry, Guinea

Natural resources in Guinea's coastal zone are crucial to local economies, which depend on their immediate environment for freshwater, fuelwood, fisheries, and agriculture. Guinea's coastal zone is also home to one-fourth of West Africa's mangroves, which are linked to the vitality of the terrestrial and marine ecosystems that they bridge. These resources are being exploited at an unsustainable pace due to rapid population growth which without changes in resource management practices will lead to irreversible environmental degradation.

The city's need for agricultural land and space for urban expansion are in direct competition.

Population in Guinea's resource-rich coastal zone nearly tripled between 1963 and 1996. In the capital of Conakry, rural-to-urban migration, including refugees from Liberia and Sierra Leone in the 1990s, dramatically increased the population. Estimated at approximately 39 000 in the 1960s, Conakry's population had increased to nearly two million by 2006. Conakry's growing population puts intense pressure on the surrounding woody savannahs and mangroves, which are being converted to agriculture and exploited for fuelwood.

Conakry was founded on Tombo Island at the tip of Kaloum Peninsula. Its growth since then has followed the peninsula, hemmed in on either side by mangrove forests. In the 1975 image, dense settlement has reached the airport and beyond, but natural vegetation still covered much of the area. By 2007, however, nearly all of that vegetation has been overtaken by Conakry's rapid growth.

Mining a "Hotspot": Sangaredi Mine, Guinea

The Sangaredi Mine in the Upper Guinea Forest falls within one of the world's most biologically rich, yet seriously threatened, ecosystems. Recent biological assessment of the area surrounding the bauxite mine and proposed alumina processing facility identified five reptile species, 17 amphibian species, 140 species of birds, 16 species of mammals, and eight primate species, including the endangered West African chimpanzee and western red colobus.

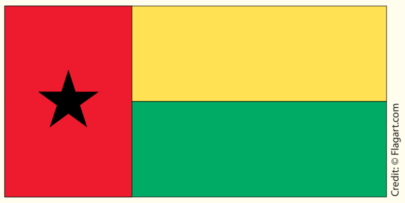
The Sangaredi Mine is Guinea's largest and most profitable. A proposed alumina refinery, sited approximately 25 km to the west of the mine, is expected to bring a US$3 000 million capital

investment, thousands of jobs, and infrastructure development. The consortium which is building the refinery is working with Conservation International to incorporate ecological considerations into the plans. A biological assessment of the area was conducted as a part of that process.

Bauxite mines and alumina refineries typically create serious ecological problems. Bauxite ore is mined in open pits, requiring the removal of vegetation and topsoil. In the 2007 image, the Sangaredi Mine is visible as a vast open pit approximately 20 km from one end to the other. Alumina refining produces highly caustic "red mud" that negatively affects surface and groundwater quality. In addition to direct environmental impacts, the increased population and infrastructure development associated with the mine will likely put immense pressure on this environmental "hotspot."

Republic of Guinea-Bissau

Total Surface Area: 36 125 km²
Estimated Population in 2006: 1 634 000



Guinea-Bissau is a small country bordering the Atlantic Ocean, lying primarily on a flat coastal plain no more than 40 m above sea level. Over half of the country's 1.7 million inhabitants live in this coastal zone and one-third of the population lives in cities. In the east, the terrain rises to a low savannah, eventually attaining a maximum elevation of 300 m. Just offshore, the Bijagos Archipelago comprises over 80 islands and is the only deltaic archipelago on Africa's Atlantic coast.

Important Environmental Issues

- Deforestation
- Cashew Farming and Soil Erosion
- Threats to the Bijagos Biosphere Reserve

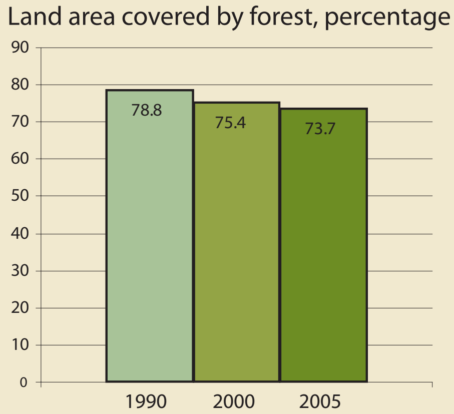
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

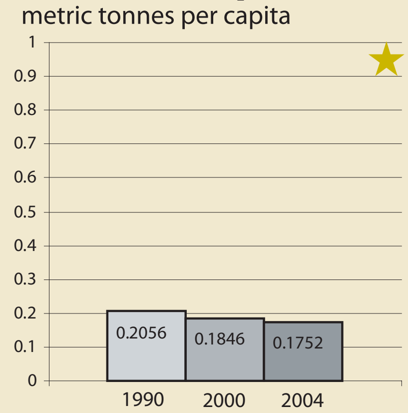
In Guinea-Bissau, fire destroys 40 000 hectares of land per year and contributes to the country's deforestation rate of about 570 km² per year. Guinea-Bissau lost over 75 per cent of its original mangroves by the mid-1980s; the remaining mangroves—some of the most important in Africa—are still giving way to rice fields and hydroelectric projects. However, thanks to a small population and minimal industry, Guinea-Bissau has few other serious environmental problems.

★ Indicates progress

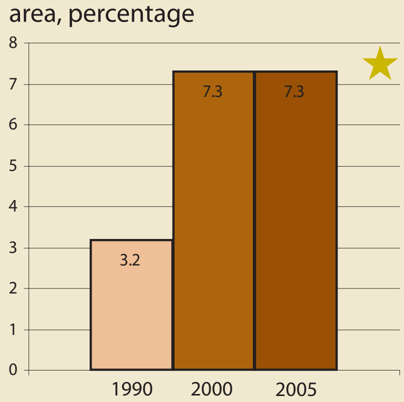
Land area covered by forest, percentage



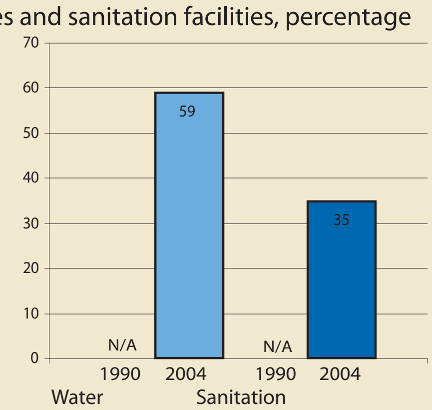
Carbon dioxide (CO_2) emissions, metric tonnes per capita



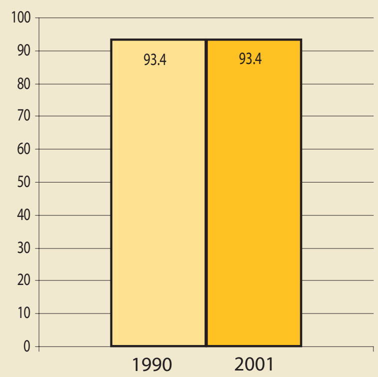
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

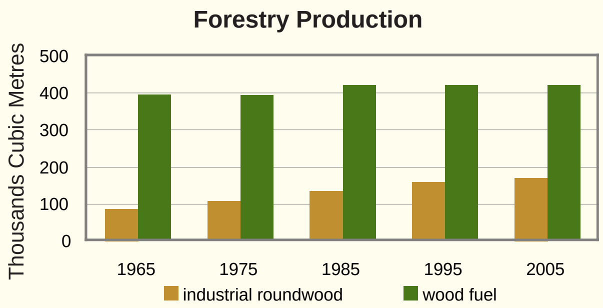


Guinea-Bissau is the world's sixth largest producer of cashew nuts, which account for over 90 per cent of its export earnings.

senegal.usaid.gov (2005)

Deforestation

Nearly three-quarters of Guinea-Bissau is forested (UN 2007), of which nearly half is considered primary forest (Mongabay 2006). Although the deforestation rate is currently only 0.5 per cent per year, (FAO 2005) the country is enduring rapid population growth and development despite being one of the smallest African countries. Mangrove forests are increasingly giving way to rice cultivation, hydroelectric projects, and charcoal production.

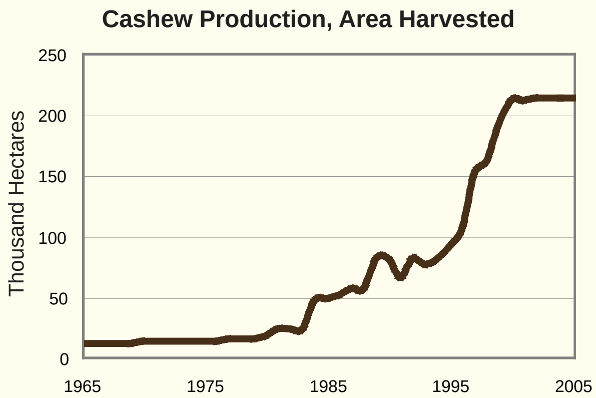


Source: FAOSTAT

Cashew Farming and Soil Erosion

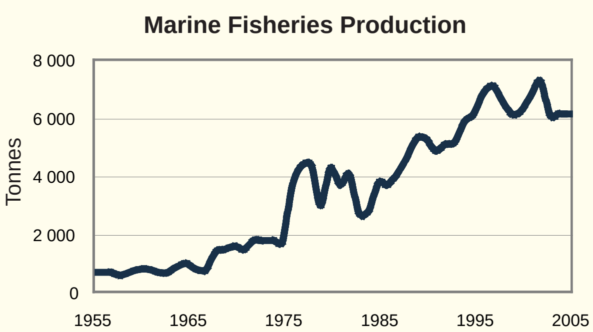
Over four-fifths of the population in Guinea-Bissau is involved in agriculture (FAO 2006); cashew nuts, rice, and livestock are the primary commodities. Overgrazing and rapid expansion of cultivated land have resulted in significant land degradation: 75 per cent of soils are moderately eroded (FAO AGL 2003).

In particular, cashew farming has grown dramatically over recent decades to become the most important cash crop and source of export earnings for Guinea-Bissau. However, increasing production of cashew nuts has come at the expense of food crops, leaving food security vulnerable to fluctuations in the global cashew market.



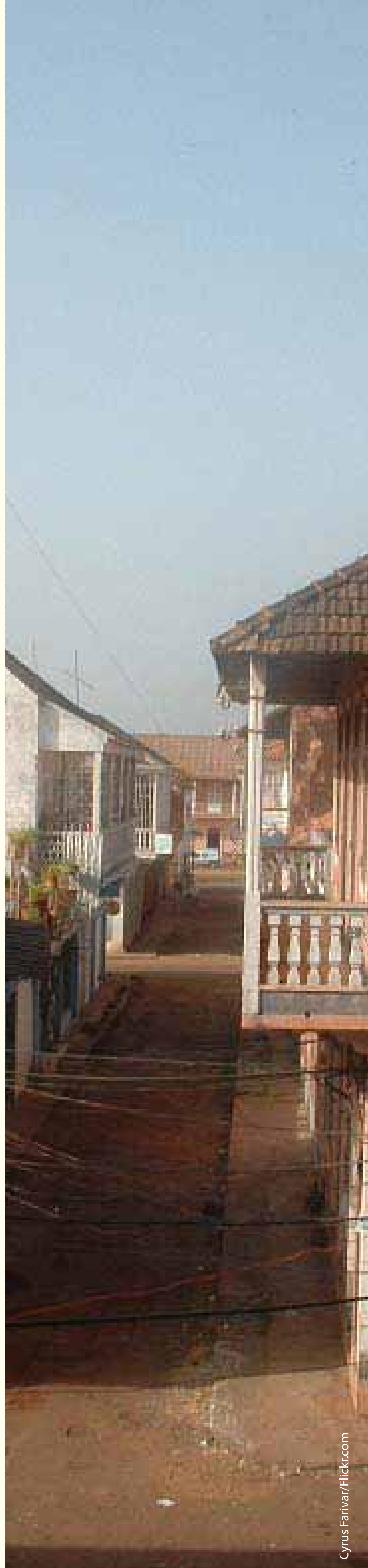
Source: FAOSTAT

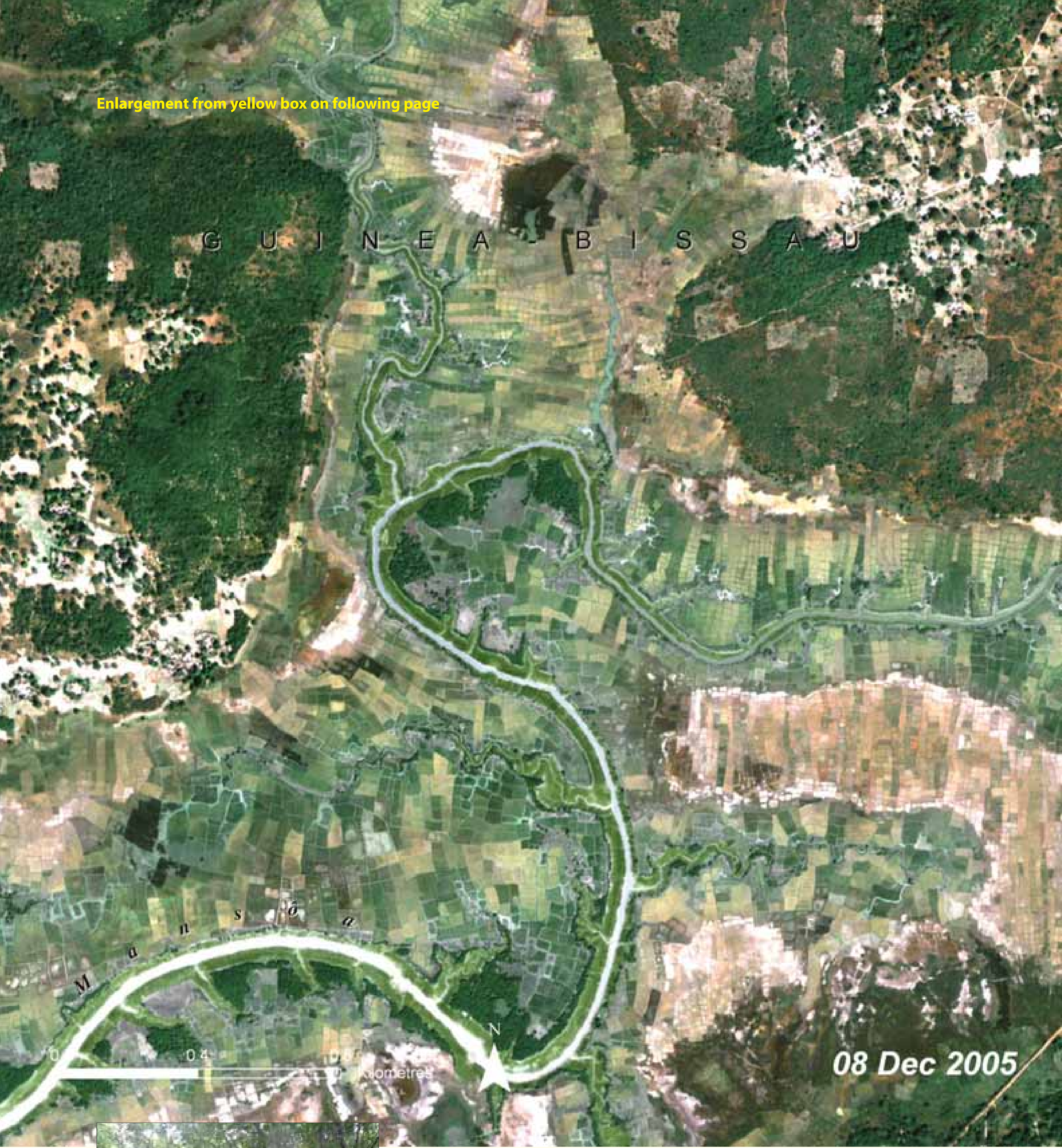
Threats to the Bijagos Biosphere Reserve



Source: FISHSTAT

The Bijagos Islands cover an area of nearly 10 000 km^2 and support over 25 000 inhabitants. The islands contain diverse ecosystems including mudflats, mangroves, and savannah grasslands, which in turn support a multitude of floral and faunal species. The Bijagos Biosphere Reserve protects 60 km^2 of this territory, including one of the most important green turtle breeding grounds in the eastern Atlantic. Threatened by overfishing, the reserve has been declared a no-fishing zone, but enforcement has been a challenge.





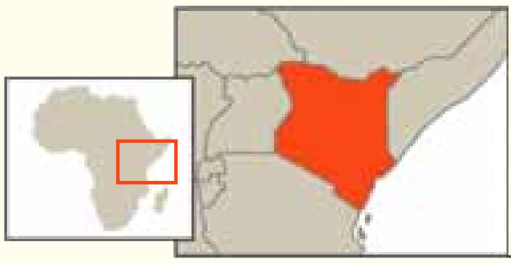
Balanta Rice Farming: Gêba Estuary, Guinea-Bissau

Rice is a major crop and staple food in Guinea-Bissau. The production of paddy, or "wetland," rice started in the late 17th and early 18th centuries, when the Balanta (the country's largest ethnic group) started organising men and women for agricultural production. Rice paddies have replaced many of the mangroves along the Gêba and Mansôa Rivers to the north of the capital, Bissau (2007 image).

These rice paddies are built by cutting a path through the mangroves and piling up mud to form a dike that will keep back the tide. The mangroves, cut off from the ocean, quickly die.

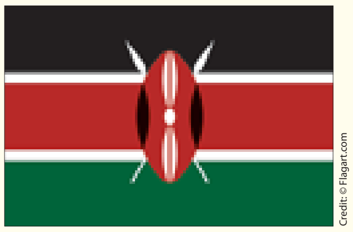
The ground is then burned to clear remaining undergrowth. After the paddies are constructed, their walls trap rainwater, in which rice will grow.

The 2007 image (above right) shows several dark green belts of mangrove forests adjacent to the Gêba and Mansôa Rivers. Intensive rice farming is indicated by the light-grey areas bordering these mangroves. This pattern is observed around Bissau, as well as the smaller towns of Cufar, Mansôa, Bissassema de Cima, and Nã Balanta. The 2005 high-resolution image (above left) shows the intensity of rice cultivation in an area near Cufar (from yellow box, above right). Inundated rice paddies (whitish rectangles) and rice fields (light- to dark-green rectangles) surround the meandering river. Only isolated patches of mangroves (deep-green) remain along much of the river.



Republic of Kenya

Total Surface Area: 580 367 km²
Estimated Population in 2006: 35 106 000



Kenya's diverse climate ranges from tropical along the Indian Ocean coast to arid in the extreme north. Highland areas in the centre of the country, the location of Africa's second highest peak—Mount Kenya, are bisected by the Great East African Rift Valley. Drylands account for 88 per cent of the total surface area and provide essential habitat for approximately 50 per cent of livestock and 70 per cent of Kenya's wildlife (UNCCD 2002).

Important Environmental Issues

- Water Scarcity and Pollution
- Desertification and Deforestation
- Degradation of Freshwater Ecosystems

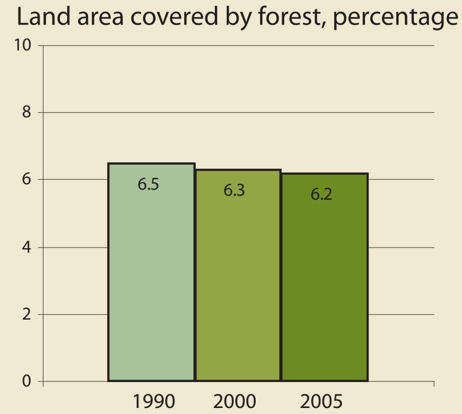
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

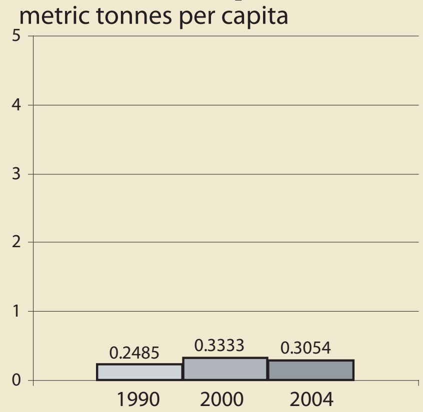
Deforestation, soil erosion, and water pollution from urban and industrial wastes are three environmental concerns for Kenya. Eighty-three per cent of Kenya's land area is vulnerable to drought and desertification. Nevertheless, Kenya's protected areas have increased to over 30 national parks and reserves.

★ Indicates progress

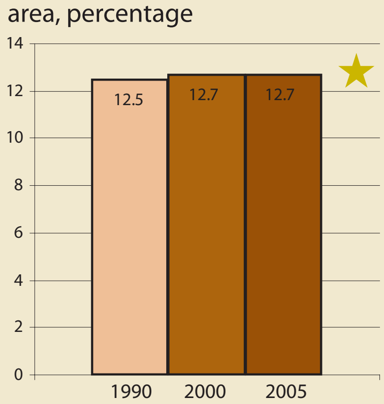
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

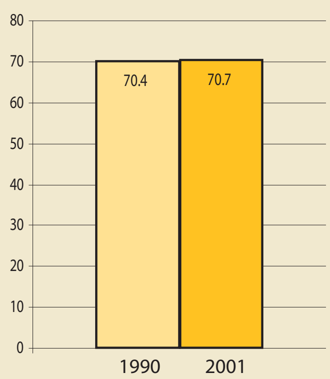


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban

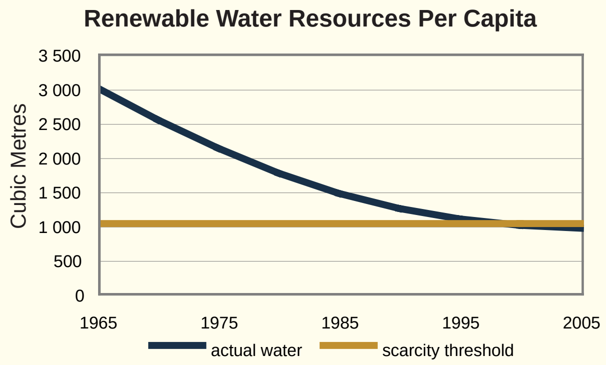


Kenya is world-famous for wildlife safaris to areas like Amboseli and Nakuru National Parks, and the Maasai Mara Game Reserve.

africaguide.com(2008); worldinfozone.com (2008)

Water Scarcity and Pollution

Kenya is below the international water scarcity threshold (1 000 m^3 per person per year (UNEP 2002)) 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). Increasing industrial and urban pollution is an additional threat to freshwater resources. Kenya has one of the largest industrial sectors in sub-Saharan Africa, and proper waste disposal is rare within city slums, which accommodate 71 per cent of all urban dwellers (UN 2007). Nairobi's Kibera slum is one of Africa's largest, with nearly one million people occupying only two square kilometres of land.

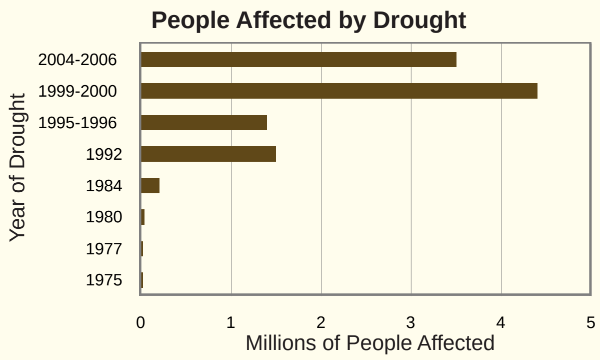


Source: AQUASTAT

Desertification and Deforestation

The Kenyan Highlands are some of the most agriculturally productive lands in Africa. However, high population density—nearly three-quarters of the population occupies only 12 per cent of the country area (UNCCD 2002)—has put extensive pressure on arable land. In the arid and semi-arid regions where livestock are grazed, recurring drought exacerbates desertification and threatens the livelihoods of over 3.5 million pastoralists (IRIN 2006).

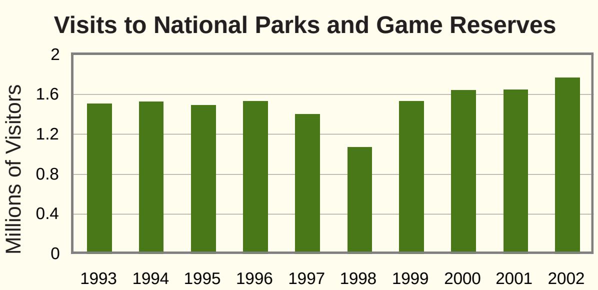
Widespread deforestation is also contributing to desertification. Much of Kenya's original forest cover has been lost and currently only six per cent of land is forested (UN 2007). Reforestation initiatives have failed to negate the combined effects of population growth, high dependence on fuelwood and charcoal, and overexploitation by commercial loggers.



Source: National Disaster Management Policy, Republic of Kenya, 2004

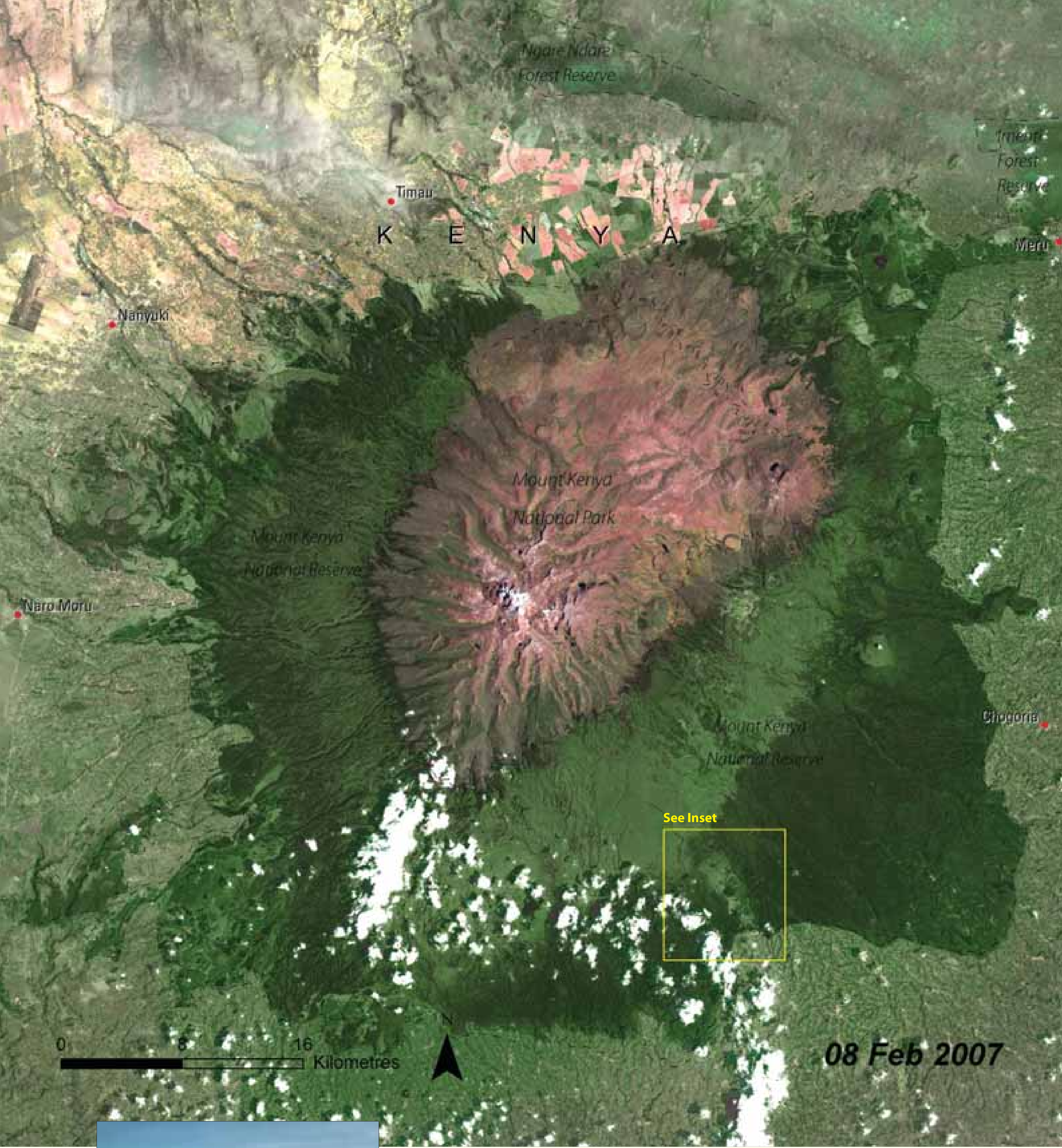
Degradation of Freshwater Ecosystems

Kenya is world renowned for its biologically rich national parks, which attract nearly two million tourists each year (UN-Water 2006). Among them, Lake Nakuru National Park is famous for the millions of flamingos that feed on its shores. Both a UNESCO World Heritage Site and Ramsar Wetland of International Importance, Lake Nakuru is threatened by siltation from surrounding agricultural activities and industrial and domestic effluent from nearby Nakuru Town (UNESCO 1999).



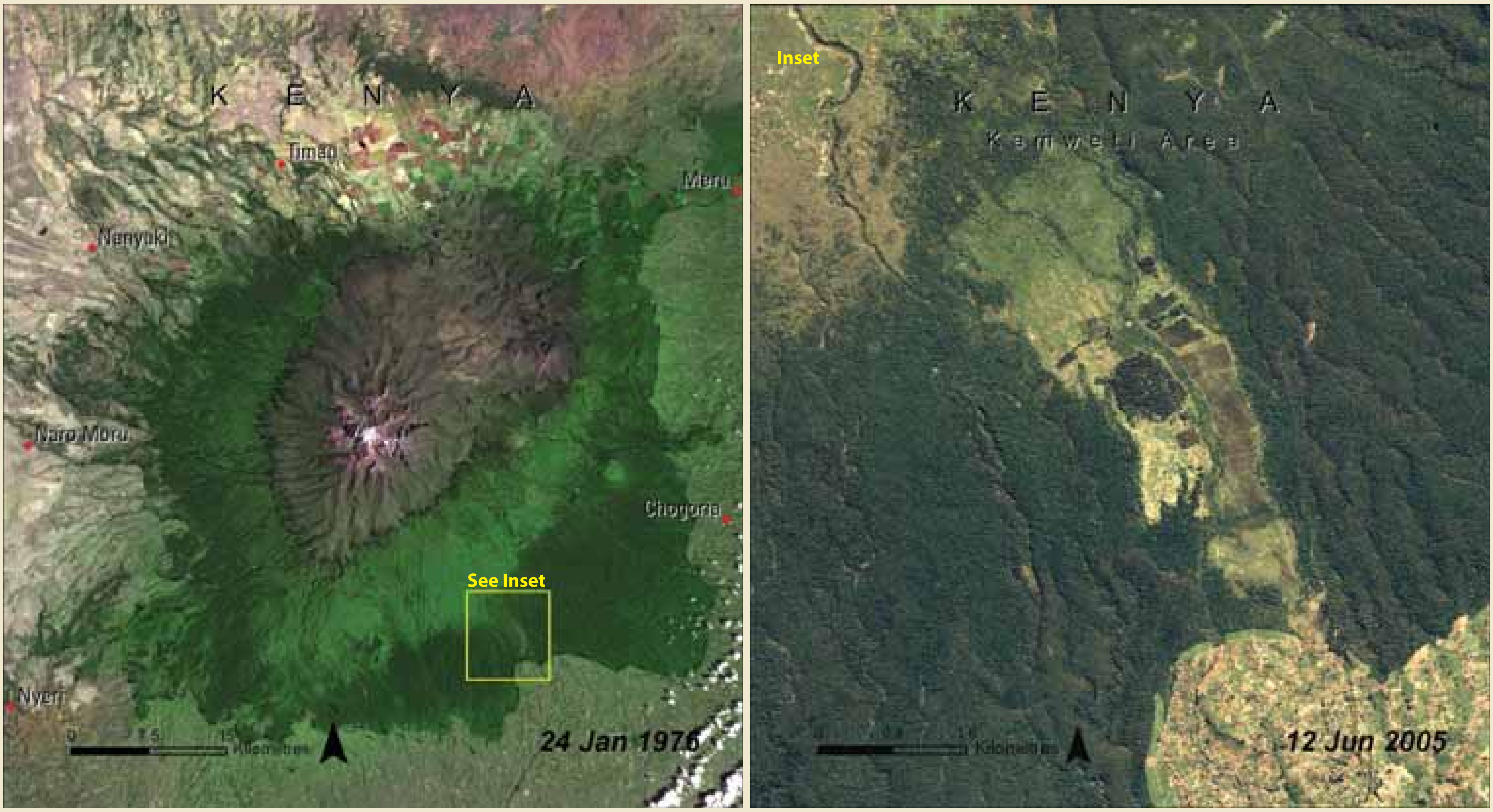
Source: Kenya National Water Development Report 2006

Lake Victoria—which accounts for most of Kenya's freshwater fish production and is shared by Uganda and United Republic of Tanzania—is similarly threatened. Increased nutrient input from agricultural runoff and the spread of the invasive water hyacinth plant have significantly reduced water quality.



Protection and Management: Mount Kenya, Kenya

Mount Kenya has been described as one of the most impressive landscape features in East Africa. In addition to its beauty and value for timber, farmland, and tourism, it is a critical water catchment for Kenya and crucial to hydro-power generation on the Tana River. Depending on altitude and rainfall, there are a variety of different ecosystems on Mount Kenya, which are visible to some degree as various shades of green in the 2007 satellite image above.



A Return to the Forest

Kamweti, part of Mount Kenya's protected forest, (see inset above) was long ago covered with moist montane indigenous forests that were cleared to create forest plantations. The plantations were established using the "shamba system", where farmers are allowed to inter-crop tree seedlings with annual agricultural crops until trees over-shadow the crops. At this point the farmers are expected to leave the area.

The shamba system was poorly implemented in Kamweti, as large areas remained devoid of trees indefinitely and were instead cultivated intensively with annual crops, converting what should have been forest plantations into settlements. Illegal logging, charcoal production, and poaching increased tremendously, posing major threats to neighbouring indigenous forests. To protect the forests the government moved the farmers out of Kamweti from the mid-1980s to the mid-1990s.

However, illegal activities in the forests continued unabated. In response, the government upgraded the Mount Kenya Forest Reserve to a National Reserve and charged its management to the Kenya Wildlife Service in 2000. This change led to a significant improvement in forest conservation. After the illegal activities were curbed, the forest began regenerating and wildlife, particularly elephants, returned, making Kamweti a beautiful tourist destination.

D. Mugo Mwangi was born in 1978 in Kamweti, where his parents cultivated fields of cabbages and potatoes. He still remembers the difficult times they faced when they had to leave the forest. Today, his parents have a small house in the village of Kimunye near the National Reserve. Mugo is back in the forest, not as a farmer, but as the caretaker of Robert's Hut, a small tourist facility located high up in the Kamweti area.


D. Mugo Mwangi

Christian Lamberhts/UNEP


Kamweti Forest

Christian Lamberhts/UNEP

After independence in 1963, the Kenyan government encouraged settlement of the Mount Kenya region and over a period of roughly forty years population increased ten-fold. In the late 1990s it was recognized that this intense population growth, along with misuse of non-resident cultivation policies, illegal charcoal production, illegal forestry, and marijuana cultivation were threatening the future of Mount Kenya. New policies and improved enforcement have significantly reduced unsustainable exploitation of the mountain's forests.

Continued monitoring and management of this majestic mountain is aimed at maintaining its immeasurable value for future generations. Sustainable uses such as eco-tourism help provide employment without undermining the essential ecosystem functions and invaluable biodiversity of this natural asset.

Irrigated Agriculture: Yala Swamp, Kenya

Yala Swamp is located in western Kenya, on the northeastern shore of Lake Victoria. It is the third-largest wetland ecosystem in the country, after Lorian Swamp and the Tana River Delta. The swamp provides a habitat for many plants and animals, some of which are extinct in the larger lake ecosystem and others that are endemic to the swamp.

Nutrient rich sediments deposited by the Yala River and the availability of water makes Yala Swamp particularly attractive for agriculture, including the intensive production of rice, cotton, and various other irrigated cash crops.

The development of this area has pitted the Kenyan government and private investors against conservationists. While the government and the investors argue that a well-planned exploitation of part of this area can help alleviate hunger and poverty in the region, conservationists feel that the Yala Swamp is too important an ecosystem to be disturbed for any economic gains.

These two images show the area before and after development of the region began. The small farm parcels in the 2002 image have largely been replaced by larger parcels, as is evident in the 2007 image. A dam (yellow arrow) has also been erected on the river, to provide water for irrigation.

Kingdom of Lesotho

Total Surface Area: 30 355 km²
Estimated Population in 2006: 1 791 000

Lesotho is a small, mountainous country surrounded entirely by the Republic of South Africa. Almost two-thirds of the country is mountainous, rising to a maximum elevation of 3 482 m, which is the highest point in southern Africa (Lesotho National Environment Secretariat 2000). The majority of the population, however, resides in the more fertile lowland region to the west. The climate is temperate and water resources are generally abundant, although somewhat irregular: 85 per cent of rainfall occurs during the summer months (Lesotho National Environment Secretariat 2000).

Important Environmental Issues

- Degradation of Rangelands
- Threats to Biodiversity in the Lesotho Highlands
- Water Resource Management and Pollution

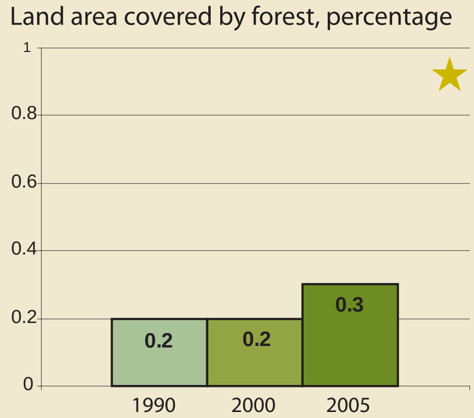
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

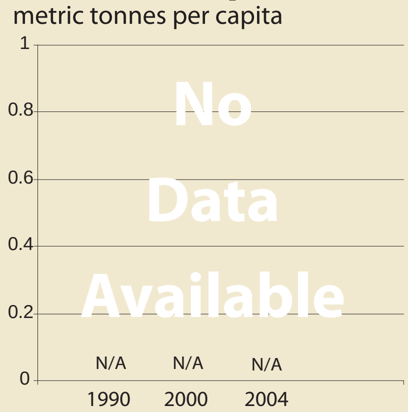
The remarkable increase in the number of people with access to improved water sources could be attributed to the Lesotho Highlands Water Project, developed in partnership between the governments of Lesotho and South Africa. This is Africa's largest water transfer scheme. In spite of issues including severe soil erosion, soil degradation, and desertification, the Highlands Water Project aims to control, store, and redirect water to South Africa.

★ Indicates progress

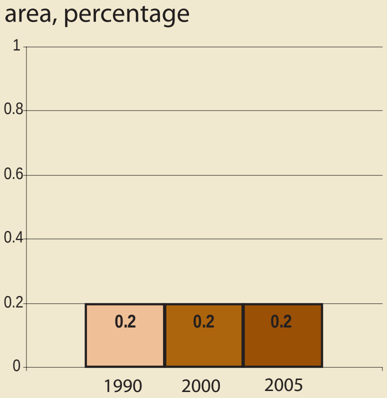
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

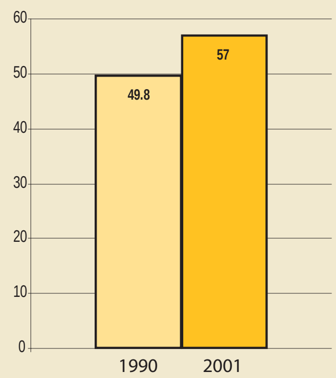


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban

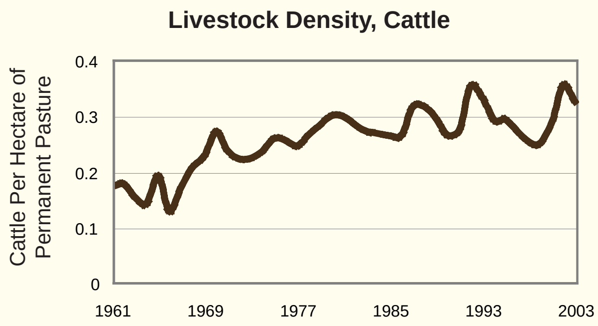


The Tlaeeng Pass, in the north of Lesotho, is 3 275 metres above sea level; it is the highest road in Africa.

worldinfozone.com (2008)

Degradation of Rangelands

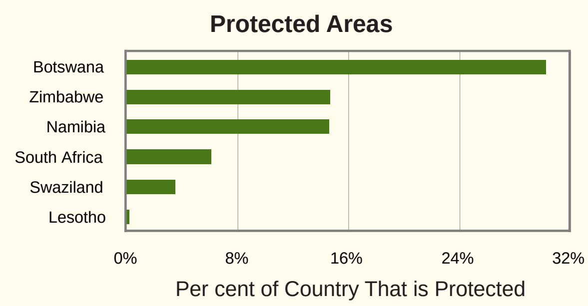
Two-thirds of Lesotho is rangeland (FAO 2007), much of which is heavily overstocked and overgrazed. Most rangelands exist in the mountainous region, which is highly vulnerable to soil erosion due to shallow soils, sparse vegetation, and steep topography. Poor range management has led to severe land degradation, especially in times of drought that are followed by heavy rains. This degradation has particularly affected wetlands, which are important domestic water sources and provide essential habitat for many species.



Source: FAOSTAT

Threats to Biodiversity in the Lesotho Highlands

Large mammals have been extirpated from Lesotho, but unique biodiversity can still be found throughout the country and particularly in the mountainous highlands. The Maloti and Drankensberg mountain ranges, 60 per cent of which lie in Lesotho, are a globally recognized biodiversity hotspot. Of the estimated 3 094 floral species found there, one-third are endemic to the region (Lesotho National Environment Secretariat 1998). These biological resources are being over-exploited by people seeking fuelwood or medicinal plants and animals. In addition, rangeland degradation is facilitating the replacement of native flora with invasive weed species. Less than one per cent of land in Lesotho is officially protected, which is the second lowest proportion in all of Africa (UN 2007).

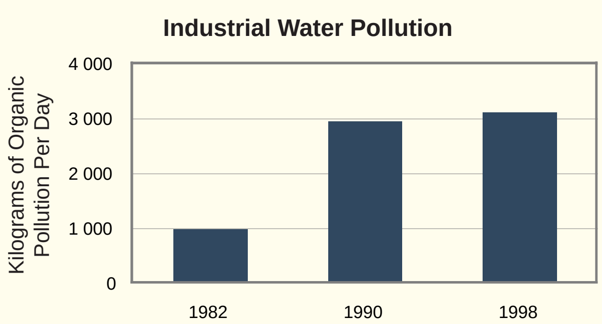


Source: MDG Indicators

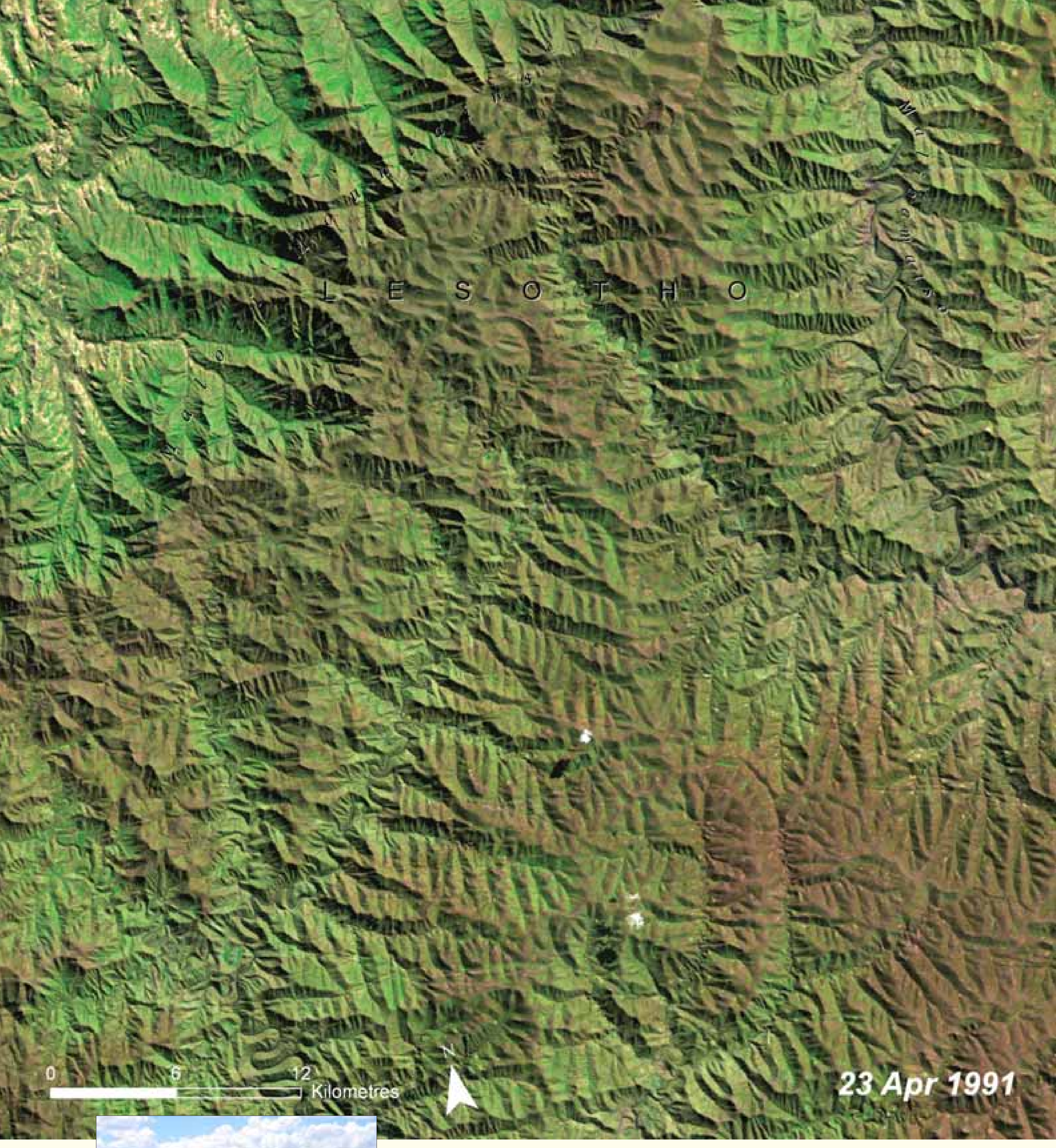
Water Resource Management and Pollution

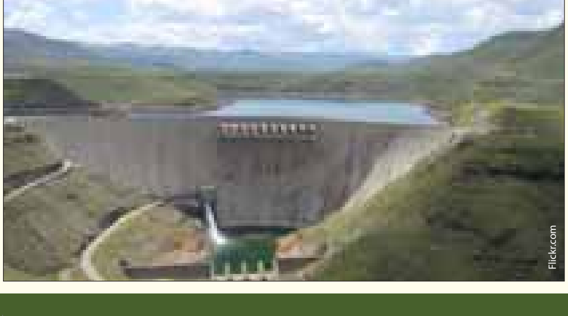
The Katse Dam, a part of the Lesotho Highlands Water Project, submerged a number of valleys in the Maloti mountains, displacing many local communities and important habitat for several endangered species. However, the dam now generates valuable hydroelectric power, some of which is sold to the Republic of South Africa, creating important revenue for Lesotho.

The industrial sector is the largest water consumer in Lesotho, accounting for over half of all water use (FAO 2005). Pollution from the industries, as well as from diamond mining activities, is known to contaminate surface water resources.



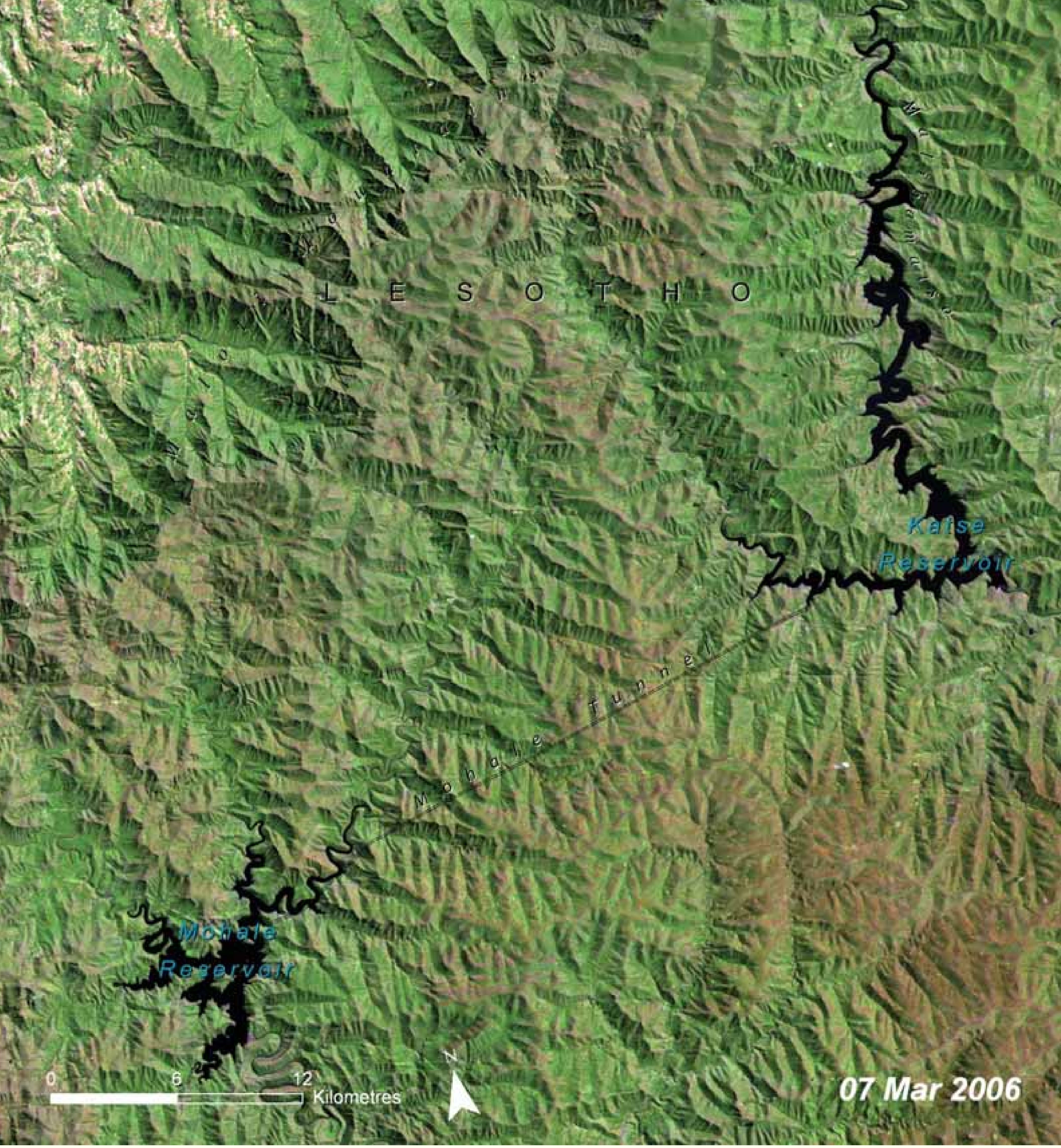
Source: World Bank World Development Indicators 2006





The Lesotho Highlands Water Project: Lesotho

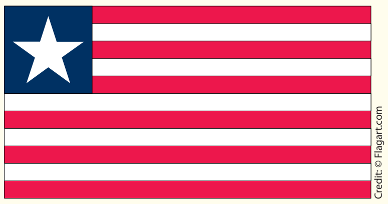
In 1986, a treaty signed by South Africa and Lesotho initiated the Lesotho Highlands Water Project. The project design included a total of five dams, but committed the parties to only the first two dams and related infrastructure at a cost of over US$1 400 million. The project's purpose was to deliver water to Gauteng Province in the industrial heartland of South Africa and hydroelectric power and income to Lesotho. In 1997, the 185-metre Katse Dam was completed on the Malibamatso River. The second phase of the project including the Mohale Dam was completed in 2003.



The Lesotho Highlands Water Project has been controversial since it began, with concerns about both social and environmental impacts. More than 20 000 people were affected by Katse Dam and 7 400 by Mohale, including loss of homes, farmland, and communal grazing land. The 1991 image shows part of the project area before the dams were constructed. The 2006 image shows the areas inundated after both dams were completed. The first two dams, Katse and Muela (not shown) took approximately 1 900 hectares of croplands and Mohale a further 1 000 hectares. Together, the three dams decreased pastureland by 5 000 hectares. In addition to the impact on the immediate area, approximately 150 000 people are affected by reduced stream flow below the dams.

Republic of Liberia

Total Surface Area: 111 369 km²
Estimated Population in 2006: 3 356 000



Liberia is a mostly flat and heavily forested country with low mountains rising to the northeast. The 560 kilometre-long coast is characterized by lagoons and mangroves and sustains 58 per cent of the population (National Biodiversity Strategy and Action Plan n.d.). Although the economy is heavily dependent on agriculture, minerals and forest products are the most valuable natural resources. Average annual rainfall ranges from 4 000 mm along the coastal belt to 1 300 mm at the forest-savannah boundary in the north.

Important Environmental Issues

- Deforestation and Rubber Plantations
- Threats to Biodiversity
- Water Pollution

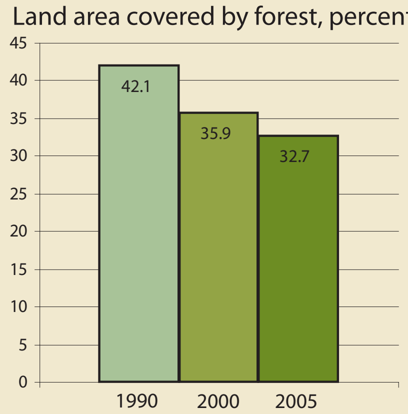
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

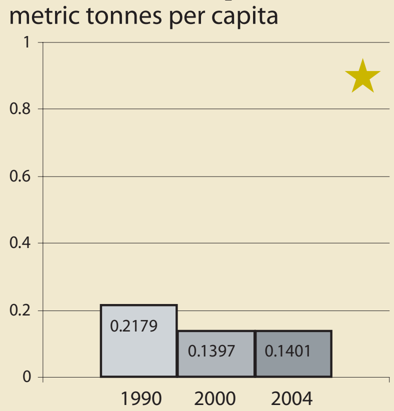
Liberia's biggest environmental challenge is the lack of proper sanitation, which has declined by 12 per cent in the MDG charts. With the population of over 3.3 million growing at a very fast rate, the problem of waste is particularly pressing. In the 1980s, Liberia had significant primary forest reserves, but recent estimates suggest that some 42 000 hectares of primary forest are converted annually to degraded forest or bushland.

★ Indicates progress

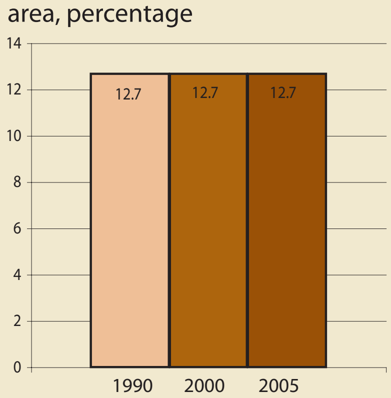
Land area covered by forest, percentage



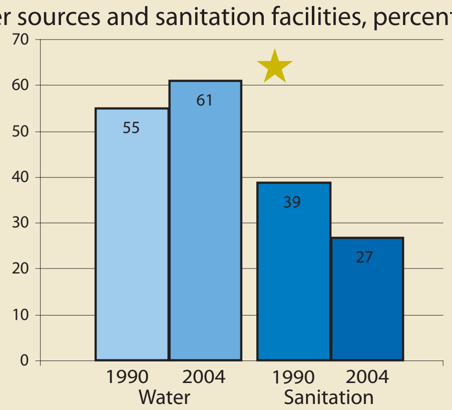
Carbon dioxide (CO_2) emissions, metric tonnes per capita



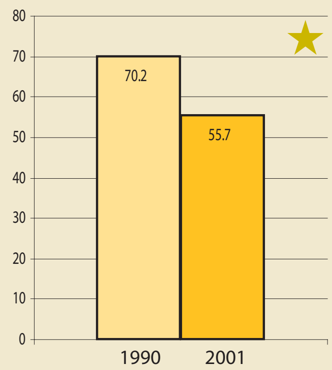
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

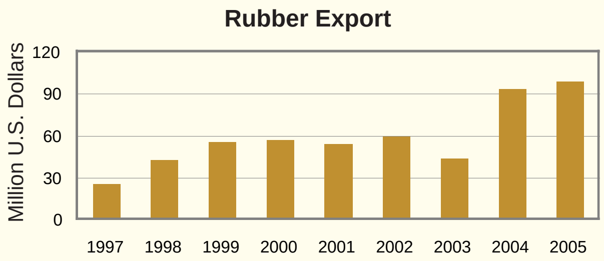


Monrovia, the capital city of Liberia, receives on average 5 140 mm of rain per year, making it one of the wettest inhabited places in the world.

bbc.co.uk (2006)

Deforestation and Rubber Plantations

Liberia is thought to be the only country in West Africa that was once entirely covered by tropical rain forest (National Biodiversity Strategy and Action Plan n.d). Thanks to uncontrolled deforestation, forests now account for only one-third of land cover and continue to disappear at a rate of roughly two per cent per year (UN 2007). Farmers cope with Liberia's generally poor soils by practising shifting cultivation, which is the major driver of forest loss. Logging, dependence on fuelwood, and rubber production are also factors.



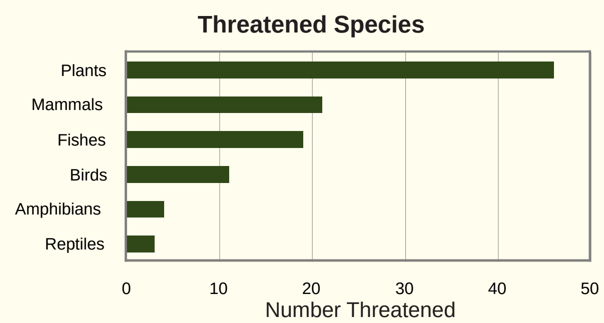
Source: IMF

Rubber is one of Liberia's top three export commodities. Rubber plantations, which are owned and operated by foreign business interests, have cleared more than 57 000 hectares of primary tropical forest and converted diverse forest ecosystems into single-species monocultures (National Biodiversity Strategy and Action Plan n.d).

Threats to Biodiversity

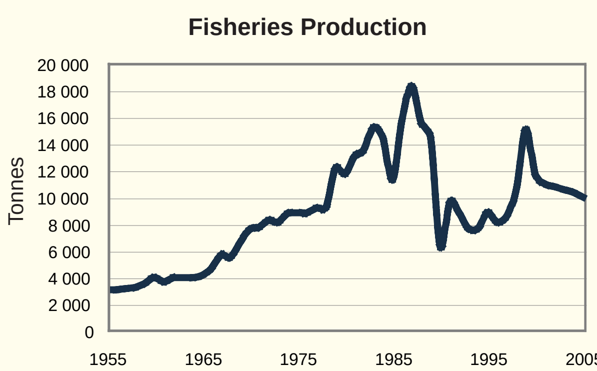
Liberia's forests are biologically rich, but species are threatened by habitat fragmentation and poaching. Wild animals are a major source of protein for most people since livestock production has been set back by prolonged civil war. Uncontrolled cutting of logging roads through virgin forests facilitates the bushmeat trade.

The Mount Nimba Nature Reserve, a UNESCO World Heritage Site, has exceptional species diversity due to the variety of habitats created by unique high altitude grasslands laced with montane forests. The area is still recovering from iron-ore mining activities in the 1990s, which left over 300 million metric tonnes of mine wastes (UNEP 2004).



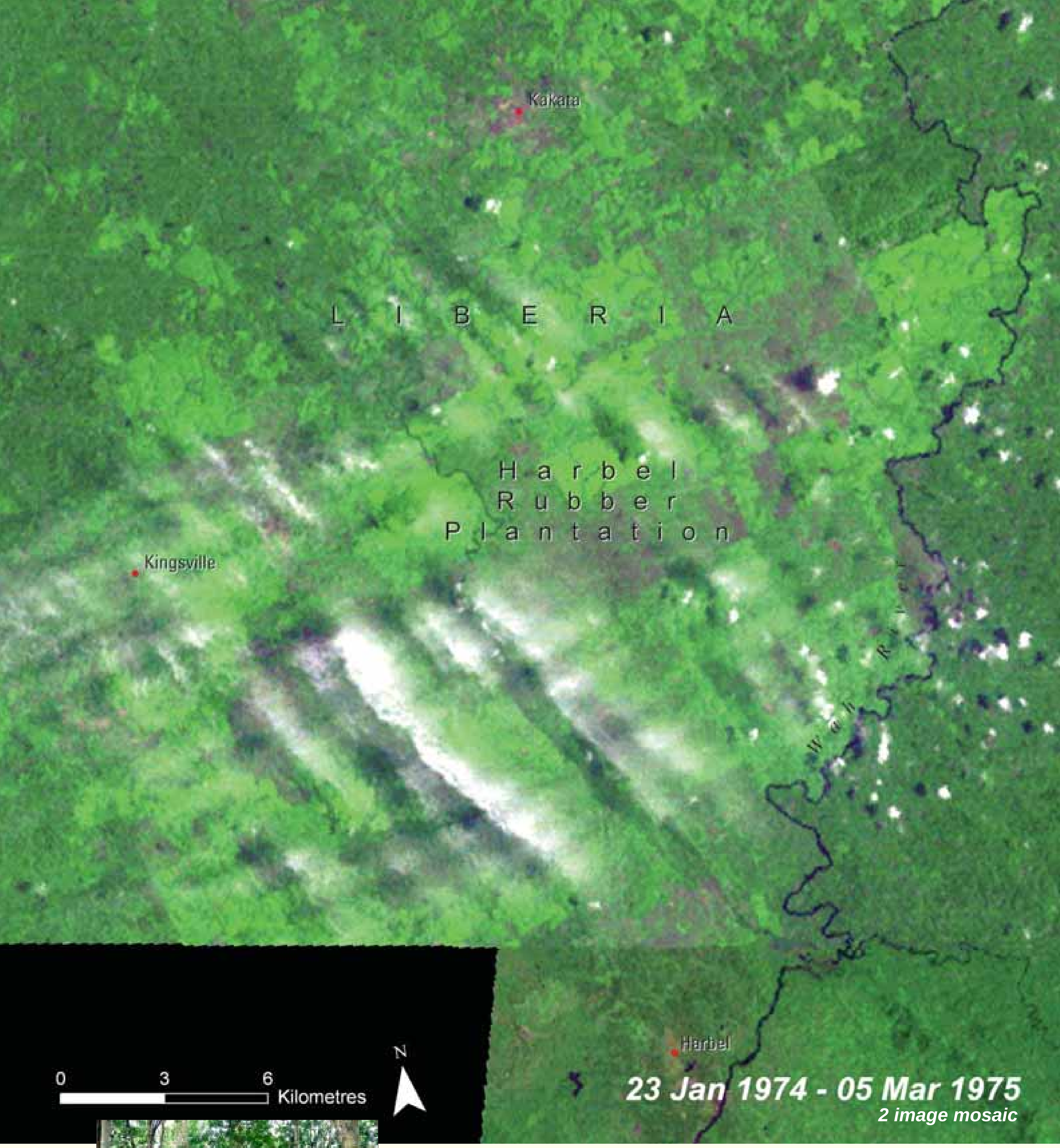
Source: IUCN Red List

Water Pollution



Source: FISHSTAT

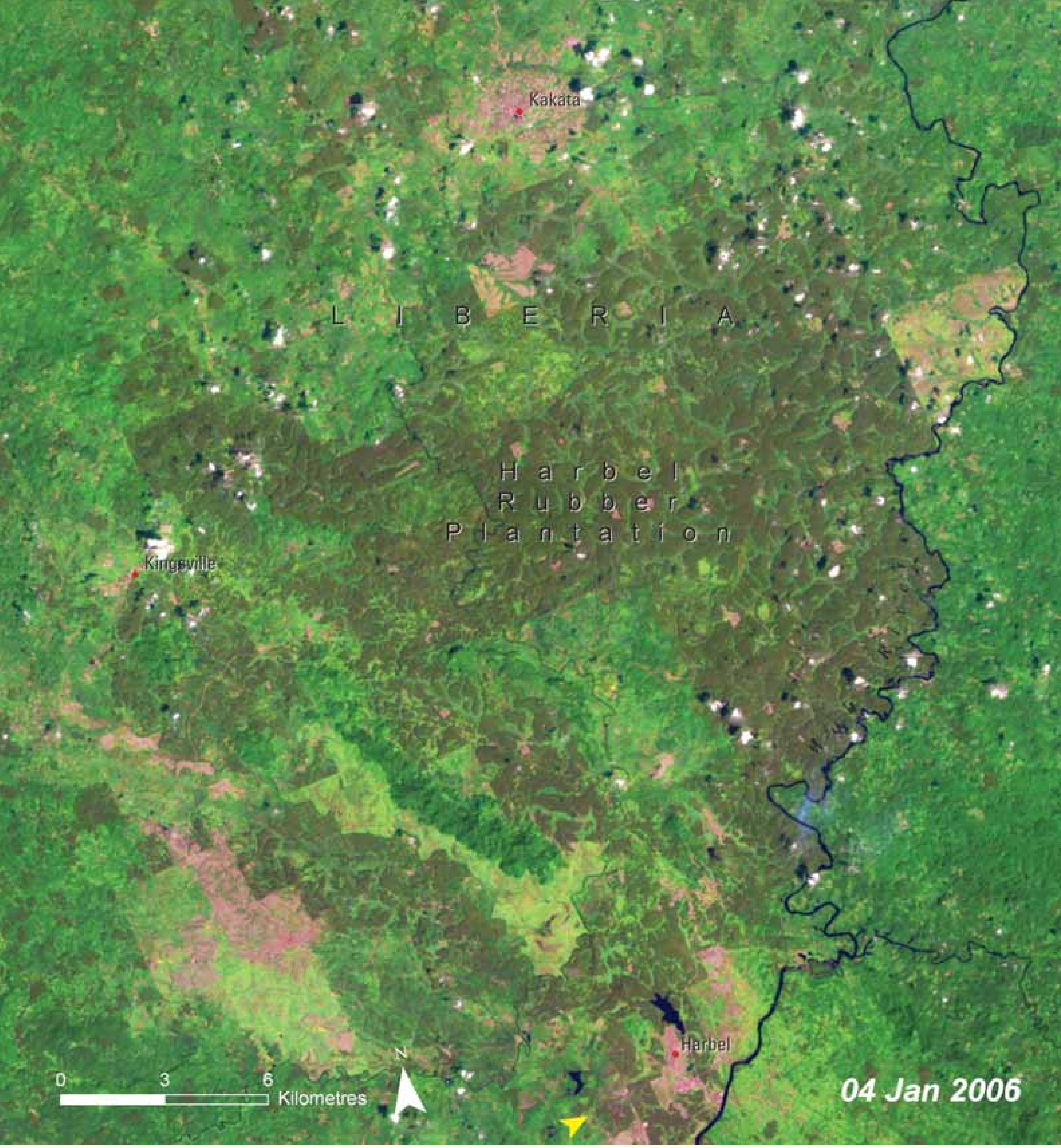
Nearly 14 per cent of Liberia's surface is covered with water (National Biodiversity Strategy and Action Plan n.d.). After 14 years of civil war, waste collection services all but ceased, leaving raw sewage to pollute surface and groundwater. In addition, gold, iron, and diamond mines, the majority of which are unlicensed, discharge toxic metals and cyanide into rivers. Finally, leaking oil storage facilities are known to contaminate coastal waters. Water pollution is a threat to Liberia's fisheries, which provide over half of the population's protein intake and ten per cent of its gross domestic product.



The Harbel Rubber Plantation: Liberia

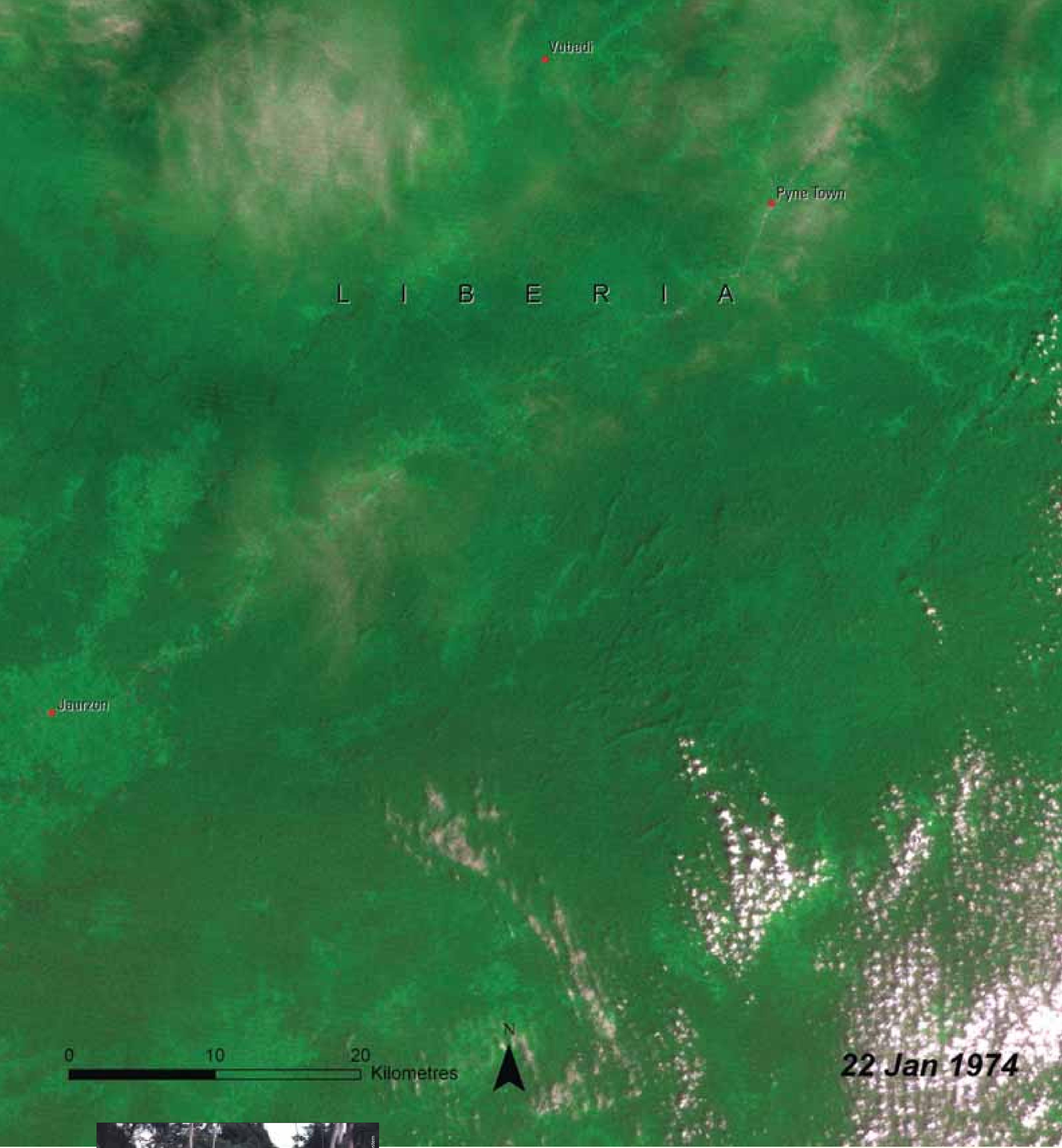
Built in the 1920s and 1930s, the Harbel rubber plantation just north of Monrovia, Liberia, is the largest in the world. This large monoculture plantation has created a host of environmental problems, including loss of biodiversity and the release of chemical waste into surface waters. Plantation workers are also exposed to compounds and chemicals that are internationally recognized as toxic and environmentally damaging.

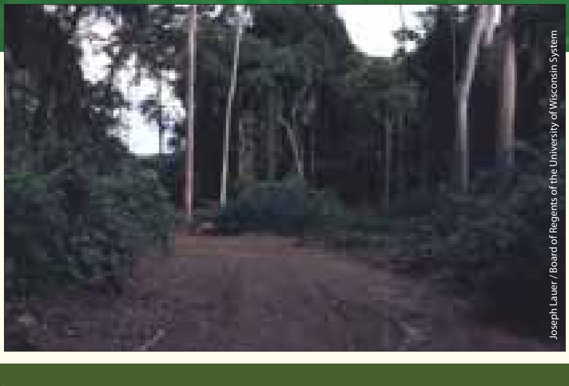
These two images show that the extent of the Harbel rubber plantation has expanded slightly in 30 years (yellow arrow). The change in colour of most of the plantation's vegetation may be



the result of seasonal variations—rubber trees drop their leaves at least once per year—or the age of the trees in the later image. Mature stands have more shadows and allow less of the leafy understory vegetation to show through than younger trees.

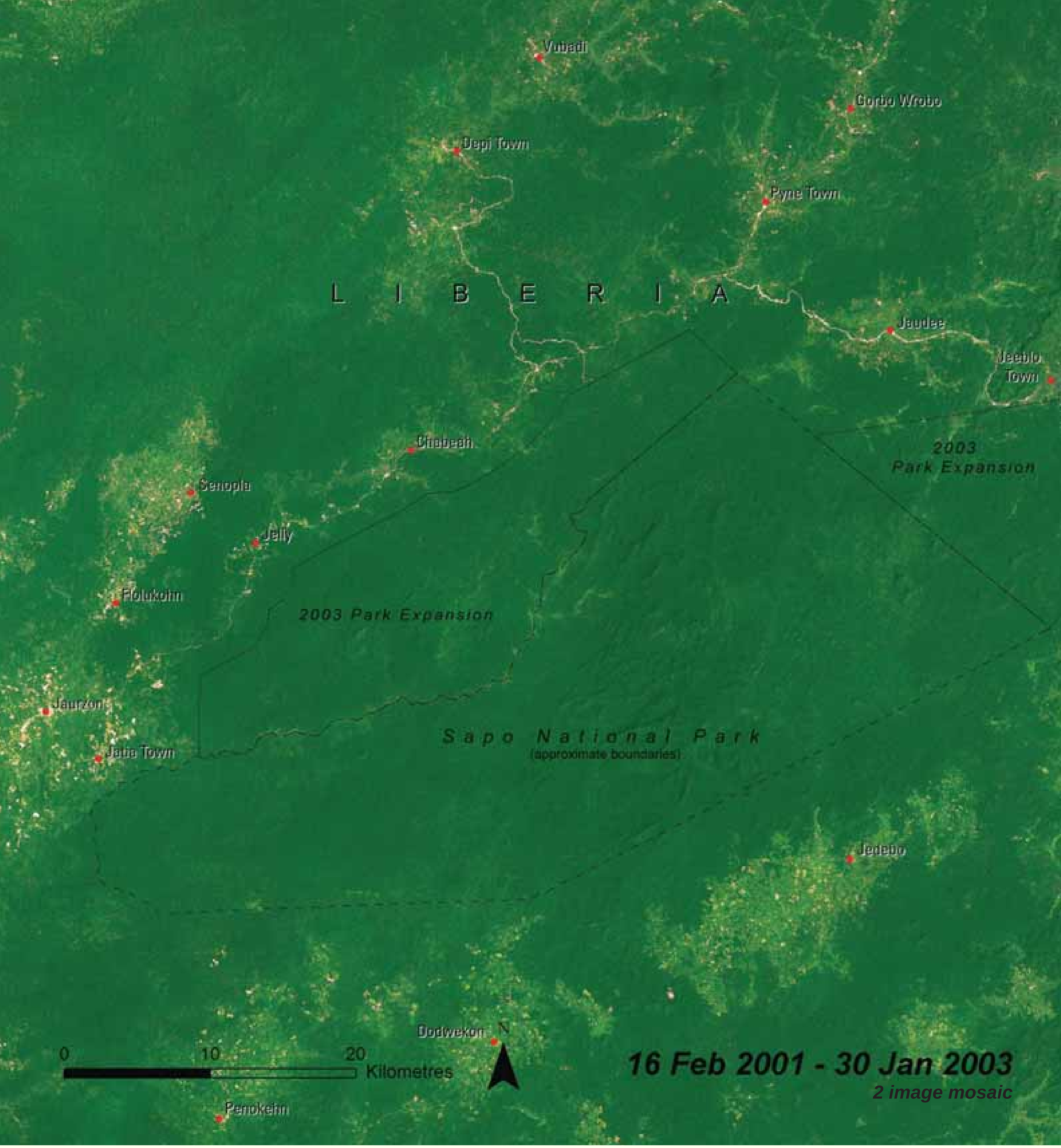
Most of the trees on Liberia's rubber plantations are nearing the end of their productive lifespan. This has brought the country's rubber industry to the brink of collapse. A new extension to the lease arrangement between Harbel's owners and the Liberian government was signed in 2005 which, according to the company, will allow for replanting to begin. However, it will likely take many years for the older trees to be replaced.





Indigenous Rain Forest: Sapo National Park, Liberia

Liberia's Sapo National Park is a largely undisturbed area (161 400 hectares) of lowland rain forest in the Upper Guinean Forest ecosystem. This ecosystem, which stretches from Cameroon to Guinea, has been decimated by logging, mining, and agriculture, leaving just three intact blocks, two of them in Liberia. Created in 1983, Sapo National Park was expanded by over 50 per cent in 2003. It is habitat for vulnerable and endangered species including the western chimpanzee, pigmy hippo, and forest elephant. The park's relatively pristine condition makes it an invaluable resource to Liberia and the world.



In the 25 years prior to Liberia's current government, the area of logging concessions granted totaled approximately 2.5 times the entire forested area of the country, with multiple concessions often overlapping one another. Concessions surrounded the area of Sapo National Park. Following a review of legality and status, all of the existing forest concessions were cancelled in February 2006. A year earlier, squatters who were illegally mining and poaching within Sapo were evicted.

The 1974 image shows the intact forest of the Sapo area prior to the park's creation. While roads and villages appear to have increased in the area surrounding the park, the 2001/2003 image shows that within the park itself, the forest remains in good condition.

Socialist People's
Libyan Arab Jamahiriya

Total Surface Area: 1 759 540 km²
Estimated Population in 2006: 5 968 000

Credit: © Flagart.com

Libyan Arab Jamahiriya is a relatively large country with a long coast bordering the Mediterranean Sea. Roughly 95 per cent of the country is desert, where rainfall is less than 100 mm per year. Although the average population density is one of the lowest in Africa, nearly three-quarters of the population is concentrated in coastal urban areas, which occupy only 1.5 per cent of the total land area (FAO 2005). Weather is influenced by the Mediterranean Sea to the north and the Sahara Desert to the south, creating an abrupt climatic transition.

Important Environmental Issues

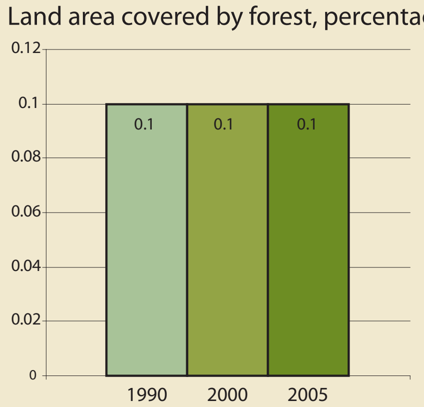
- Water Scarcity
- Land Conversion and Desertification
- Oil Production and Pollution

Progress Towards Environmental Sustainability

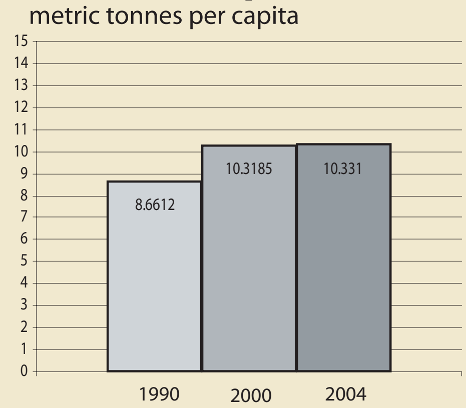
As defined by the United Nations Millennium Development Goal 7 Indicators

A major environmental concern in Libyan Arab Jamahiriya is the depletion of groundwater as a result of overuse in agriculture, causing salinisation due to sea-water penetration into the coastal aquifers. Eighty per cent of Libyan Arab Jamahiriya's agriculture is located in coastal areas.

Land area covered by forest, percentage

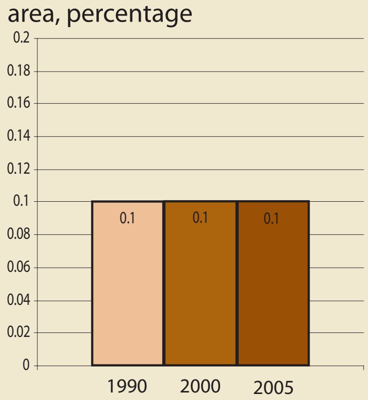


Carbon dioxide (CO_2) emissions, metric tonnes per capita

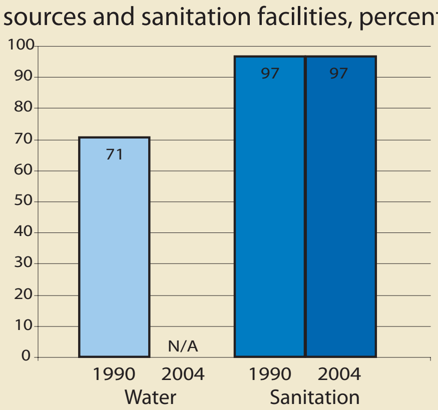


★ Indicates progress

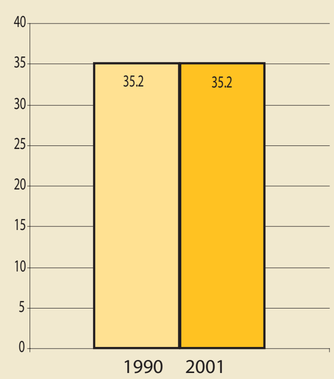
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



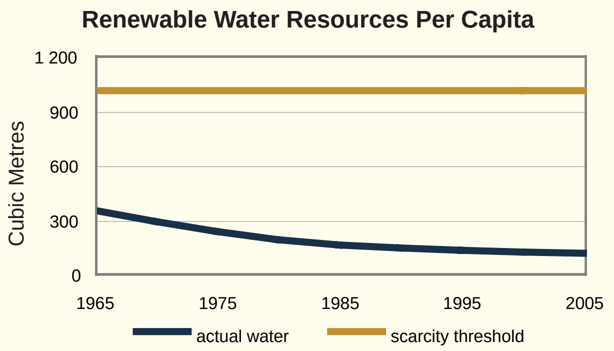
The Great Man-made River is the largest underground network of pipes in the world, supplying water from a fossil aquifer in Libyan Arab Jamahiriya's Sahara Desert to its coastal cities.

esortment.com (2002)

Water Scarcity

Libyan Arab Jamahiriya is the most water scarce country in Africa with only 104 m^3 available per person per year (FAO 2007a). Where populations are concentrated near the coast, groundwater resources have been exploited beyond annual replenishment, resulting in a severe decline in the water table and saltwater intrusion (FAO 2005). Surface water resources are minimal and there are no perennial rivers.

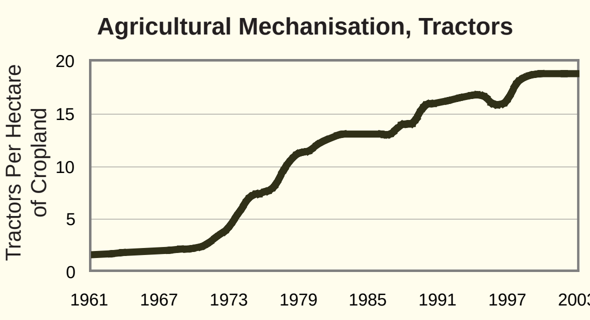
The Great Man-made River (GMMR) is an ongoing project since 1983, considered by some to be one of the greatest engineering feats in the world. The project involves the construction of 1 300 wells up to 500 m deep and 1 300 km of pipeline. Once completed, the GMMR will deliver 6.5 million cubic metres of water per day from fossil aquifers in the desert south to the heavily populated northern coast (GMRA n.d.).



Source: AQUASTAT

Land Conversion and Desertification

Just over one per cent of Libyan Arab Jamahiriya's land is considered to be arable, and virtually all of it is already being utilised. Furthermore, Libyan Arab Jamahiriya is the second most urbanised country in Africa. Continued urban expansion is anticipated to claim nearly half of the country's most fertile lands by 2025 (UNCCD 1999), to cope with limited availability of arable land. As a result agricultural production systems continue to increase in intensity. The number of sheep in Libyan Arab Jamahiriya, which are the primary livestock, has nearly quadrupled since the 1960s. The number of tractors used per hectare has multiplied in a similar fashion (FAO 2007b).

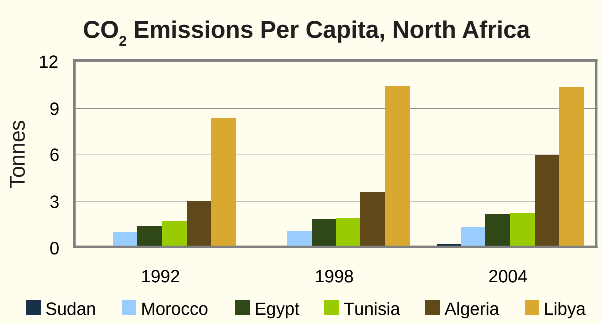


Source: FAOSTAT

Due to agricultural intensity, a naturally arid climate, and lack of forest cover (only 0.1 per cent of land is forested), Libyan Arab Jamahiriya is at extremely high risk of desertification. The government has made significant investments to combat desertification in recent decades, including an afforestation initiative that involved some 2 500 km^2 of land (UNCCD 1999).

Oil Production and Pollution

Libyan Arab Jamahiriya currently is the site of over one-third of Africa's known oil reserves, yet the country is still considered largely unexplored, with great potential for new oil discoveries. The oil industry has been state-controlled since the 1970s, but is now seeking increased foreign investment to upgrade oil infrastructure and enhance production capacity (U.S. Department of Energy 2005). Although the majority of the country's oil is exported, domestic oil refineries contribute to higher per capita carbon dioxide emissions in Libyan Arab Jamahiriya than in any other North African country. Refineries also emit other forms of air and water pollution that adversely impact surrounding communities and coastal environments.

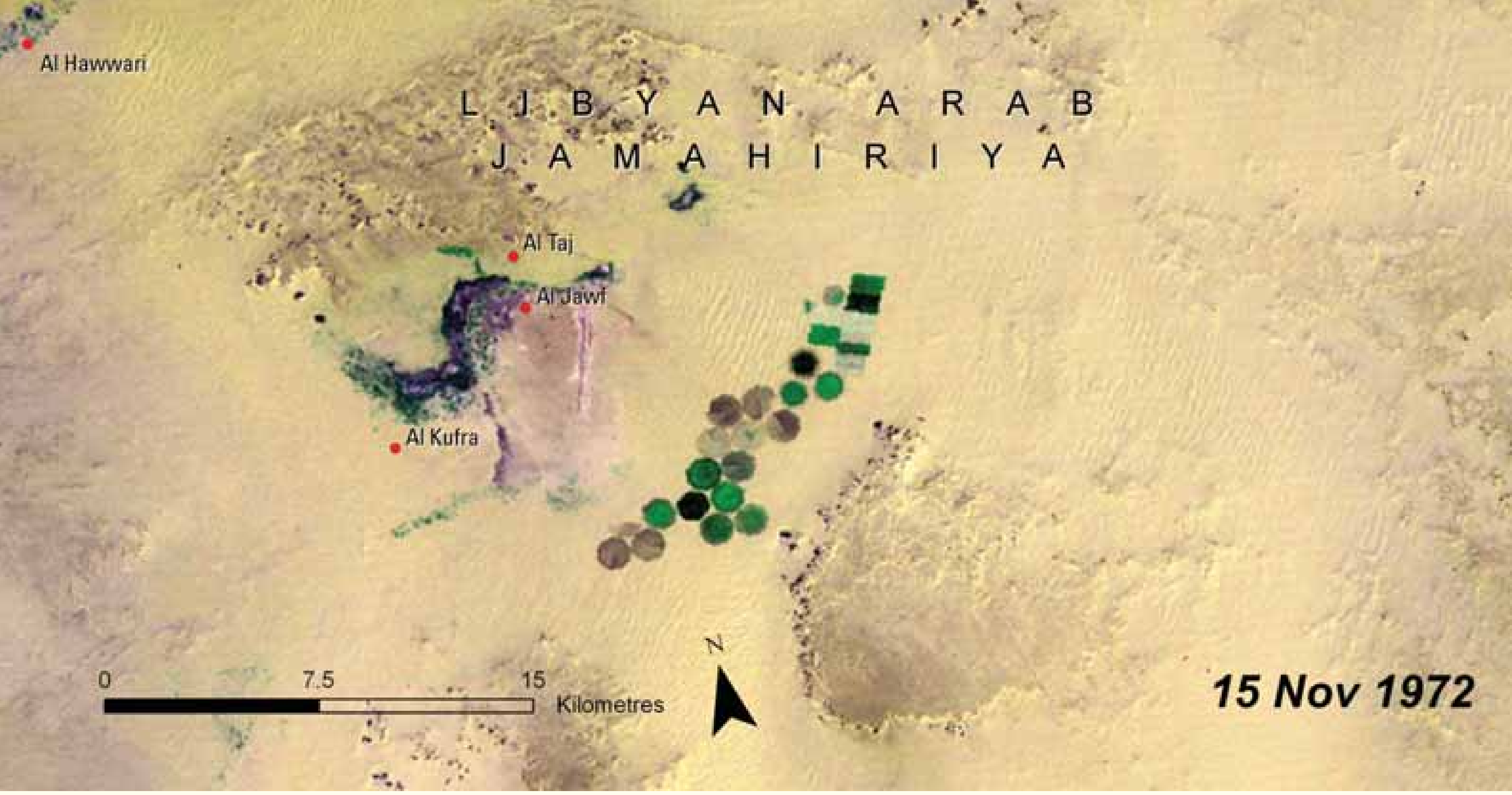


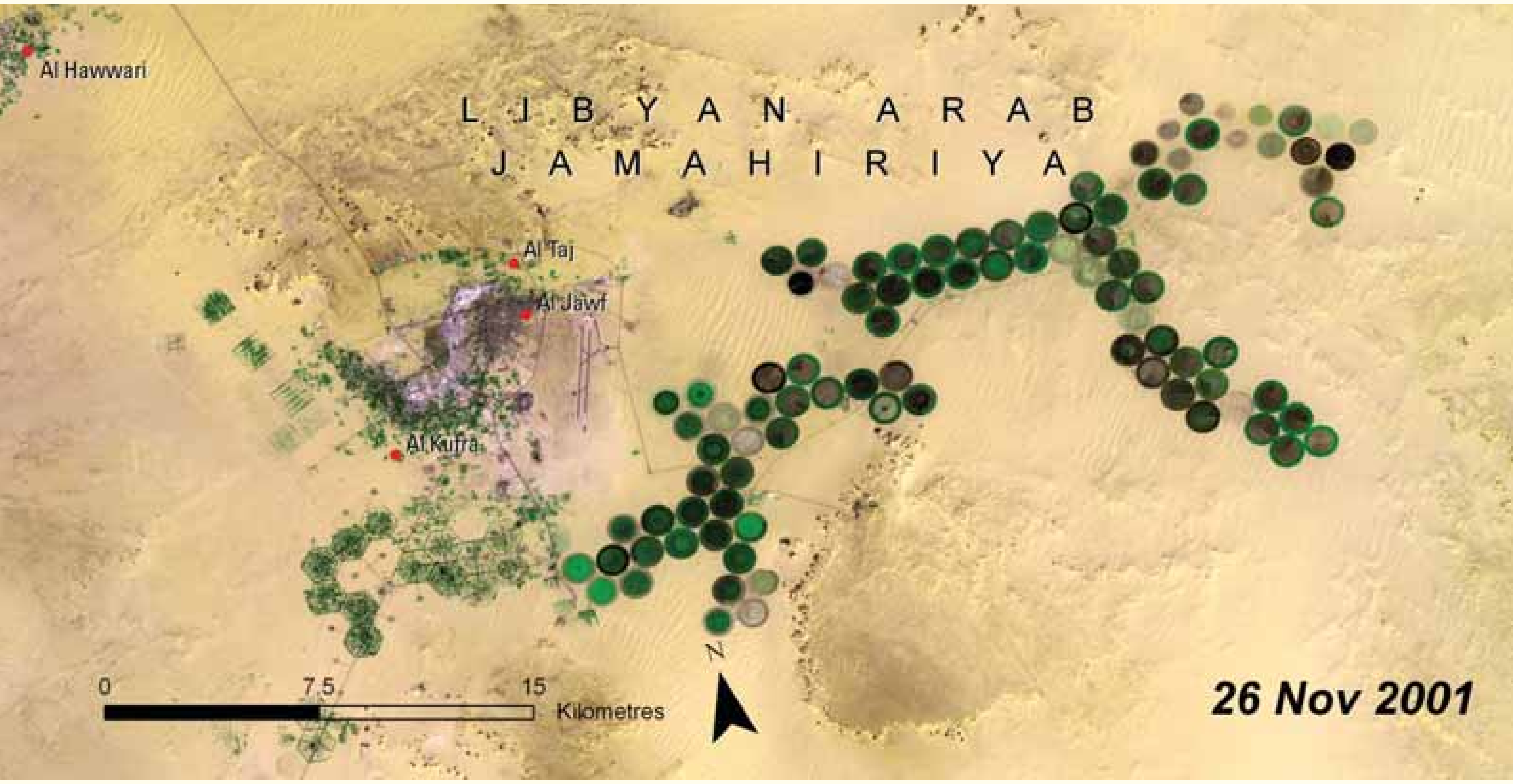
Source: MDG Indicators

Great Man-made River Project: Libyan Arab Jamahiriya

In the 1950s, oil exploration in Libyan Arab Jamahiriya turned up another resource beneath the scorching sands: the Nubian Sandstone Aquifer System. Radiocarbon analysis showed that some of the water in the aquifer system was 40 000 years old. Tapping the aquifers was chosen as the most cost-effective option for meeting the country's water needs.

In 1993, Phase I of the Great Man-made River (GMMR) Project brought water from eastern well-fields at Sarir and Tazerbo to Benghazi (not shown). In 1996, Phase II brought water from well-fields





at Jebel Hassouna to Tripoli (not shown). Phase III is still under construction. The project's largest reservoir, known as the Grand Omar Mukhtar, is located at Suluq (2006 image, yellow arrows).

When fully operational, the GMMR will pump 3.6 million cubic metres of the Nubian Aquifer water per day. Water from the aquifer is used to support extensive centre-pivot irrigation agriculture at Al Kufra (see 1972 and 2001 images above).

At current extraction rates the Nubian Sandstone Aquifer System is not likely to be depleted for a thousand years. Nevertheless, it is shared among four African nations: Libyan Arab Jamahiriya, Chad, Sudan, and Egypt. The concern of environmentalists is that eventually people will drain the aquifer faster than nature can renew it. The International Atomic Energy Agency is trying to bring the four countries together to plan rational shared use of the water.

Urban Expansion: Tripoli, Libyan Arab Jamahiriya

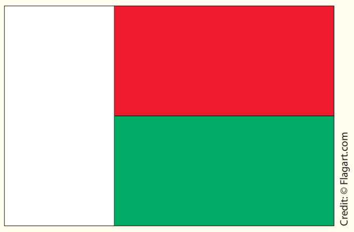
Tripoli, the capital city of Libyan Arab Jamahiriya, is located on the country's Mediterranean coast along a narrow band of fertile lowlands that quickly give way to a vast interior of arid, rocky plains and seas of sand. Tripoli has undergone steady urban growth over the past thirty years. These satellite images, from 1976 and 2006, document some of the major changes in urban extent and the intensification of agriculture in the area surrounding the city.

Urban areas appear as shades of grey. Darker patches south of the city, visible in the 1976 image, represent grasslands that have since been converted to agricultural fields. Bright green areas are planted croplands. A few small areas of natural vegetation remain (yellow arrows).

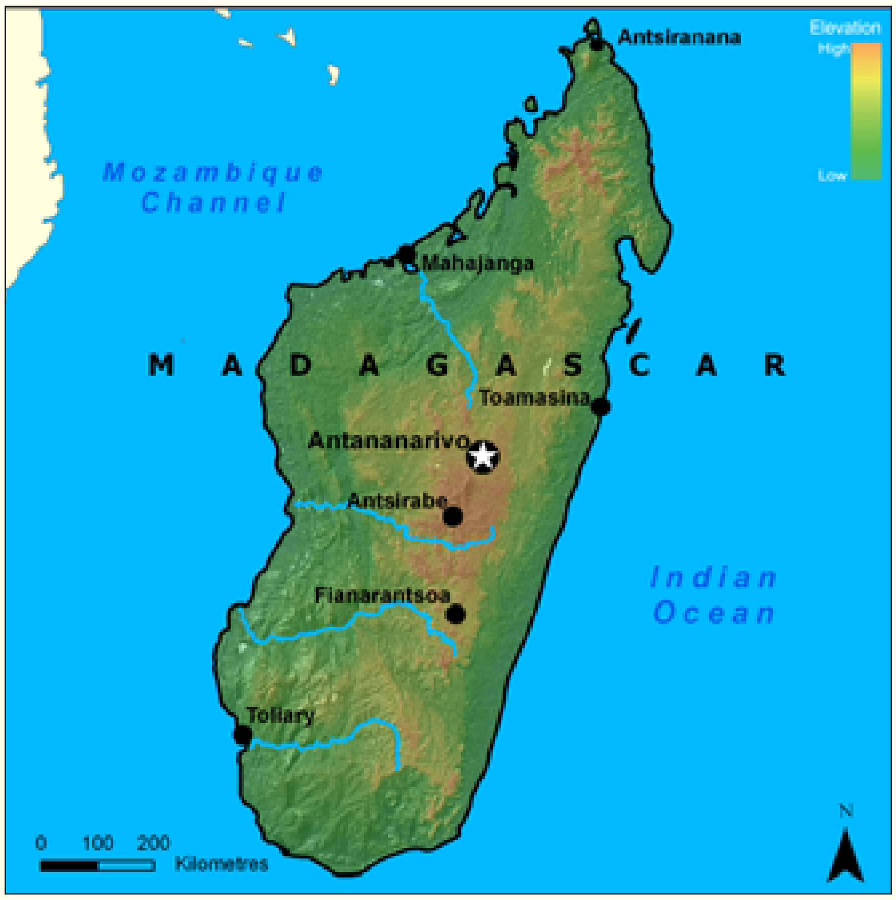
Before the GMMR project began supplying water to the Tripoli area, the city's demands on the coastal Upper Aquifer were raising concerns of unsustainable use leading to salinisation of coastal water resources. The GMMR project began supplying water to Tripoli in August 1996 and is continuing to expand its delivery across the country's coastal area.

Republic of Madagascar

Total Surface Area: 587 041 km²
Estimated Population in 2006: 19 105 000



Madagascar is one of the largest and oldest islands in the world, sometimes referred to as the "Great Red Island" because of its reddish soils. A high central plateau runs from north to south, separating the drier western lands from the tropical rain forests of the eastern coast. An average of 1 513 mm of rain falls per year, although significant regional disparities mean that some parts of the island suffer from chronic water shortages.



Important Environmental Issues

- Soil Erosion
- Endemism and Threats to Biodiversity
- Deforestation

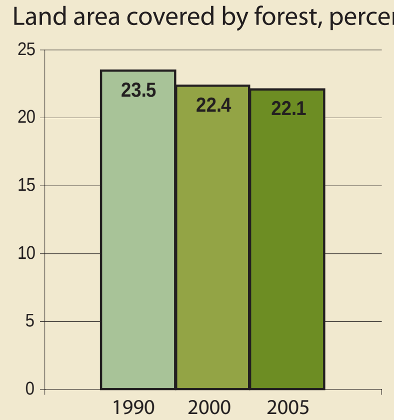
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

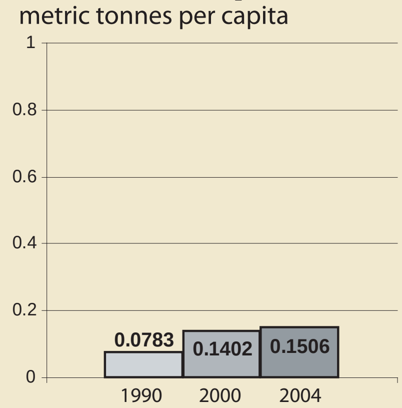
Madagascar is the world's fourth-largest island. Erosion, caused by deforestation and overgrazing, is a serious problem. Every year as much as a third of Madagascar burns. Fires set to clear land and revitalize pastures often spread into adjacent wildlands, causing damage to the island's unique ecosystems. Roughly 70 per cent of Madagascar's estimated 250 000 species are endemic. Between 1990 and 2004, Madagascar registered a marked increase in access to sustainable water source and sanitation.

★ Indicates progress

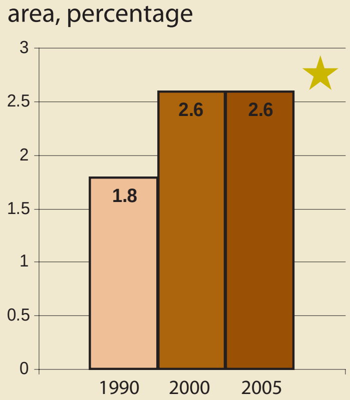
Land area covered by forest, percentage



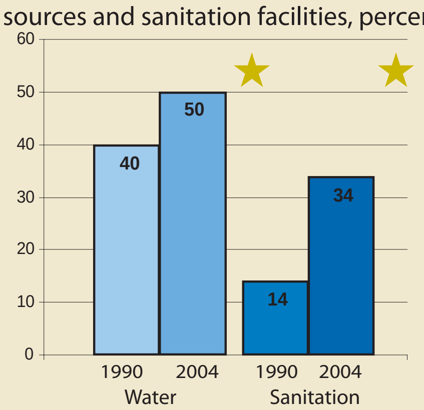
Carbon dioxide (CO_2) emissions, metric tonnes per capita



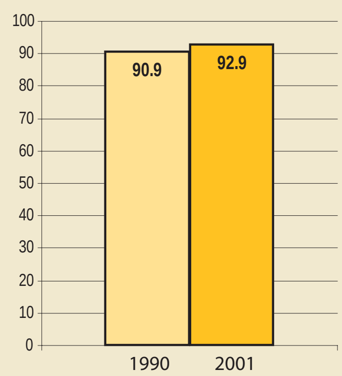
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

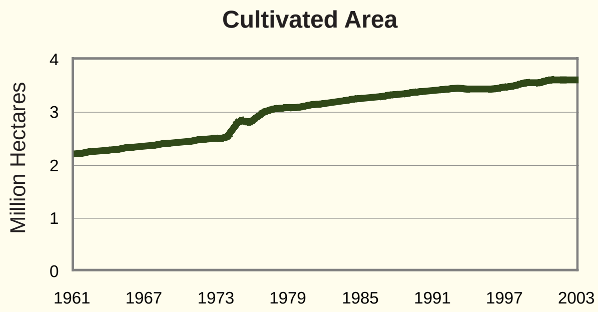


An astonishing 98 per cent of Madagascar's land mammals, 92 per cent of its reptiles, 68 per cent of its plants, and 41 per cent of its breeding bird species exist nowhere else on Earth.

atlas.aaas.org (2008)

Soil Erosion

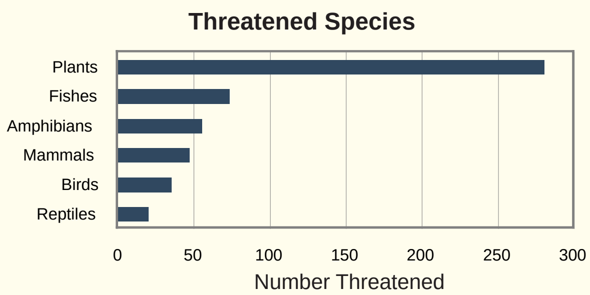
Madagascar experiences some of the worst soil erosion in the world, with nearly three-quarters of its land classified as severely degraded (FAO AGL 2003). Estimated annual soil loss ranges between 200 to 400 metric tonnes per hectare, which is approximately 20 to 40 times the global average (Rasambainarivo and Ranivoarivelo 2003). This is largely a result of frequent torrential rainfall, deforestation, and overgrazing on Madagascar's naturally steep and erosion-prone slopes.



Source: FAOSTAT

Endemism and Threats to Biodiversity

Geographically and biologically isolated for millions of years, Madagascar is home to a vast array of plants and animals found nowhere else in the world, including an estimated 102 endemic mammals, 202 endemic amphibians, 111 endemic birds, 332 endemic reptiles, and approximately 6 500 endemic vascular plants (UNEP-WCMC 2004). However, habitat destruction from expanded agriculture and increased deforestation threatens this biodiversity. Madagascar has more endangered species than any other country in Africa (IUCN-SSC 2007).

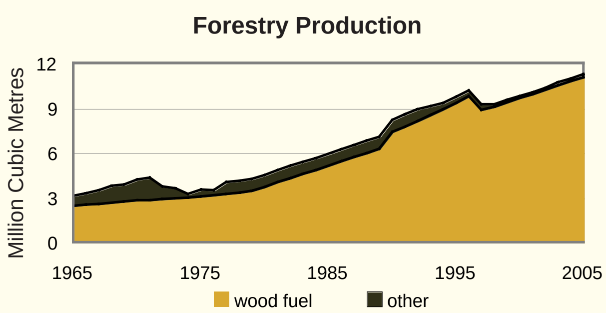


Source: IUCN Red List

Unique to Madagascar, lemurs are a group of primates that evolved after Madagascar split from the rest of the African continent roughly 150 million years ago. Of the island's 32 species of lemurs, a number are already extinct. Lemur species are quite diverse, ranging from the 2.5-kg ring-tailed lemur to the pygmy mouse lemur, which at 85 grams is the world's smallest primate.

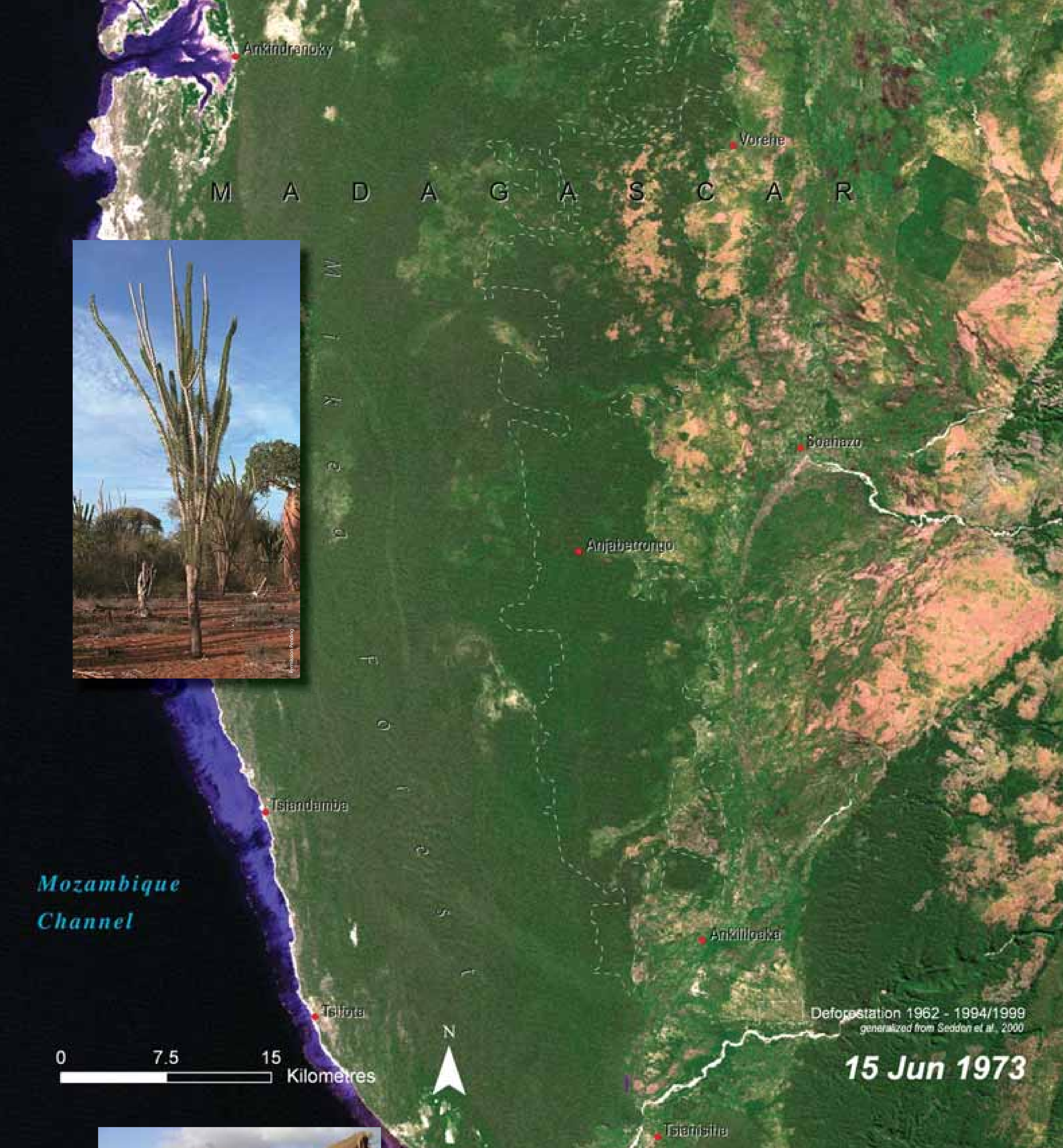
Deforestation

Forests once covered nearly all of Madagascar, but less than one-quarter of the island's original forest extent remains today (UN 2007). Rising fuelwood consumption, expanded agricultural activities, and logging are the major drivers. In addition, wildfires destroyed approximately 3.74 million hectares of forest between 1997 and 2000 alone (FAO 2005).



Source: FAOSTAT

Madagascar has over 300 000 hectares of mangroves, the vast majority of which are found on the western coast (Wilkie and Fortuna 2003). Coral reefs lie offshore from mangroves in many places. The reefs protect the mangroves from ocean swells, while the mangroves in turn catch sediment runoff that can damage the reefs. Mangrove ecosystems are in danger from urban development, over fishing, erosion, and aquaculture.



Permission Pending

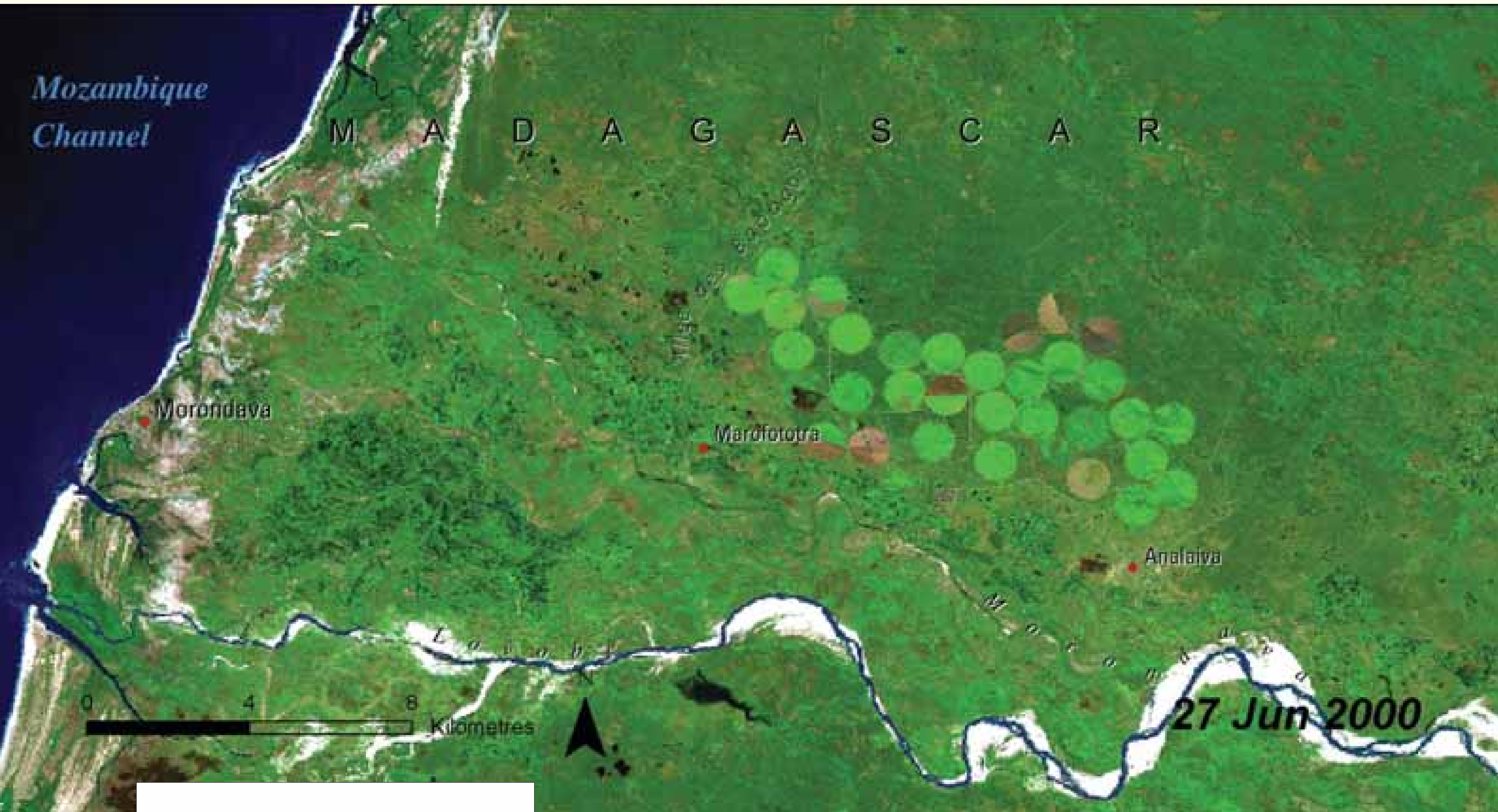
Deforestation in Mikea Forest: Madagascar

On an island known for endemic species, the South Malagasy spiny forests in the southwestern corner of Madagascar are one of the islands most distinct ecosystems. Within Mikea Forest, the unusual *Didierea madagascariensis* (see photo) and *Euphorbia stenoclada* as well as the more common *Adansonia fony* are among the most widespread tree species. Mikea Forest is also home to many endemic reptile and bird species. Two bird species unique to the Mikea Forest, the subdesert mesite (*Monias benschi*) and the long-tailed ground-roller (*Uratelornis chimaera*), are classified as vulnerable.

The village of Anjabetrongo, in the center of the two satellite images, is surrounded by trees in the 1973 image and by cropland in the 2002/03 image. This recent aerial photo of the village shows tall baobabs scattered across the landscape of brush and croplands.

The area of Mikea Forest shown in these images has lost approximately 28 per cent of its primary forest cover in the last three decades and the rate of loss appears to be accelerating. The white dashed line shows loss between 1962 and 1999. The 2002/2003 image shows deforestation advancing still further to the west.

A large portion of the forest has been lost to charcoal production, most of it for commercial sale in Toliara. This is especially true at the southern edge of the forest where road accessibility is greatest. Further north, slash-and-burn maize cultivation is practiced by the Mikea people native to the area. Most of this maize is for local consumption. This appears to be the driving force of forest loss along the eastern edge of the forest, which has moved almost 10 km to the west since 1973.



Centre Pivot Irrigation: Morondava, Madagascar

The large circular fields of irrigated sugarcane near Morondava in western Madagascar are an anomalous sight in this area more known for its baobab trees. While the average temperature in the area is ideal for sugarcane cultivation, a long dry season (April to November) makes irrigation necessary. These three images show the region before irrigation (1973), after irrigation was introduced (2000), and after further expanded irrigation (2006). Managed by a foreign company, most sugar cane grown in the area is exported. Ironically, sugar must be imported for the local market. Roughly 22 000 metric tonnes of sugar were produced here in 2006.

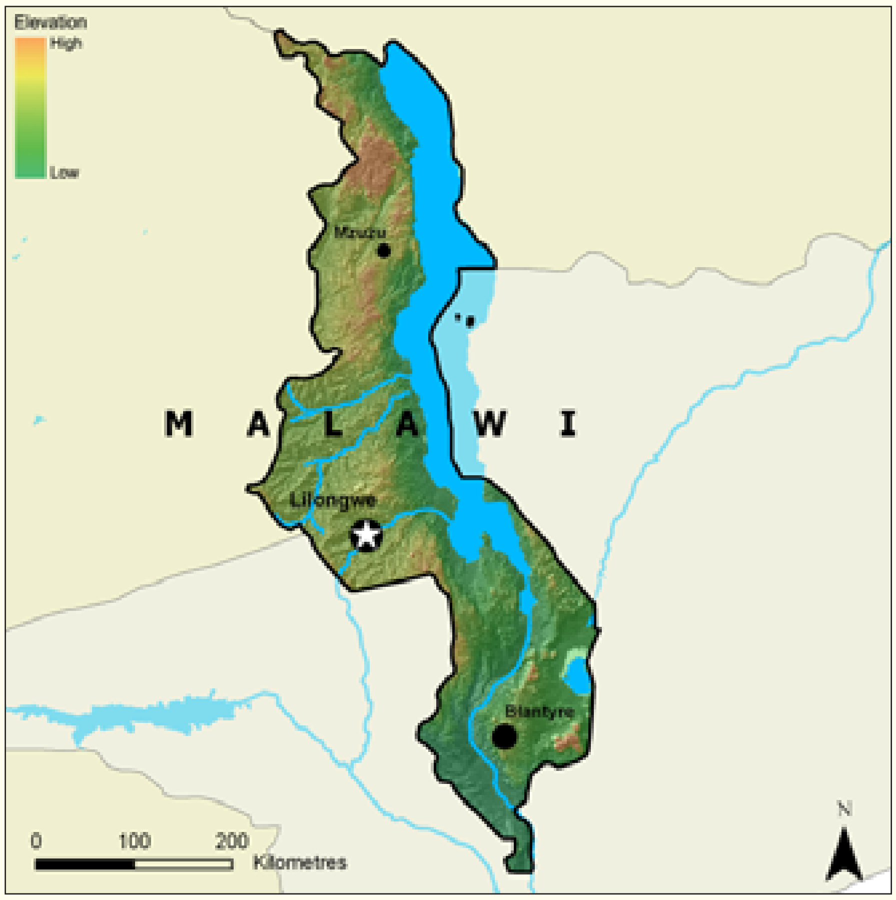
Baobab trees growing among the sugar cane fields are surrounded by rice paddies.

Baobabs, sometimes called "upside down trees" can live for up to 5 000 years. While there is only one baobab species on the African continent, Madagascar is home to seven different species. The volume of water needed for irrigating sugar cane fields may threaten the survival of these ancient trees if sugar cane farming extends into baobab areas—particularly the "allée des Baobabs" (Baobabs Boulevard, yellow arrows). Baobabs are also under threat by local community rice farming. Since August 2007 the "allée des Baobabs" has been temporarily classified as a protected area, the result of consultation between local communities, local authorities, and government authorities.

Republic of Malawi

Total Surface Area: 118 484 km²
Estimated Population in 2006: 13 166 000

Malawi is a small and densely populated country characterized by extremely diverse physical features, which support a wide variety of plant and animal life. The climate varies from semi-arid to sub-humid and is strongly influenced by the presence of Lake Malawi (Nyasa), which spans almost two-thirds of the nation's eastern border and is the third largest lake in Africa (FAO 2005). Including Lake Malawi (Nyasa), surface water covers one-fifth of the total country area.



Important Environmental Issues

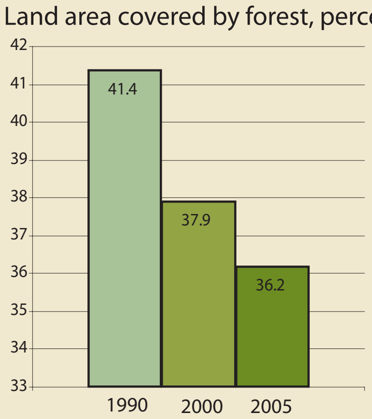
- Land Scarcity and Soil Erosion
- Deforestation for Fuelwood
- Water Pollution and Aquatic Biodiversity

Progress Towards Environmental Sustainability

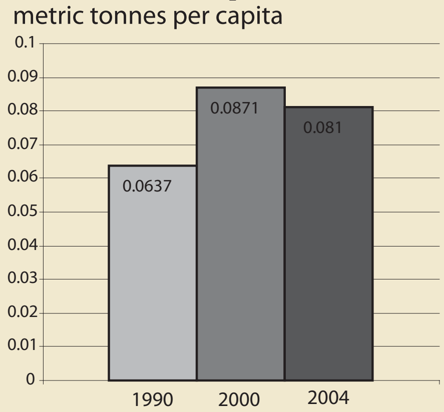
As defined by the United Nations Millennium Development Goal 7 Indicators

Deforestation is a serious problem in Malawi. Between 1990 and 2005, the country lost nearly 13 per cent of its total forest cover due to fuelwood collection and subsistence and commercial agriculture; tobacco farming accounts for nearly 80 per cent of the nation's export earnings. About 21 per cent of Malawi's total land area is arable. Malawi is self-sufficient in food production, except during droughts.

Land area covered by forest, percentage

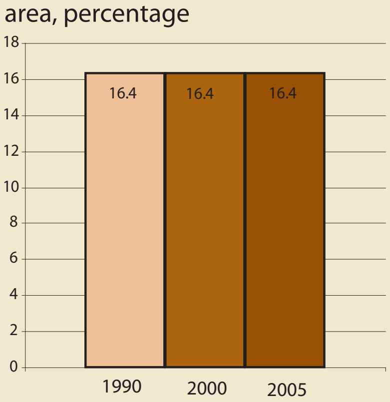


Carbon dioxide (CO_2) emissions, metric tonnes per capita

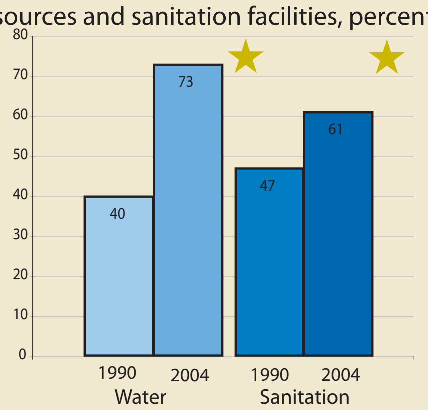


★ Indicates progress

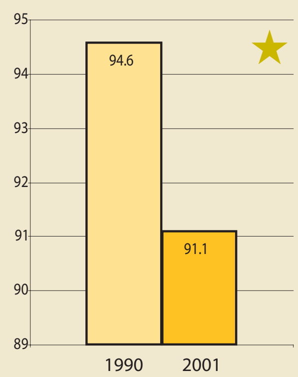
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



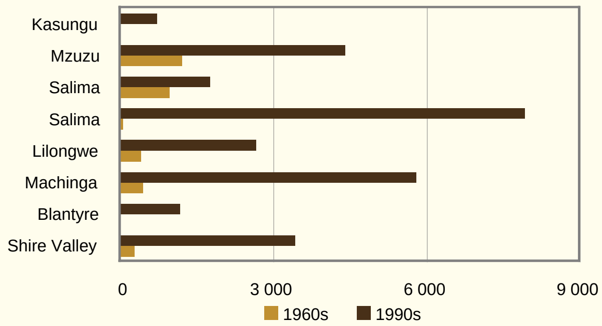
With over 1 000 species, many of them endemic, Lake Malawi (Nyasa) is home to the largest variety of fish of any lake in the world.

unep-wcmc.org (n.d)

Land Scarcity and Soil Erosion

Arable land is Malawi's most valuable natural resource and agriculture is vital to local livelihoods and the national economy. Cultivated area has more than doubled since 1961 (FAO 2007a) to accommodate rapid population growth, resulting in a growing land shortage. In 2002, an estimated 16 per cent of cultivation was taking place on marginal or unsuitable lands (SoE 2002). As a result, widespread soil erosion is sapping soil fertility and causing siltation of lakes and rivers, including the Shire River, which is the major outlet of Lake Malawi (Nyasa) and is important for hydroelectric power generation.

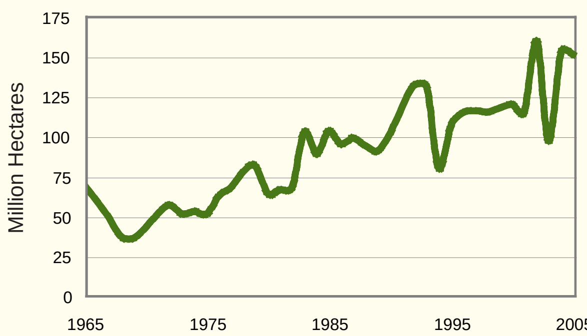
Farmers Per Agricultural District



Source: Rwanda State of the Environment Report 2002

Deforestation for Fuelwood

Tobacco Production, Area Cultivated



Source: FAOSTAT

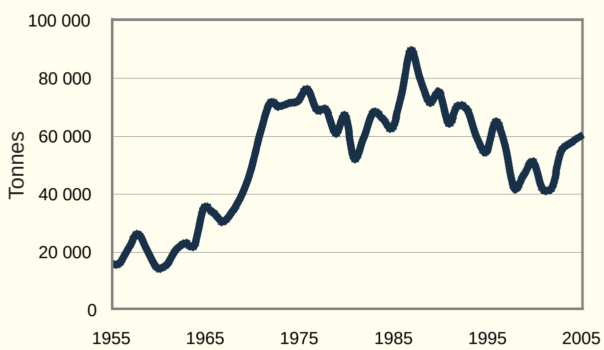
Deforestation, driven significantly by fuelwood harvesting and tobacco production, is also contributing to the rapid degradation of Malawi's intensively used lands. Malawi is the second largest tobacco producer in Africa after Zimbabwe (FAO 2005). Harvesting wood to fuel the tobacco-curing process accounts for roughly one-quarter of household wood consumption (Poitras 1999). Overall, it is estimated that demand for wood exceeds supply by 30 per cent (SoE 2002). The rising price of alternative energy sources, such as oil, has actually increased reliance on fuelwood in recent years to over 90 per cent of energy use (FAO 2003).

Water Pollution and Aquatic Biodiversity

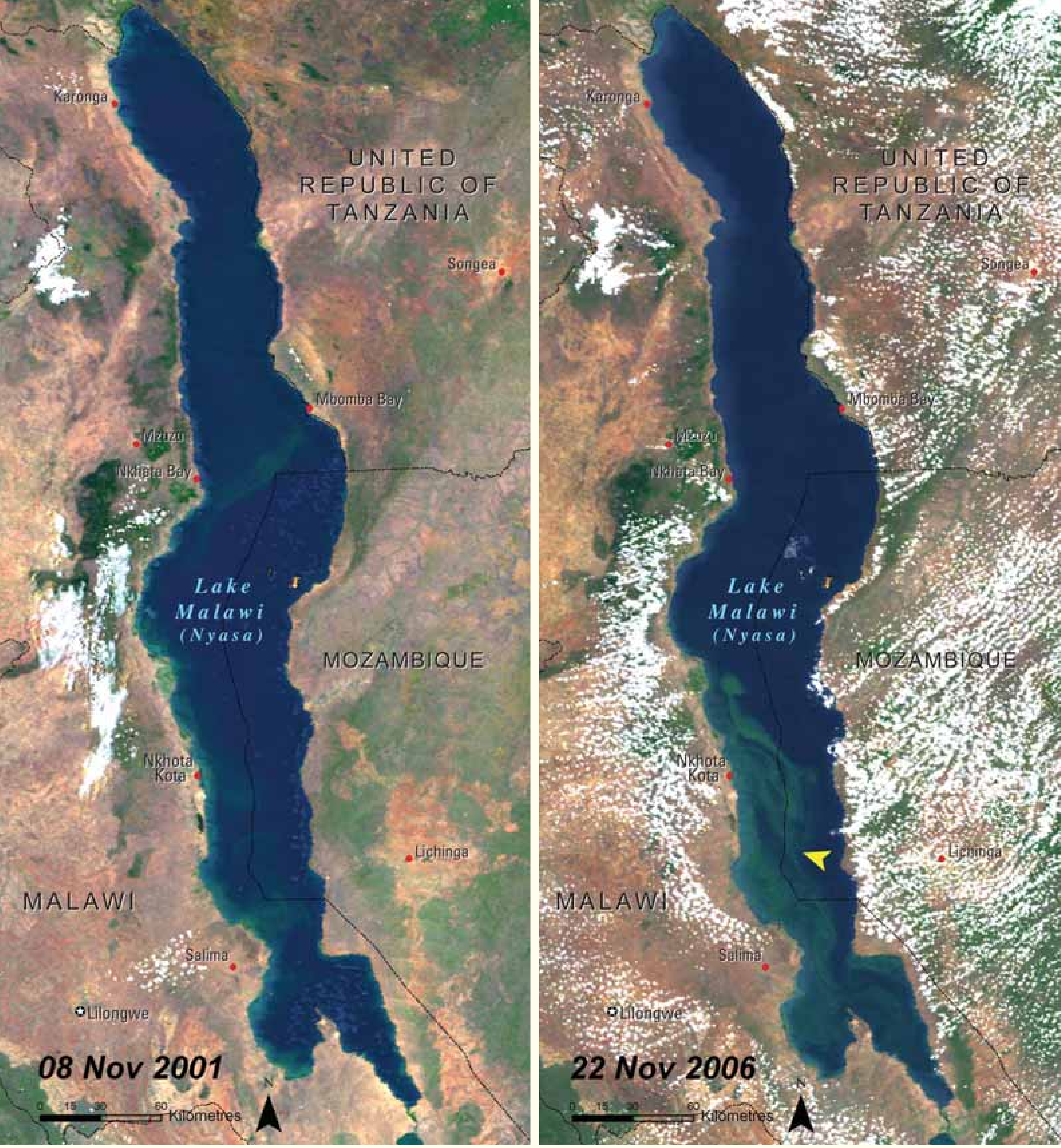
The annual internal surface water production for Malawi was 16.14 km^3 in 2007. In spite of this, Malawi is classified as a water stressed nation, since only 1 374 m^3 of water is available per person annually (FAO 2007b). Siltation from soil erosion and pollution from agricultural runoff and sewage are major threats to Malawi's surface water resources. Three-quarters of all rivers are significantly polluted by human waste (SoE 2002).

Water pollution affects Malawi's unique aquatic resources, which include over 1 000 fish species, accounting for nearly 15 per cent of global freshwater fish biodiversity. Lake Malawi (Nyasa) in particular contains more unique fish species than any other lake in the world, over 90 per cent of which are endemic (CBD 2007). There is evidence of localized overfishing in Lake Malawi's (Nyasa's) inshore waters, although offshore resources are thought to be underexploited due to lack of appropriate fishing gear.

Freshwater Fisheries Production



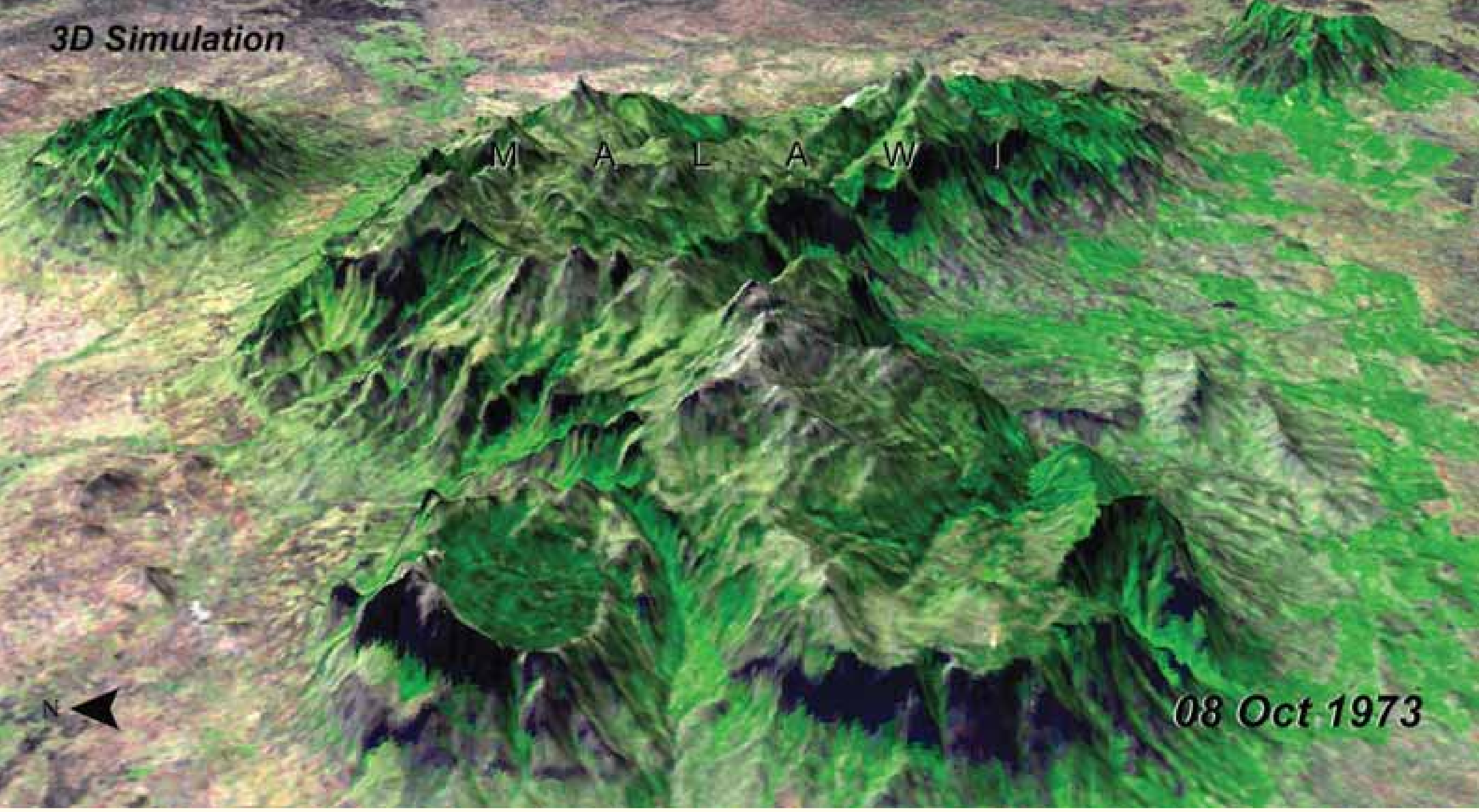
Source: FISHSTAT



Algae Blooms: Lake Malawi (Nyasa), Malawi

Lake Malawi (Nyasa), the third-largest lake in Africa, is an essential water resource for Malawi, Mozambique, and United Republic of Tanzania. A 2003 study indicated that sediments and nutrients from densely settled areas surrounding Lake Malawi (Nyasa) are entering lake waters, increasing nutrient loading by as much as 50 per cent.

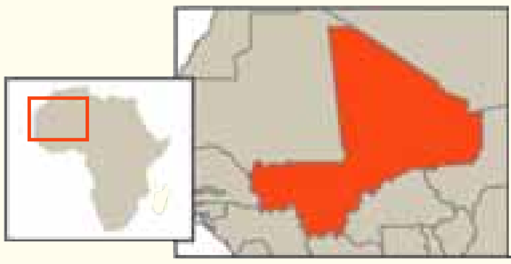
In these images, the bluish green swirls in the lake are algae blooms caused by these excess nutrients. Among other things, the algae reduce dissolved oxygen levels in the water. This poses a threat to the lake's fish species. The algae blooms appear worse in 2006 (note their concentration along the lake's western shore, yellow arrow), suggesting that water quality may be continuing to decline.



Mountain Deforestation: Mount Mulanje, Malawi

Rising to 3 000 metres, Mount Mulanje is the tallest peak in south-central Africa. It is an important source of water for almost every river that runs through southern Malawi. Mulanje Mountain Forest Reserve was created in 1927, primarily to safeguard the water catchments and to control the extraction of the endemic Mulanje cedar—Malawi's national tree.

Forest cover in and around the park is threatened by agricultural conversion, wildfires, fuelwood collection, and invasive species. Between 1973 and 2006, the top of the mountain underwent notable deforestation (yellow arrow).



Republic of Mali

Total Surface Area: 1 240 192 km²
Estimated Population in 2006: 13 918 000

Mali is a large landlocked country stretching from the Sahara Desert in the north to the Niger and Senegal River Basins in the centre and south. Average rainfall is low, at only 280 mm per year, although there is a strong north-south gradient. As a result, the majority of economic activity, food production, and human settlement is concentrated in the more hospitable riverine areas of southern Mali. Between the cities of Tombouctou and Bamako, the Niger River forms a large inland delta, a unique geographical formation of streams, marshes, and lakes that provide important habitat for many plant and animal species.

Important Environmental Issues

- Desertification and Drought
- Water Availability and Pollution
- Threats to Biodiversity

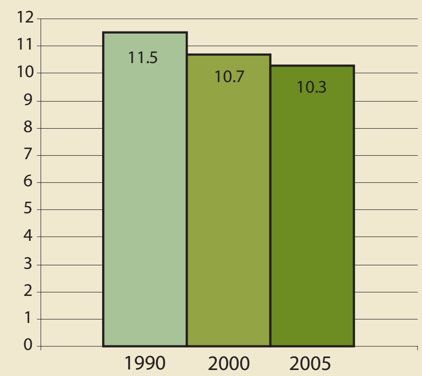
Progress Towards Sustainability

As defined by the United Nations Millennium Development Goal 7 indicators

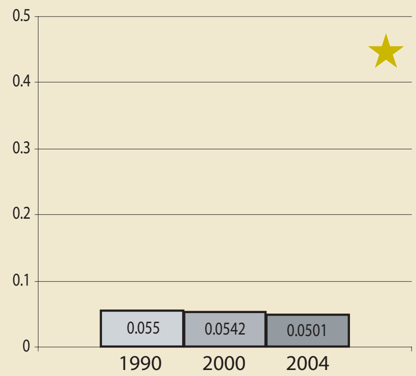
Wood is Mali's primary energy source. Overcutting for fuel is a serious problem that has resulted in the decline of forested area. The major environmental problem in Mali is increasing desertification. Mali—with one national park, four animal reserves, and six forest reserves —shows some improvement in the percentage of protected area to total surface area.

★ Indicates progress

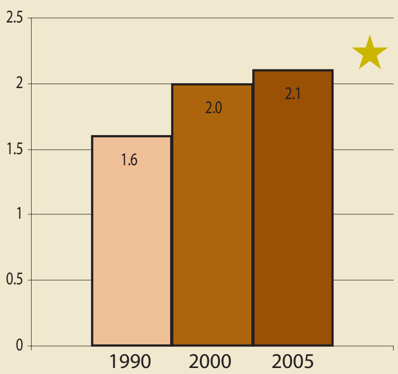
Land Area Covered by Forest, percentage



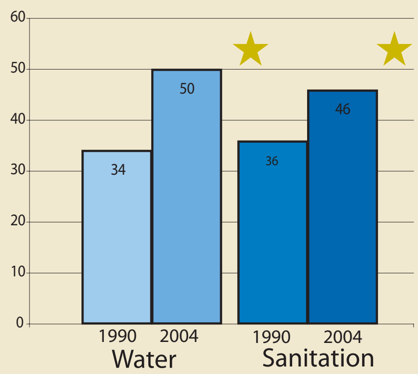
Carbon Dioxide Emissions (CO_2), Metric Tonnes per Capita (CDIAC)



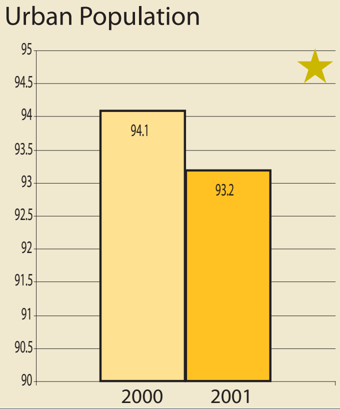
Protected Area to Total Surface Area in per cent



Access to Improved Water Source and Sanitation (per cent of total population)



Slum Population as per cent of Urban Population



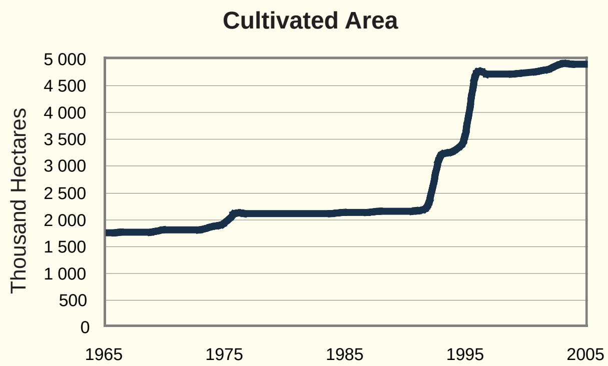
The Dogon people of Mali use an endemic plant (Acridocarpus monodii) as an effective remedy for malaria and various other illnesses.

biodiversity-day.info (2005)

Desertification and Drought

Prolonged drought is the greatest threat to livelihoods and ecosystems in Mali, and is a leading driver of desertification when combined with increasing human pressure on land resources. Mali is among the fastest growing countries in Africa with an annual population growth rate of nearly three per cent (UNESA 2005), resulting in the conversion of an estimated 100 000 hectares of land each year to cope with rising food needs (CBD 2001).

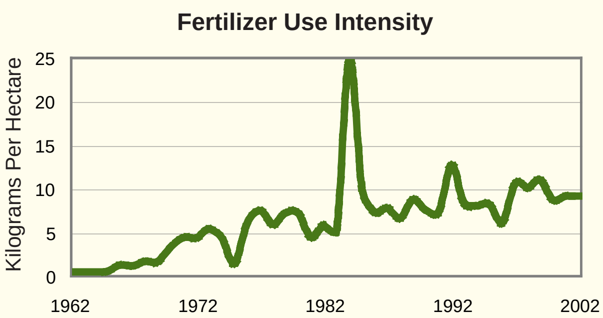
The use of fire to manage agricultural land is one of the leading causes of land degradation; an estimated 14.5 million hectares of pasture are burned each year, equivalent to 17 per cent of the country (CBD 2001). Overall, approximately 98 per cent of Mali's territory is at risk from desertification (FAO AGL 2003). The fertile areas surrounding the Niger River are particularly vulnerable due to the high concentration of people and agriculture.



Source: FAOSTAT

Water Availability and Pollution

Mali's water supplies, like its population and agricultural areas, are unevenly distributed. The Sahara Desert covers over half of the country, but the Niger and Senegal River systems ensure that total water resources are relatively large. Only 50 per cent of the total population and 36 per cent of the rural population have access to an improved water source (UN 2007).

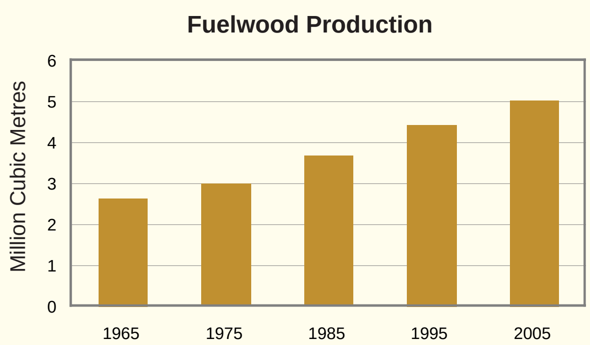


Source: Earth Trends (from FAOSTAT)

Pollution is another threat to Mali's water resources. Nearly all the commercial and residential effluent from the Malian capital of Bamako flows into the Niger River untreated (UN 2004). Other major sources of pollution include agricultural runoff of pesticides and fertilizer, and cyanide and sediment from gold mining activities.

Threats to Biodiversity

Due to its varied ecosystems and climatic zones, Mali supports tremendous biodiversity including over 1 700 plant species and nearly 1 000 animal species. However, biological resources are over-exploited by the growing human population. Deforestation is a major problem, especially as demand for fuelwood and charcoal continues to rise. In 1997, deforestation caused economic damage amounting to an estimated 5.35 per cent of GDP (CBD 2001). In addition, fish species are threatened by over-harvesting, the use of chemicals and explosives for fishing, and water pollution.



Source: FAOSTAT

The Drying Up of Lake Faguibine: Mali

When Mali's Lake Faguibine is full, it is among the largest lakes in West Africa—it covered an estimated 590 km^2 in 1974—and is an important source of water for the surrounding area. The lake is at the end of a series of basins that receive water from the Niger River when it floods. Thus, water levels in Lake Faguibine are closely tied to the flow of the Niger River. A lack of rainfall in the catchments of either the lake or the river can affect water levels in Lake Faguibine.

Water levels have fluctuated widely in Lake Faguibine since the beginning of the 20th century. However, in the late 1980s, an extended period of reduced precipitation led to a complete drying

up of the lake in the 1990s, making the traditional livelihoods of fishing, agriculture, and pastoralism difficult if not impossible. Despite relatively normal rainfall in recent years, Lake Faguibine remains nearly dry.

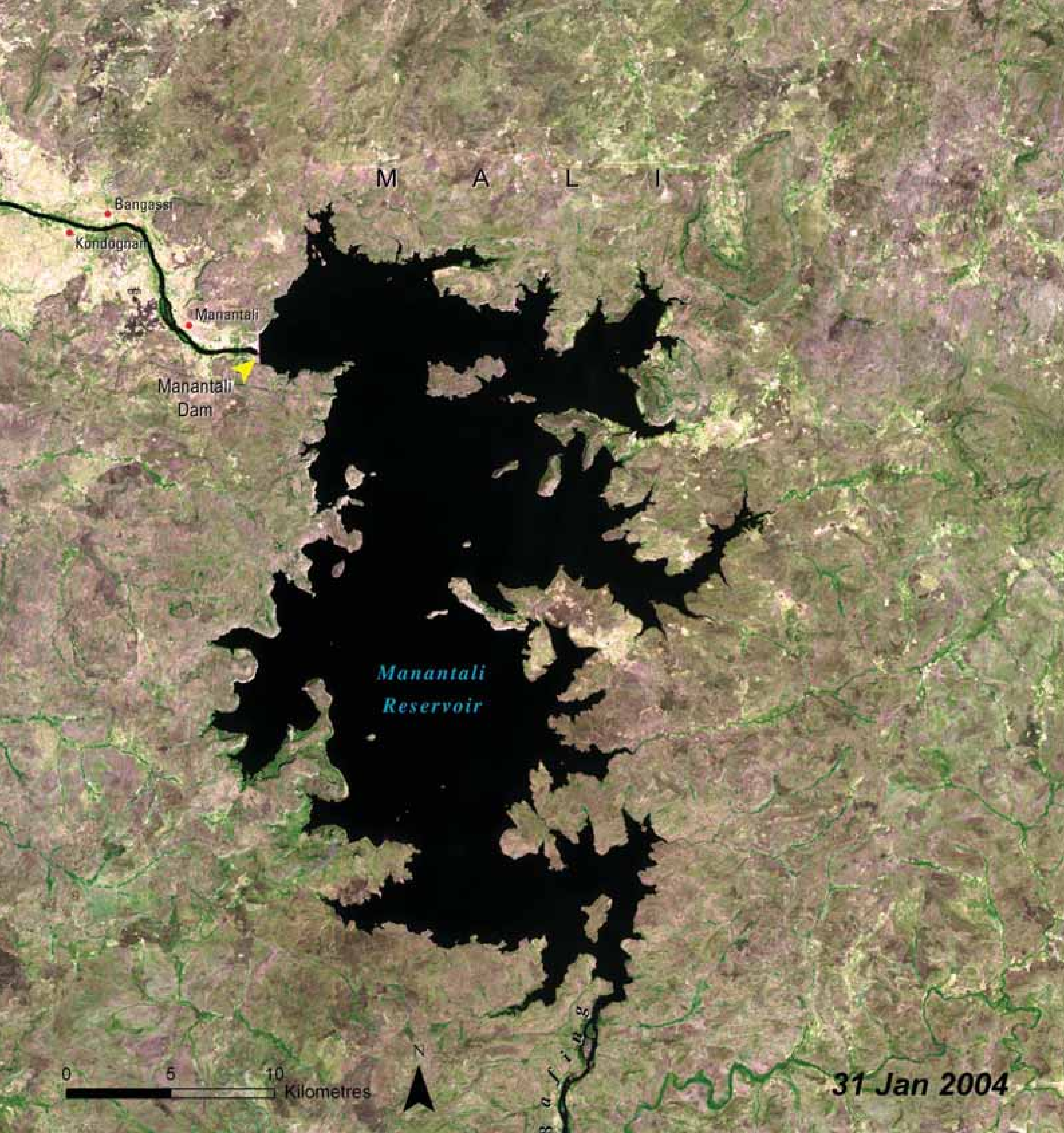
A 2003 Columbia University study linked changes in sea surface temperature to drought in the Sahel during the 1970s and 1980s. More recent research has linked sea surface temperatures to human induced global warming. As global warming intensifies, there may be more change in store for West Africa and for the people who depend on water resources such as Lake Faguibine for their livelihoods.

erdinand Reus/Flickr.com

Consequences of Manantali Dam: Mali

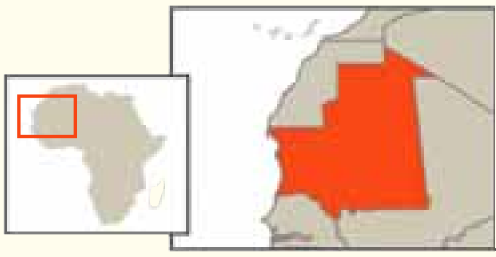
Seasonal rainfall at the source of the Bafing River in Guinea has historically led to seasonal flooding along the Senegal River, which receives over half of its flow from the Bafing. Prior to the 1970s, this pattern of inundation provided the basis for flood recession agriculture that supported hundreds of thousands of people.

Drought in the 1970s, however, spurred the formation of the multinational Organization for the Development of the Senegal River (OMVS) to develop irrigation, power generation, and navigation. The Manantali Dam in western Mali was one of two large dams built as part of the



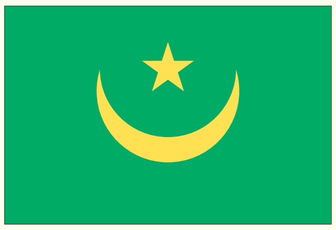
OMVS project. These images show the vast extent of land inundated by the filling of the dam's reservoir. Roughly 10 000 to 11 000 thousand people were displaced above the dam.

Below the dam, loss of the normal annual cycle of flood and recession reduced traditional agriculture substantially. Village-scale irrigation schemes have had limited capital for equipment and have been constructed without adequate drainage, resulting in soil salinisation. Flood recession farming was shown to give small farmers a better return with less risk than irrigated rice. Reduced flooding may also be contributing to deforestation along the Senegal River. The Manantali Dam did not produce any hydroelectric power until 13 years after its completion, and only after additional money was provided by the World Bank and others.



Islamic Republic of
Mauritania

Total Surface Area: 1 025 520 km²
Estimated Population in 2006: 3 158 000


Credit: © Flagart.com

Mauritania is a large country dominated by desert and semi-desert landscapes. Its population density is among the lowest in Africa, with an average of only one person per square kilometre (Earth Trends 2006, FAO 2005a). The majority of the population resides in the more hospitable southern region bordering the Senegal River and in the coastal zone. Rainfall is meager and irregular throughout the country, and severe drought is common.

Important Environmental Issues

- Desertification and Deforestation
- Iron Mining
- Fisheries and Coastal Ecosystems

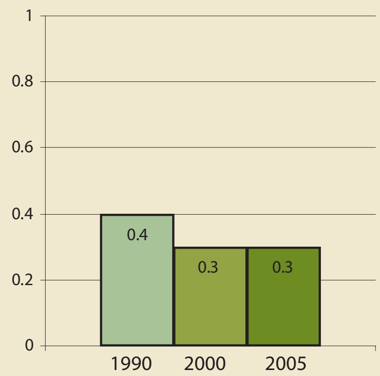
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

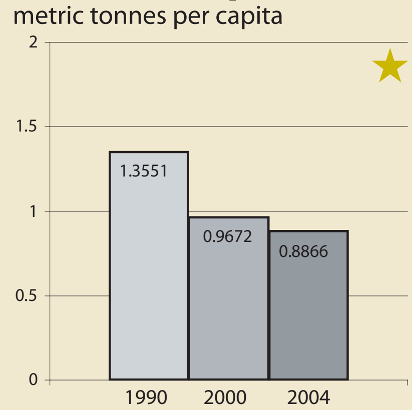
Mauritania is generally desert-like with three climatic regions: southern Mauritania has a Sahelian climate with one rainy season from July to October; coastal regions are arid; and about two-thirds of the country (north of Atar) has a Saharan climate. The forested area decreased by 0.1 per cent between 1990 and 2005. Even though deforestation in Mauritania is a serious problem, the protected 1.7 per cent of Mauritania's total land area has remained intact since 1990.

★ Indicates progress

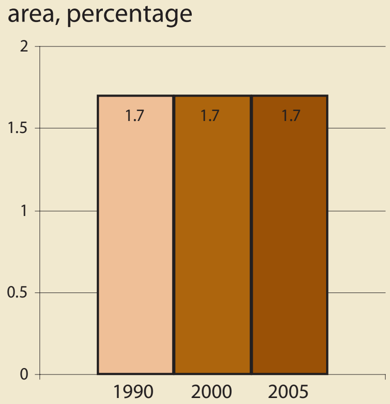
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

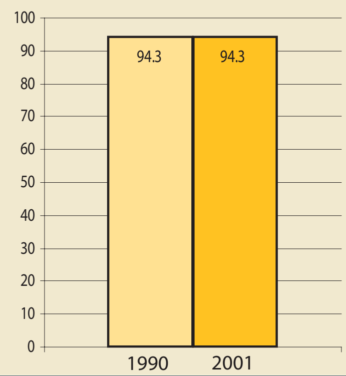


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban



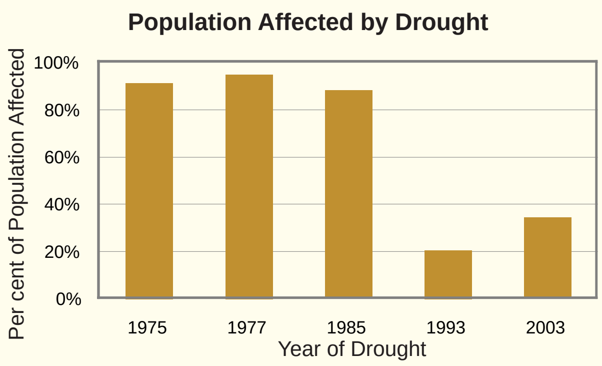
The eye of Mauritania, thought to have been caused by uplifted sedimentary rock layers sculpted by erosion, is nearly 50 kilometres across.

apod.nasa.gov (2002)

Desertification and Deforestation

Mauritania is one of the driest countries in Africa, receiving an average of only 92 mm of rain per year (FAO 2007). The majority of the population is concentrated in the south near the country's only perennial river, the Senegal. Arable land accounts for less than one per cent of the country's total surface area (Earth Trends 2007), so livestock production is the primary agricultural activity. Years of drought coupled with overgrazing and deforestation are causing the desert to expand southward, threatening the capital city of Nouakchott and the fragile agricultural belt.

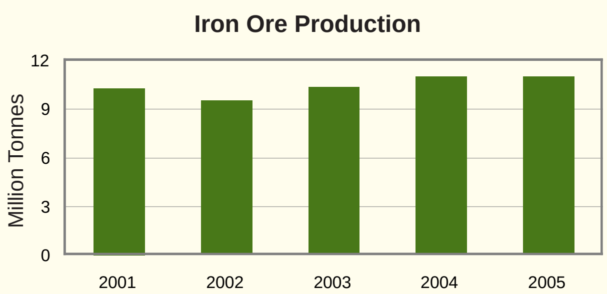
Forests cover only 0.3 per cent of Mauritania's surface (UN 2007), yet the deforestation rate is high at 3.4 per cent per year (FAO 2005b). The remaining forests provide an important buffer against the advancing Sahara Desert, but are threatened by growing demand for fuelwood and agricultural land.



Source: EM-DAT Disaster Database

/Flickr.com

Iron Mining



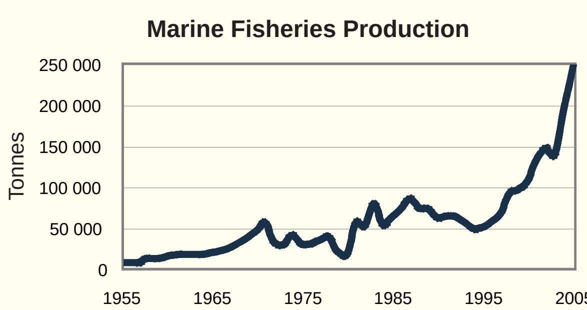
Source: USGS International Mineral Statistics and Information

Iron ore is one of Mauritania's most important natural resources; Mauritania is the fifteenth-largest producer of iron ore in the world. Mining activities have driven rapid urbanisation in those towns associated with iron production and shipping, such as Zouîrât and Nouadhibou in the northwest. Open-pit mining has resulted in severe localised land degradation as well as unsustainable exploitation of groundwater resources.

Fisheries and Coastal Ecosystems

Mauritania contains the richest fishery off the West African coast, but commercial exploitation only began 25 years ago when the world iron market experienced a recession. The fisheries sector now accounts for 12 per cent of the gross domestic product, but overfishing by foreign industrial fleets, which represents 90 per cent of all production, is a growing concern (FAO 2000-2007).

Mauritania's northern coast is a unique example of the transition zone between the Sahara Desert and the Atlantic Ocean. Banc d'Arguin National Park protects this valuable wetland, which is the most important bird breeding area on Africa's Atlantic seaboard and has the largest winter concentration of wading birds in the world (UNEP-WCMC 2002).



Source: FISHSTAT

Ferdinand Reus/Flickr.com


Christine Vaufrey/Flickr.com

Wetlands around Diawling National Park: Mauritania

Prior to construction of Diama Dam across the Senegal River, land surrounding the Senegal Estuary was flooded with fresh water from late July to late September each year. During the dry season, these delta wetlands would become saltier than the ocean, as their waters were reduced by evaporation.

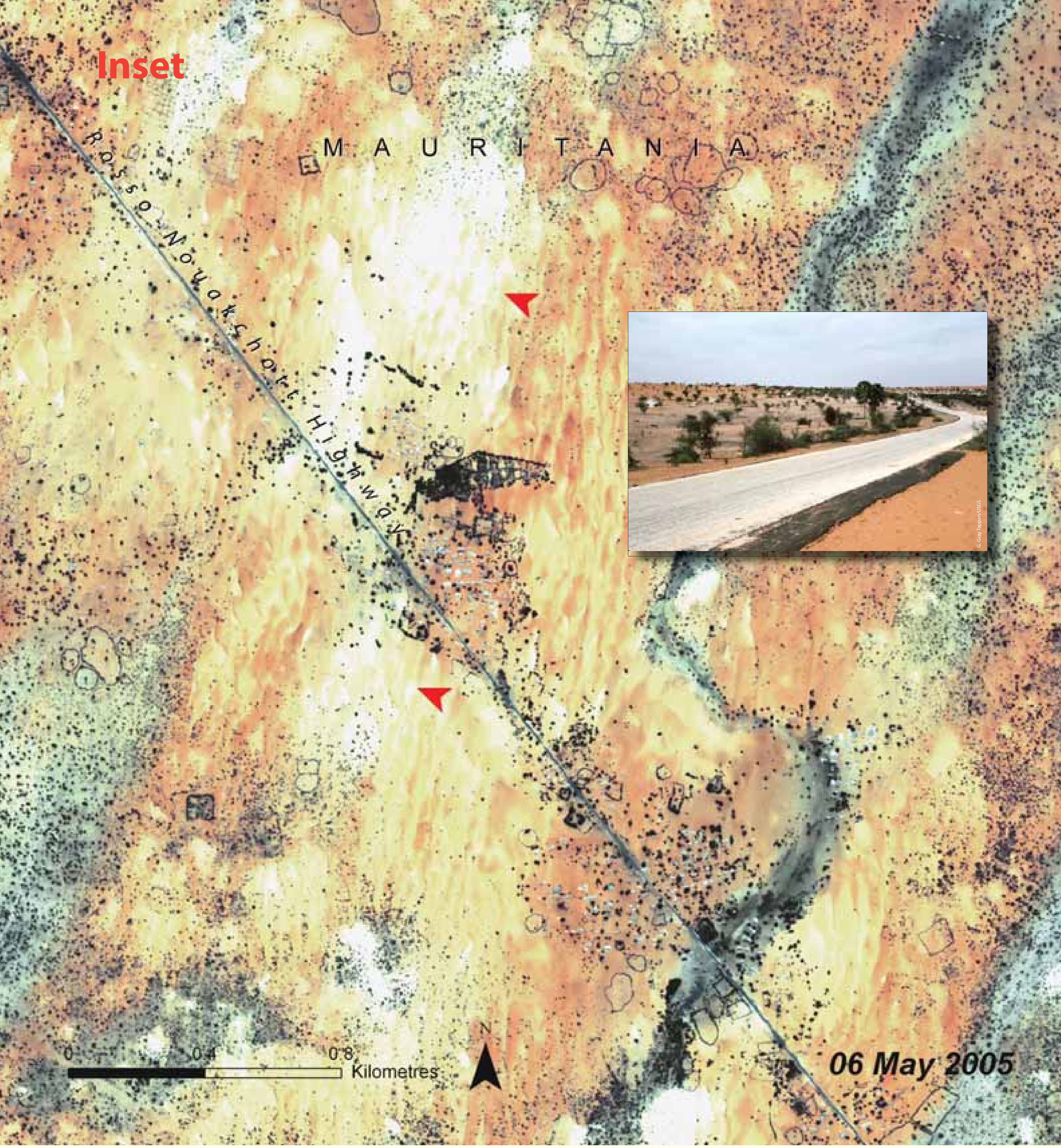
This yearly cycle was disrupted by the construction of the Diama Dam in 1986 (yellow arrow). Both the Diama Dam, and the Manantali Dam constructed upstream in Mali, were intended to regulate the flow of the Senegal River, generate hydroelectric power, and facilitate development

of irrigated agriculture. However, irrigation in the delta has been less successful and less productive than planned; lacking proper drainage systems, the land is becoming waterlogged and saline after just a few years under irrigation.

Drought had already begun to impact the wetlands before construction of the dams in the 1980s (1979 image). Following their construction in the 1980s, fish stocks decreased and wetland vegetation was decimated. In the early 1990s, a restoration project began using controlled flooding of the delta by managed water releases. It has revived the wetlands and restored much of the lost flora and fauna to the area. The 2006 image shows the restored wetlands in and around Diawling National Park.

Along the Rosso-Nouakchott Highway: Mauritania

North of the border between Mauritania and Senegal, National Highway 2 connects Mauritania's coastal capital Nouakchott with the regional capital of Rosso. The highway has brought increased settlement to this arid area, leading to the loss of natural vegetation for building, grazing, and fuel, and beginning the process of desertification. Without vegetation to retain water and decrease wind erosion, the fertility and productivity of the soil declines, dry sandy soil begins to drift, and vegetation is less able to reestablish itself.



The signs of progressive degradation of the land along the Nouakchott–Rosso Highway can be seen in these images. In the 1972 image, bright reflection from the sandy soils surrounding the highway is mixed with some vegetation (shades of green). In the 1990 image, the path of the highway shows as a bright yellow corridor from northwest to southeast through El Haedi. The 2006 image shows the same pattern of vegetation loss along the highway.

The 2005 high-resolution image is an enlarged view of the outlined area (red box) on the 2006 image. Red arrows on the 2005 image indicate areas of almost total vegetation loss. Continued population growth is increasing the demands made on this arid landscape.

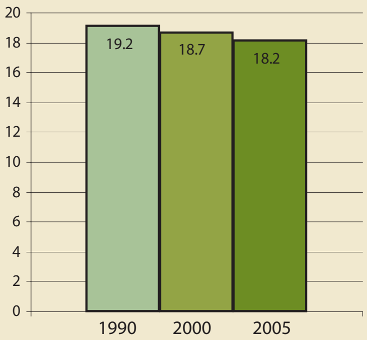
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goals 7 Indicators

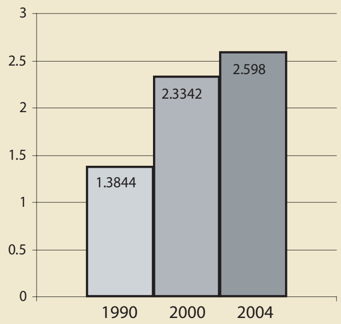
Sugar cane is the major crop of Mauritius, occupying 70 per cent of its cultivated land. The 100 per cent access by Mauritius' inhabitants to improved water sources is attributable to the country's actions to improve water quality over the past decade.

★ Indicates progress

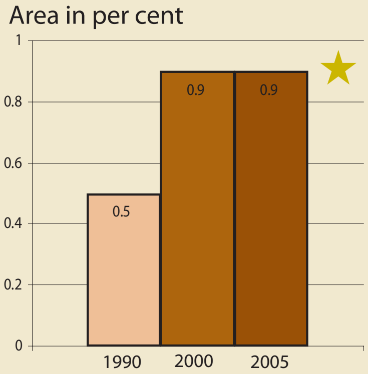
Land Area Covered by Forest, percentage



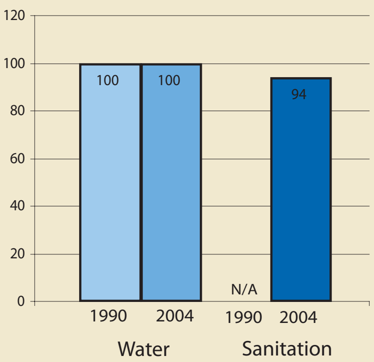
Carbon Dioxide (CO_2) Emissions, Metric Tonnes per Capita (CDIAC)



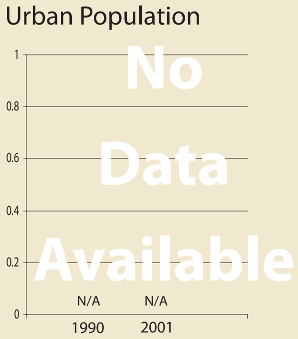
Protected Area to Total Surface Area in per cent



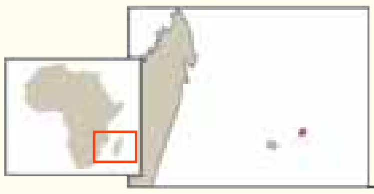
Access to Improved Water Source and Sanitation (per cent of total population)



Slum Population as per cent of Urban Population



Republic of Mauritius



Total Surface Area: 2 040 km²
Estimated Population in 2006: 1 256 000

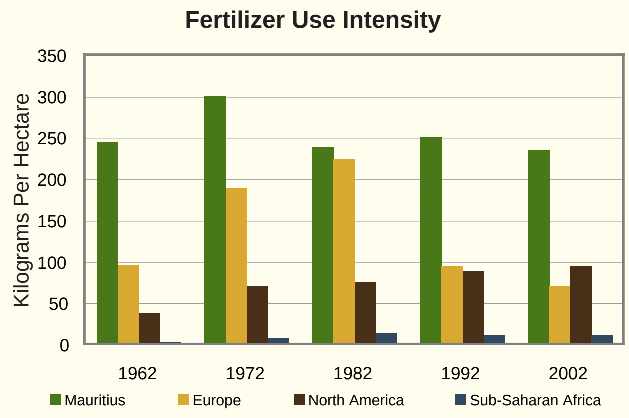
The Republic of Mauritius consists of six small islands in the southwestern Indian Ocean. The largest of these, the Island of Mauritius, is formed by an ancient volcano and is ringed by coral reefs. Over half of its population lives in rural areas, and with a population density of 652 people per square kilometre, it is the most densely populated country in Africa (PRB 2007).

Important Environmental Issues

- Coastal Water Pollution
- Threats to Biodiversity

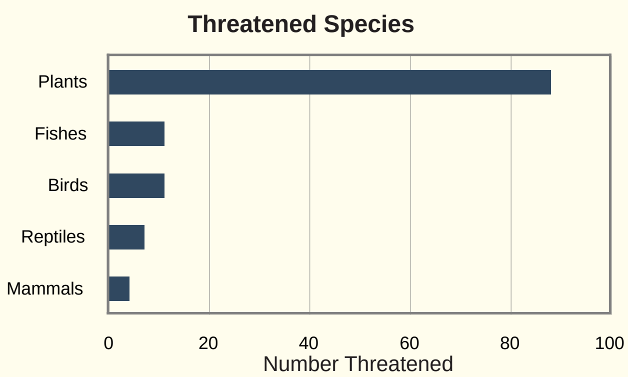
Coastal Water Pollution

Water pollution from Mauritius' large industrial and agricultural sectors poses a significant threat to its coastal and marine environments. Over half of the country's total surface area is under cultivation (Earth Trends 2007), nearly all of which is dedicated to sugar cane, the nation's most important crop. To ensure high yields, Mauritian farmers use large amounts of fertilizers, herbicides, and pesticides, all of which contribute to water pollution. Recent efforts to improve water quality are evidenced by increased wastewater treatment and a general improvement in water quality parameters since 1997 (Mauritius Ministry of Environment and National Development Unit 2006).



Source: Earth Trends (from FAOSTAT)

Threats to Biodiversity



Source: IUCN Red List

Fourty-one different animal species have gone extinct in Mauritius (IUCN 2007a), which is the highest number of extinctions for any country in Africa. Extinct species include the famous Dodo, a large flightless bird that succumbed to habitat loss and introduced predators during the 1700s. Mauritius' surviving species remain under threat, with 75 animal and 88 plant species listed as endangered or vulnerable (IUCN 2007b). Water pollution, deforestation, and intense population pressure are all implicated in biodiversity loss. Thanks to conservation measures, however, Mauritius has some of the most well-preserved coral reefs in the world.

Population of the Echo Parakeet (Psittacula eques), found in Black River Gorges National Park, increased from 10 in the 1980s to over 320 in 2000.

iucn.org (2007c)

Threatened Coral Reefs, Mauritius

Over the past 50 years, the population of Mauritius has nearly doubled, to 1.2 million. It currently has the highest population density of any African country, 652 people per km^2. Mauritius has also seen a dramatic growth in its economy, which has increased demands on its environment.

Coral reefs almost surround Mauritius. Coral reefs are complex ecosystems, rich in biodiversity yet only able to survive in very clear, warm and nutrient-poor ocean waters. In these satellite images, coral reefs (yellow arrows) form a fringe along the island's shores and create shallow lagoons that are extremely important to the fishing and tourist industries. The island's population density as well as agricultural runoff, untreated sewage, changes in freshwater runoff, tourist activity, and global warming all threaten the health of the reefs.

Kingdom of Morocco

Total Surface Area: 446 550 km²
Estimated Population in 2006: 31 943 000

Credit: Wikipedia

Morocco's diverse geography and climate are jointly influenced by the Atlantic Ocean to the west, the Mediterranean Sea to the north, and the Sahara Desert of the interior. Over 90 per cent of the country is classified as arid or semi-arid, and the population is concentrated primarily in the sub-humid and humid zones in the northwest. Morocco's mountains are some of the highest in Africa, with the Atlas range reaching 4 165 m in some areas.

Important Environmental Issues

- Drought and Desertification
- Water Scarcity
- Pollution

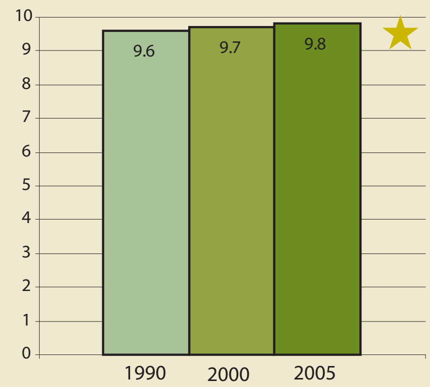
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

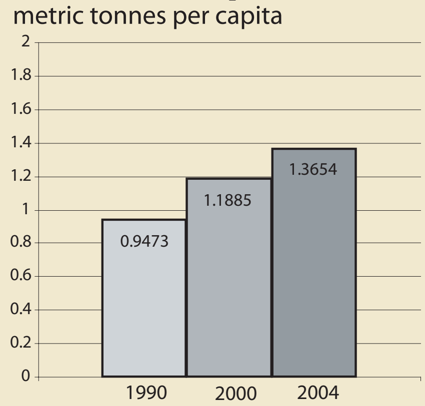
Morocco's cities produce about 2.4 million metric tonnes of solid waste per year, but a decrease in the slum population should improve this situation in the near future. Reforestation has become a major goal of the Moroccan government, which has resulted in an increase in forested area. Between 1984 and 1994, the area of forests and woodlands increased by an estimated 1 120 000 hectares.

★ Indicates progress

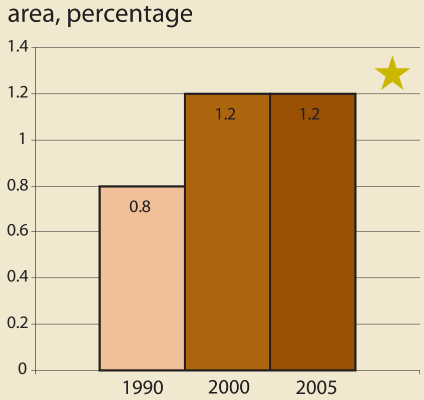
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

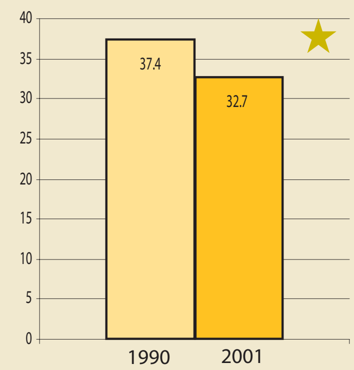


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban

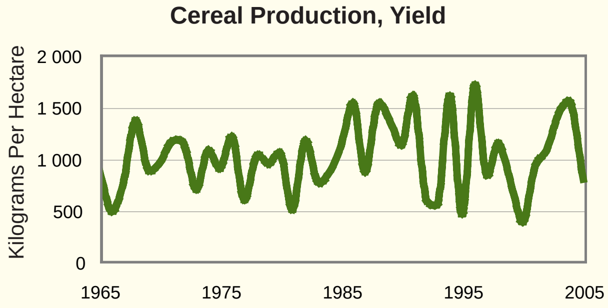


The oil-yielding Argan tree (Argania spinosa) is unique to Morocco and grows only in the Souss Valley of the southwest.

nationsencyclopedia.com (2007)

Drought and Desertification

Nearly 80 per cent of Morocco's lands are at high risk of desertification, and an estimated 22 000 hectares of arable land are lost each year to the desert (Ouali 2005). Since 1990, Morocco has experienced one year of drought out of every two years, compared to one out of five years during previous decades. During droughts, crop production may decrease by as much as 85 per cent, resulting in extreme annual variation in cereal yields (Karrou n.d.). Droughts also fuel wild fires that may destroy thousands of hectares of forest and exacerbate desertification.

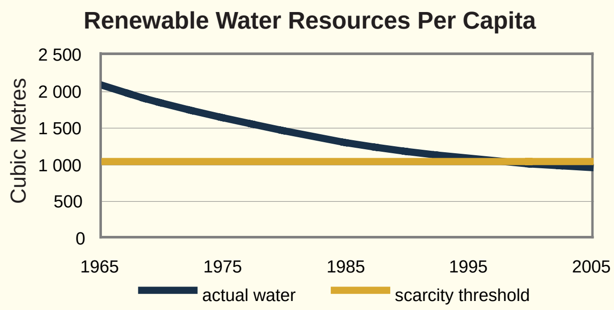


Source: FAOSTAT

Water Scarcity

Water availability recently dropped below the international water scarcity threshold of 1 000 m^3 per person per year. Surface water is unevenly distributed throughout Morocco, and although groundwater is more universally available, exploitation in several basins has surpassed natural replacement rates. By 2020, it is estimated that groundwater exploitation at the national level will exceed natural replacement by 20 per cent (FAO 2005).

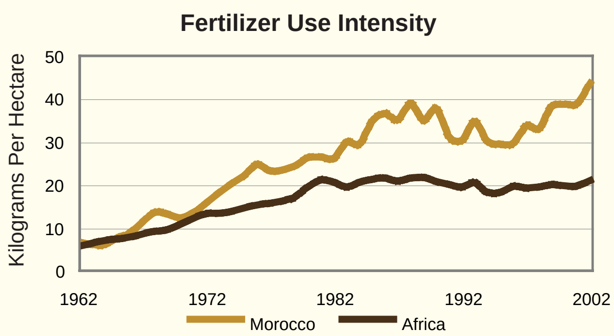
Morocco has over 100 dams providing roughly 16 000 million cubic metres of water for agricultural, domestic, and industrial purposes. Accumulation of sediment as a result of soil erosion, however, has caused dam capacity to decline by ten per cent (FAO 2005).



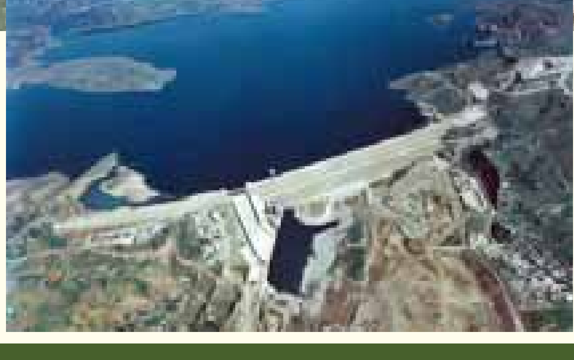
Source: AQUASTAT

Pollution

Major river basins, including the Sebou River Basin that constitutes nearly one-third of Morocco's water resources, have been heavily polluted by untreated industrial and municipal waste and agricultural runoff. Morocco's farmers are among the greatest users of fertilizer and other agricultural chemicals in Africa (FAO 2006). Wastewater generated in urban areas is often discharged untreated into the environment; 43 per cent is released into the ocean, 30 per cent into freshwater resources, and 27 per cent onto the soil (World Bank 2001).



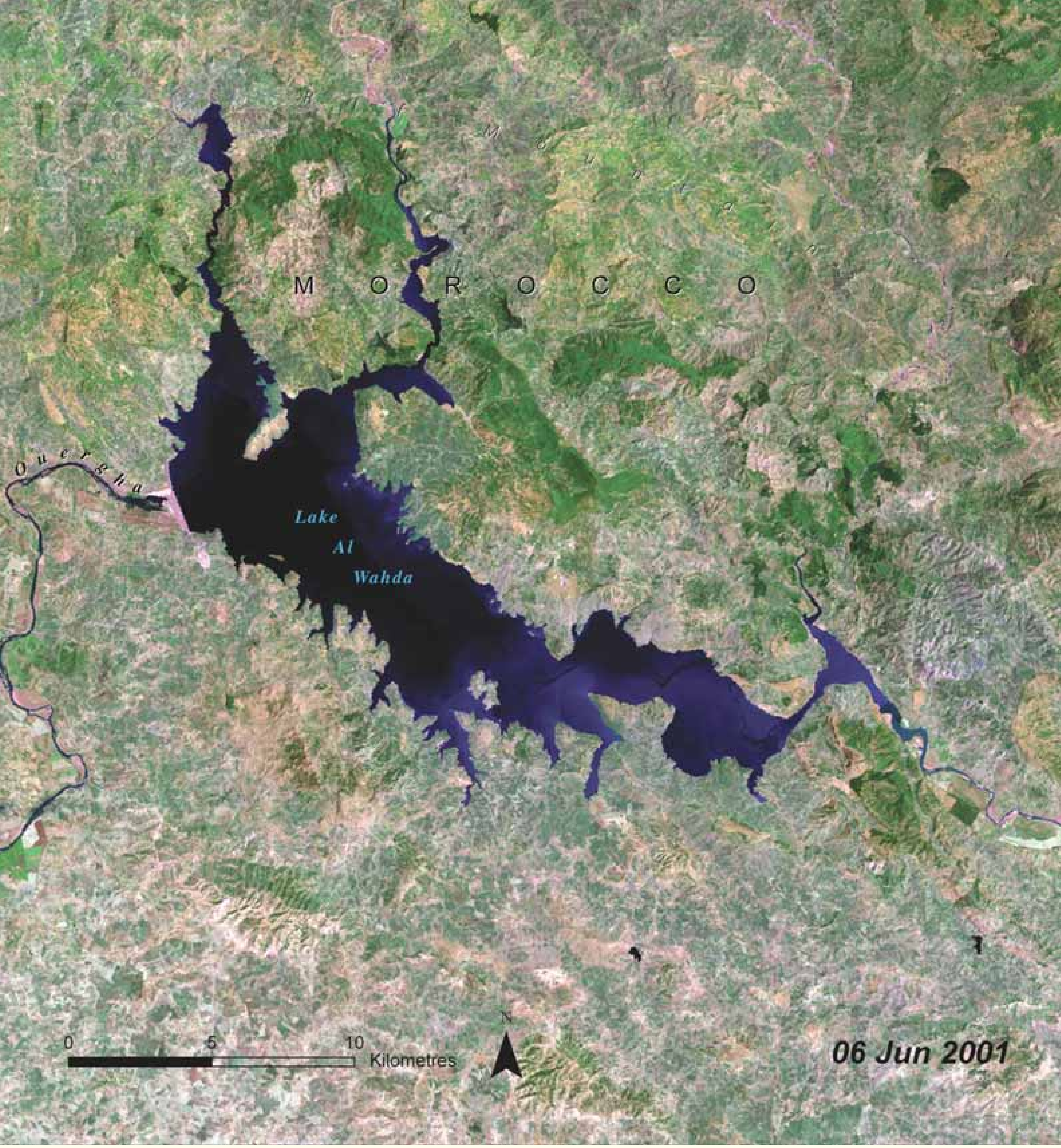
Source: Earth Trends (from FAOSTAT)



The Sustainability of Al Wahda Dam: Morocco

The second-largest dam in Africa and the largest in Morocco, Al Wahda Dam has a capacity of 9 714 million m^3. Located in the Gharb Plain, the dam was built in 1996 to reduce devastating flooding along the Ouergha River, provide water for irrigation, and generate hydroelectricity.

Since completion of the dam, flooding has decreased by 90 per cent, potential irrigation has increased by about 110 000 ha, and hydroelectricity production has reached approximately



400 Gwh per year. The electricity produced by the dam allows the Moroccan government to avoid burning 140 000 metric tonnes of fossil fuels per year, thereby reducing greenhouse gases released into the atmosphere.

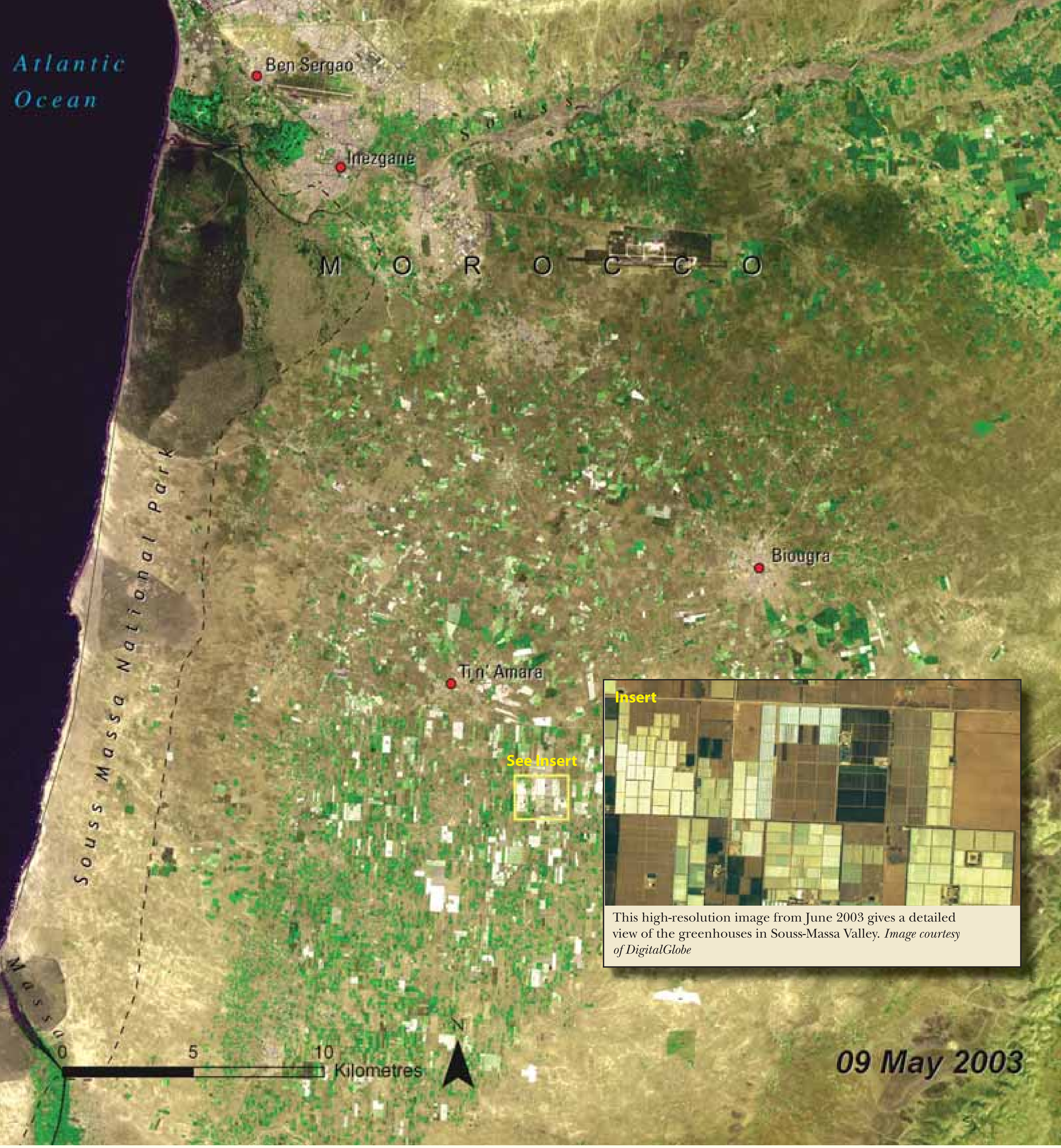
However, natural and human-caused erosion is filling the dam with silt and threatens its long term sustainability. It is estimated that the reservoir loses 60 million m^3 of capacity each year to siltation. In addition, these sediments trapped in the reservoir do not reach the coastal estuary, which has altered the balance of siltation and erosion along the coast in favour of erosion. Another potential threat to the dam's future viability is suggested by climate and hydrological modeling, which predicts that a 1° Celsius increase in average air temperature between 2000 and 2020 might reduce runoff to the Al Wahda Dam by 10 per cent.

Desertification-Fighting Tree

The Argan (*Argania spinosa*) tree's long roots bring groundwater to the surface and help to fight against desertification. The species' survival is threatened by declining water levels in the Souss-Massa aquifer.

Greenhouse Agriculture: Souss-Massa Valley, Morocco

The Souss-Massa Valley is located in southwestern Morocco. Rainfall in the valley is only about 200 mm per year, which is not enough to support most types of agriculture. In 1968, Morocco's King initiated a plan to irrigate one million hectares. In 1972, the Youssef Ben Tachfine Dam (left photo) was built on the Massa River, creating a reservoir that supported a substantial growth in agriculture in the valley and allowed development of a modern agricultural area of 18 000 hectares, primarily dedicated to vegetable and citrus cultivation.



This high-resolution image from June 2003 gives a detailed view of the greenhouses in Souss-Massa Valley. *Image courtesy of DigitalGlobe*

Irrigated agriculture in the valley also uses groundwater; however, groundwater withdrawal has exceeded the natural rate of recharge. Since the 1970s groundwater resources have declined, forcing farmers to drill much deeper wells to reach water.

In the 1970's, greenhouse agriculture was introduced to the area. It requires 80 per cent less water per kg of crop than unprotected agriculture. The 1988 satellite image shows a few greenhouses (light blue squares) scattered throughout the valley. The 2003 image shows the expansion that has occurred in greenhouse agriculture, with greenhouses (white squares) covering a substantial portion of the valley's agricultural land.

The Souss-Massa Valley is Morocco's leading region for greenhouse agriculture, covering 14 530 hectares in 2004. Vegetables are the primary crops, with tomatoes covering more than half the greenhouse area.

Republic of Mozambique

Total Surface Area: 801 590 km²
Estimated Population in 2006: 20 158 000

Mozambique is a large country bordering the Indian Ocean that has many sizeable rivers and lakes. The climate is generally tropical, although precipitation varies widely from north to south and from the coast to the inland areas. Drought in the southern regions and prolonged civil war led to significant migration to coastal and urban areas, which are growing by over four per cent per year (UNESA 2006).

Important Environmental Issues

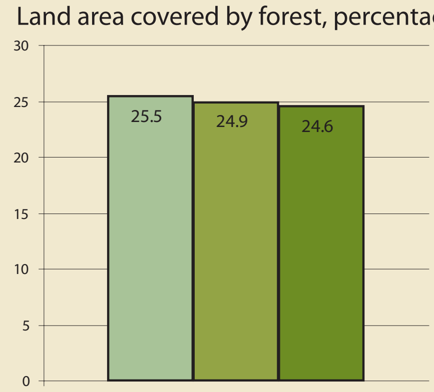
- Water Access and Natural Disasters
- Land Use
- Protecting Wildlife and Forests

Progress Towards Environmental Sustainability

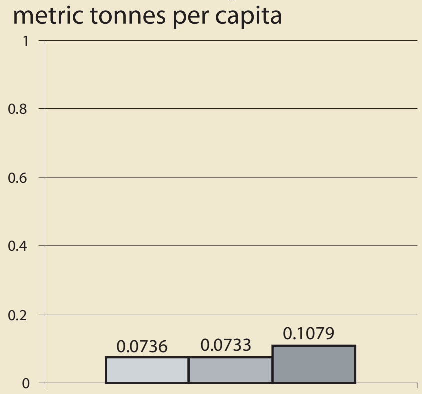
As defined by the United Nations Millennium Development Goal 7 Indicators

The geographical location of Mozambique favours the occurrence of floods and environmentally related diseases such as malaria and cholera, with severe negative impacts on human well-being. Mozambique lost 7.7 per cent of its forest and woodland between 1983 and 1993 alone, but has since launched reforestation projects, which have fostered denser forest cover in the wet and fertile regions; thin savannah vegetation characterizes the drier interior.

Land area covered by forest, percentage

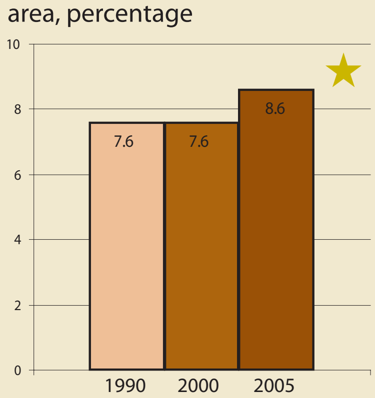


Carbon dioxide (CO_2) emissions, metric tonnes per capita

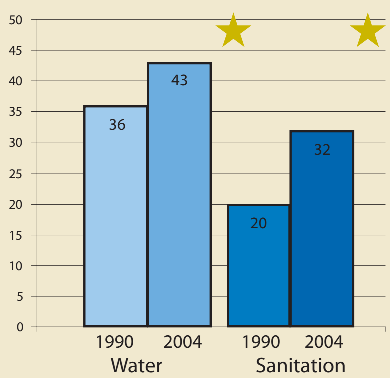


★ Indicates progress

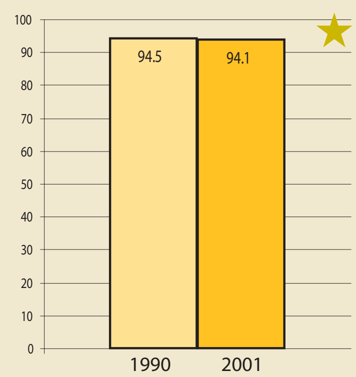
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



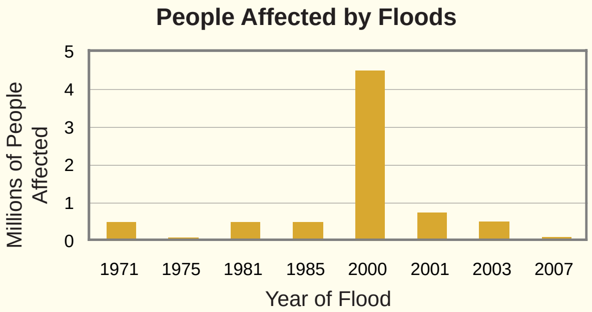
Mozambique has roughly 5 000 km² of mangroves along its coast, the most of any country along Africa's Indian Ocean shoreline.

worldwildlife.org (2008)

Water Access and Natural Disasters

Levels of access to potable water and adequate sanitation facilities in Mozambique are among the lowest in Africa, although the situation has improved somewhat. The problem is most widespread among rural residents, which account for nearly three-quarters of the total population. Access is also lacking in urban slums, which account for 94 per cent of all city dwellers (UN 2007).

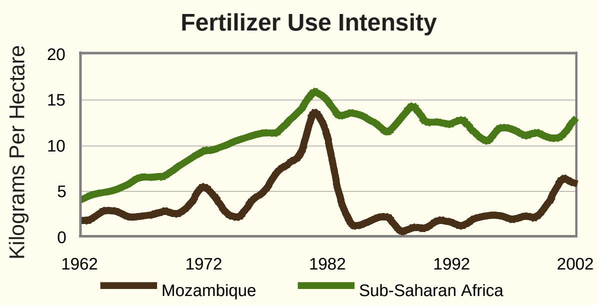
Natural disasters such as droughts, floods, and cyclones frequently strike Mozambique, exacerbating water and sanitation problems, destroying crops, and threatening food security and human health. In 2000, the worst floods in over 50 years destroyed 140 000 hectares of crops and affected millions of people (UN 2000).



Source: EM-DAT Disaster Database

Land Use

Mozambique has immense agricultural potential, with 36 million hectares of arable land, equivalent to almost half of the total country area. Fewer than five million hectares are currently being utilized, however, predominantly by poor, smallholder farmers using minimal chemical inputs, irrigation, and machinery (FAO 2005). As a result, land degradation is not as severe in Mozambique as in other African countries, although continued population growth could alter this trend.

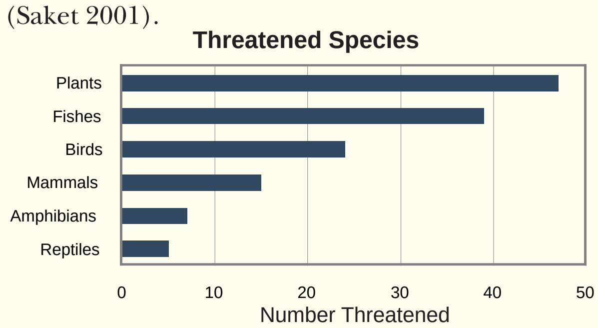


Source: FAOSTAT

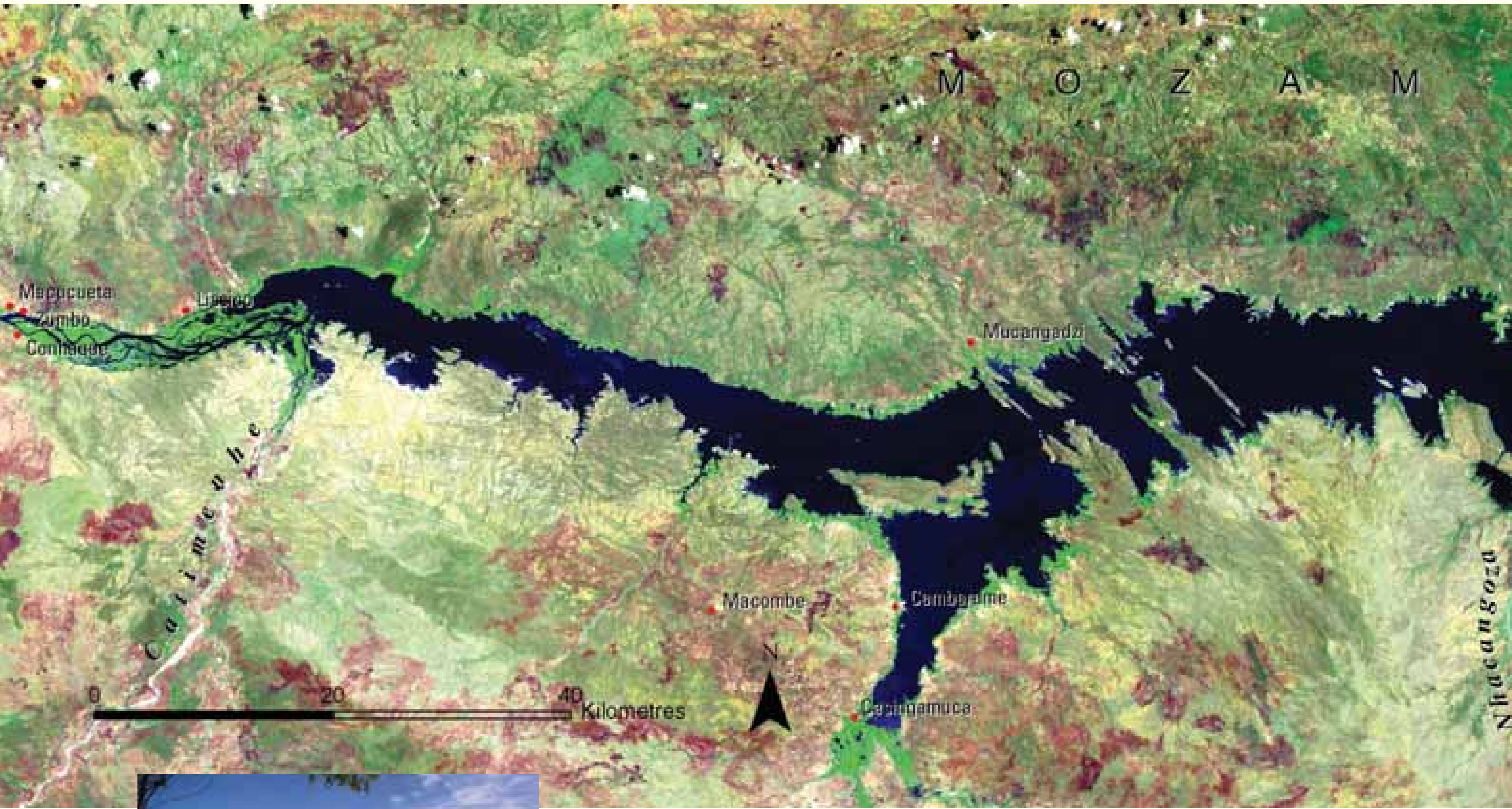
Protecting Wildlife and Forests

Civil war during the 1970s and 1980s disrupted conservation efforts in Mozambique, taking a heavy toll on the nation's wildlife. Although still among the poorest countries in the world, Mozambique is now expanding its protected areas. It shares a section of the Great Limpopo Tranfrontier Park—Africa's largest wildlife refuge that spans 35 000 km²—with South Africa and Zimbabwe.

Wildfires remain a significant threat to Mozambique's forests and wildlife. Every year, approximately 40 per cent of the country is burned by fire, of which 80 per cent is forest. Human activities, and particularly slash-and-burn agriculture, are suspected to be responsible for 90 per cent of all fires (Saket 2001).



Source: IUCN Red List



Cahora Bassa Dam: Zambezi River, Mozambique

The Zambezi River drains an area of roughly 1.5 million km^2 from Angola to Mozambique. In 1974, the Cahora Bassa Dam was completed about 300 km upstream from where the Zambezi River empties into the Indian Ocean. The dam created Lake Cahora Bassa, the second largest human-made lake in southern Africa. Prior to the dam's construction, surrounding natural ecosystems and traditional agriculture were shaped by annual floods.

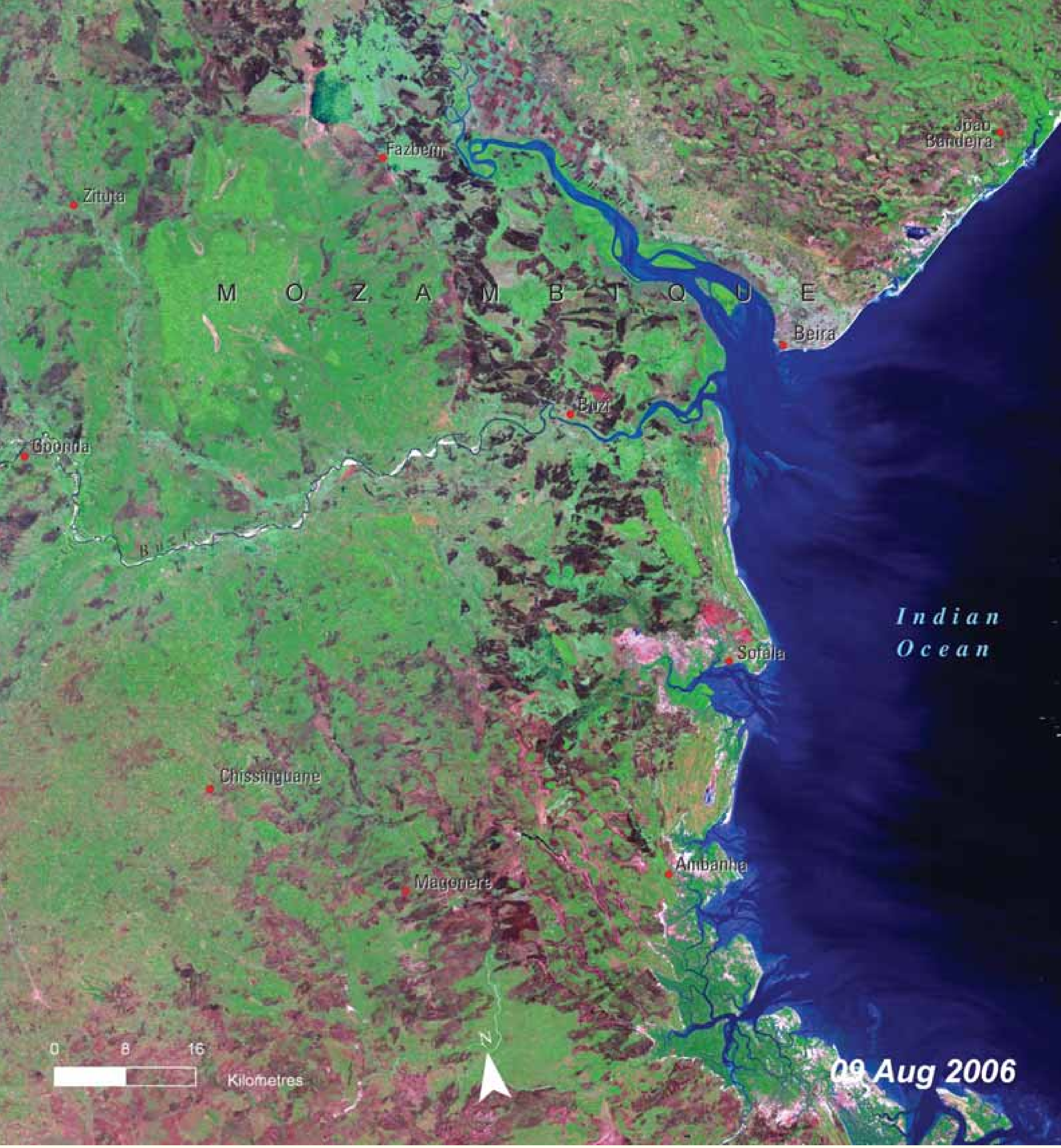
As the dam neared completion, experts recommended that Lake Cahora Bassa be filled slowly, over a period of at least two years. Furthermore, they recommended that a minimum flow

be maintained, with extra releases to simulate natural flooding, and that the filling of the reservoir should not begin until after the 1975 flooding season. These recommendations were not followed.

The 1972 image shows a 250-km stretch of the Zambezi River prior to the construction of the Cahora Bassa Dam. The same stretch was flooded, in a single year, following the dam's completion in 1974. In the ensuing years, flooding of the lower Zambezi has been notoriously mistimed. These erratic water releases have negatively impacted hundreds of thousands of downstream residents and decimated the ecosystem of the Zambezi River delta. The 2006 image shows the current extent of the reservoir. Strategies to better manage Cahora Bassa Dam are being explored in order to restore damaged ecosystems and some traditional land use.

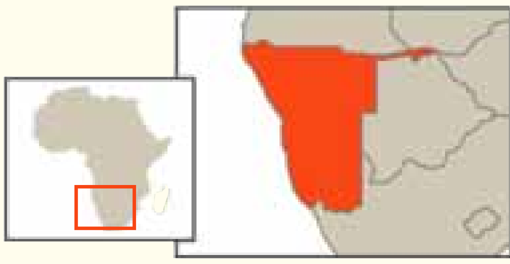
Fire Scars: Beira, Mozambique

During Mozambique's dry season—May to October—fires leave burn scars on the landscape. Over one-third of the country is affected by fire each year. NASA's Earth Observatory recorded an especially large number of fires in August 2006. The widespread nature of the fires suggests that they may have been intentionally set. Population growth in Mozambique has drastically intensified the need for agricultural land as well as for forestry and wildlife products, thus putting increased pressure on limited resources. Fires have become a primary means of clearing land for cultivation.



The 21 May 2006 satellite image was acquired at the beginning of the 2006 dry season, before many fires had left their mark. The 9 August 2006 image shows the same area roughly 2.5 months later. Pink, dark red, and black fire scars cover much of the landscape.

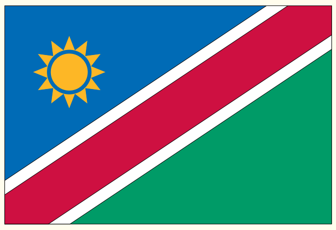
Many plants in Mozambique are adapted to periodic fire. However, the increasing frequency of fires affects the natural regeneration of vegetation and is believed to be reducing species diversity in Mozambique's forests. Frequent fires can also increase soil erosion and negatively impact hydrology.



Republic of

Namibia

Total Surface Area: 824 292 km²
Estimated Population in 2006: 2 052 000



Namibia is the most arid country south of the Sahara Desert, receiving an average of only 258 mm of rain per year (FAO 2007). With only 2.5 people per square kilometre, it is also among the least populated countries in the world (UNESA 2005). Namibia is divided into three topographical regions. A coastal desert strip, which includes the Namib Desert, follows the country's entire Atlantic coast. Stretching from north to south, an inland plateau covers more than half of the country and is home to the majority of the population. Finally, the Kalahari (Kgalagadi) Desert to the east and south of the inland plateau contains a variety of localised ecosystems.

Important Environmental Issues

- Land Degradation and Desertification
- Aridity and Water Scarcity
- Threats to Biodiverstiy

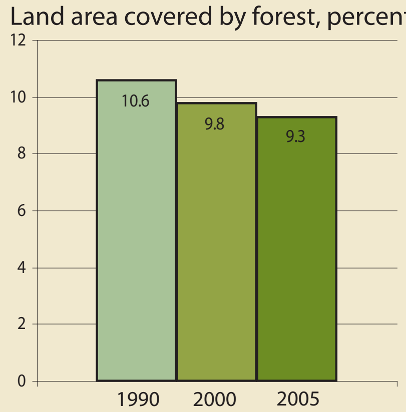
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

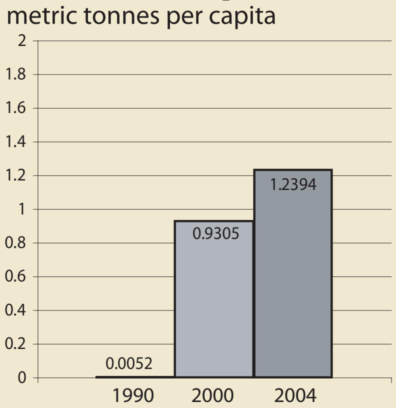
Although Namibia has seen an increase of 30 per cent between 1990 and 2004 in the access of its people to improved water sources, the country's primary environmental concerns remain water pollution and insufficient water resources for its growing population. Deforestation and soil erosion also threaten Namibia's land. The percentage of protected land area remained constant between 1990 and 2005.

★ Indicates progress

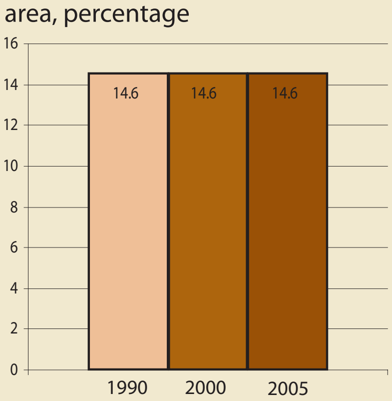
Land area covered by forest, percentage



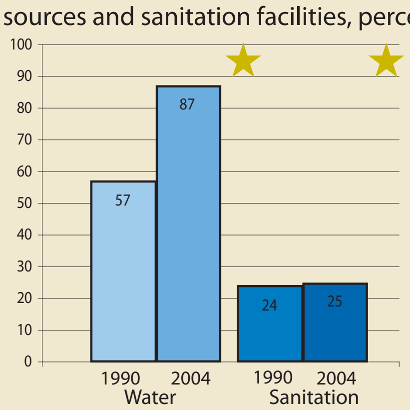
Carbon dioxide (CO_2) emissions, metric tonnes per capita



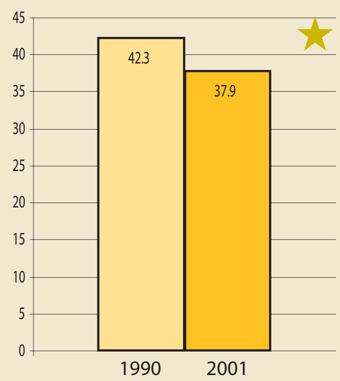
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

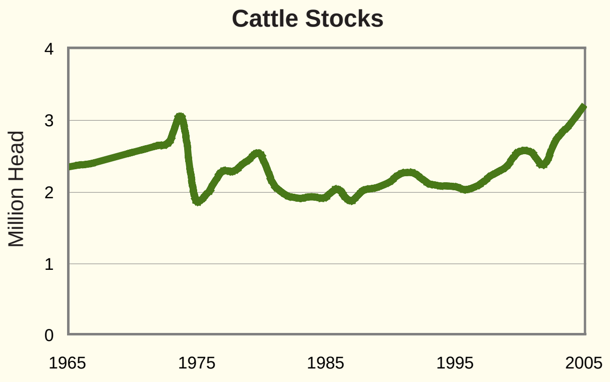


Slum population as percentage of urban



At 55 million years, Namib is the world's oldest desert.

Land Degradation and Desertification



Source: FAOSTAT

Desertification is the foremost environmental problem in Namibia—an estimated 99 per cent of lands are at high risk (FAO AGL 2003). Despite the scarcity of arable land, almost half of the population is involved in agriculture (FAO 2007b), which is characterized by low-input, continuous cultivation of naturally poor soils. Overgrazing is the largest threat since cattle, which outnumber people in Namibia, have surpassed the carrying capacity of the land. Current evidence of desertification includes declining groundwater levels, soil erosion, reduced soil fertility, increased salt content in soils, and loss of woody vegetation.

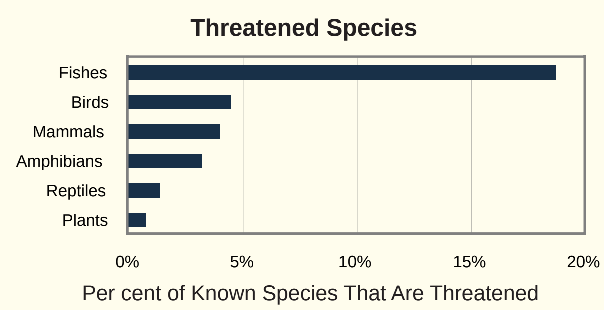
Aridity and Water Scarcity

Water availability is the single greatest factor limiting development in Namibia. Extreme temporal variability and uneven spatial distribution of water resources constrain livelihoods, particularly for the 64 per cent of the population that live in rural areas (UNESA 2006). There are limited perennial surface water resources located primarily along the northern and southern borders, but all of these sources suffer from significant population pressure and degradation. Groundwater accounts for roughly half of all water consumption (Namibia Ministry of Environment and Tourism 2001), but only one per cent of Namibia's meager rainfall goes towards recharging groundwater (FAO 2005), making over-extraction a growing concern.

Threats to Biodiversity

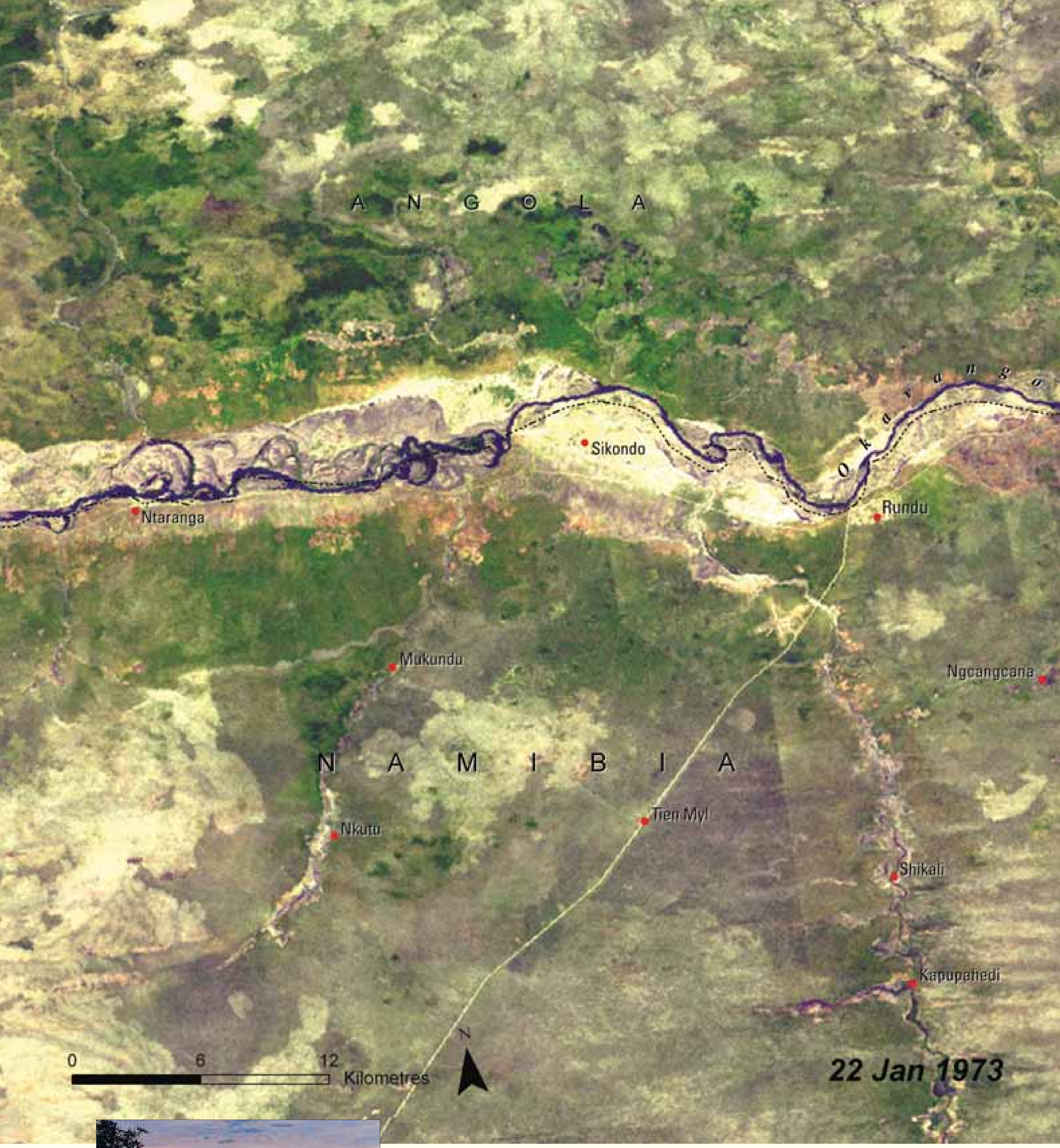
Namibia is home to abundant biodiversity, including unique desert-adapted ecological communities, charismatic megafauna, and productive coastal fisheries. The Succulent Karoo of the Namib Desert is one of the few arid biodiversity hotspots in the world. It contains the richest collection of succulent flora on Earth and an estimated 2 439 endemic plant species (CI 2007). Threats to this region include grazing, agriculture, and mining, although low population densities have allowed for enhanced preservation.

Namibia also has one of the largest remaining populations of black rhinos, a highly endangered species threatened primarily by poaching. Roughly three-quarters of the national rhino population can be found in Etosha National Park (WWF 2006) where poaching has been virtually eliminated, making it a conservation success story in a country where illegal poaching was once rampant.



Source: IUCN Red List

Namibia's fisheries are some of the most productive in the world, thanks to nutrient-rich upwelling from the Benguela Current System. Prior to independence in 1990, overfishing by European fleets threatened several fish stocks with collapse. Over the past decade, national fisheries management has improved dramatically, and most major commercially exploited species are regulated under a Total Allowable Catch system (Nichols 2003).



Kavango Region: Namibia

The Kavango Region, located in Namibia's relatively wet northeastern corner, is part of the eight per cent of the country that receives about 500 mm of rain per year—the minimum considered necessary for non-irrigated agriculture. However, because this rainfall is irregular and evaporation rates are high, it is often inadequate for successful farming. Many of the soils in this area, with low nutrients or high salinity, are also marginal for farming. Nevertheless, roughly 55 per cent of the region is used for subsistence agriculture with pearl millet being the predominant crop.

Savannah woodlands are the natural vegetation in the sandy soils surrounding Rundu, near the Okavango River. Many of the woodlands along the river were cleared for agriculture long ago. More recently, government-dug wells have enabled settlement and farming further from the river, leading to further deforestation, particularly in the dry river beds (omurambas), where the soils are better for farming.

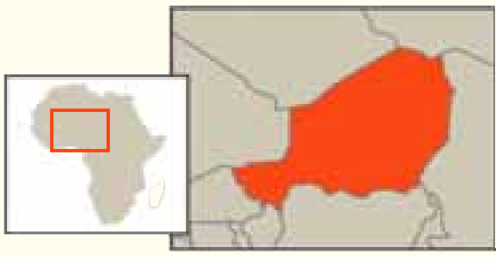
The Namibian government considers this area an important focus of economic activity and supports many water and agricultural projects. Along with rapid development, the population of Rundu is growing at a staggering pace—911 per cent between 1981 and 1991. These images, from 1973 and 2007, show the dramatic increase in the land area cleared for agriculture (light yellow patches) around Rundu and elsewhere along the river.

Salt Production and Wetlands: Walvis Bay, Namibia

Walvis Bay is an economic and environmental hotspot in Namibia. It has been designated as a free-trade area and placed on the Ramsar List of Wetlands of International Importance. The Walvis Bay lagoon, the largest area of shallow, sheltered water on the Namibian coast, supports a wide range of birdlife. Walvis Bay's tidal channels, mudflats, and sandbanks support roughly 150 000 birds, including the African black oystercatcher, lesser and greater flamingo, chestnut banded plover, and blacknecked grebe.

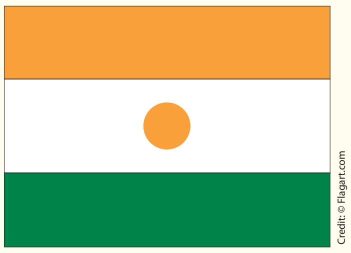
Walvis Bay's solar evaporation facilities process 24 million metric tonnes of seawater each year, producing more than 400 000 metric tonnes of high-quality salt. The solar evaporation process occurs in a series of connected ponds through which seawater flows, evaporates, and deposits salt in crystallizing ponds. In 1973, the salt evaporation ponds were still relatively small (red and blue rectangles in the centre of the image). By 2005, however, they had grown to cover 3 500 hectares in the lagoon.

Most of the energy required to extract salt from seawater comes simply from sunlight and salt produced by this method is 99.7 per cent pure. About one-third of worldwide salt production uses this method, which, when properly managed, is very environmentally friendly.



Republic of the Niger

Total Surface Area: 1 267 000 km²
Estimated Population in 2006: 14 426 000



Niger is the fourth-largest country in Africa, although 65 per cent of the territory lies within the Sahara Desert and is largely uninhabited (FAO 2005a). Moving from north to south, the climate transitions from arid desert to semi-arid savannah to a small tropical zone along the edges of the Niger River Basin. Niger shares a portion of Lake Chad on its southeastern border with Nigeria and Chad.

Important Environmental Issues

- Desertification and Deforestation
- Threats to Wildlife
- Environmental Consequences of Mining

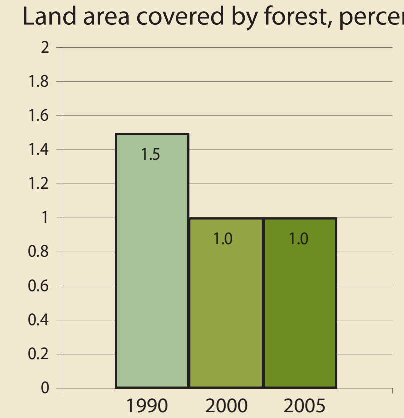
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

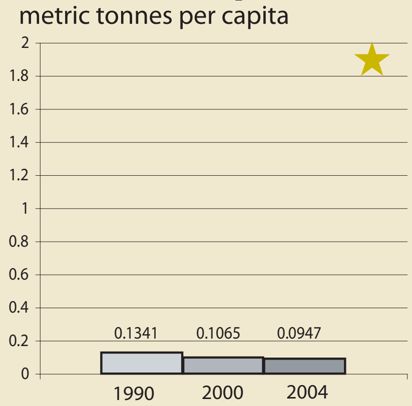
Niger has a serious problem of vegetation depletion. This is caused by the burning of bush and grass to prepare for the planting of crops, overgrazing of rangelands, and by tree cutting for fuel and construction—all on marginal lands. Soil erosion and increasing desertification are also factors. The increase in slum population coincides with the urban population growth rate, which was 5.5 per cent between 2000 and 2005.

★ Indicates progress

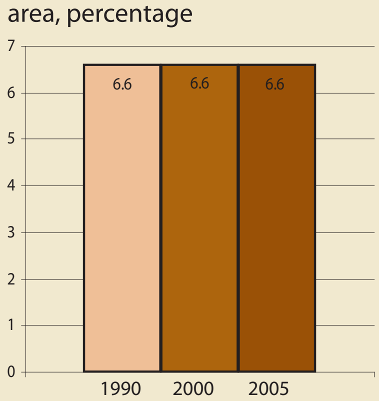
Land area covered by forest, percentage



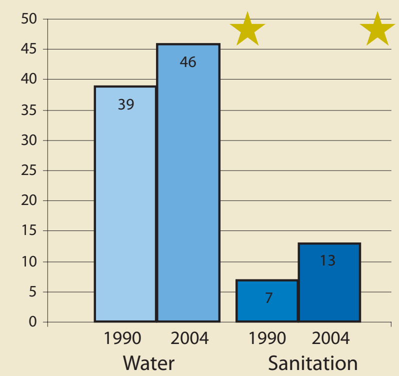
Carbon dioxide (CO_2) emissions, metric tonnes per capita



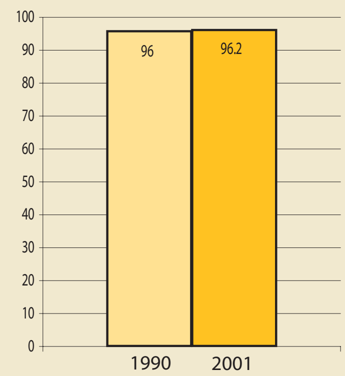
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



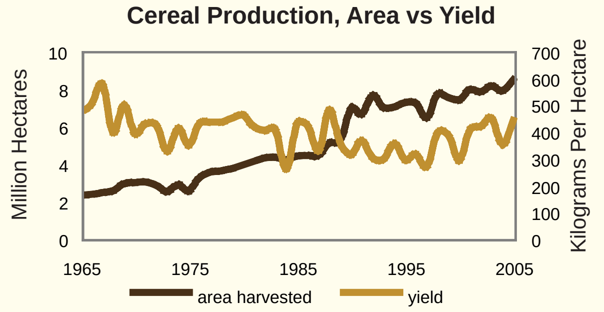
Niger is one of the hottest countries in the world, with four-fifths of its territory lying in the Sahara desert.

news.natinalgeographic.com (2008)

Desertification and Deforestation

It is estimated that the desert in the Republic of Niger is expanding by approximately 200 000 hectares per year (Mongabay 2006), overtaking degraded agricultural land and encroaching on human settlements. Government efforts to combat desertification through reforestation have been promising, but recurrent drought and poor cultivation practices continue to pressure vulnerable lands.

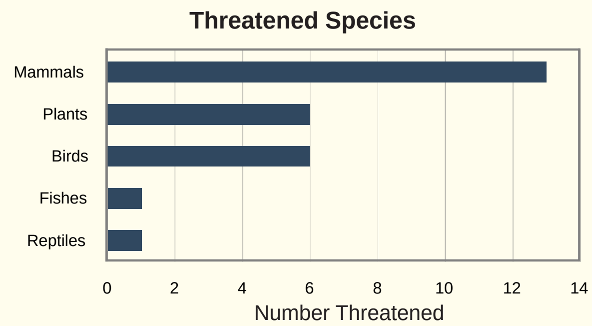
Niger's forests are its most important buffer against desertification, but they are threatened by a rising demand for agricultural land and fuelwood, driven by the fourth-highest population growth rate in Africa (UNESA 2005). Niger has lost one-third of its forest cover since 1990, and now only one per cent of the land is forested (UN 2007).



Source: FAOSTAT

Threats to Wildlife

Niger is remarkably rich in plant and animal life, especially considering that three-quarters of the country is desert. Although hunting is banned nationwide, poaching and habitat loss are taking a heavy toll on biodiversity; wildlife populations are less than one-tenth of the size they were in the 1960s (CBD 2004). Competition with domestic animals over resources and conflict with farmers are particularly problematic in the densely populated southern regions.

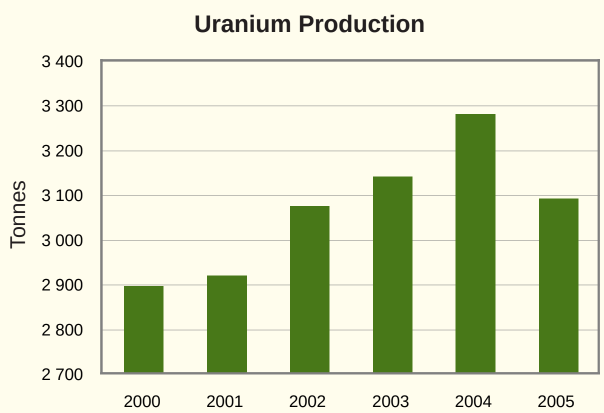


Source: IUCN Red List

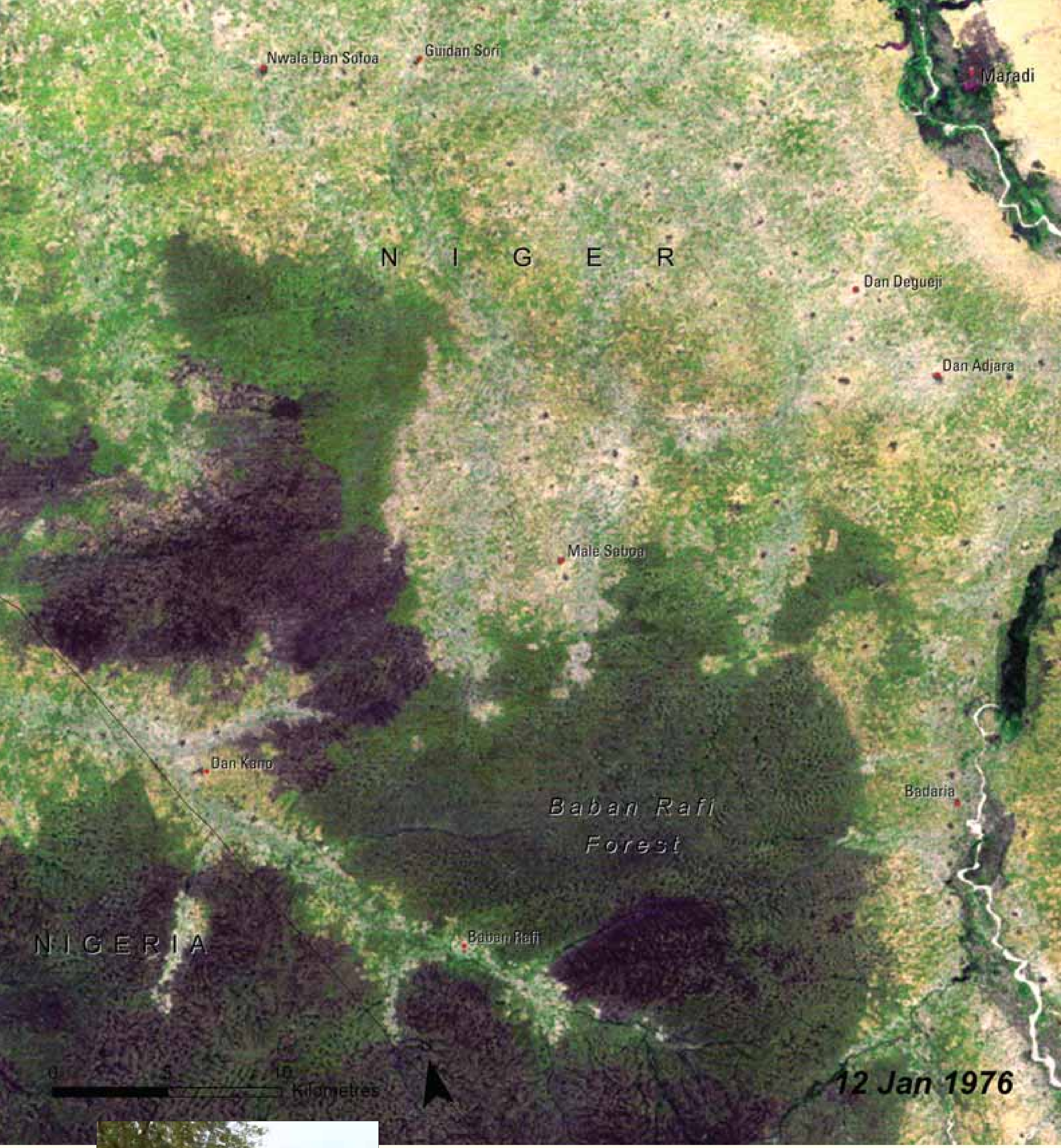
The last remaining giraffes in West Africa are found in Niger only 60 km from the country's capital, Niamey. Thanks to conservation measures, the giraffe population has slightly recovered from a low of only 40 individuals in the 1990s; a few decades ago there were over 3 000 (UN 2001).

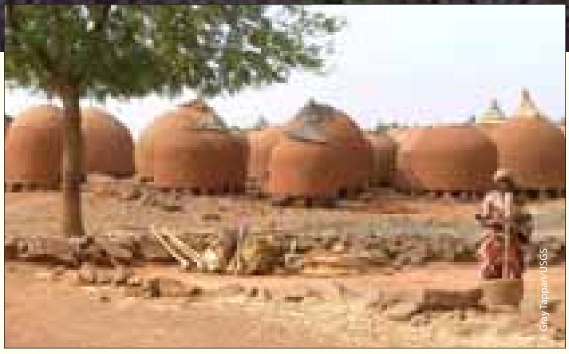
Environmental Consequences of Mining

Niger is the world's third-largest producer of uranium, generating over 3 000 metric tonnes in 2005 (Omarya 2006). The government announced intentions to increase production to 10 500 metric tonnes in 2007, eliciting concerns regarding the environmental and human health consequences of further exploration. In addition to the environmental degradation that occurs at uranium extraction sites, the cities and towns that spring up near mining activities increase human pressure on natural resources such as wildlife and timber. There are also concerns that phosphorus and iron mining in "W" National Park, which is a haven for 80 per cent of the country's biodiversity, may threaten the ecological integrity of the area.



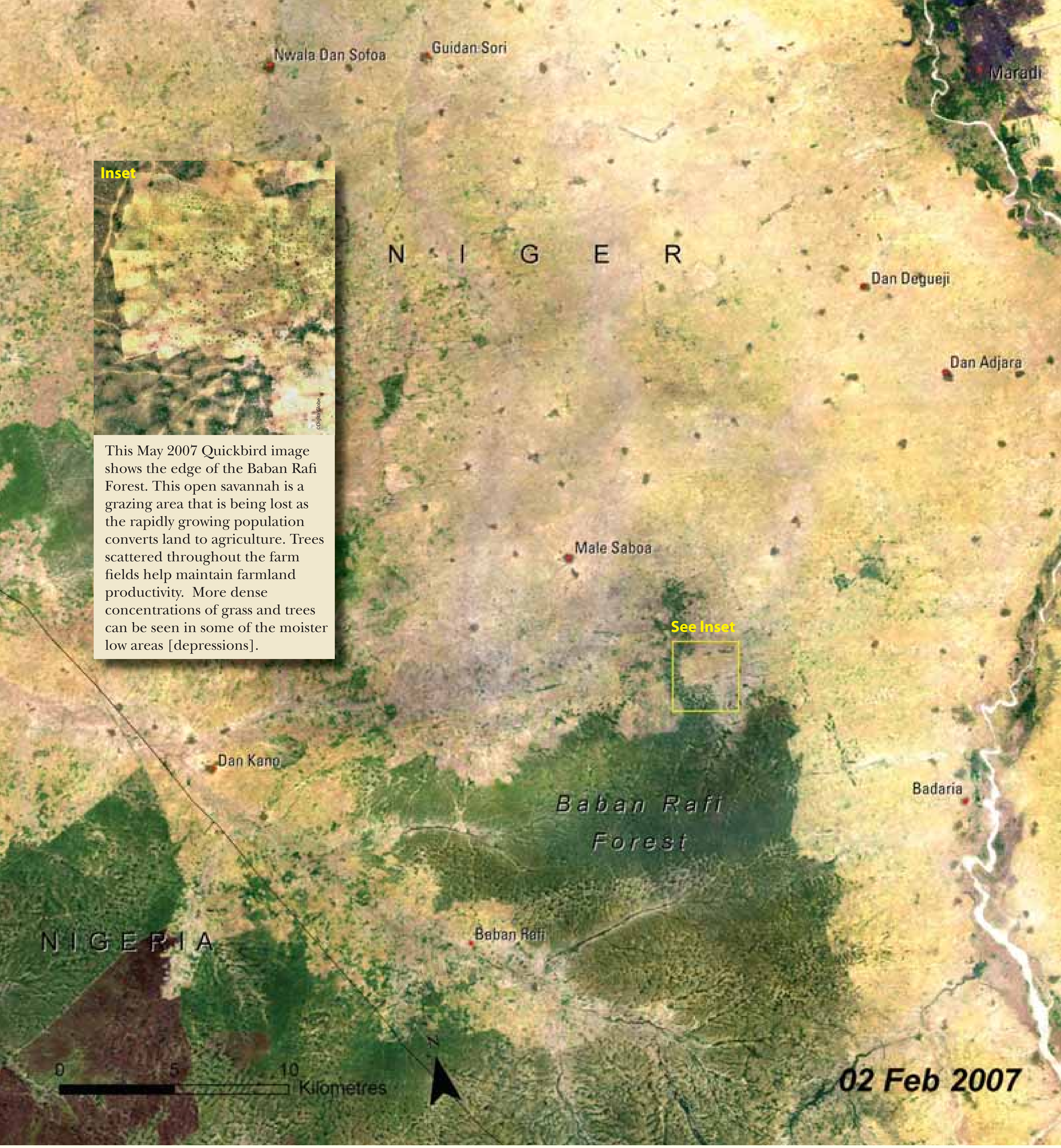
Source: USGS International Mineral Statistics and Information





Forest Degradation: Baban Rafi Forest, Niger

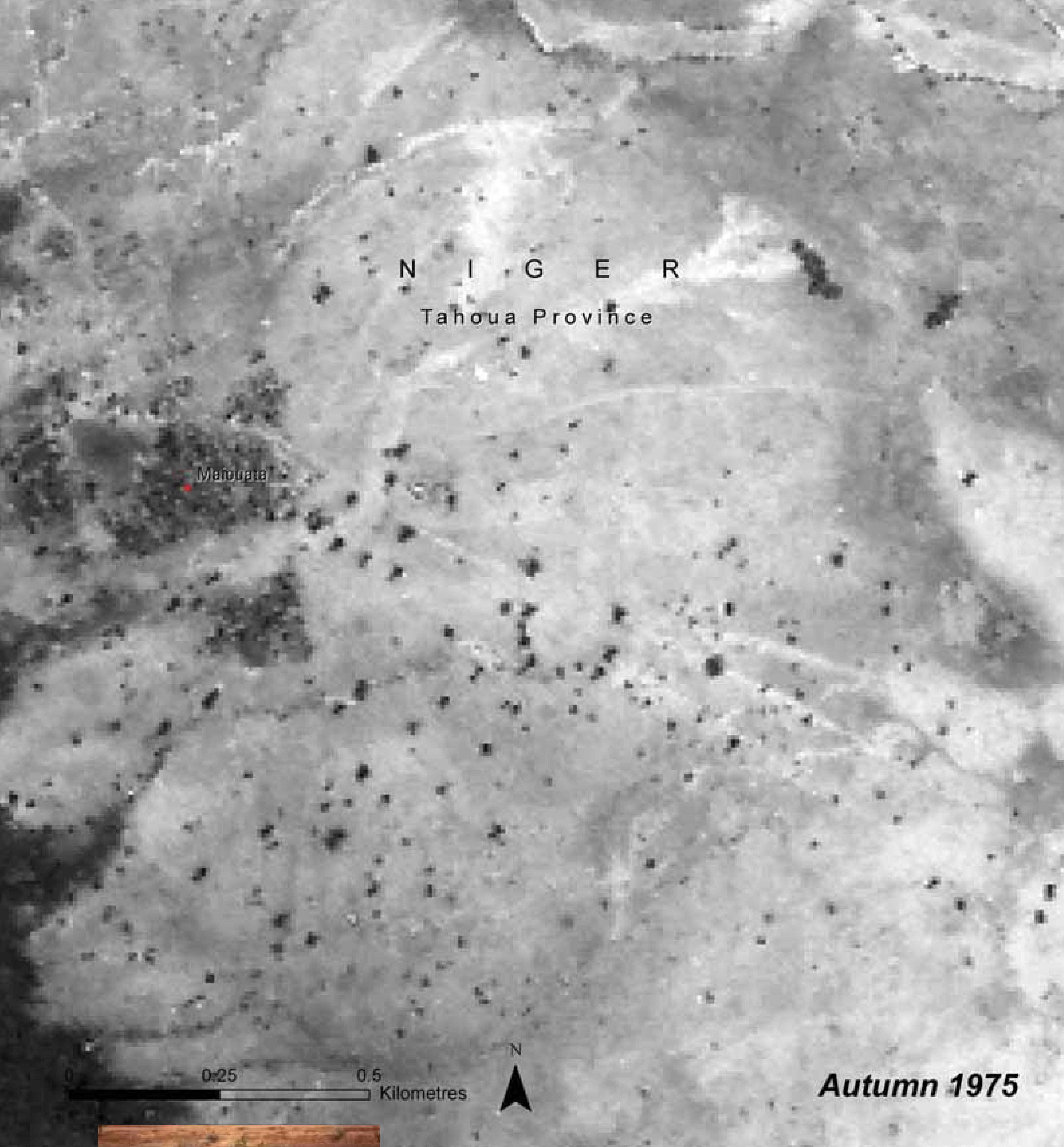
Along the southern border of Niger in the Department of Maradi, population has increased by roughly 400 per cent over the past 40 years. The area under agriculture in the department as a whole grew by 26 per cent between 1975 and 1996. In the south of the district, this expansion of population and agriculture has meant the loss of a large portion of the Baban Rafi Forest to agriculture. The remaining woodlands are being degraded by overexploitation for fuelwood and non-wood forest products.



This May 2007 Quickbird image shows the edge of the Baban Rafi Forest. This open savannah is a grazing area that is being lost as the rapidly growing population converts land to agriculture. Trees scattered throughout the farm fields help maintain farmland productivity. More dense concentrations of grass and trees can be seen in some of the moister low areas [depressions].

Baban Rafi Forest is the most significant area of woodland in the Maradi Department. Located at the southern extreme of the Sahel, it has areas of both savannah and Sahelian vegetation. In the savannah areas, the balance of trees, grasses, and shrubs varies. The wooded areas are dominated by just four species of trees—*Guiera senegalensis, Combretum micranthum, Combretum nigricans,* and *Acacia macrostachya*—likely as a result of selective exploitation and some combination of drought and disease.

These satellite images show the loss of a significant fraction of the natural landscape (darker green areas) of Baban Rafi Forest to agriculture between 1976 and 2007. The intensity of demand for agricultural land has also led to near continuous use of farmland in the area, with shortened or no fallow period for it to recover fertility. Continuing population growth will put further demands on this already dramatically changed landscape.



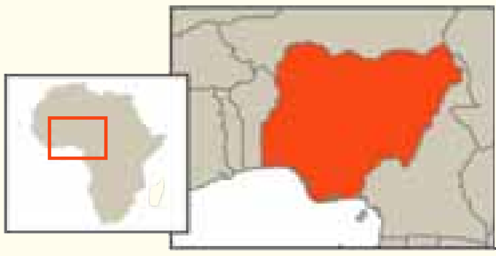
Revitalised Land: Tahoua Province, Niger

A band across the southern third of Niger receives enough rain (250-750 mm) to sustain most of the country's rain-fed agriculture and pastoralism. This stretch of semi-arid Sahel is also where most of Niger's rapidly growing population lives. However, the Sahelian climate is quite variable and in this ecologically frail region this poses serious problems for traditional livelihoods.

In recent decades, Niger's climate and its demographic problems have negatively impacted its agricultural land by forcing agriculture onto land that had been historically used for livestock—

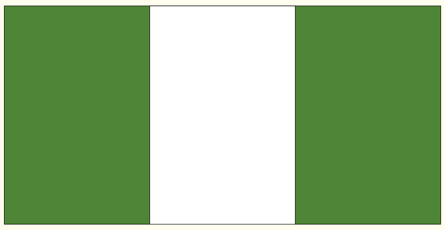
land receiving less than 350 mm of rain per year. This intense pressure on fragile lands led to acute environmental degradation (1975 image).

More recently, a combination of various projects and farmer initiatives has led to significant revitalization of the land in large part by the planting and protection of trees. Farmers no longer clear tree saplings from their fields before planting crops. Instead they protect and nurture the trees, carefully plowing around them when sowing millet, sorghum, peanuts, and beans. A recent study revealed 10 to 20 times the number of trees across three of Niger's southern provinces than there were in the 1970s (2005 image). This transformation of the land has reduced drought vulnerability and will help people diversify their livelihoods so as not to rely solely on rain-fed crops.



Federal Republic of Nigeria

Total Surface Area: 923 768 km²
Estimated Population in 2006: 134 375 000



Nigeria is the most populous country in Africa with over 134 million inhabitants, or approximately one-seventh of the continent's total population (UNESA 2005). The climate is generally tropical and natural resources are plentiful, including dense coastal mangroves, abundant ground and surface water resources, a high proportion of arable land, and vast oil reserves. The Niger River Delta region covers 75 000 km² of the Nigerian coast, making it the third-largest wetland in the world (UNDP 2006).

Important Environmental Issues

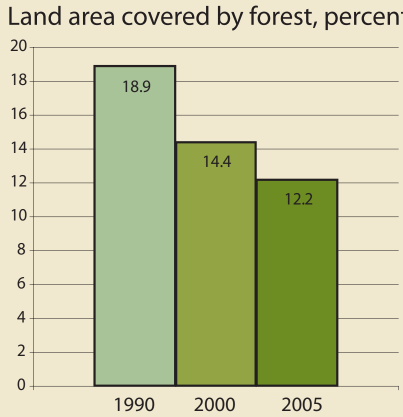
- Desertification
- Deforestation and Threats to Biodiversity
- Oil Pollution

Progress Towards Environmental Sustainability

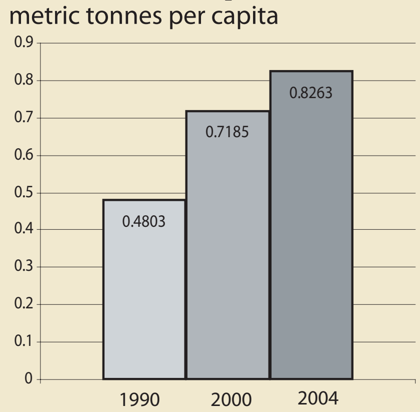
As defined by the United Nations Millennium Development Goal 7 Indicators

In the early 1990s, Nigeria was among the world's top 50 emitters of carbon dioxide, and this upward trend continued through 2004. Nigeria has the highest deforestation rate of natural forest on the planet, including old-growth forests, which are its most biodiverse ecosystems. Between 1990 and 2005, the country lost 79 per cent of its old-growth forests.

Land area covered by forest, percentage

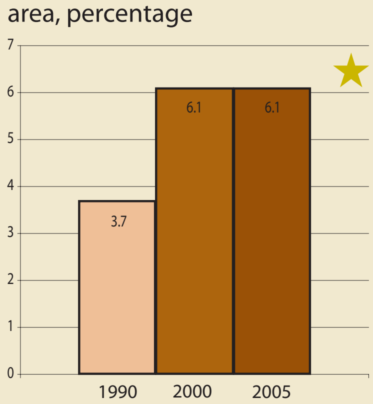


Carbon dioxide (CO_2) emissions, metric tonnes per capita

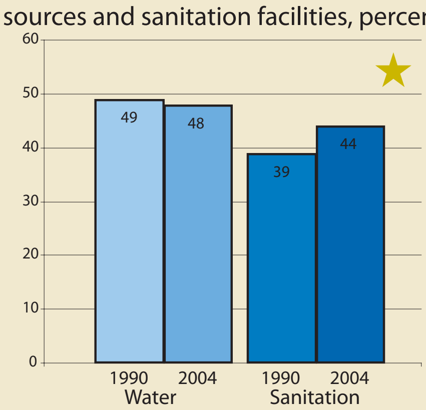


★ Indicates progress

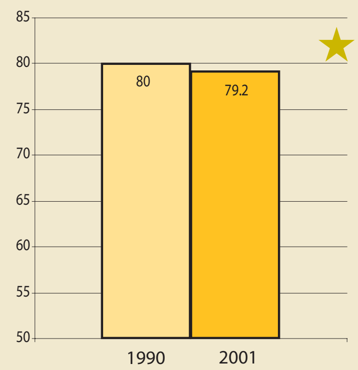
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



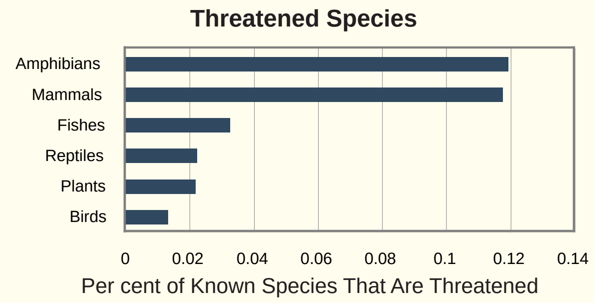
Nigeria is the largest producer of oil in Africa and the eleventh largest producer of crude oil in the world.

eia.doe.org (2007)

Desertification

Desertification affects Nigeria's semi-arid northeast region, where extensive agriculture, river damming, and periodic droughts have resulted in significant land degradation. The Sahara Desert is thought to be expanding southward by one kilometre every year (FAO 2001), accounting for nearly three-quarters of the total cost of all environmental degradation in the country, which is estimated at US$ 5 110 million per year (UNESCO 2000).

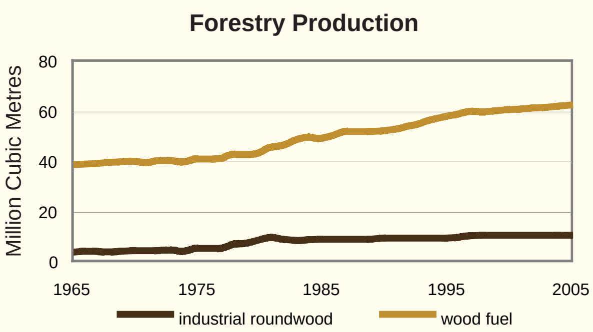
Desertification is just one of the threats facing Nigeria's 7 856 plant species and 22 000 vertebrate and invertebrate species (CBD 2007). Other forms of land use change and ecosystem degradation resulting from agriculture, urbanisation, and direct exploitation of biological resources threaten at least 250 species with extinction (IUCN 2007).



Source: Nigeria NBSAP and IUCN Red List

Deforestation and Threats to Biodiversity

Nigeria has one of the highest deforestation rates in Africa at 3.3 per cent per year (FAO 2005), and roughly 90 per cent of its original forest cover has already been lost. Although the government banned the export of unprocessed logs in 1976, rising domestic demand for fuelwood and timber make Nigeria the largest wood producer on the continent (FAO 2001).



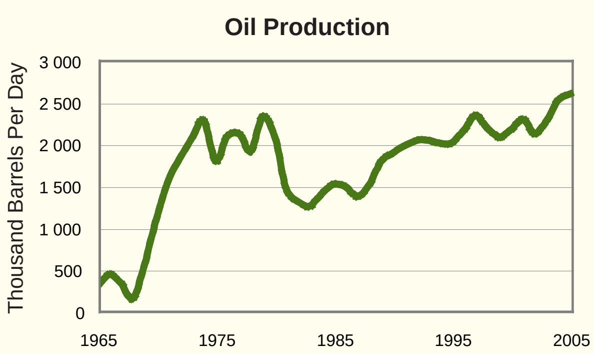
Source: FAOSTAT

Nigeria's mangrove ecosystems are the third largest in the world (FAO 2004) and provide critical habitat for migratory birds and many endangered aquatic and terrestrial species. Forty per cent of mangroves had been destroyed by 1980 (UNEP 2002), and those that remain are threatened by oil production and exploration, coastal development and erosion, and by invasive plants such as nipa palm and water hyacinth.

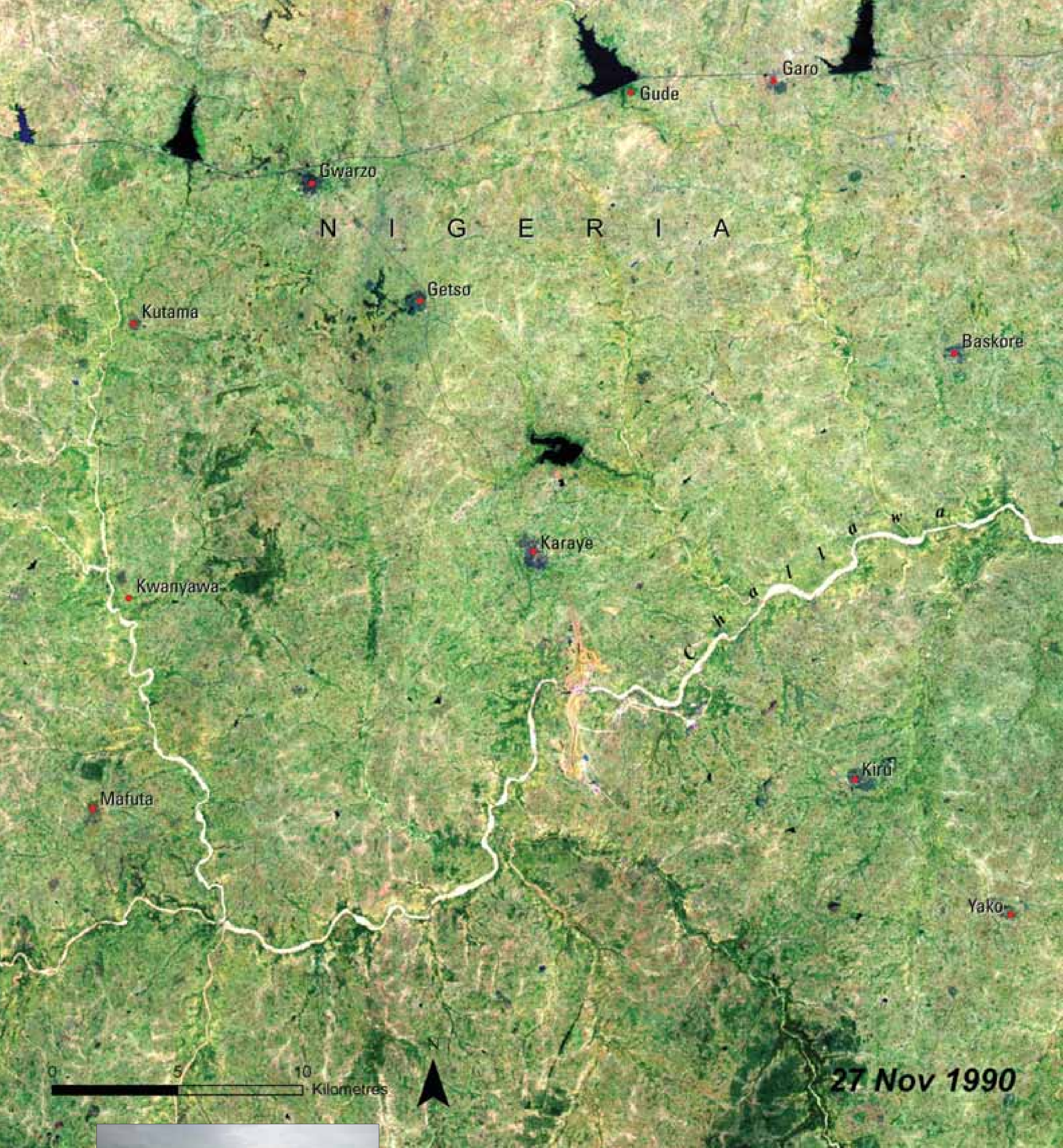
Oil Pollution

Nigeria is the eleventh-largest oil producer in the world (EIA 2007), deriving over 90 per cent of its national income from the petroleum industry (National Biodiversity Strategy and Action Plan n.d.). Oil production, which primarily takes place in the Niger Delta region, has resulted in considerable water and air pollution from oil spills and gas flaring. To check, monitor, and respond to oils spillage, Nigeria established the National Oil and Spill Detection Agency. Alongside this, the country has been gradually reducing the amount of gas flared, with the aim of stopping the practice altogether (World Bank 2007)

In addition to the petroleum industry, Nigeria's growing urban centres produce significant quantities of solid waste and local air pollution. Nearly half of the country's population resides in cities, which are growing by 3.7 per cent per year (UNESA 2006).

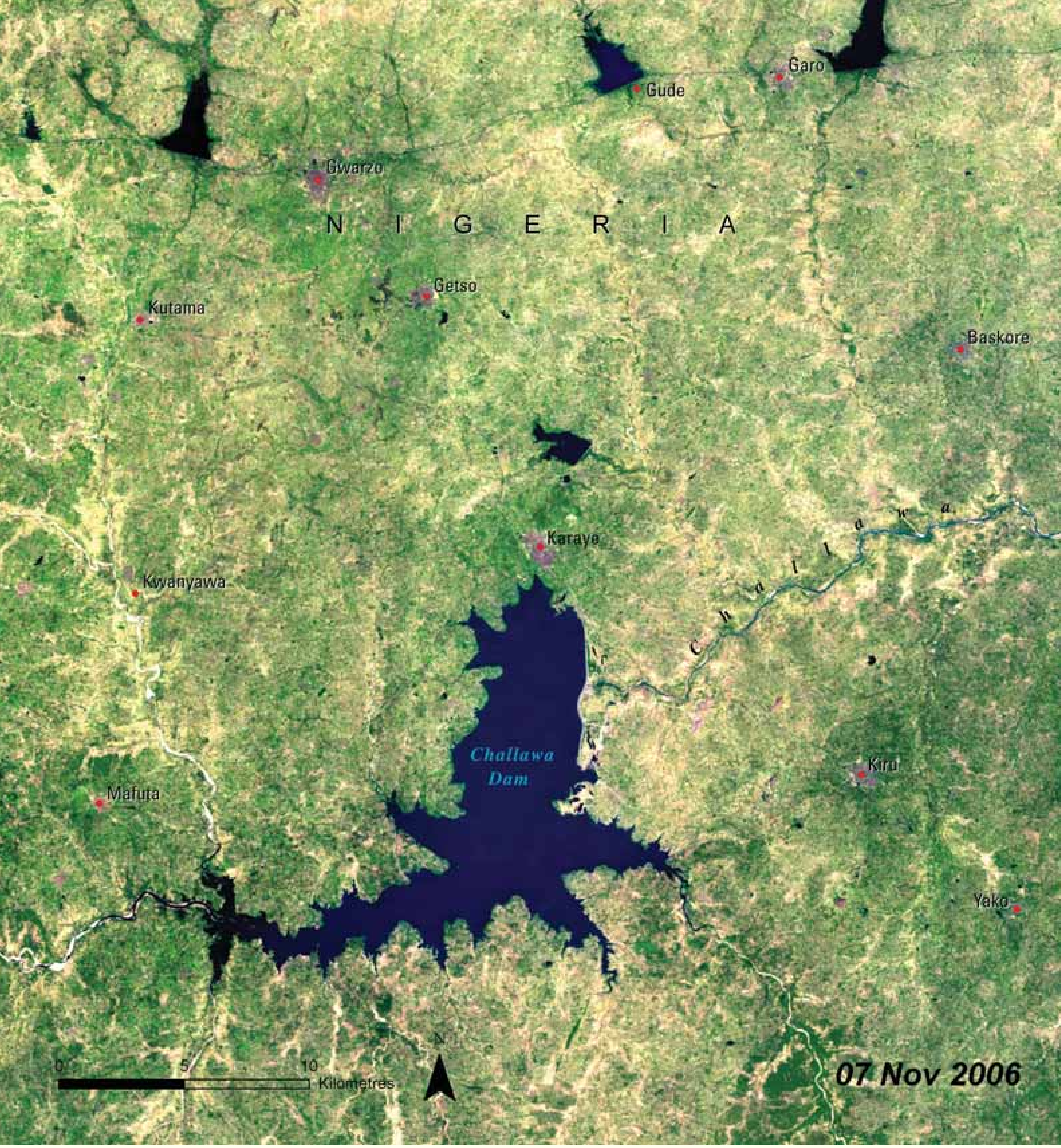


Source: BP Statistical Review of World Energy 2007



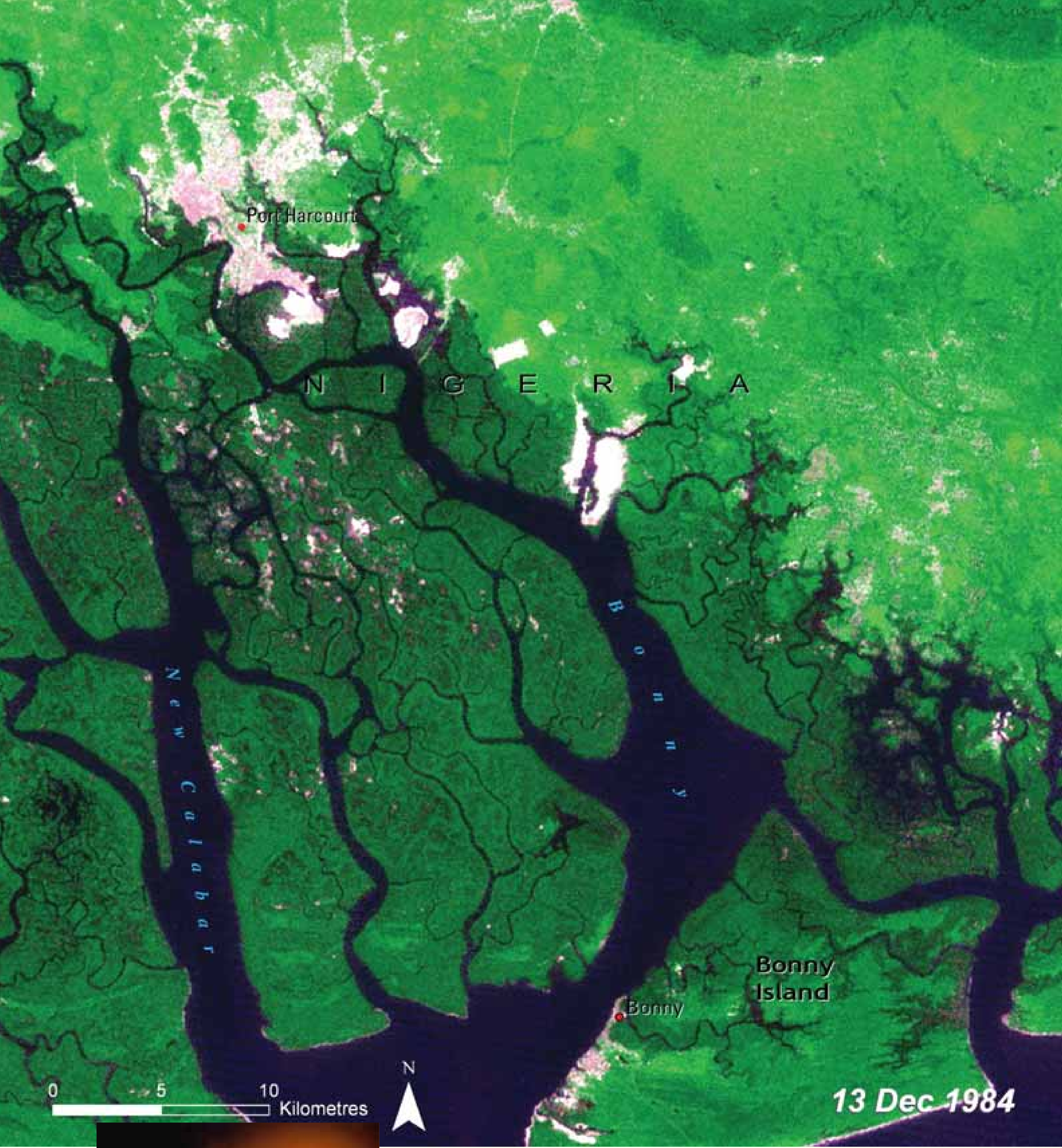
Impacts of Challawa Dam: Nigeria

The Challawa Dam in Kano State, Nigeria, was built to control flooding caused by seasonal and variable rainfall and to support irrigation. It also supplies water to Kano, Nigeria's third-largest city with a population of seven million. The Challawa River feeds into the Hadejia River, which then flows into the Hadejia-Nguru wetlands. Local rainfall peaks in August, with a subsequent dry season lasting from November to April. This rainfall pattern makes water levels in the Hadejia-Nguru wetlands highly seasonal.



The Challawa Dam has tamed highly seasonal downstream flooding at the expense of the Hadejia-Nguru wetlands. The combined effect of drought and the dam reduced the extent of seasonally flooded land from 300 000 hectares in the 1960s to between 70 000 and 100 000 hectares in recent years. Such severe reduction of the annual flooding extent has put the wetlands at risk and reduced the economic and environmental benefits they provide, including agriculture, cattle, fuelwood, fish, shallow aquifer recharge, and habitat for migratory and local bird species.

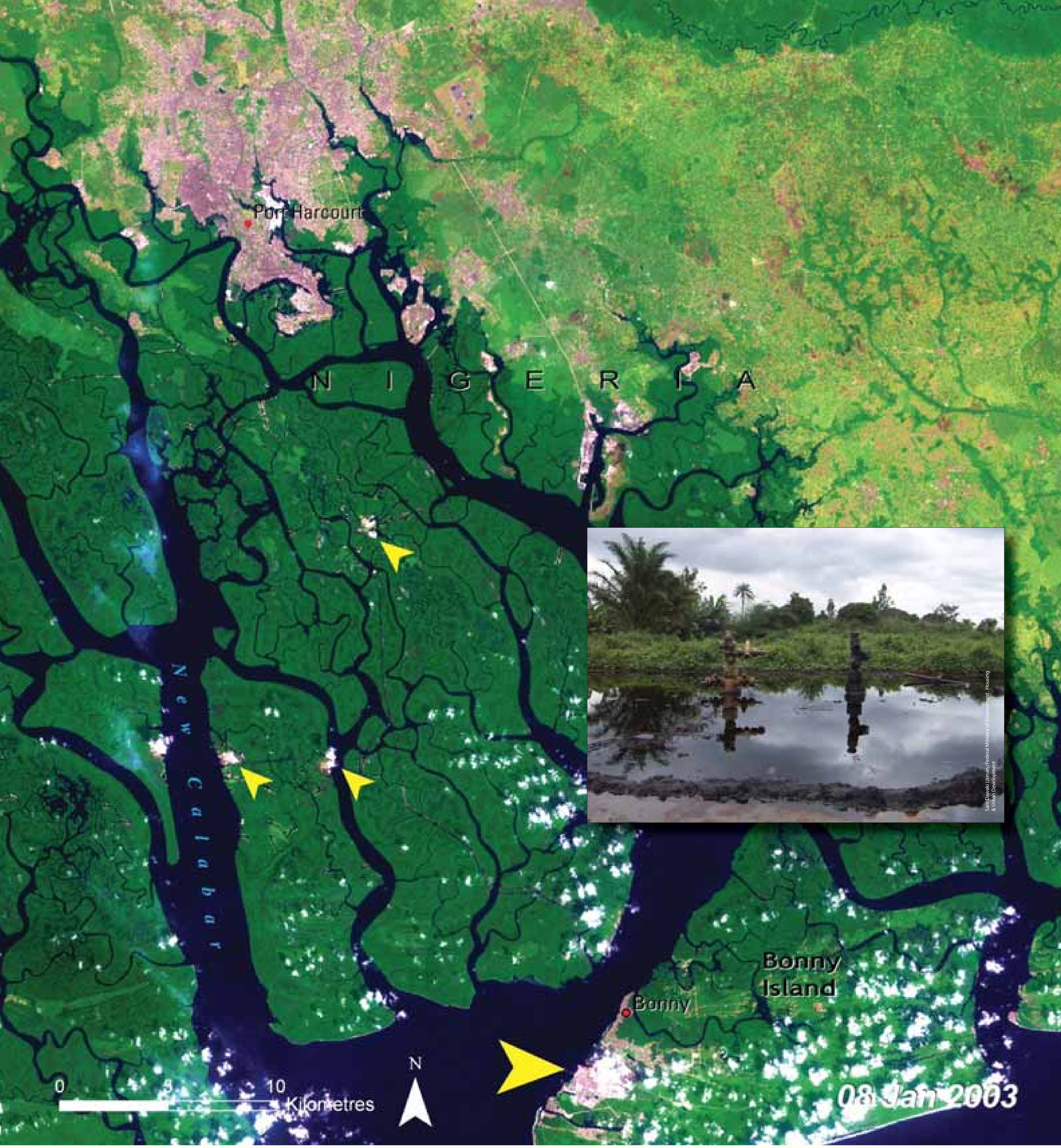
The economic impact of the Challawa Dam (and the Tiga Dam further upstream) has also been negative, eventually incurring millions of dollars more in losses than were yielded in benefits. In addition, while flood control was among the intended benefits of the dam, heavy rains often cause serious flooding above the dam.



Oil Development: Niger River Delta, Nigeria

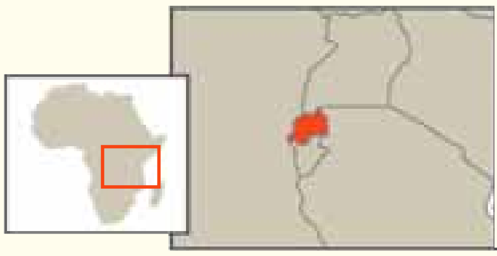
The Niger River Delta spans the coast of Nigeria from the Benin River in the west to the Imo River in the east. The delta supports the world's third-largest mangrove forest, and is home to over 150 species of fish, West African manatees, hippopotamuses, spot-necked swamp otters, and rare pygmy hippos.

Since the discovery of oil in the delta in the 1950s, the promise of improved lives through a share of the oil wealth has eluded area residents. Instead, they have found their traditional livelihoods increasingly undermined by environmental degradation.



The 1984 image shows the delta 20 years after oil operations began in the early 1960s. The 2003 image shows concentrations of oil wells (small yellow arrows) as well as pipelines connecting them. Also visible are a large storage facility, liquified natural gas plant and terminal station on Bonny Island in the lower right corner of the image (large yellow arrow).

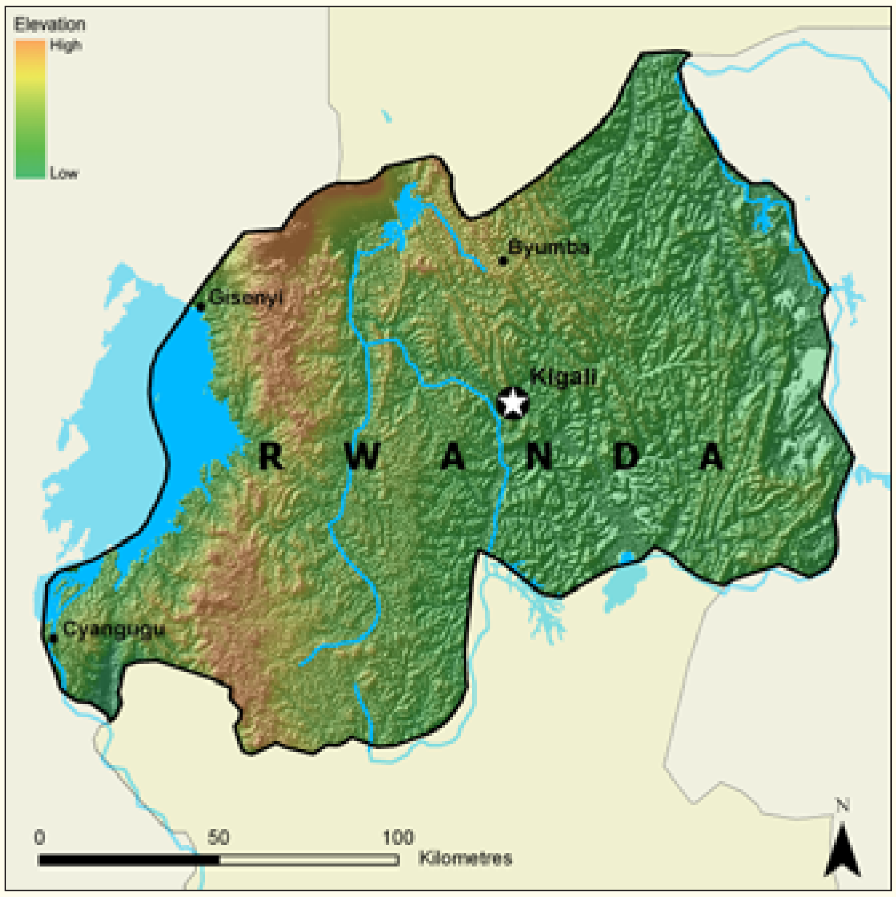
Currently, about 66 gas fields and over 500 oil wells are located in the delta area. Between 1976 and 1996 there were more than 4 640 oil spills totalling three million barrels of oil. In addition, between 70 and 90 per cent of the natural gas from these oil fields is flared (burned as waste), releasing massive amounts of carbon dioxide into the atmosphere, causing local air pollution and acid rain, and wasting roughly US$300 million per day worth of energy.



Republic of Rwanda

Total Surface Area: 26 338 km²
Estimated Population in 2006: 9 230 000

Rwanda is a small, mountainous country located only a few degrees south of the equator, but its high elevation provides for a tropical temperate climate with two rainy and two dry seasons. Terrain is dominated by the hills and valleys of the central plateau, which are bordered to the east by marshy lowlands, to the north by a chain of volcanoes, and to the west by a mountain system that forms the boundary between the watersheds of the Nile and Congo River Basins. Surface water is relatively abundant in Rwanda, covering over eight per cent of the country (FAO 2005).



Important Environmental Issues

- Population Pressure on Land
- Soil Erosion and Sedimentation
- Deforestation and Threats to Biodiversity

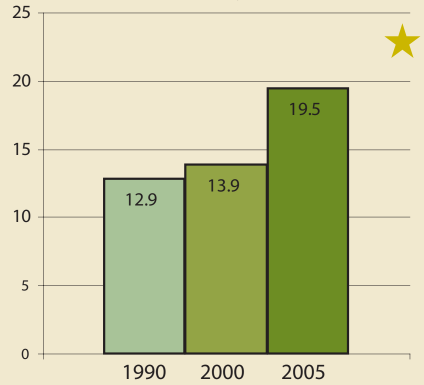
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

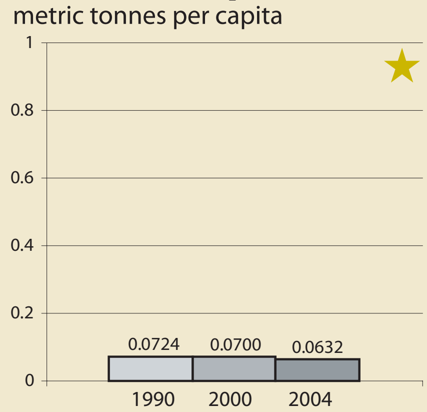
The slum population in Rwanda has seen an increase between 1990 and 2001, alongside an urban population growth rate of 4.2 per cent from 2000 to 2005. Rwanda is the most densely populated country in mainland Africa. Rwanda's protected area increased by 3.7 per cent between 1990 and 2005. Volcano National Park is one of the last existing habitats of the mountain gorilla.

★ Indicates progress

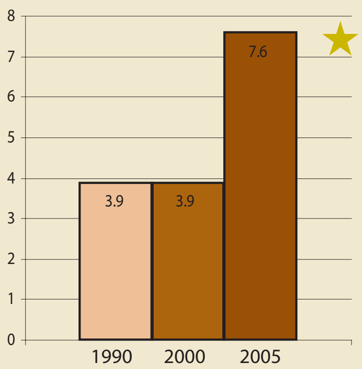
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

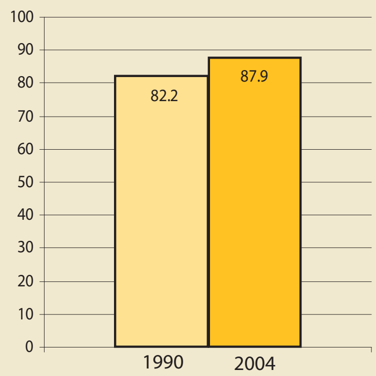


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban



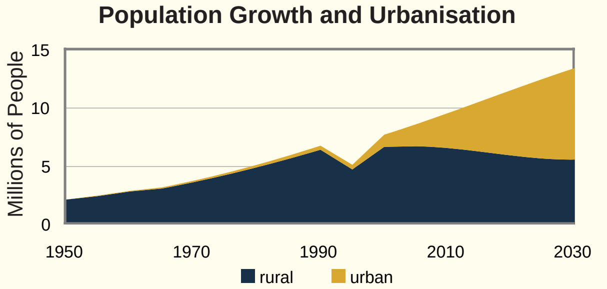
Nyungwe National Park is the largest block of montane forest in East and Central Africa, and among the largest on the continent.

rwanda-nyungwe-forest.com (2007)

Population Pressure on Land

Rwanda is the most densely populated country in mainland Africa. Rwanda's current population density is 382 people per square kilometre (Earth Trends 2006, FAO 2005a). Approximately 80 per cent of the population is rural and engaged in agriculture, placing significant pressure on land resources and biodiversity. Modification and destruction of natural ecosystems for agriculture, and particularly the drainage and reclamation of wetlands, has resulted in the loss of many plant and animal species. An estimated 115 different plant species are threatened with extinction (CBD 2003).

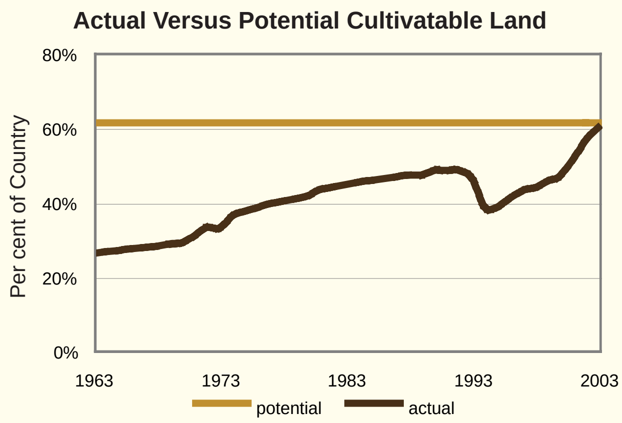
As a result of a declining availability of arable land, the urban population is increasing by nearly 12 per cent per year, the highest urbanisation rate in Africa (UNESA 2006). Nearly nine out of ten urban residents in Rwanda are slum dwellers, where access to improved sanitation facilities barely exceeds 50 per cent (UN 2007).



Source: UN Population Division, World Urbanization Prospects 2005 Revision

Soil Erosion and Sedimentation

Rwanda's rich volcanic soils are historically fertile, but population pressure has resulted in over-cultivation and expansion onto marginal lands and steep slopes. As of 2003, arable land accounted for over half of the country's surface area and approximately 98 per cent of all potentially cultivatable land in the country (FAO 2005b). An estimated 71 per cent of land is considered to be severely degraded (FAO AGL 2003) and approximately 500 metric tonnes of soil are lost to erosion each year, an amount that could support crops to feed 40 000 people (USAID 2004). Excessive siltation resulting from erosion constitutes a major threat to many of Rwanda's lakes and wetlands.

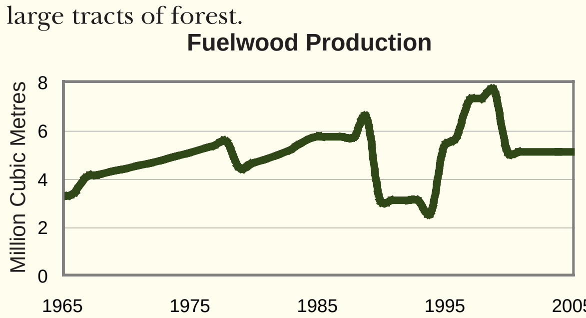


Source: FAOSTAT and AQUASTAT

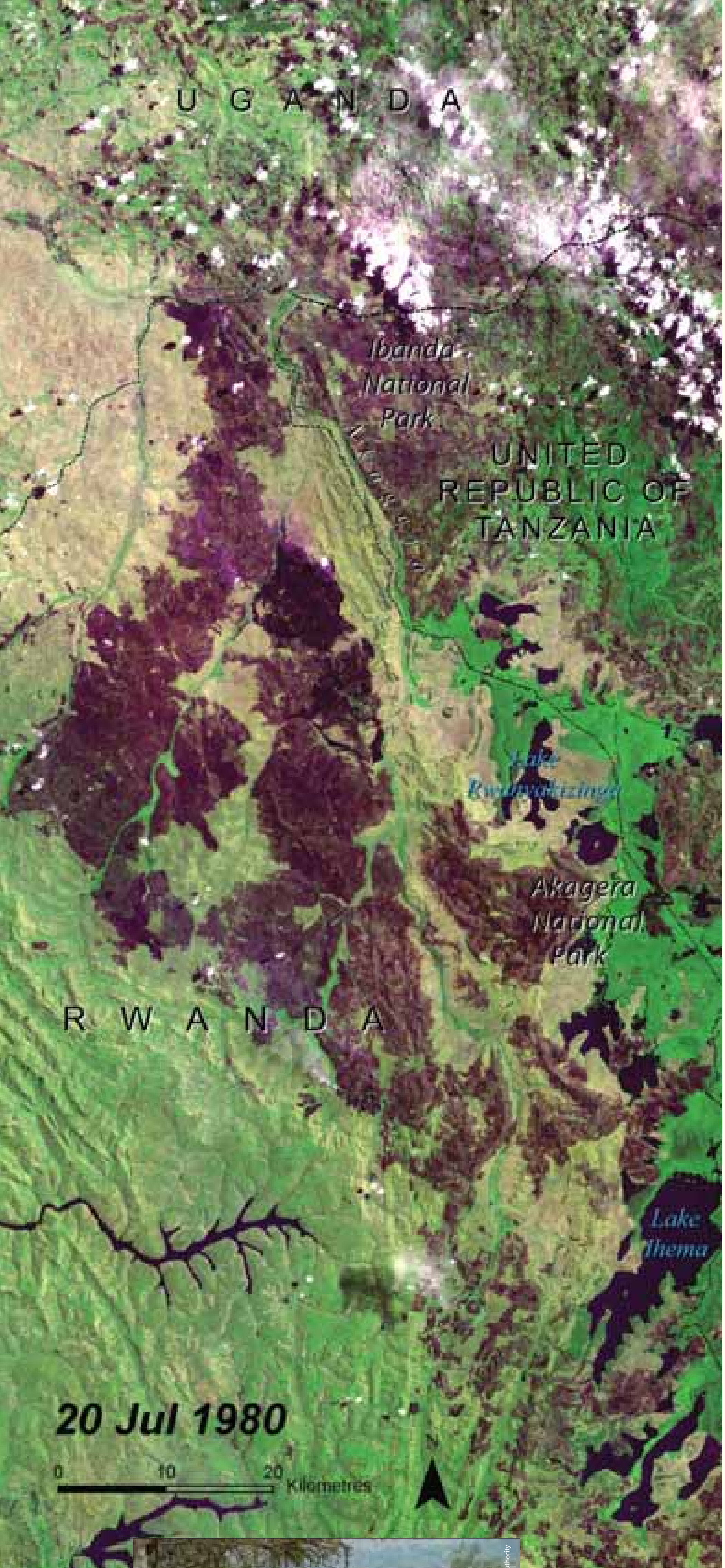
Deforestation and Threats to Biodiversity

Forests were once extensive throughout Rwanda, but they are now concentrated primarily in the western mountains. The swampy gallery forests that historically characterized the eastern lowlands now exist only in small stands. Despite recording a net increase in overall forest cover since 1990 (UN 2007), natural forests remain threatened by human encroachment and high dependence on fuelwood and charcoal.

Nyungwe National Park is the largest tropical montane forest in Africa, covering over 1 000 km² of rain forest, bamboo, grassland, swamps, and bogs. It harbours 13 different primate species, 62 Albertine Rift endemic species, and one of the largest surviving populations of chimpanzees (WCS 2007). Buffalo and elephants have been extirpated due to human encroachment and illegal poaching, and fires started by honey collectors have damaged large tracts of forest.



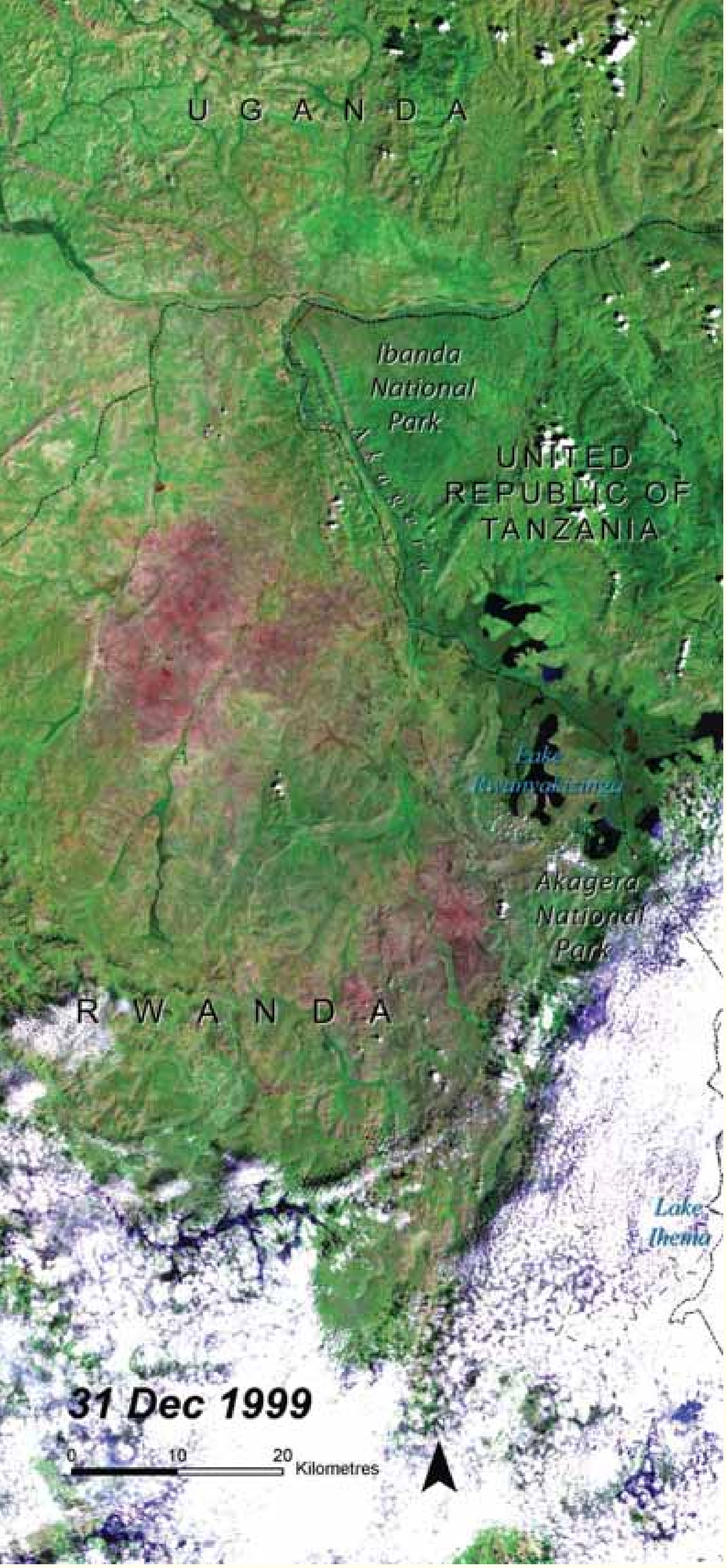
Source: FAOSTAT

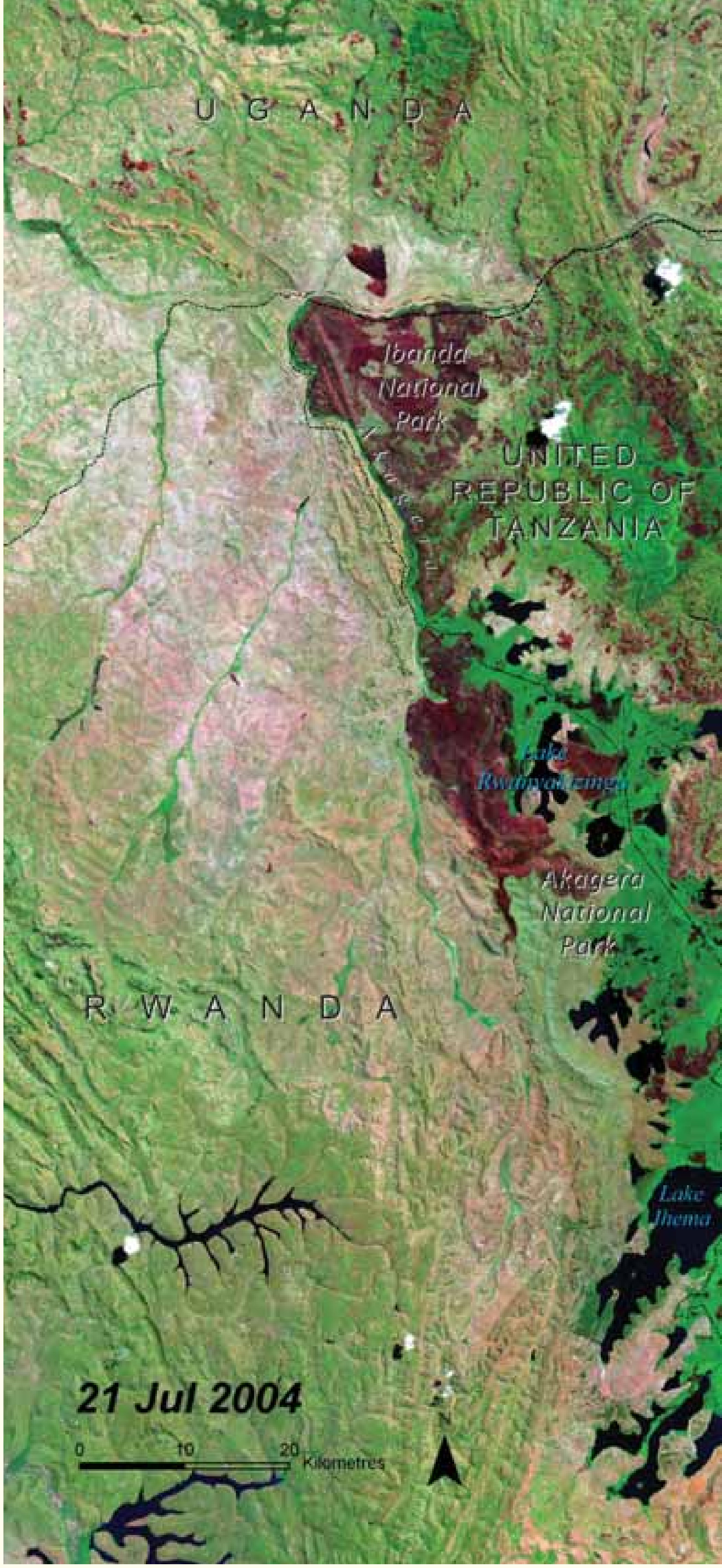


Fire Scars: Akagera National Park, Rwanda

Akagera National Park in northeastern Rwanda is considered to be among the most complex savannah ecosystems in eastern Africa. Across its landscape are areas of tangled acacia trees interspersed with patches of open grassland, patches of gallery forest in the north, and wetlands and lakes along the course of the Akagera River.

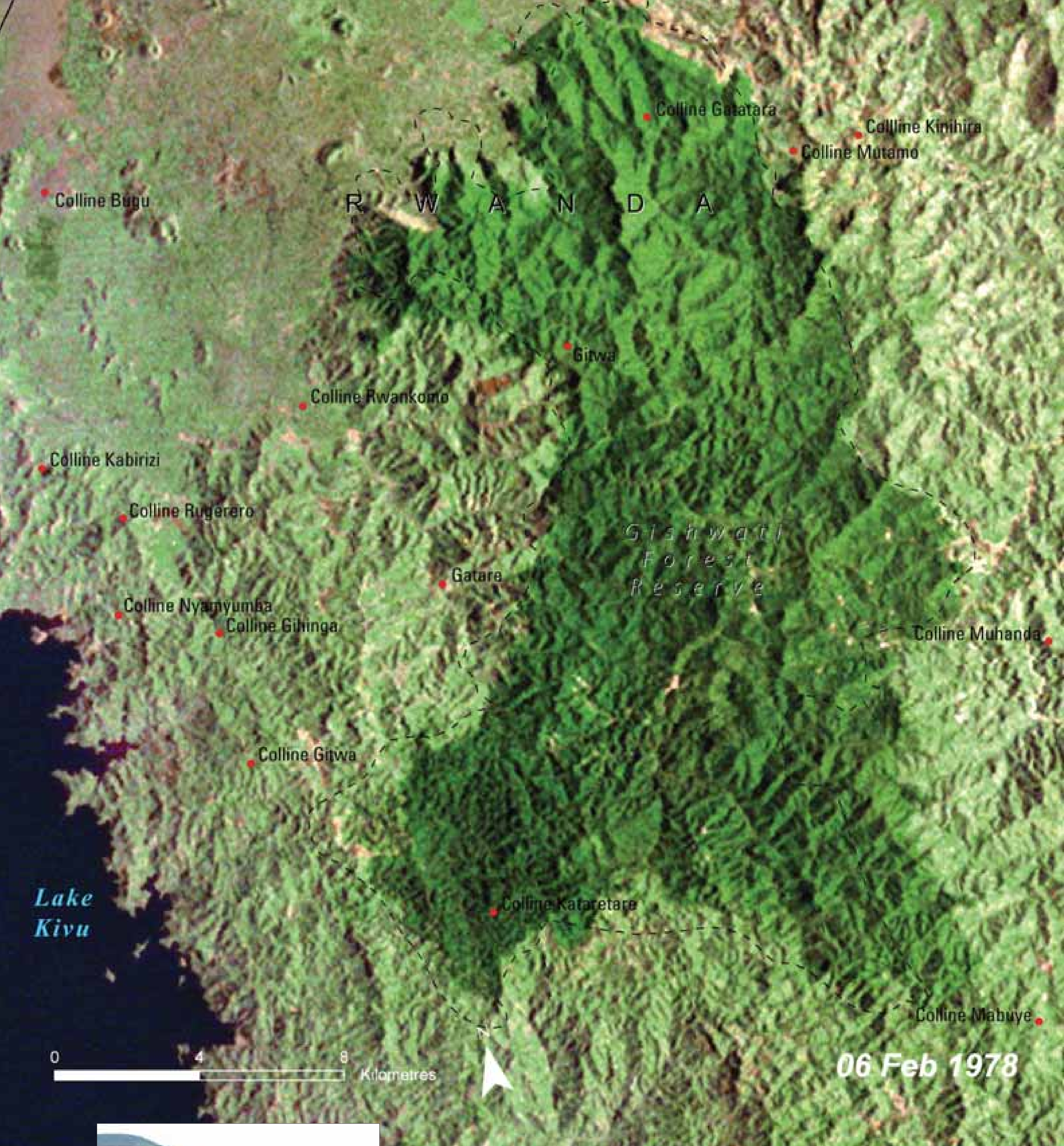
Fire is common in the savannah portions of the park. Fire tends to maintain the savannah's vegetation structure, composition, nutrient cycling, and distribution. Satellite images from July





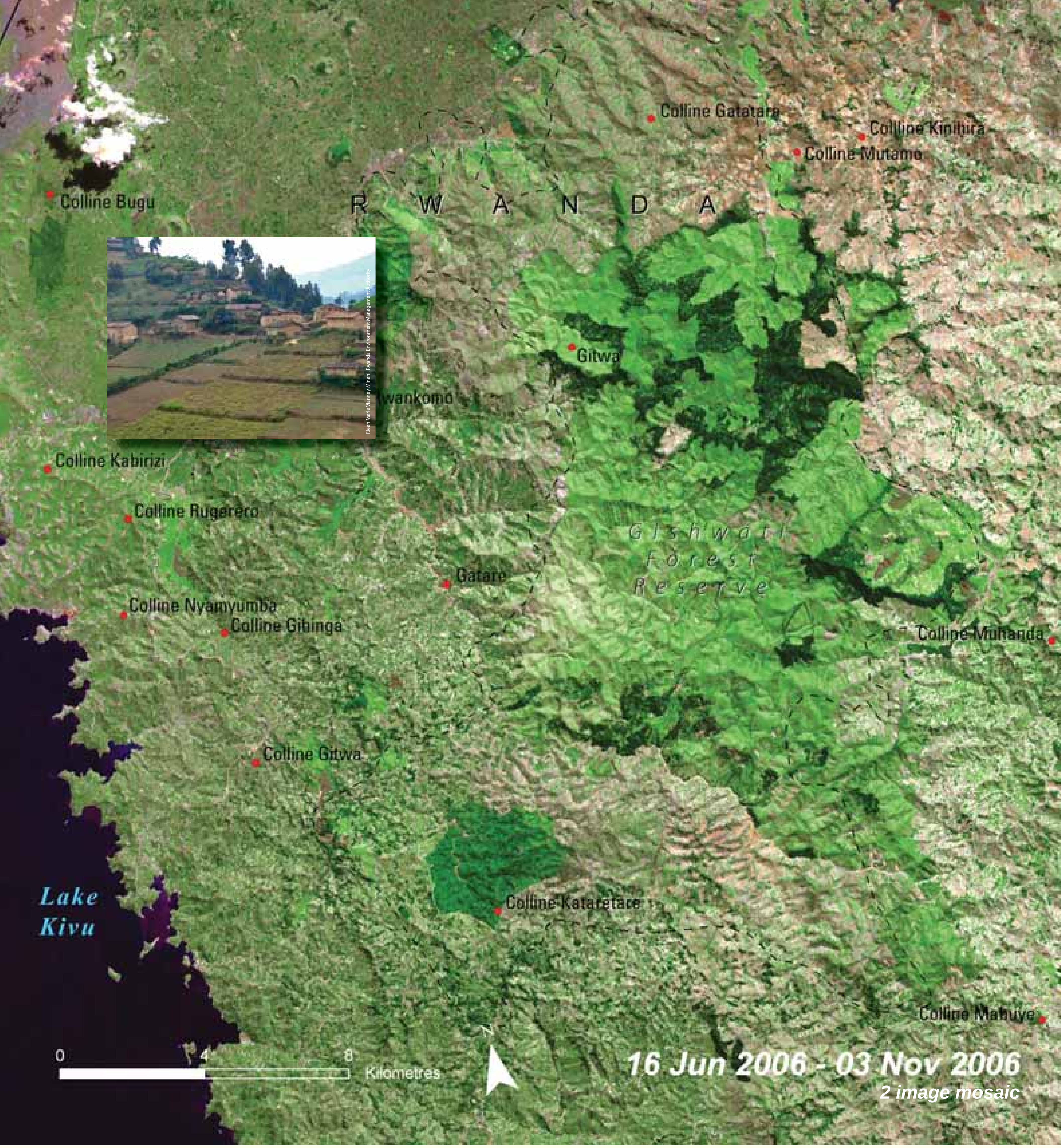
1980, June 1984, and July 2004 show the area surrounding Akagera National Park with large fire scars (dark purple patches). In 1980, fires left a scar 35 km wide and well over 100 km long. In 2004, fires burned nearly one-third of the park; they are believed to have been set by poachers. In contrast to these dry season images, the December 1999 image shows the region during the rainy season, when fires occur infrequently.

The size of Akagera National Park was reduced by approximately two-thirds in 1997 to allow for the resettlement of large numbers of refugees. Heavy grazing pressure, agricultural encroachment, charcoal production, the felling of trees for fuelwood and construction, and deliberately set fires have seriously fragmented the ecosystem. Wildlife populations are now concentrated in scattered enclaves.



Dramatic Deforestation: Gishwati Forest, Rwanda

Gishwati Forest Reserve in northwestern Rwanda is one of the most severely deforested areas in the country. Exploitation of the forests for commercial products such as charcoal, timber, medicine, and food has been the main driver of this deforestation. The 1978 satellite image shows the Gishwati Forest Reserve as a dark-green carpet of dense forest nearly covering the entire protected area. The 2006 image shows that most of the forest has been cleared; the



dark-green areas have been replaced by patches of pink and light green where the vegetation has been largely removed. Only a fraction of the forest that was intact in 1978 remains; what is left is in degraded condition.

On a positive note, reforestation efforts in parts of the region, using agroforestry techniques such as radical terracing, progressive terracing, and live mulches, are currently being researched and implemented. Seedlings of species such as *Calliandra calothyrsus* and *Leucaena diversifolia* are being planted in several provinces of the country with collaboration from stakeholders and the local community. If such efforts continue and are successful, the Gishwati Forest Reserve may experience considerable regeneration within the next five to ten years.

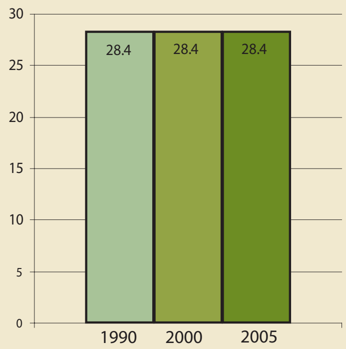
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goals 7 Indicators

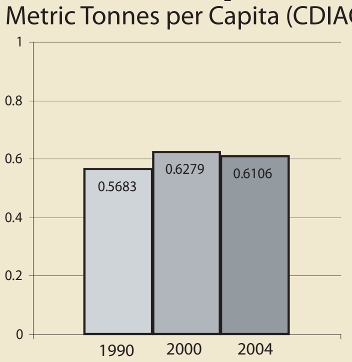
Water and land pollution are the most significant problems in São Tomé and Príncipe. Soil erosion and soil exhaustion are other major environmental challenges.

★ Indicates progress

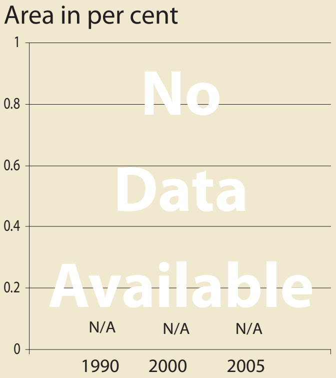
Land Area Covered by Forest, percentage



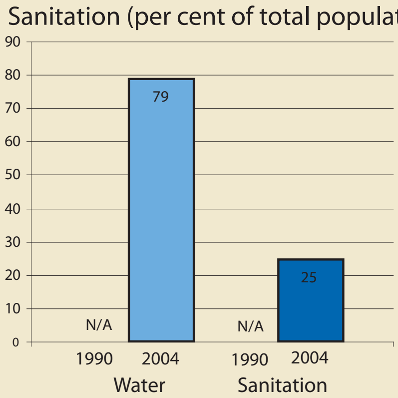
Carbon Dioxide (CO_2) Emissions, Metric Tonnes per Capita (CDIAC)



Protected Area to Total Surface Area in per cent



Access to Improved Water Source and Sanitation (per cent of total population)



Slum Population as per cent of Urban Population

Democratic Republic of

São Tomé & Príncipe

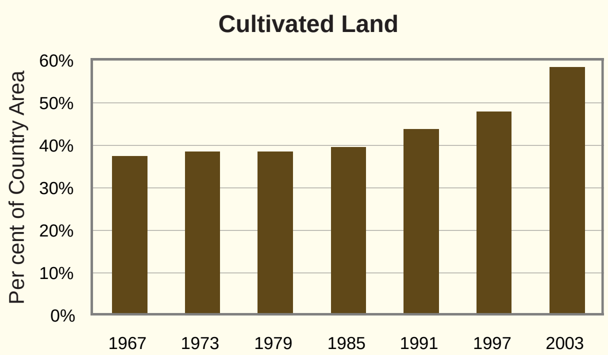
Total Surface Area: 964 km²
Estimated Population in 2006: 160 000

The two major islands of São Tomé and Príncipe, together with a number of smaller islands and islets, form one of the smallest nations in Africa in terms of both population and total surface area. The islands are of volcanic origin and quite mountainous, and their irregular relief contributes to dramatic variations in rainfall, temperature, and vegetation. These islands are among the most densely populated countries in Africa with almost 171 inhabitants per square kilometre (Earth Trends 2006 and FAO 2007).

Important Environmental Issues

- Degradation of Forest Ecosystems
- Threats to Biodiversity

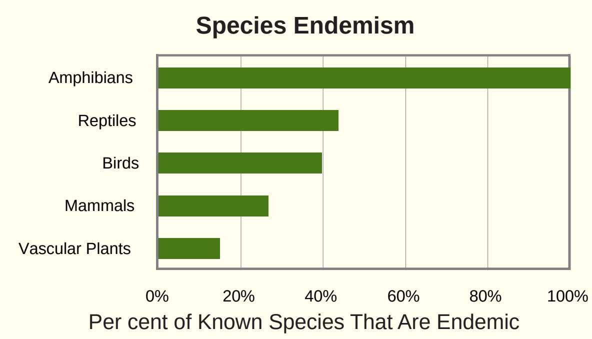
Degradation of Forest Ecosystems



São Tomé and Príncipe have three forest types: low altitude moist closed forest, moist submontane evergreen forest, and closed cloud forest. While total forest cover has held steady over the past several decades, much of the island's primary forests have been cut and many tree species remain threatened. This is particularly true of the low altitude forests, which were almost completely cleared to make way for expanding cocoa farming, the nation's most important cash crop (FAO 2000). As a consequence of deforestation, erosion has substantially reduced the islands' soil fertility.

Threats to Biodiversity

São Tomé and Príncipe's biodiversity is characterised by exceptionally high rates of endemism, meaning that many of the islands' species are found nowhere else in the world. Several of these native species display unusual evolutionary features such as gigantism (for example, the São Tomé giant sunbird) and dwarfism (for example, the dwarf olive ibis). The threats to biodiversity are numerous, including coastal erosion, pollution, deforestation, hunting, and the introduction of exotic species. As a result, 93 plant and animal species are threatened with extinction (IUCN 2007).



Source: National Report on the Status of Biodiversity

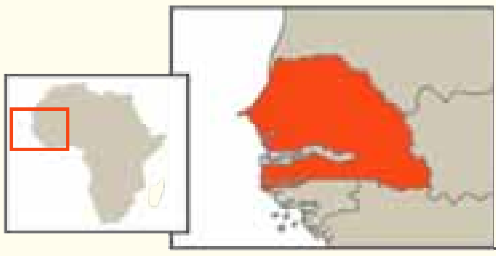
The geographic isolation of São Tomé and Príncipe has resulted in high levels of endemism, notably among plants.

nationsencyclopedia.com (2007); rainforests.mongabay.com (2007

Urban Expansion: São Tomé Island, São Tome and Príncipe

São Tomé is the capital city of the island that shares its name. Located in the island's Agua Grande district, the population of São Tomé increased from a mere 8 431 in 1940 to 51 886 in 2001.

The satellite image shows how settlements, especially along roads, have expanded inland from the city. While much of the island still retained its natural vegetation in 2007, vegetation loss is obvious near the capital city and surrounding settlements, where forests have been converted to croplands. Substantial oil reserves have recently been discovered off the island of São Tomé, which will most likely fuel increased development.



Republic of Senegal

Total Surface Area: 196 722 km²
Estimated Population in 2006: 11 936 000

Senegal is a low-lying and flat country subject to seasonal lowland flooding and periodic droughts in the semi-arid north. It is drained by four perennial rivers: the Senegal, Gambia, Saloum, and Casamance. The climate is Sahelian with well-defined wet and dry seasons and rainfall ranging from 1 500 mm per year in the south to only 200 mm per year in the north. Over 80 per cent of the population lives within 200 km of the coast (FAO 2005) and 42 per cent lives in cities (UNESA 2006).

Important Environmental Issues

- Urban Pollution
- Deforestation
- Coastal Wetlands and Fisheries Over-exploitation

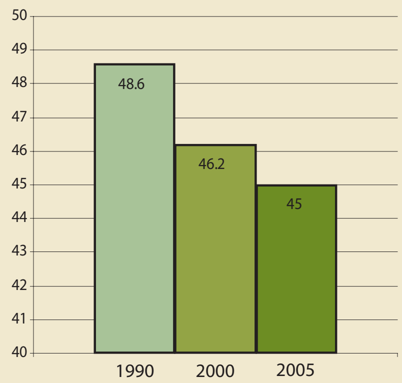
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

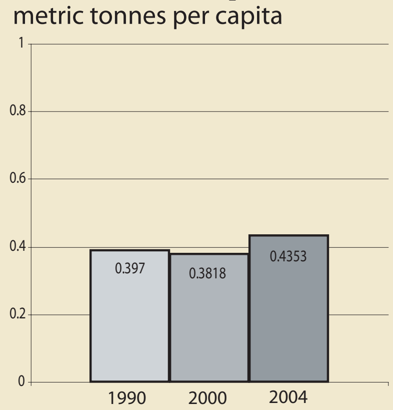
Senegal is highly vulnerable to declining rainfall and desertification. Vegetation varies in different areas of Senegal, depending on the average precipitation. Approximately 46 per cent of Senegal is classified as semi-arid. The capital city, Dakar, suffers from typical urban problems such as improper sanitation (especially during the rainy season, when sewers overflow) and air pollution from motor vehicles.

★ Indicates progress

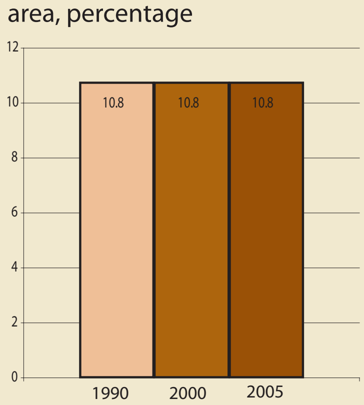
Land area covered by forest, percentage



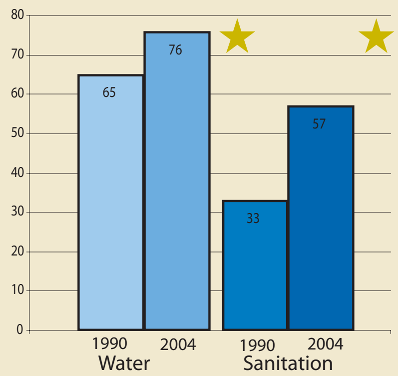
Carbon dioxide (CO_2) emissions, metric tonnes per capita



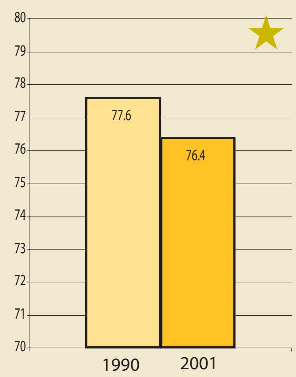
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

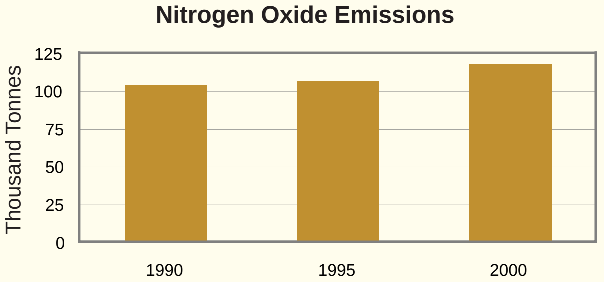


Senegal is one of the world's most famous migratory bird sanctuaries.

cites.org (2000)

Urban Pollution

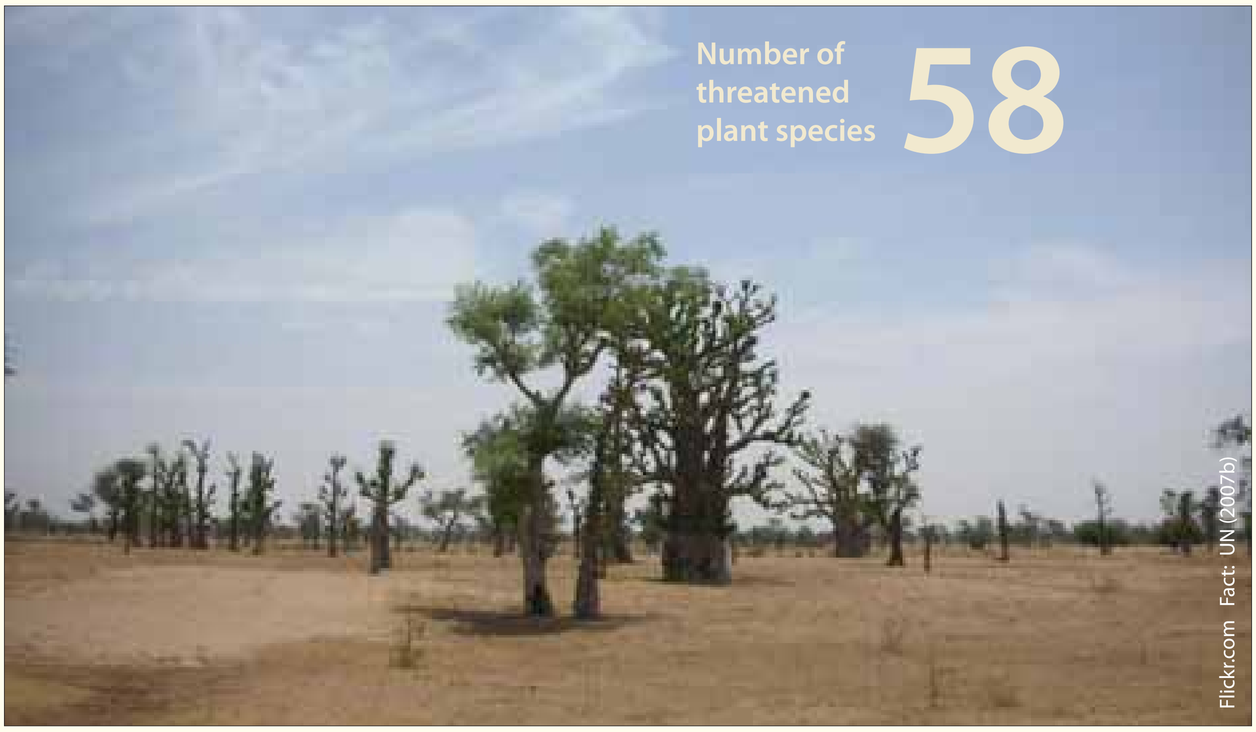
One out of four Senegalese people (approximately 55 per cent of the urban population) lives in the coastal capital city Dakar (FAO 2005). The urban growth rate is 3.6 per cent per year, compared to 2.3 per cent for the country as a whole (UNESA 2006). Due to rapid population growth and poor urban planning, road traffic and congestion have increased significantly. As a result, air pollution is estimated to result in health costs equivalent to five per cent of the GDP (UNEP 2002). Recent investments in urban transport infrastructure are expected to relieve traffic congestion, but probably at the cost of increased carbon dioxide emissions.



Source: EDGAR, Netherlands Environment Assessment Agency

Deforestation

Forests cover nearly half of Senegal's land surface, although this forest cover is steadily declining (UN 2007a). Agriculture claims more than 80 000 hectares of forest each year, and wildfires, which are used for land clearing and hunting, degrade an additional 350 000 hectares annually. On the coast, approximately 50 per cent of mangroves have been degraded as a result of over-exploitation and drought. Overall, deforestation has been blamed for recent increases in soil erosion, desertification, and flooding.

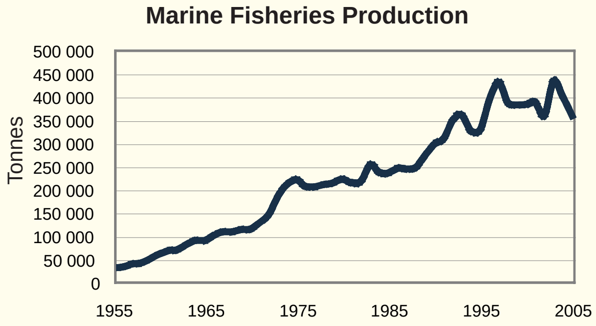


Flickr.com Fact: UN (2007b)

Coastal Wetlands and Fisheries Over-exploitation

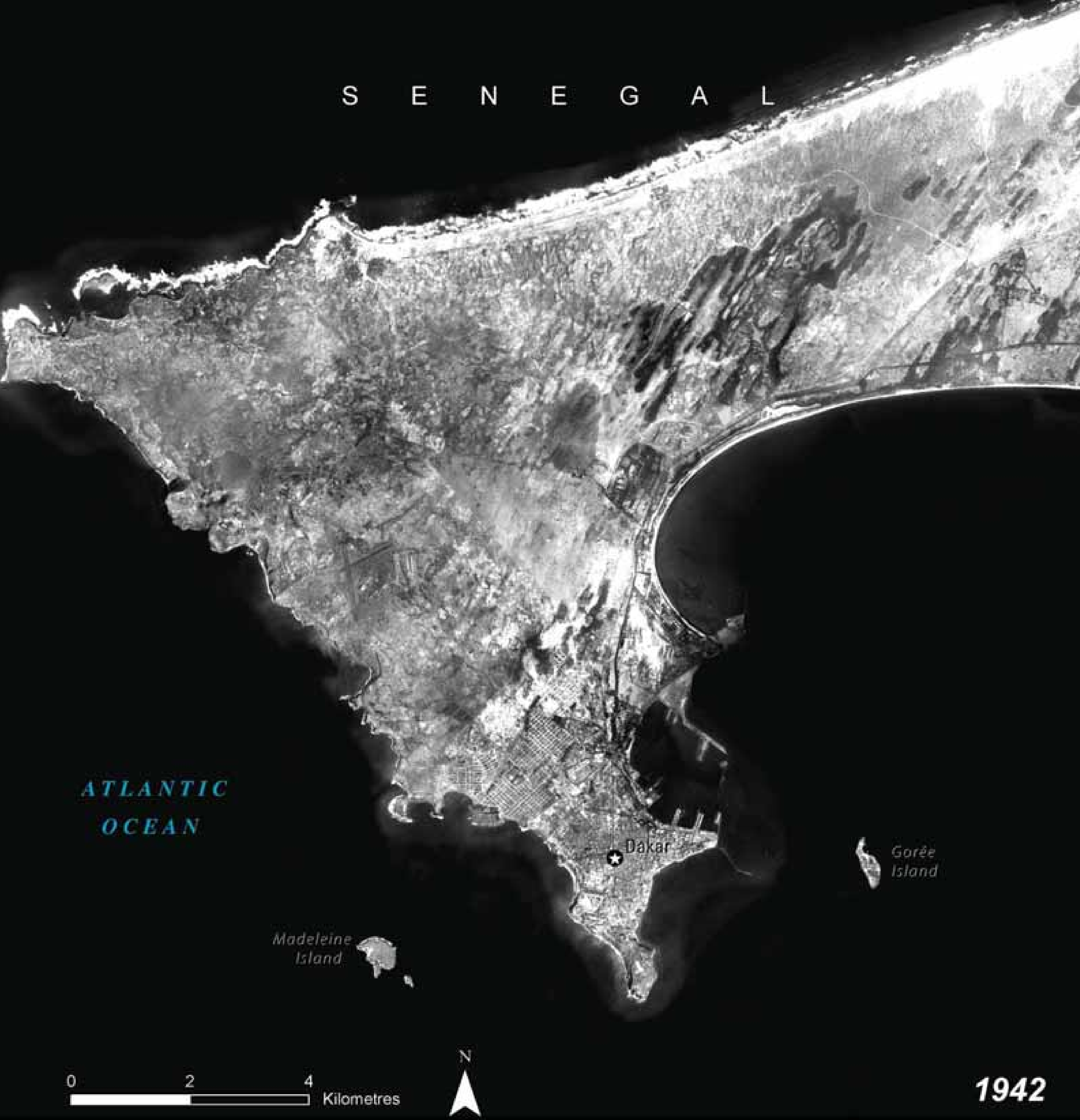
Senegal's biologically important wetlands are threatened by invasive plant species, mangrove degradation, and coastal development and erosion. The Djoudj National Bird Sanctuary is a large wetland on the floodplain of the Senegal River delta, covering 16 000 hectares of seasonally flooded lakes, ponds, and streams. It provides a haven for over three million migrant birds as well as large breeding populations of flamingos, pelicans, and other species.

Fish account for three-quarters of local protein consumption and fishing accounts for 17 per cent of employment in Senegal (FAO 2000-2007). However, overfishing by European vessels and the degradation of coastal ecosystems have threatened fish stocks, leading to decreased catches for local fishermen.



Source: FISHSTAT

Flickr.com



Urbanisation of Cap Vert Peninsula: Dakar, Senegal

Like many West African cities, Senegal's capital city of Dakar has grown dramatically over the past several decades. Growth is expected to continue. While birth rates have begun to decline, natural growth still accounts for much of Dakar's expansion. In addition, Dakar experienced a large rural-to-urban migration beginning in the 1960s, when Senegal suffered from declining precipitation and periods of extreme drought. By 2005, Senegal's urban population exceeded its rural population. By 2030, two-thirds of the country's population is expected to be urban.

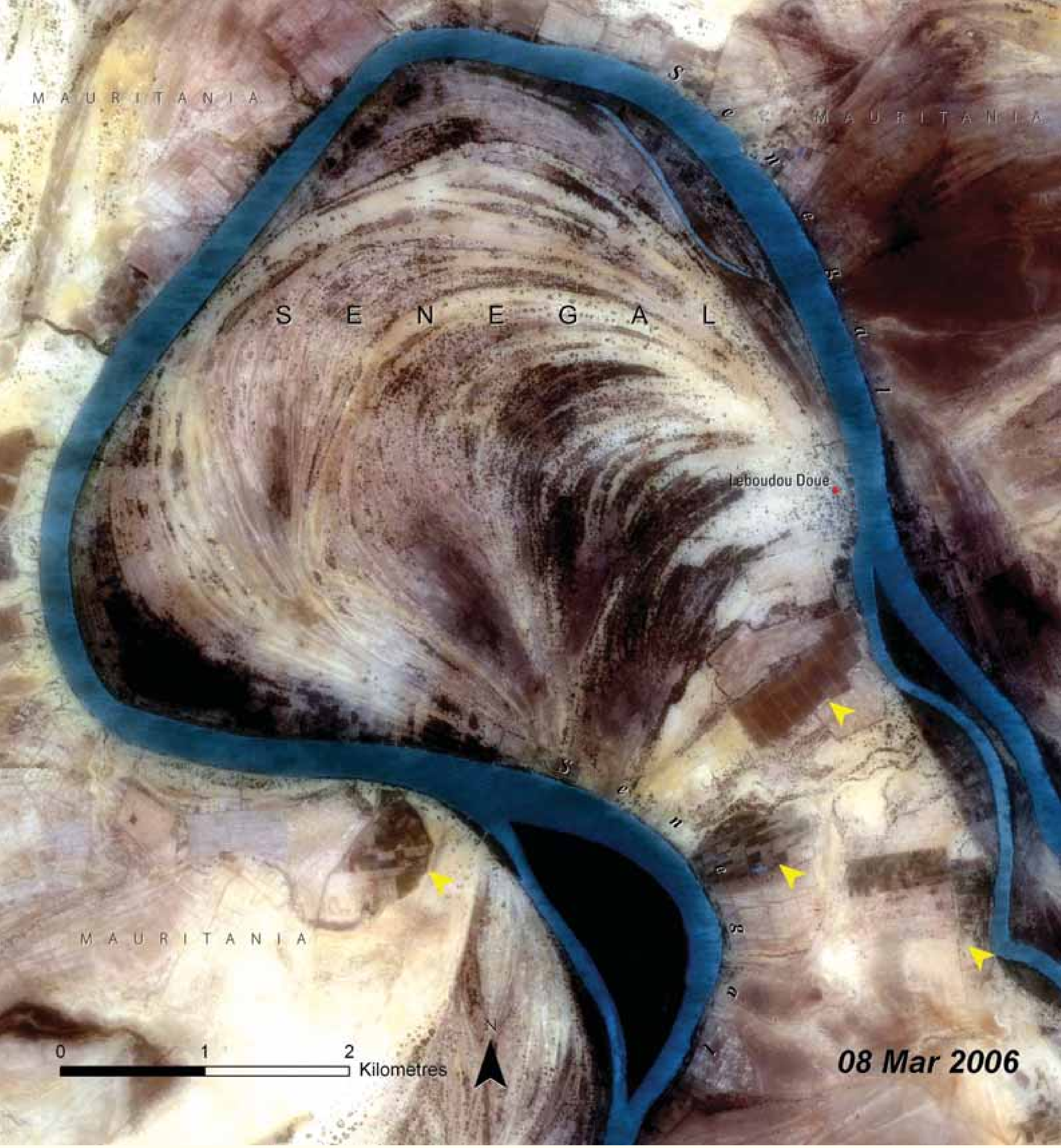
Roughly half of Senegal's urban population lives in the greater Dakar metropolitan area. Urban population growth has turned the Cap Vert Peninsula into a sprawling metropolis, where settlements reach ever-further inland and onto the prime farmland that has historically supported the city. Pikine, initially begun as a resettlement of urban slum dwellers 15 km east of Dakar, has grown to over one million people. Its location in the fertile Niayes region displaced large areas of urban and peri-urban agriculture that once provided livelihoods for a substantial portion of the population.

In the aerial photo mosaic from 1942, Dakar is concentrated at the southern tip of the peninsula, with only the airport and a few scattered roads and settlements to the north. The 2006/2007 image shows only a portion of the greater Dakar area, which currently stretches another 14 km to the city of Rufisque (not shown).

Riverine Forest Degradation: Leboudou Doue, Senegal

In the black and white image, the darker areas of the land enclosed by this great loop on the Senegal River show the extent of the riverine forest in 1966. The 2006 image shows very little of that forest remains.

Similar deforestation has occurred in the fertile floodplains along hundreds of kilometres of the Senegal River. Much of the forest was cleared by local people to make way for subsistence agriculture. The most common riverine tree species, *Acacia nilotica*, is also the preferred source of



wood for fuel and construction, and for charcoal production. Production of charcoal for sale as far away as Dakar and Saint Louis has further increased the pressure on what remains of these woodlands. *Acacia nilotica* woodlands that covered 39 000 hectares along the Senegal River in 1966 had been reduced to 9 000 hectares by 1992—a reduction of 77 per cent.

These pressures were compounded by two developments in the late 1980s. In 1988, the Manantali Dam was built upstream in Mali. The dam controls roughly half of the Senegal River's discharge. While controlled releases of water from the dam can recreate natural flooding, below-normal flood levels may be contributing to loss of *Acacia nilotica* stands. The area's population has also grown dramatically over the past several decades, including the influx of some 120 000 Mauritanian refugees and Senegalese expatriates following an ethnic conflict in 1989.

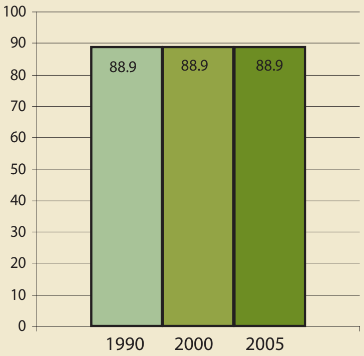
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goals 7 Indicators

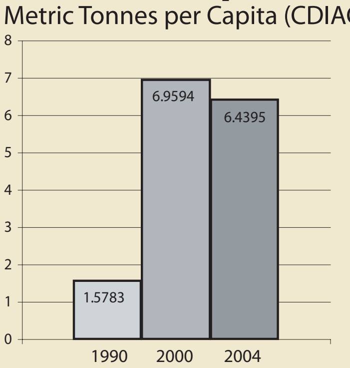
Seychelles does not have the resources to maintain a comprehensive program of environmental regulation, evident in the MDG graphs. The monitoring of the environment is complicated by the fact that the nation consists of 15 islands distributed over a 1.3 million km² area.

★ Indicates progress

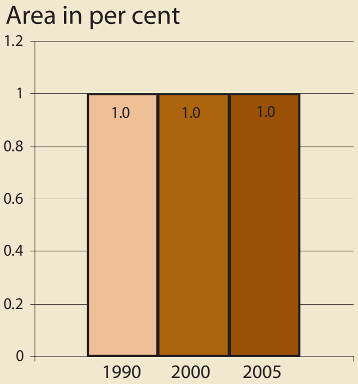
Land Area Covered by Forest, percentage



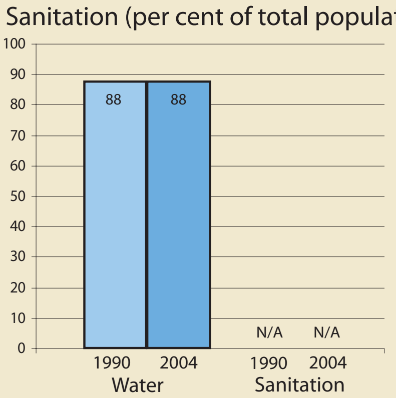
Carbon Dioxide (CO_2) Emissions, Metric Tonnes per Capita (CDIAC)



Protected Area to Total Surface Area in per cent



Access to Improved Water Source and Sanitation (per cent of total population)



Slum Population as per cent of Urban Population

Republic of Seychelles

Total Surface Area: 455 km²
Estimated Population in 2006: 83 000

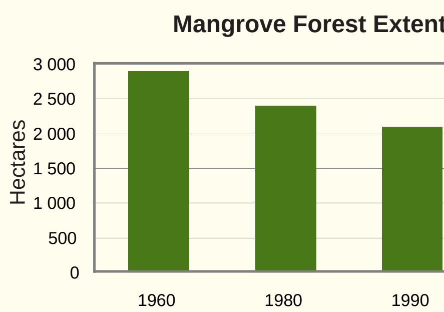
Seychelles is a large archipelago of 115 islands located north of Madagascar in the western Indian Ocean. Forty-two of the islands are classified as "micro-continental," having been left behind by the Indian subcontinent during its northward drift towards Asia. The remaining 73 islands are coral atolls and sandbanks that formed in the region's shallow waters. Lying only four degrees south of the equator, Seychelles has a tropical wet climate dominated by patterns of monsoons.

Important Environmental Issues

- Severe Weather and Coastal Erosion
- Loss of Mangrove Forests and Protection of Coral Reefs

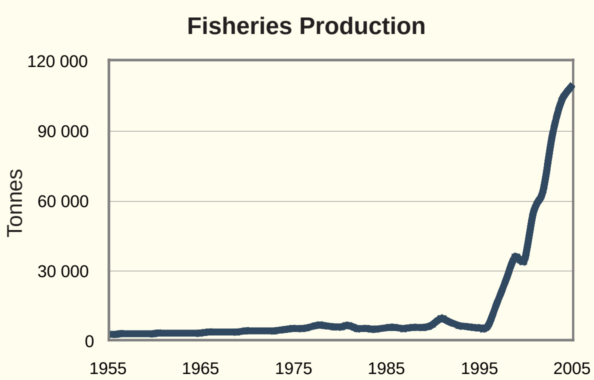
Severe Weather and Coastal Erosion

While Seychelles lies beyond the western Indian Ocean's main cyclone belt, its islands have experienced increasingly frequent and intense storms over the past decade (UNEP 2006), resulting in millions of dollars in damage. Global climate change is expected to contribute to rising sea levels and even more extreme weather events, which is particularly threatening in light of increased coastal erosion. Stabilisation efforts and a national beach monitoring program were initiated in 2003 to address this problem.



Source: Status and Trends in Mangrove Area Extent Worldwide

Loss of Mangrove Forests and Protection of Coral Reefs



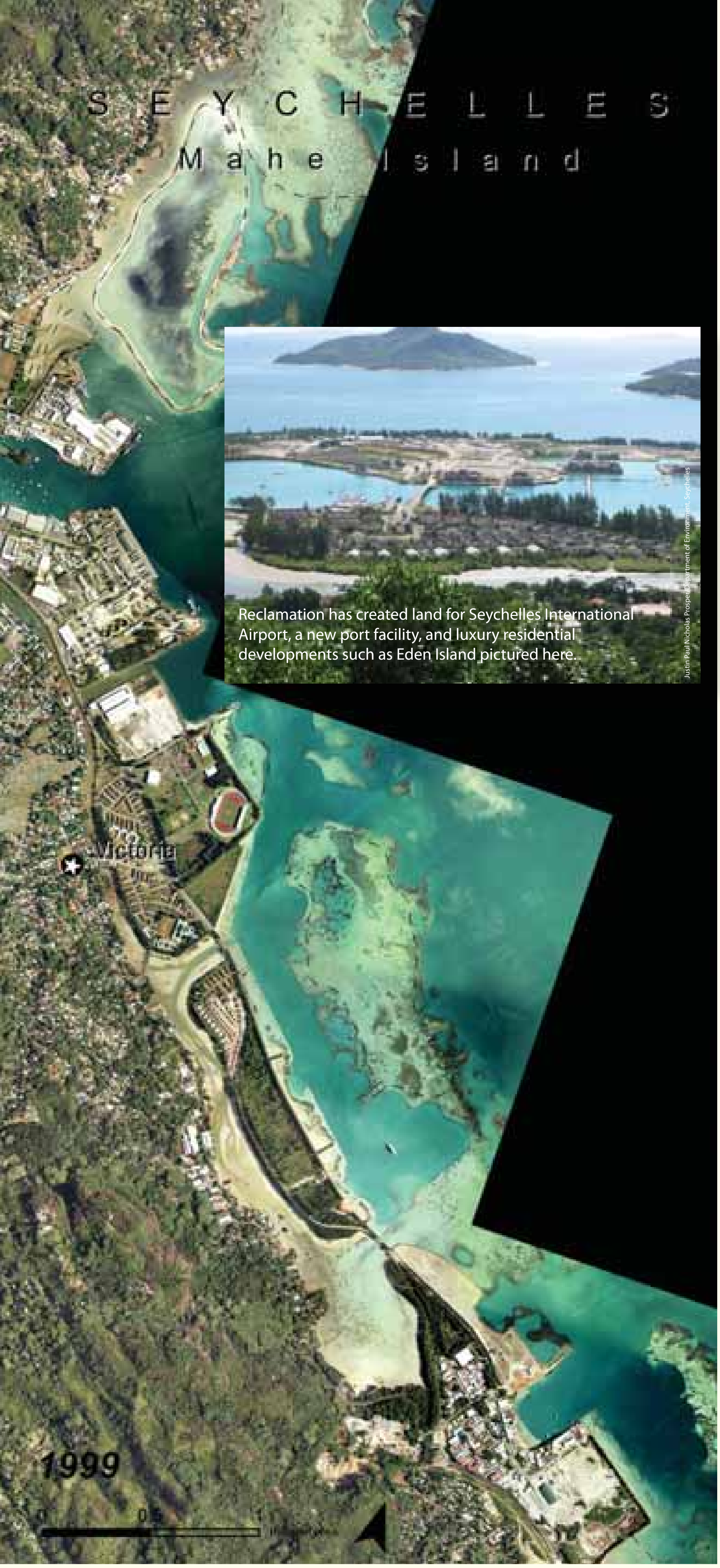
Source: FISHSTAT

Mangroves provide important habitat for fish and birds and protect coral reefs by capturing sediments before they enter ocean waters. Mangroves are found mainly on the granite islands. As a result of wetlands reclamation and coastal development, one-third of Seychelles' mangroves have been lost since 1960 (Wilkie and Fortuna 2003).

Aldabra atoll in the western Seychelles is a UNESCO World Heritage Site and one of the most exceptional examples of the country's coral reefs, which span 1 690 km² (UNEP-WCMC 2001). Aldabra is home to 152 000 giant tortoises, the largest population of this reptile in the world (UNESCO 2007).

The smallest country in Africa made up of 115 islands in the Indian Ocean, Seychelles also has the smallest population.

UN (2007)



Reclamation has created land for Seychelles International Airport, a new port facility, and luxury residential developments such as Eden Island pictured here.

Land Reclamation: Mahe Island, Seychelles

The east coast of Seychelles' Mahe Island has undergone major environmental change during the last 30 years, primarily due to land reclamation projects. In 1973, land was reclaimed to create a site for the Seychelles International Airport, and in 1986, for a new port facility. Two further phases of reclamation were completed in the early 2000s, parts of which can be seen in the 2007 image above (yellow arrows).

These reclamation projects have impacted both marine and coastal environments. Several new wetland areas have been created, some of them colonized by mangroves, which provide valuable bird habitat and nursery areas for marine species. However, sedimentation from reclamation projects has killed some of the coral along Mahe's eastern coast as well.

Republic of
Sierra Leone

Total Surface Area: 71 740 km²
Estimated Population in 2006: 5 679 000

Credit: © Flagart.com

Sierra Leone has a humid tropical climate, with the highest average rainfall on the African continent—over 2 500 mm of rain per year (FAO 2007). There are four main topographical regions: coastal plains, low inland plains, an upland plateau, and small mountain ranges in the north and east. The country is rich in natural resources including minerals, fish, forests, and wetlands.

Important Environmental Issues

- Deforestation
- Land Degradation
- Overfishing

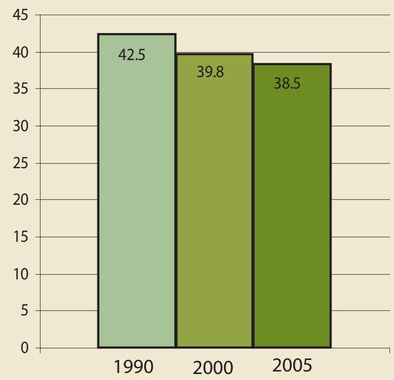
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

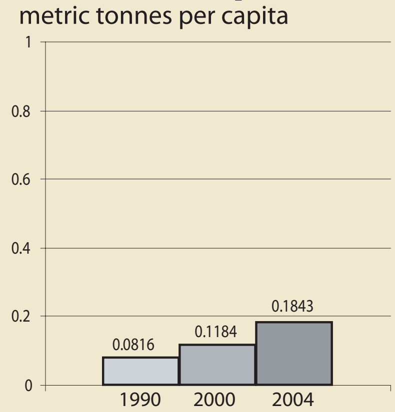
Water pollution is a significant problem in Sierra Leone due to mining by-products and sewage. An increase in slum population can be attributed to population pressure that has led to an intensification of agriculture resulting in soil depletion. Logging, cattle grazing, and slash-and-burn farming have decimated the primary forest. The mining sector officially accounts for over 90 per cent of the country's export earnings.

★ Indicates progress

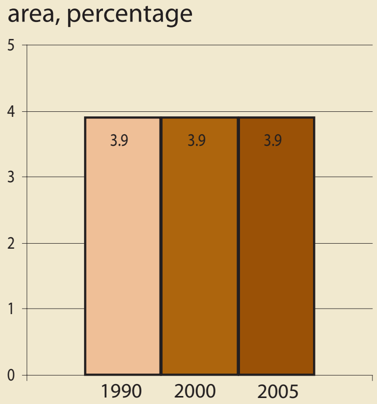
Land area covered by forest, percentage



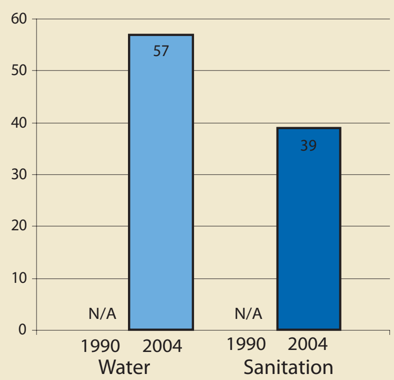
Carbon dioxide (CO_2) emissions, metric tonnes per capita



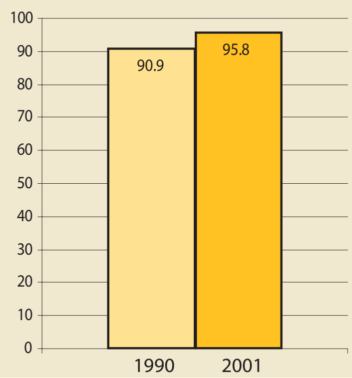
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

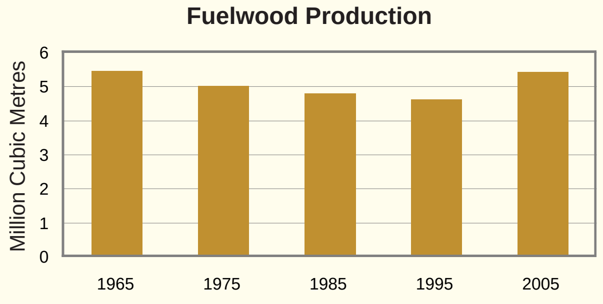


Sierra Leone had the second highest population growth rate in Africa between 2000 and 2005—4.2 per cent per year.

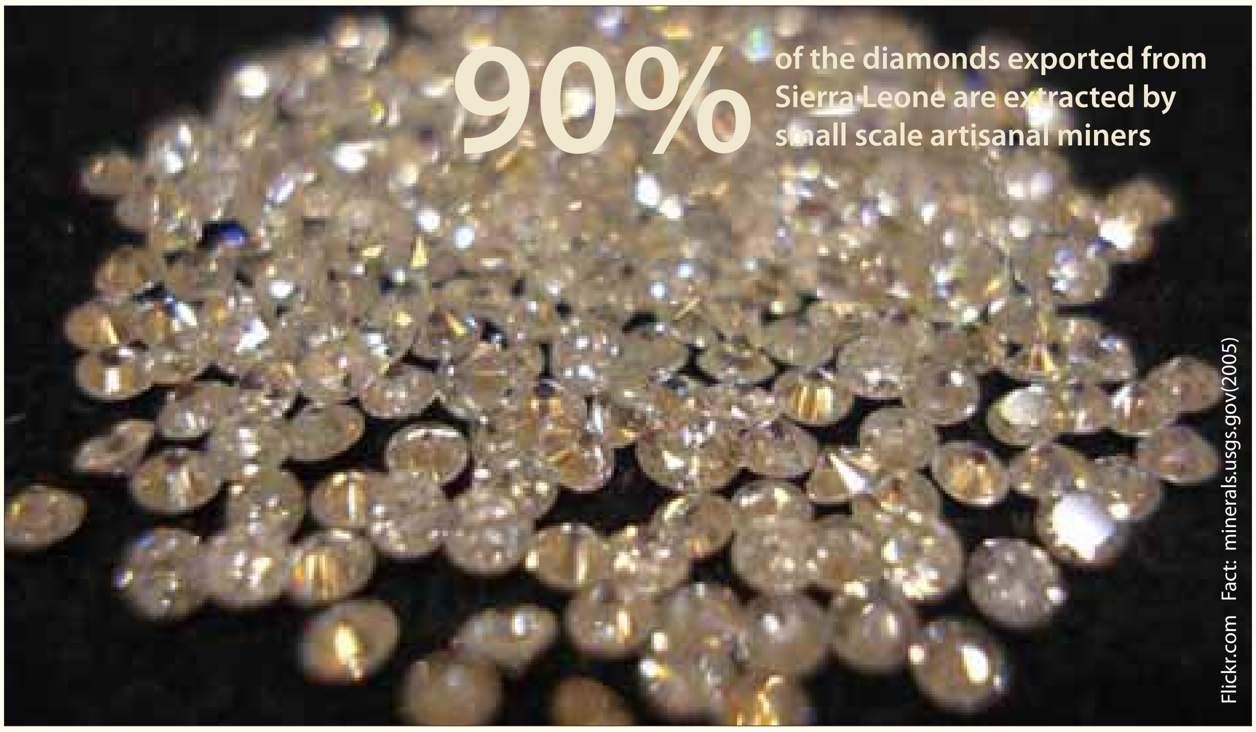
geodata.grid.unep.ch (2006)

Deforestation

Sierra Leone's forests are rich in biodiversity, including over 2 000 plant species, 74 of which are found nowhere else in the world (CBD n.d.). It is estimated that dense tropical forests once covered 65 per cent of the country; these have been reduced to only five per cent today (UNCCD 2004). There are many human pressures on the forest, including logging (both legal and illegal), slash-and-burn agriculture, mining, and dependence on fuelwood by 85 per cent of the population (CBD n.d.).



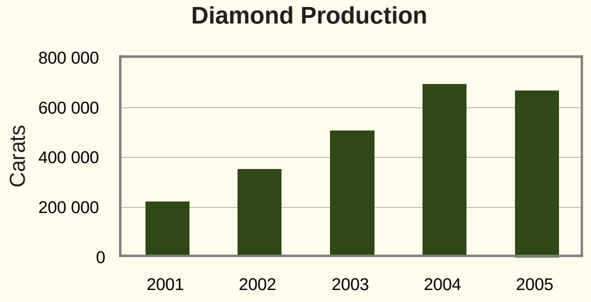
Source: FAOSTAT



Land Degradation

Sierra Leone's population and economy depend heavily on agriculture. Population pressure has reduced fallow periods to less than five years and encouraged clearing of forests for cultivation (CBD n.d.), resulting in soil erosion and nutrient leaching. Land degradation very likely has reduced yields of major crops such as rice.

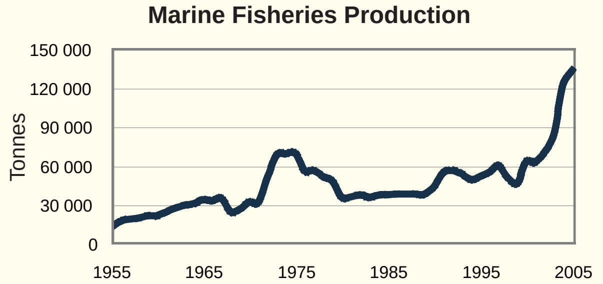
Mining is a significant source of localised land degradation. Diamonds are Sierra Leone's primary export commodity and are mined by both large international companies as well as small artisanal operations. Both have brought about significant environmental degradation including deforestation, soil erosion, pollution, and siltation of water resources; plans for rehabilitation are lacking.



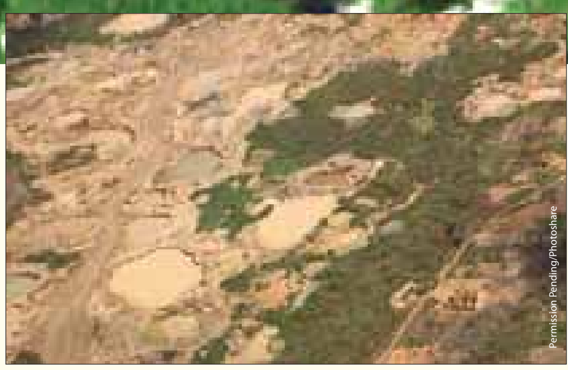
Source: USGS International Mineral Statistics and Information

Overfishing

Sierra Leone's marine and inland fisheries are biologically rich. Although production significantly declined during the decade-long civil war that ended in 2002, the sector is again on the rise. Widespread illegal fishing is increasing concerns about overexploitation. Although not yet believed to be overexploited, several fish stocks may be in decline, although reliable data is lacking (Blinker 2006).



Source: FISHSTAT

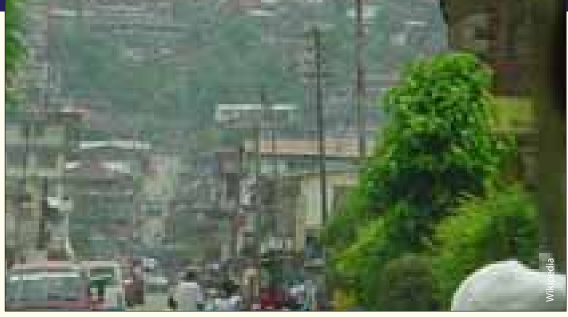


Rutile Mining: Moyamba District, Sierra Leone

Sierra Leone is mineral rich; titanium minerals such as rutile and ilmenite are its principle mineral exports. Before war erupted in 1991, mining represented 90 per cent of Sierra Leone's registered exports and roughly 20 per cent of its GDP—rutile accounted for well over half of that. The Moyamba District, which borders the Atlantic Ocean in the west and Bonthe to the south, is the most active rutile mining area in the country. Although mining companies left during the war, they returned when the war ended in 2002.

Rutile is mined by creating large artificial lakes which are then dredged, leaving behind large water-filled pits up to 600 m long. In Sierra Leone, these activities have left vast areas of land deforested and degraded. It is estimated that between 80 000 and 120 000 hectares of land have been mined out in different parts of the country with minimal efforts at restoration.

In the 1974 image, one small mining operation is visible (centre); however, much of the Moyamba District was still covered with relatively intact forests at that time. By 2003, mining activities had replaced large portions of forest with water-filled pits. These mining sites have extremely poor health and sanitary conditions; the pits teem with mosquitoes and bacteria that are linked to a high incidence of malaria, cholera, and diarrhoea.



Western Area Forest Reserve: Freetown, Sierra Leone

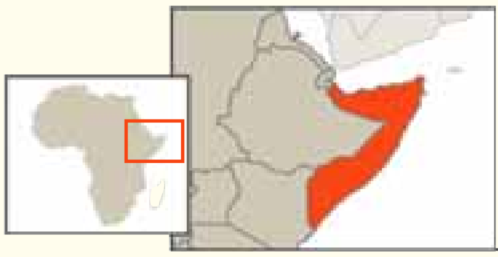
Freetown, Sierra Leone's capital city, shares a peninsula with the Western Area Forest Reserve—a small remnant of the Guinean Forests that historically stretched from Guinea to Cameroon. The century-old reserve covers a chain of forested hills that are home to approximately 300 species of birds and a small population of chimpanzees.

Intense population growth began in Freetown in the 1970s. However, a buffer of forested land remained between the Reserve and the edge of the city. By the mid-1980s, however, the growing

The urban expansion of Freetown is encroaching on the forest and at many places into the Western Area Reserve. *Image courtesy of DigitalGlobe Quickbird.*

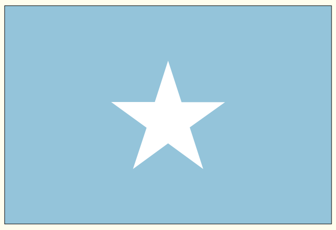
city had expanded into the buffer zone and much closer to Reserve borders (1986 image). Between 1991 and 2002, as many as one million people fled to Freetown as a result of war in Sierra Leone. Many of these refugees moved into the hills of the Reserve, where they relied on its resources to survive. Deforestation and land degradation of these valuable protected lands was the result. By 2003, the border of the Reserve had been breached in many places (2003 image), with urban populations encroaching from several directions.

The Reserve is now recognized as vital, not only to the biodiversity and natural systems it supports, but to the people of Freetown as well. The forest is crucial for recharging of Freetown's reservoirs, which are already struggling to meet the city's water needs.



Somali Republic

Total Surface Area: 637 657 km²
Estimated Population in 2006: 8 496 000



Credit: © Flagart.com

Somalia is a large, relatively flat country located on the Horn of Africa. Its coast is the longest in Africa and borders the Gulf of Aden to the north and the Indian Ocean to the east. The climate is highly arid and hot year-round with seasonal monsoon winds and low, sporadic rainfall arriving in two rainy seasons. Average annual rainfall is estimated at less than 280 mm.

Important Environmental Issues

- Threats to Biodiversity
- Desertification, Overgrazing, and Deforestation
- Water Scarcity and Drought

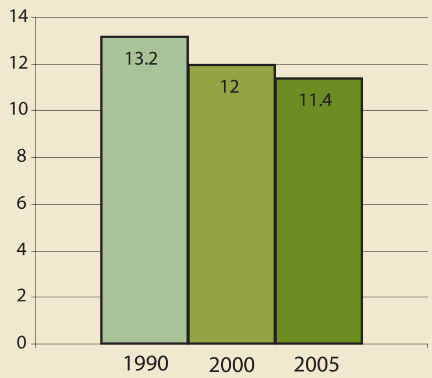
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

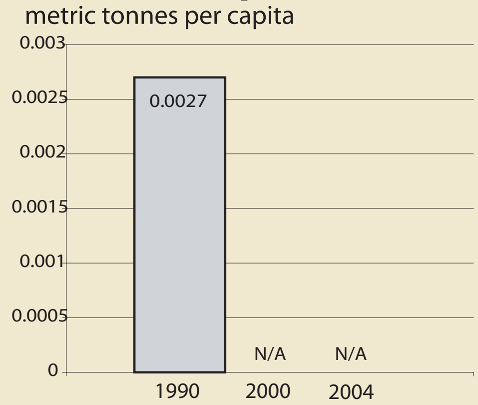
The increasing aridity of Somalia climate, coupled with excessive timber cutting and overgrazing, has led to deforestation and expansion of the desert area. The Indian Ocean tsunami of December 2004 affected stretches of coast. Ongoing internal conflict, which began in the 1980s, has severely hindered sustainable management of natural resources.

★ Indicates progress

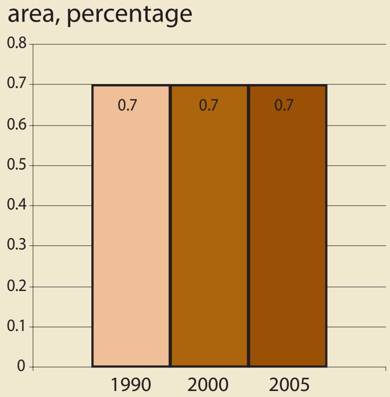
Land area covered by forest, percentage



Carbon dioxide (CO_2) emissions, metric tonnes per capita

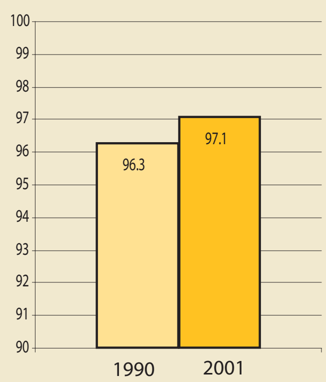


Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban



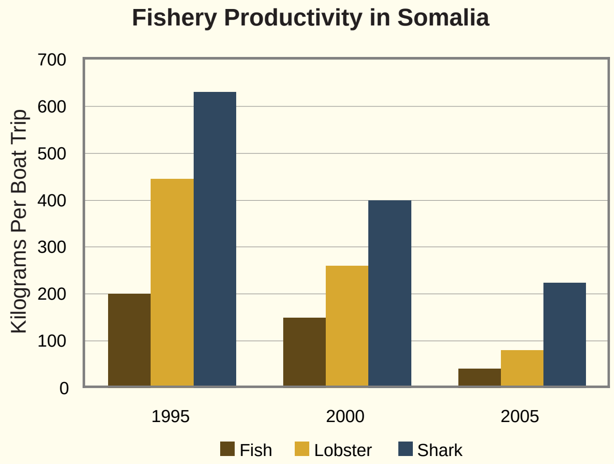
Northern Somalia is the world's largest source of myrrh and other incense.

uneca.org(2002)

Threats to Biodiversity

Seventeen per cent of all identified plant species in Somalia are endemic, which is the second-highest level of floral endemism in continental Africa (UNEP 2005). The coastal region is home to extensive coral reefs, mangrove forests, seabird colonies, and turtle nesting beaches that are currently unprotected and suffer from heavy exploitation. Although the state of most fish stocks is unknown, sharks, lobsters, and certain fish species are thought to be over-exploited. Although Somalis do not traditionally consume much fish, fish exports are important to the economy and illegal fishing by foreign fleets is common.

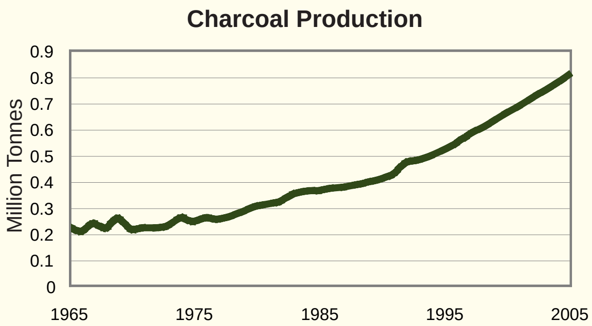
Somalia wildlife has also been severely over-exploited and many species, including the black rhino and elephant, are approaching national extirpation. Lack of official protection and loss of habitat due to agriculture-related land degradation are major threats.



Source: UNEP 2005 State of the Environment in Somalia: A Desk Study

Desertification, Overgrazing, and Deforestation

Due to overall aridity and drought frequency, 100 per cent of land is at high risk of desertification (FAO AGL 2003). Despite water and feed constraints, however, Somalia has the highest proportion of pastoralists in Africa; livestock accounts for 40 per cent of the GDP product (UNEP 2005). Overstocking and overgrazing have resulted in declining fertility of pastureland, which accounts for nearly 70 per cent of Somali Republic's total land area (WRI 2007).



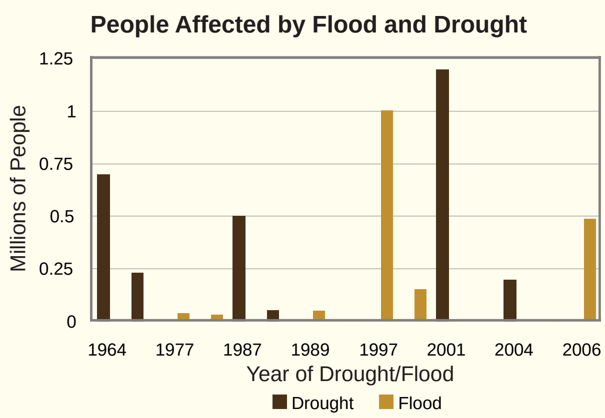
Source: FAOSTAT

Deforestation is another leading driver of land degradation and desertification. Charcoal, produced primarily from slow-growing acacia trees, is an important domestic energy source, although its production in Somalia is largely driven by foreign demand. In 2006, a ban on charcoal exports was imposed in an attempt to curb uncontrolled deforestation of acacia forests, which are also under heavy grazing pressure.

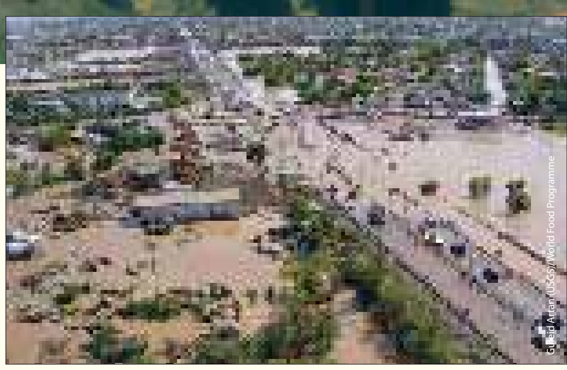
Water Scarcity and Drought

In the Somalia's arid north and east, sub-surface water resources are generally saline; deep boreholes are the only permanent source of freshwater. In the south, two perennial rivers, the Juba and Shabelle, play a major role in water access. Due to prolonged civil conflict, lack of water management, and erratic rainfall, Somalia has the second-lowest level of access to safe water in Africa, at only 29 per cent of the total population (UN 2007). In the tsunami-impacted regions, where many wells were clogged or buried, the situation is particularly severe.

Natural rainfall variation, exacerbated by climate change, contributes to regular droughts every two to three years that are often followed by severe floods. In 2002, water shortages caused losses of up to 40 per cent of cattle and 10 to 15 per cent of goats and sheep (FAO 2005).



Source: EM-DAT Disaster Database

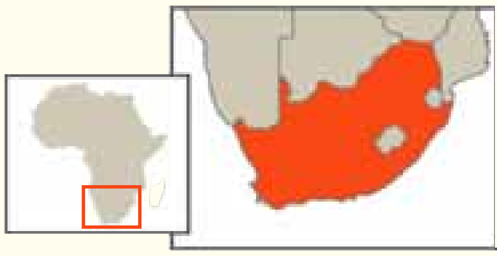


El Niño Flooding: Juba River, Somalia

Late in the fall of 2006, the Horn of Africa received heavy rains generally believed to have been the consequence of an El Niño weather pattern over the Pacific Ocean. By late November and early December, flooding had displaced roughly half a million people, destroyed crops and villages, and caused outbreaks of disease. The severity of the floods made relief efforts extremely difficult. By December these floods were the worst Somalia had seen in ten years. In March 2007, predictions of above-normal spring rains in the upper reaches of the Juba River watershed threatened more flooding.

On the left page, September 2006 and December 2006 images show a portion of the Juba River before and after the rains came, respectively. Flooded areas appear as dark-green to black. Small portions of these images (yellow rectangles) are shown above in greater detail.

In spite of profound negative impacts of the flooding in the Juba River region, two consecutive seasons of heavy precipitation may have benefited cereal grain production and improved pastoral conditions in the region, substantially reducing the need for humanitarian assistance.



Republic of South Africa

Total Surface Area: 1 221 037 km²
Estimated Population in 2006: 47 594 000

South Africa is the southern-most country in Africa, with a long coast spanning across both the Atlantic and Indian Oceans. Although the climate is generally temperate, at least 65 per cent of the country is too arid to support rain-fed agriculture (FAO 2005). The Great Escarpment, a stretch of rugged and scenic terrain running from the northeast to the southwest of the country, separates a wide central plateau from a narrow coastal plain. The mineral riches beneath these lands make South Africa the world's largest producer of platinum, gold, and chromium (CIA 2007).

Important Environmental Issues

- Water Availability and Quality
- Land Degradation
- Threats to Biodiversity

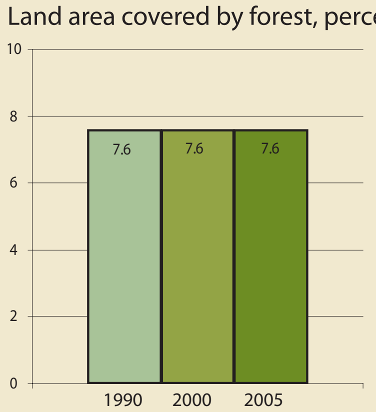
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

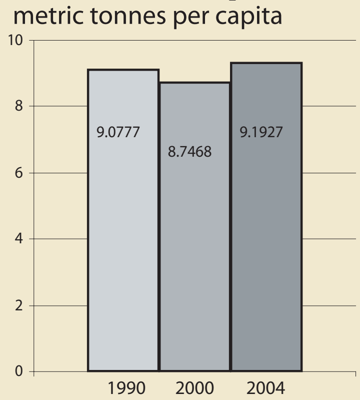
South Africa's limited water resources have been impaired by mineralization, eutrophication, and acidic mine drainage. In 2002, 74 per cent of total energy consumption in South Africa came from coal. Because coal is a highly carbon-intensive fossil fuel, overreliance on it for energy needs can have negative environmental impacts, including air pollution due to coal combustion, groundwater pollution, and disruption of ecosystems due to mining.

★ Indicates progress

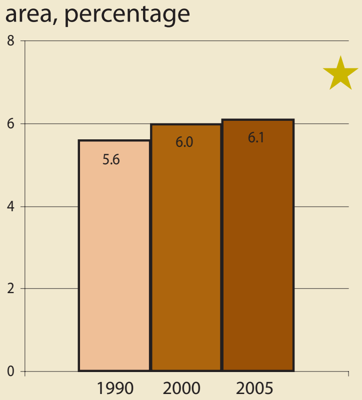
Land area covered by forest, percentage



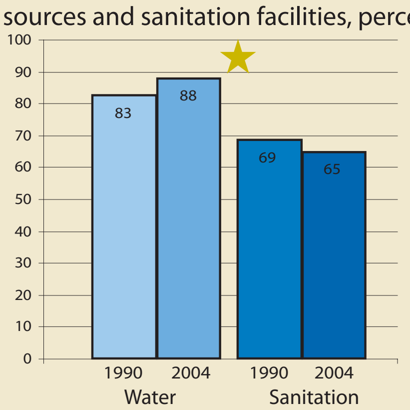
Carbon dioxide (CO_2) emissions, metric tonnes per capita



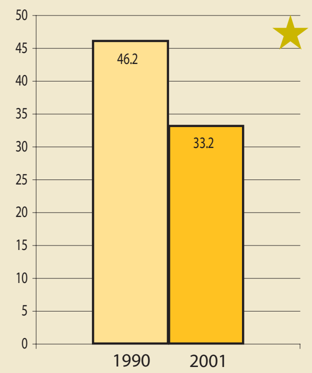
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



The South African Fynbos, with 8 500 species of vascular plants, is one of the six botanical kingdoms of the world and has a richer flora than any other comparable sized area in Africa.

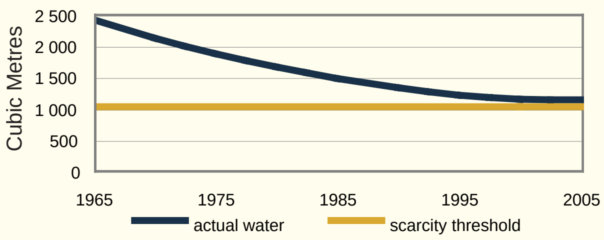
panda.org (2006)

Water Availability and Quality

South Africa is a semi-arid country with unevenly distributed rainfall. In northern regions in particular, freshwater resources are nearly fully-utilised and many are under stress. Population and economic growth are anticipated to increase water demand by 52 per cent between 2000 and 2030 (SoE 1999), making freshwater availability one of the primary constraints on development.

There are over 320 large dams in South Africa, with a total capacity of 32 400 million cubic metres (SoE 2006). Sedimentation has reduced the capacity of some dams by as much as 25 per cent (SoE 1999). Of the 30 dams in Africa with the highest levels of sedimentation, 18 are in South Africa (FAO 2007a). Furthermore, the spread of alien invasive plant species has decreased the national mean annual run-off by three per cent (SoE 2006). Finally, pollution from industrial and domestic effluents has reduced the quality of groundwater and surface water resources, especially near urban areas.

Renewable Water Resources Per Capita

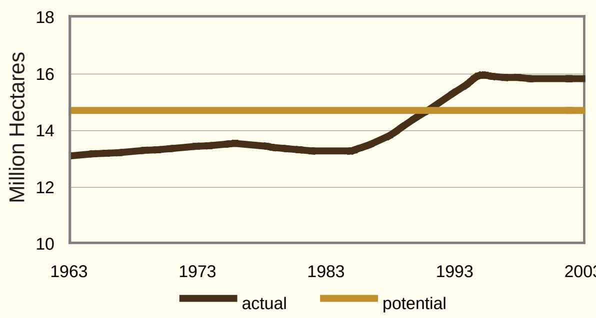


Source: AQUASTAT

Land Degradation

An estimated 67 per cent of South Africa's total land area is severely degraded (FAO 2007b). The primary drivers are wind and water erosion, spurred by overgrazing and cultivation of land unsuitable for agriculture specifically on the steep slopes of enscarptments in the Limpopo, KwaZulu Natal, and Eastern Cape (SoE 2006). Declining soil fertility has affected many farmers, with an average of 2.5 metric tonnes of topsoil lost per hectare per year, which is approximately eight times the rate of natural soil formation (SoE 1999).

Potential Versus Actual Cultivated Land



Source: AQUASTAT and FAOSTAT

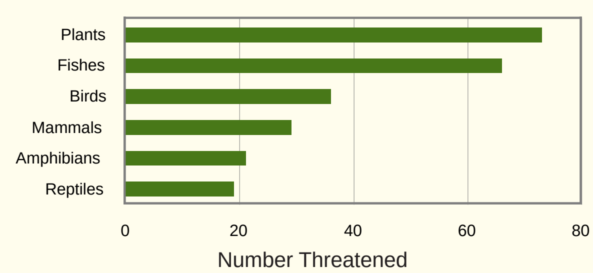
Mining is another significant contributor to land degradation in the form of acid mine drainage, water pollution, and the drastic alteration of landscapes. The Witwatersrand region near Johannesburg, South Africa, has the richest concentration of mineral resources in southern Africa. Mine wastes cover over 200 000 hectares in South Africa (SoE 2006).

Threats to Biodiversity

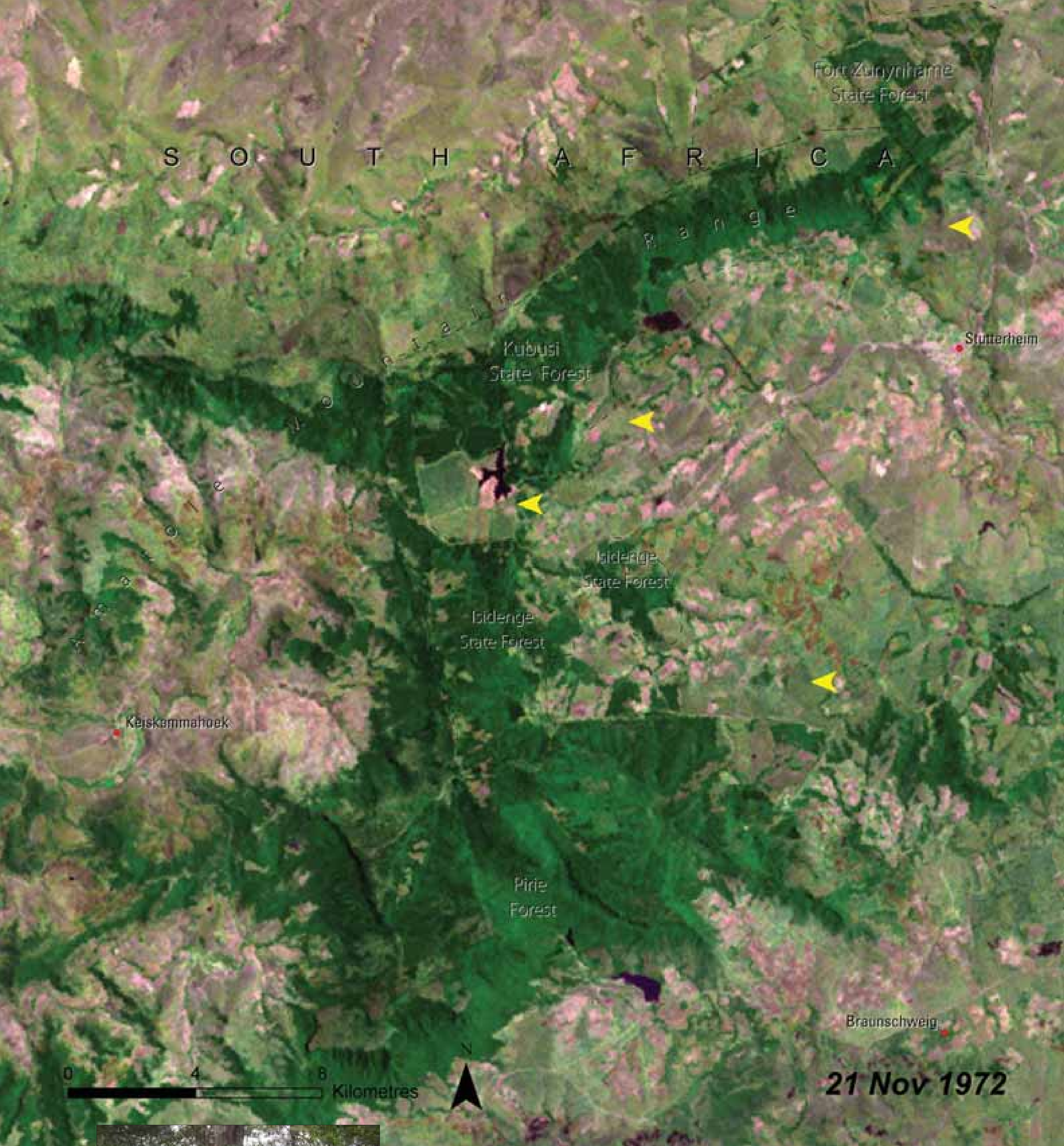
South Africa is one of the most biodiverse countries in the world, with almost ten per cent of the world's plant species, six per cent of its mammal species, 16 per cent of its marine fish species, and eight per cent of the world's bird species (CBD 2005). The country also has the fifth-highest level of endemism on the African continent.

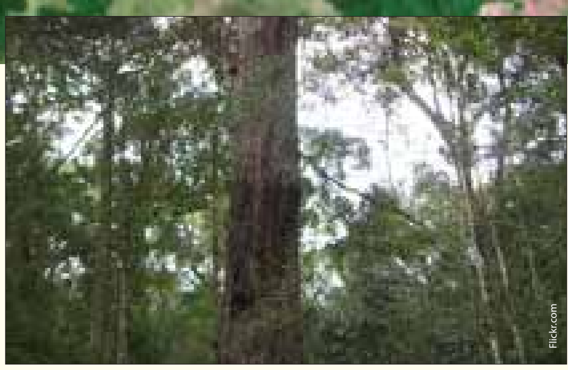
Many species are threatened due to agricultural activities, urban development, mining, the spread of invasive alien species, and over-harvesting. An estimated 34 per cent of terrestrial ecosystems and 82 per cent of river ecosystems are considered threatened, and approximately half of all wetlands have been lost (CBD 2005). Marine ecosystems are especially endangered due to rapid coastal development, pollution, and reduced freshwater inflow from estuaries. Approximately 1.3 million m^3 of sewage and industrial effluent are discharged into the sea daily (SoE 2006).

Threatened Species



Source: IUCN Red List

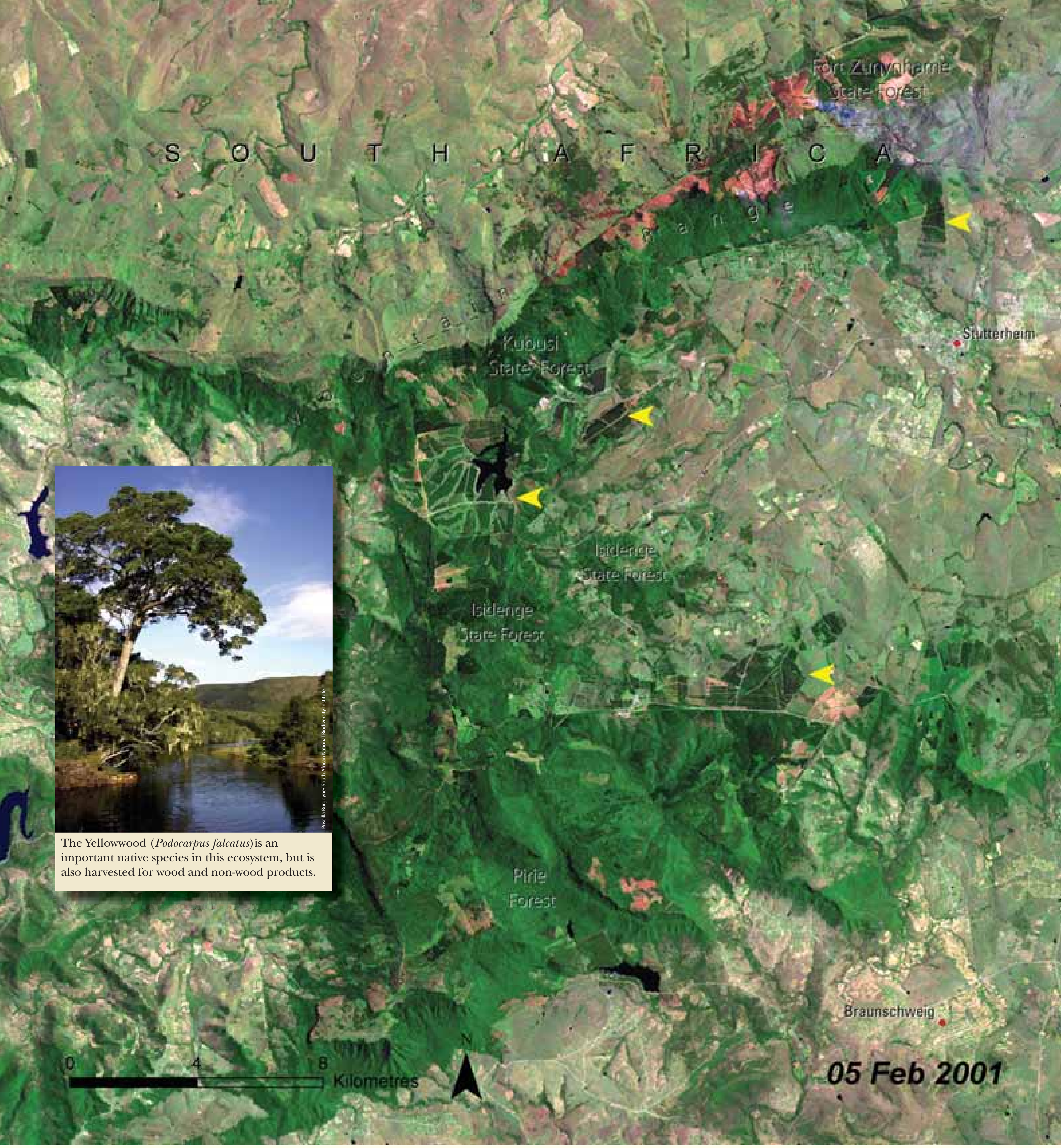




Indigenous Forests: Amatole Mistbelt, South Africa

While forests are not believed to have ever covered a large part of South Africa, logging, clearing for agriculture, and forest plantations have much reduced their original extent. Indigenous forests now cover only 0.33 per cent of South Africa's land area.

South Africa's Amatole Mistbelt Forests are part of the southernmost areas of Afromontane forest in Africa. They contain some small remaining patches of indigenous forest. These forests fall within the Maputaland-Pondoland-Albany biodiversity hotspot and are home to variety of unique plant and animal species, including several endemic species such as the endangered



The Yellowwood (*Podocarpus falcatus*)is an important native species in this ecosystem, but is also harvested for wood and non-wood products.

giant golden mole (*Chrysospalax trevelyani*). They are also important resources for local people who rely on them for wood and non-wood products. Some of the characteristic tree species are yellowwood (*Podocarpus falcatus*), (see photo), red currant (*Rhus chirindensis*), and black ironwood (*Olea capensis*).

South Africa's Department of Water Affairs and Forestry defined the areas of Isidenge and Pirie as "irreplaceable" patches of indigenous forest. While nearly half of the forests in the Amatole Mistbelt Forests are under state management, less than 1.5 per cent are under strict protection. Comparison of these 1972 and 2001 images shows some new areas of tree cover, (yellow arrows); however, these are primarily plantation forests of pine and eucalyptus, which threaten to alter the hydrology and reduce the biodiversity of these ecosystems.

Natural Area Loss: Cape Floristic Region, South Africa

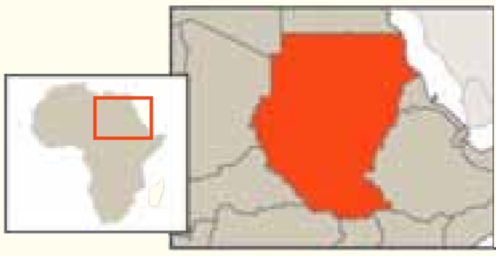
The Cape Floristic Region is a Mediterranean-type ecosystem unique to the southwest tip of Africa. It has the greatest concentration of plant species in the world outside of tropical ecosystems, with 6 210 of its 9 000 species occurring nowhere else in the world. Although the region is relatively small, its plant biodiversity is the richest per unit area on Earth, prompting its designation as a biodiversity hotspot.

The characteristic and most widespread type of vegetation in the Cape Floristic Region is fynbos, an Afrikaans word that translates as "fine bush." Covering some 46 000 km², fynbos is

a shrubland comprising hard-leafed, evergreen, fire-adapted shrubs. Fynbos covers half of the surface area and accounts for 80 per cent of the plant varieties of the Cape Floristic Region.

The 1978 image shows large, relatively intact areas of native fynbos vegetation. Over subsequent decades, however, large tracts of fynbos have been cleared for agriculture or lost to urban expansion around Cape Town. The 2007 image shows how roads, urban development, and agriculture have overtaken much of the area.

Fynbos areas are also threatened by invasive alien species, particularly wattle and acacia species from Australia, as well as pine plantations. Many fynbos species have gone extinct, and more than 1 000 are endangered. Their conservation is a priority, and reserves have been established in many areas.



Republic of the Sudan

Total Surface Area: 2 505 813 km²
Estimated Population in 2006: 36 992 000

As the largest African country, Sudan extends over three major climatic zones: the Saharan north, the Sahelian centre, and the equatorial south. The population is concentrated largely along the Nile River and its tributaries, where soil fertility and agricultural productivity are high. Rainfall is widely variable throughout the country, ranging from only 25 mm per year in the dry arid north to over 1 600 mm per year in the tropical rain forests of the south (FAO 2005a).

Important Environmental Issues

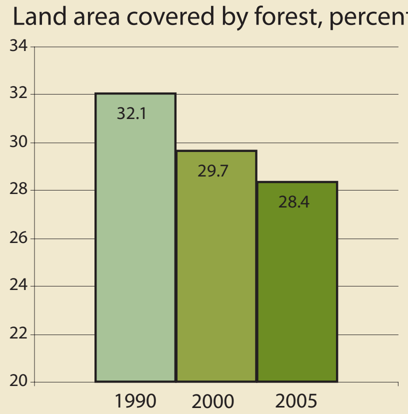
- Soil Erosion and Land Degradation
- Poaching and the Ivory Trade
- Forests and Fisheries

Progress Towards Environmental Sustainability

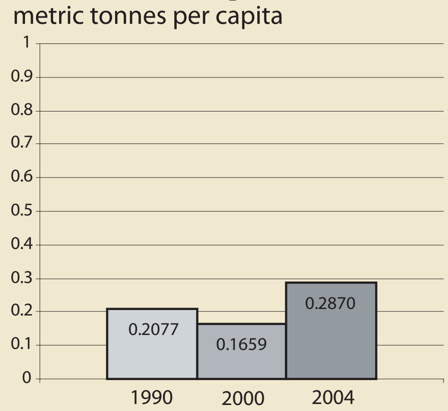
As defined by the United Nations Millennium Development Goal 7 Indicators

Sudan faces a number of critical environmental challenges, including land degradation, deforestation, and the impacts of climate change. There has been a southward shift—ranging from 50 to 200 km—of the boundary between semi-desert and desert since rainfall and vegetation records were first kept in the 1930s. This boundary is expected to continue to move southwards due to declining precipitation.

Land area covered by forest, percentage

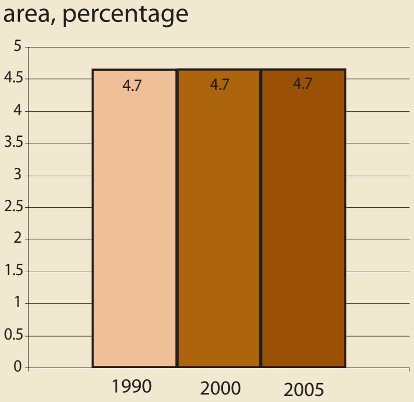


Carbon dioxide (CO_2) emissions, metric tonnes per capita

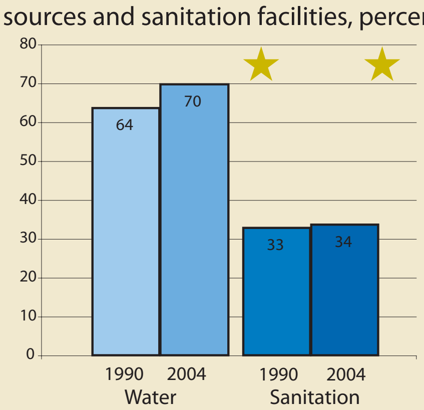


★ Indicates progress

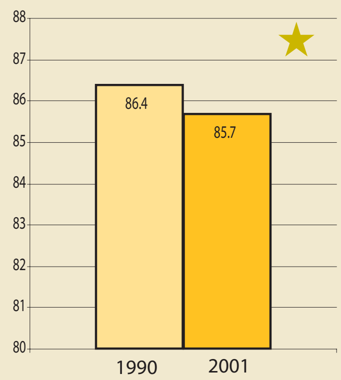
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



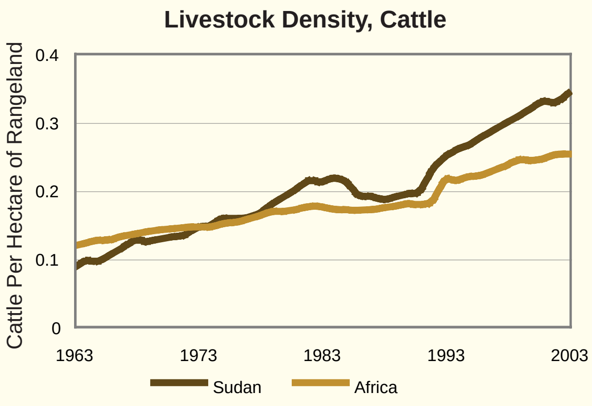
Slum population as percentage of urban



Sudan is the largest country on the African continent; likewise, its Sudd Wetland—one of the largest tropical wetlands in the world—is Africa's largest.

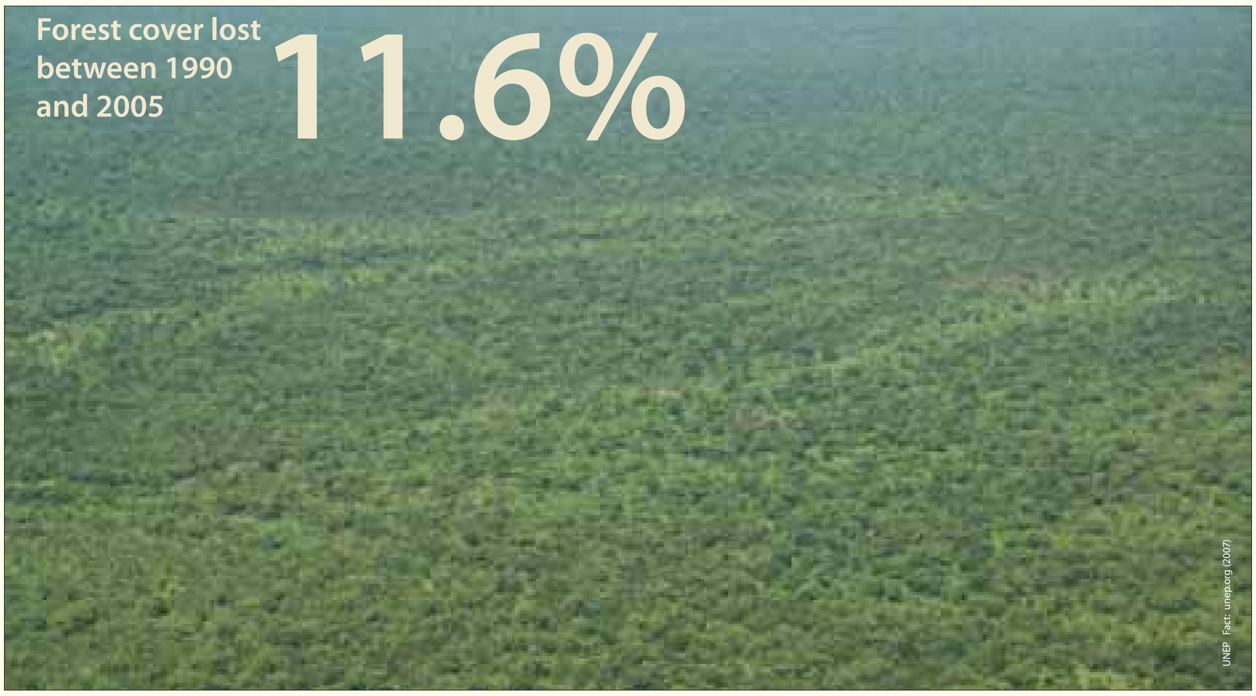
ramsar.org (2006)

Soil Erosion and Land Degradation



Source: Earth Trends (from FAOSTAT)

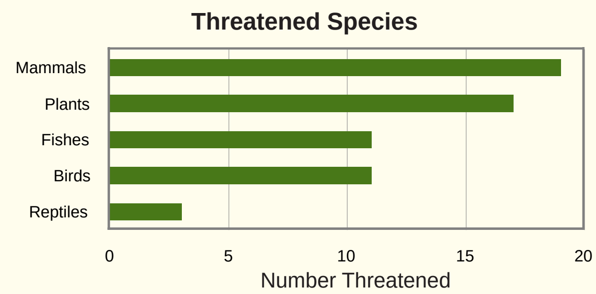
In the agricultural areas surrounding the Nile River, population densities reach 370 people per square kilometre (Salih 2001). Sudan is a land of relatively fertile soils and it has the second-largest irrigated area in Africa, which accounts for 11 per cent of cultivated area and over half of all production (FAO 2005ba). However, poor cultivation practices as well as overgrazing have led to pollution and land degradation. Resulting soil erosion has already consumed nearly one-fifth of the storage capacity in the country's four primary dams and damaged irrigation canals. Reduced irrigation capacity has decreased production by up to 40 per cent in some areas (FAO 2005b).



Poaching and the Ivory Trade

The Republic of the Sudan has significant biodiversity, much of which can be found in the tropical south. However, decades of civil war have facilitated illegal poaching, increased subsistence hunting, and thwarted meaningful conservation measures. Surveys in Boma National Park in southeastern Sudan have found a 75 per cent decrease in wildlife populations since 1980 (USAID 2002).

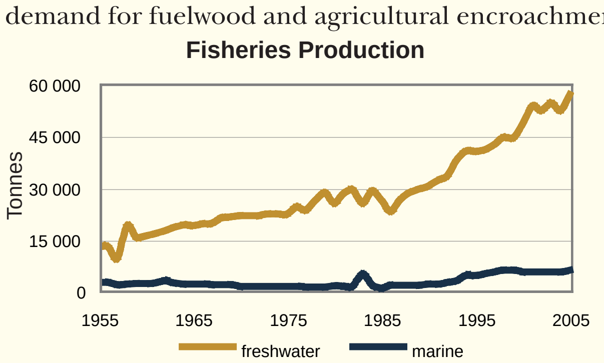
The elephant ivory market in Khartoum is thought to be one of the largest in the world. Sudan accounts for over one-third of elephants' range in eastern Africa, yet fewer than 300 individuals are estimated to remain in the country (Blanc and others 2007). Sudanese poachers have also targeted wildlife in neighbouring countries, such as the rhinos and elephants of Garamba National Park—a UNESCO World Heritage Site—in Democratic Republic of the Congo (Lovgren 2004).



Source: IUCN Red List

Forests and Fisheries

The majority of Sudan's forest resources are located in the country's centre and south, where growing demand for fuelwood and agricultural encroachment contribute to a deforestation rate of nearly one per cent per year (FAO 2005a). It is estimated that crop production advances into virgin forests at a rate of 3 000 km² per year (Salih 2001).

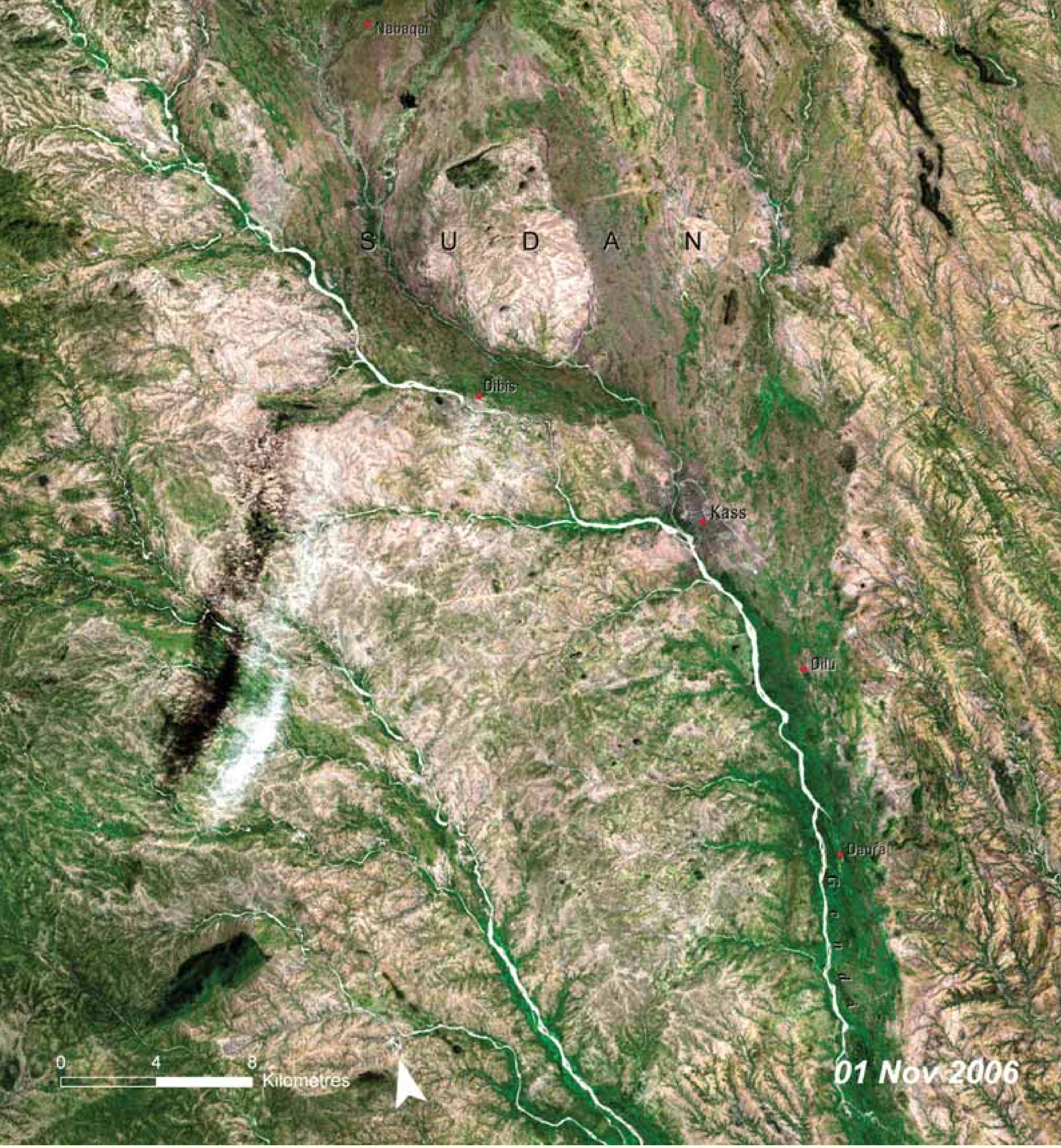


Source: FISHSTAT

Inland fisheries account for 90 per cent of the total fish catch in Sudan. Some major reservoirs associated with the Nile and its tributaries, such as the Gebel Aulia and Roseires, are being fished at a level close to 90 per cent of their estimated capacity. Marine fisheries along Sudan's Red Sea coast, however, are thought to be underexploited, with only half of their estimated potential fish stocks currently being utilised (FAO 2000-2007).

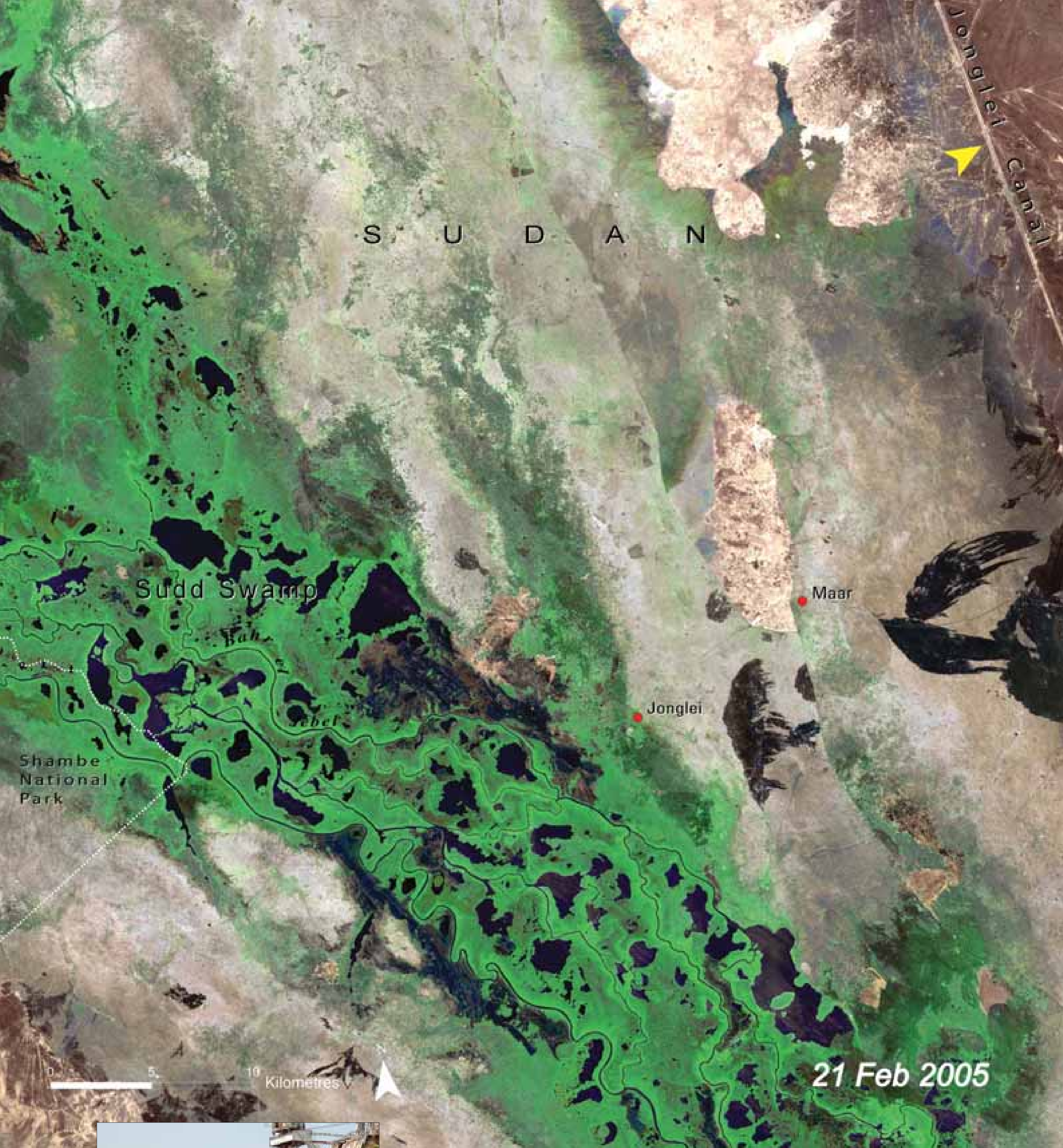
Tree Loss in the Foothills: Jebel Marra, Sudan

The Jebel Marra Massif is a region of high, jagged peaks and fertile valleys in western Sudan. The southern foothills of the Jebel Marra receive an average of 600 to 800 mm of precipitation annually, just above the minimum needed to support rain-fed agriculture. Crops include sorghum, millet, groundnuts, and cowpeas that are raised along watercourses and adjacent areas. Pastoralists seasonally graze their cattle on the natural vegetation in the region; the number of grazing herds has increased in recent decades as droughts have made water and pasture scarce further north.



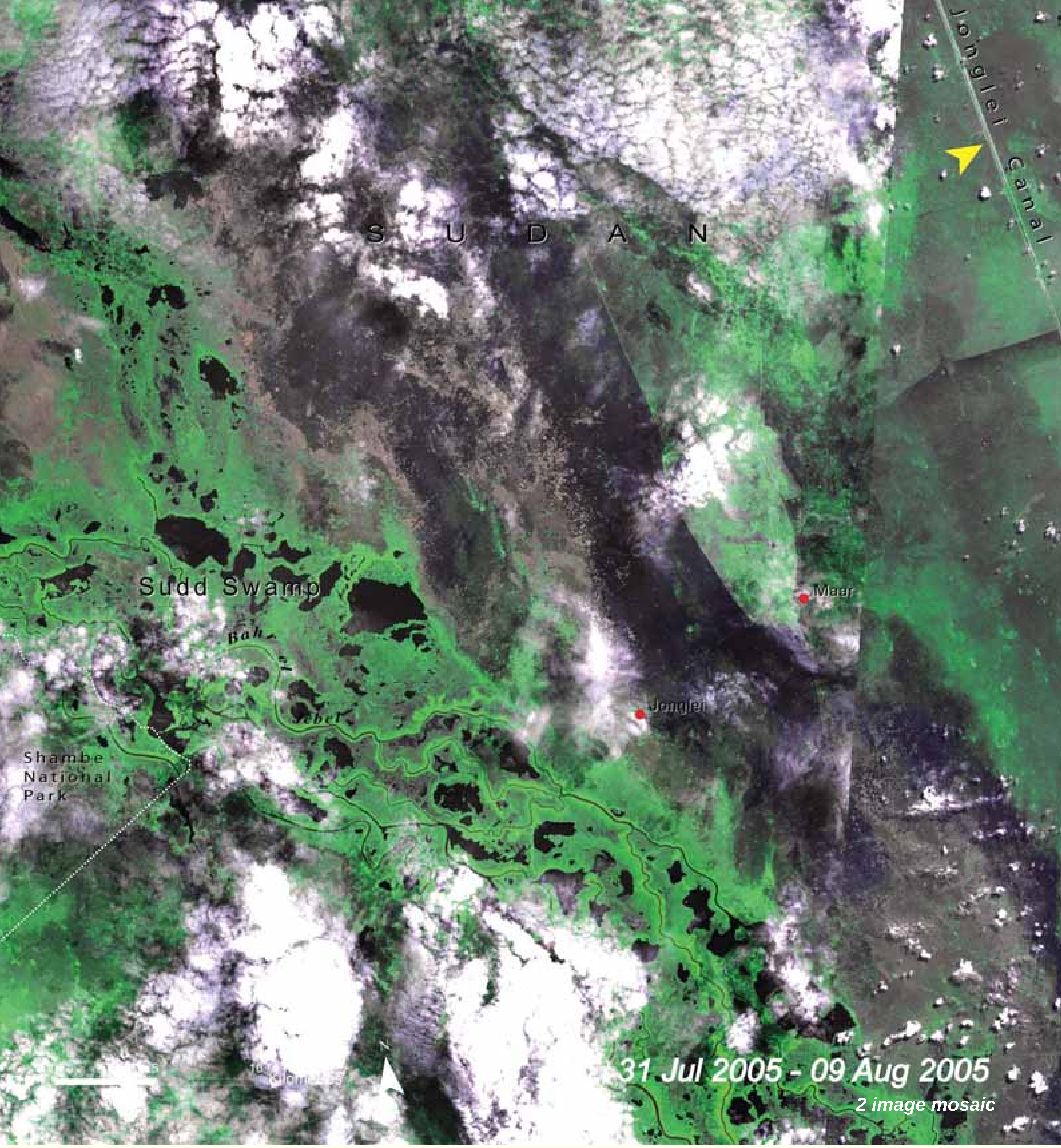
Population growth , especially in the latter half of the 20th century, coupled with an influx of refugees from drought and conflict in Northern Darfur have put increasing pressure on this fragile ecosystem. Human activities have greatly altered the natural open-savannah woodlands.

The 1972 image shows substantial tree cover across much of the lower left half of the image. The 2006 image shows the degree to which vegetation has been reduced, particularly in the less hilly areas and away from croplands concentrated along the watercourses. The loss of trees and shrubs in this fragile environment is leading to land degradation and reduced capacity to support the area's ever-increasing population.



Flooding and the Jonglei Canal: Sudd Swamp, Sudan

The Sudd is a vast wetland ecosystem in southern Sudan where the Nile River meanders for nearly 645 km through the landscape. During the dry season (February 2005 image), the wetlands contract to approximately 8 300 km^2 of permanent swamp. During the wet season (July/August 2005 image), the Sudd floods, expanding to cover 80 000 km^2. This annual pattern of water rising and receding shapes the entire ecosystem and is crucial to the survival of the wetlands' plants and animals and to the nomadic lifestyle of the Nuer, Dinka, and Shilluk people who live in the region.



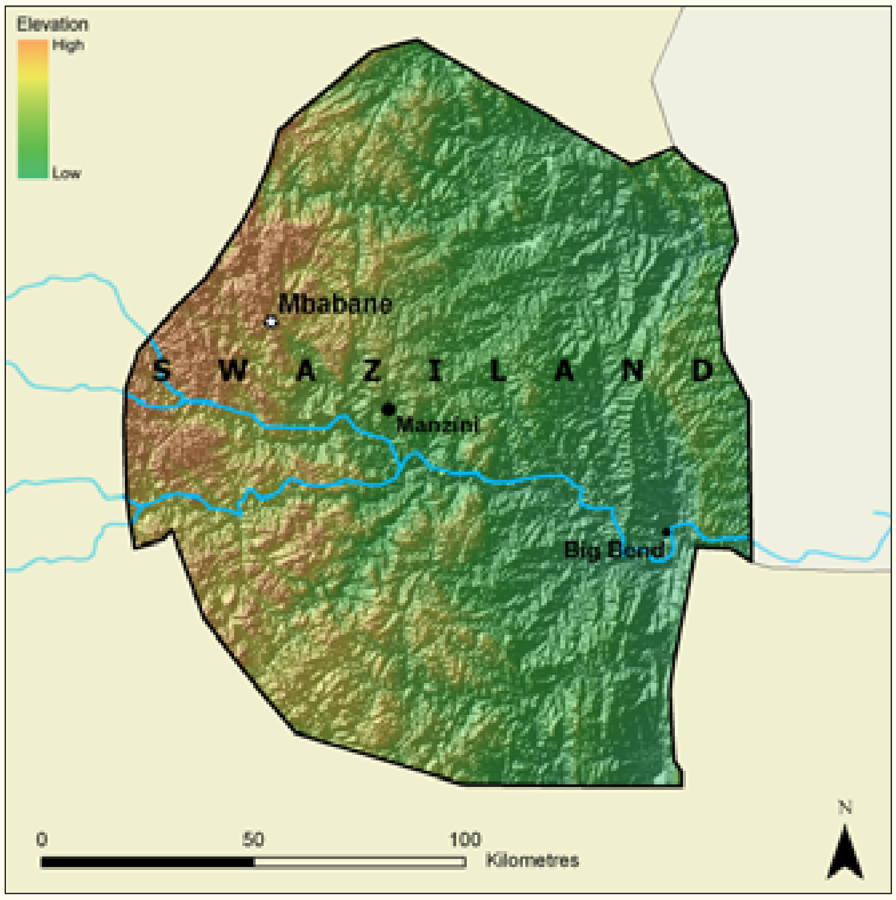
The Jonglei Canal project (yellow arrow), begun in 1978, was designed to speed the movement of Nile water around the Sudd wetlands, reducing evaporation and making more water available downstream. Despite the possible downstream benefits, the proposed 360-km canal could have a devastating effect on the wetlands of the Sudd. Recent studies also show that the project could impact the regions's climate, groundwater recharging, and water quality as well.

Construction of the canal stopped in 1983 because of armed conflicts in the area during the second Sudanese civil war. This conflict has now ended and plans to resume the canal's construction are being evaluated. Efforts to preserve the wetlands received a major boost in 2006 when the Sudd was added to the Ramsar List of Wetlands of International Importance.

Kingdom of Swaziland

Total Surface Area: 17 364 km²
Estimated Population in 2006: 1 029 000

Swaziland is a small, land-locked country surrounded by South Africa on three sides and by Mozambique to the east. The population is three-quarters rural, with the majority of the residents engaged in subsistence agriculture (FAO 2005). Swaziland has a unique system of land tenure, with 46 per cent of the country owned by private individuals and the remainder occupied by communal lands managed by the government (FAO 2005).



Important Environmental Issues

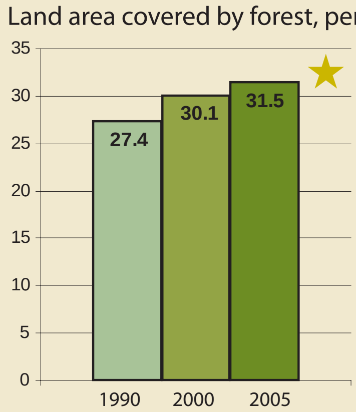
- Population Encroachment and Land Degradation
- Irrigation and Soil Degradation
- Threats to Biodiversity and Invasive Alien Species

Progress Towards Environmental Sustainability

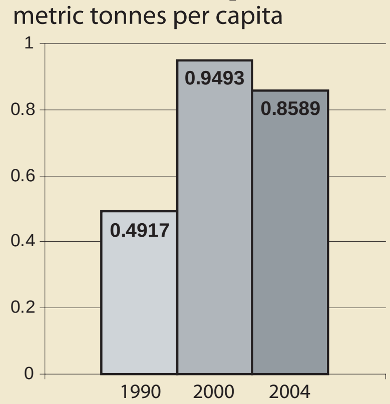
As defined by the United Nations Millennium Development Goal 7 Indicators

Swaziland's major environmental problems are soil erosion and land degradation, particularly because of overgrazing. Air pollution from transportation vehicles and emissions from other countries in the area is another significant environmental concern. Grassland, savannah, mixed bush, and scrub cover most of Swaziland. There are some forests in the highlands, which have seen a small but steady increase since 1990.

Land area covered by forest, percentage

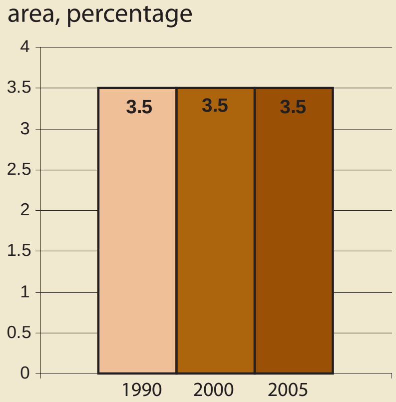


Carbon dioxide (CO_2) emissions, metric tonnes per capita



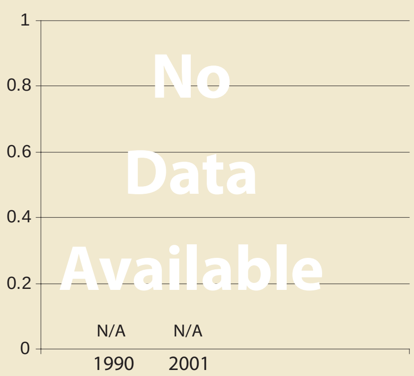
★ Indicates progress

Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

Slum population as percentage of urban

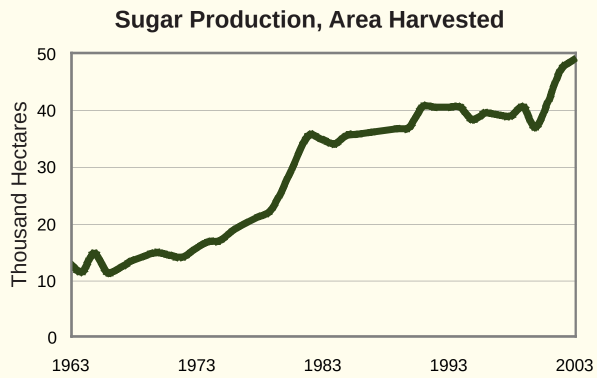


Swaziland has 1 400 km² of forest plantations, which cover 8.1 per cent of the country's total land area.

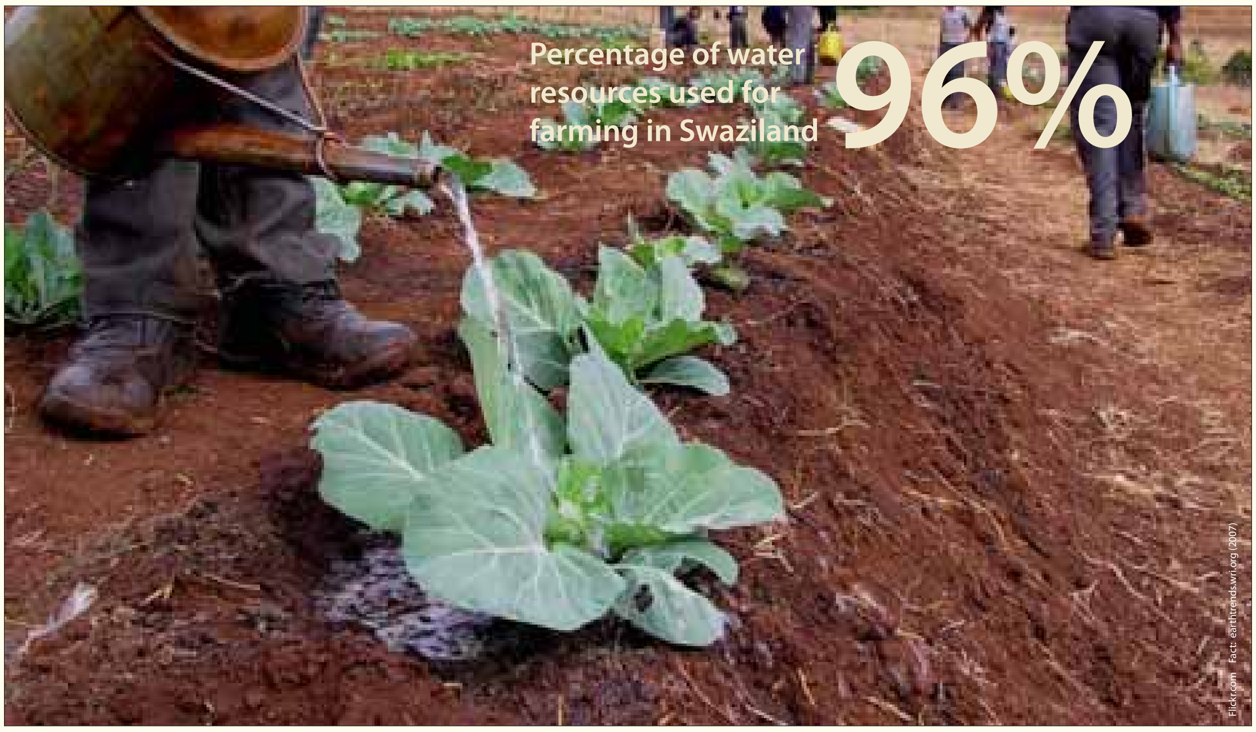
fao.org (2003)

Population Encroachment and Land Degradation

Agriculture accounts for 80 per cent of total land use in Swaziland and is the principal driver of land degradation. Overgrazing is a dominant factor, particularly on communal lands, where more than half of soils are seriously affected by soil erosion (SoE 2001). Rapid population growth has also added to the land degradation problem by putting increased pressure on land resources for shelter and food production. The population density in Swaziland has nearly quadrupled since 1950 (UNESA 2005) and sugar plantations have subsequently claimed an additional 520 km^2 of virgin savannah ecosystems (SoE 2001).

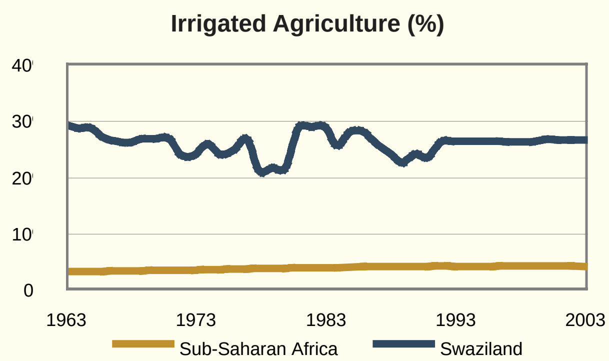


Source: FAOSTAT



Irrigation and Soil Degradation

Irrigation accounts for over 95 per cent of total water use in Swaziland, and irrigated cropland for roughly one-quarter of the total cultivated area (FAO 2005). While irrigation generally increases production levels, the use of poor quality or excessive amounts of water has also led to increased soil salinity and water-logging. In one large sugar plantation alone, more than 2 500 hectares of cropland have been abandoned due to these problems (SoE 2001). To provide for irrigation, Swaziland has already constructed seven large dams and has plans to build more (FAO 2005).

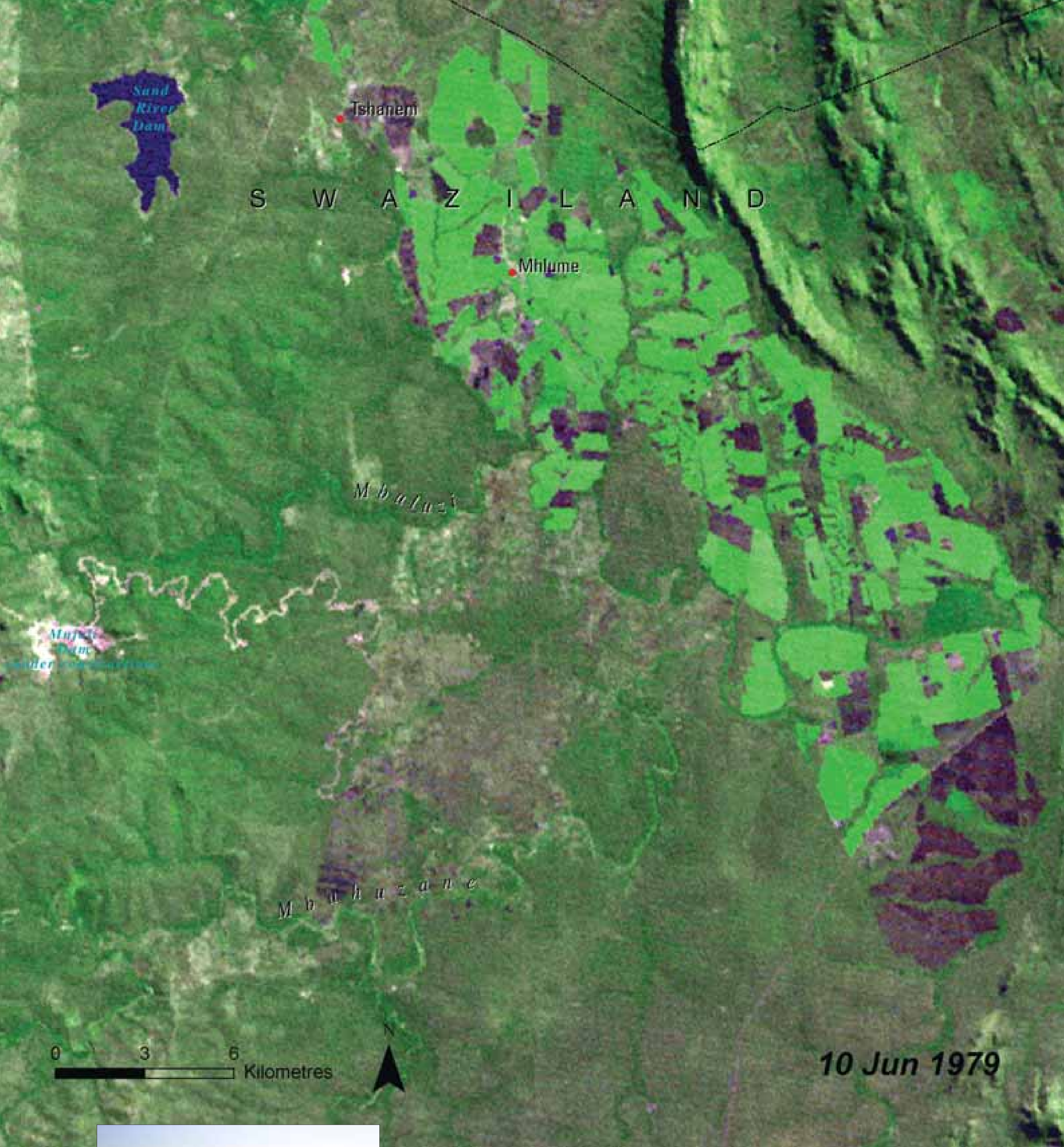


Source: AQUASTAT

Threats to Biodiversity and Invasive Alien Species

Swaziland is topographically and climatically diverse and supports a wide array of unique species and ecosystems of global significance. The eastern region forms part of the Maputaland Centre of Plant Diversity, known for its floral and faunal species richness and endemism. To the west, lies the Drakensberg Escarpment Endemic Bird Area.

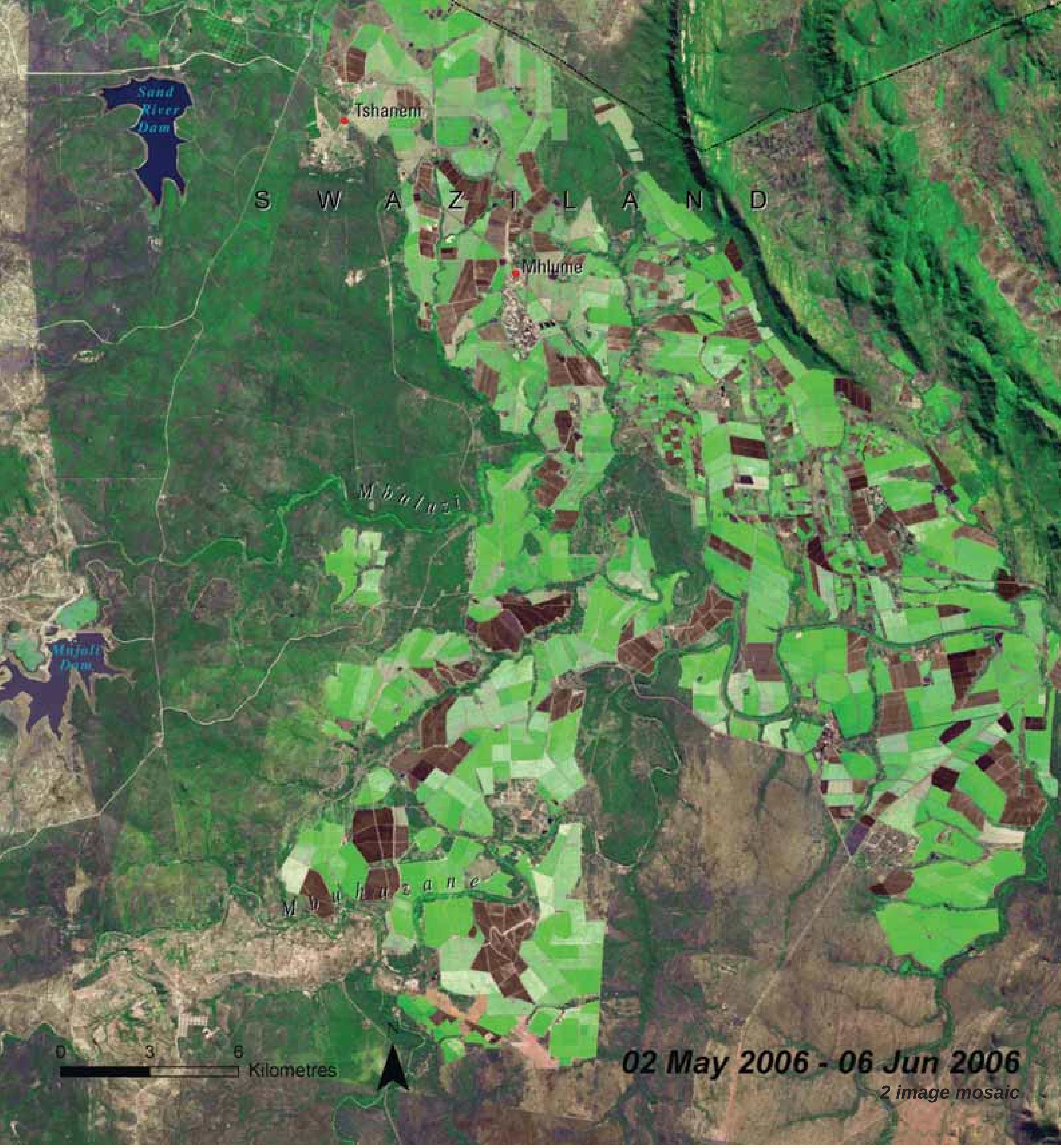
Land degradation and pollution due to agriculture and the recent explosion of invasive non-native plants such as eucalyptus and triffid weed are the greatest threats to Swaziland's biodiversity. Non-native plant species have crowded out indigenous competitors, reducing biodiversity and even impacting agricultural productivity. In 2005, the Swazi government declared invasive alien species a national disaster and committed US$1.4 million to their eradication.



Sugar Cane Farming: Lubombo Province, Swaziland

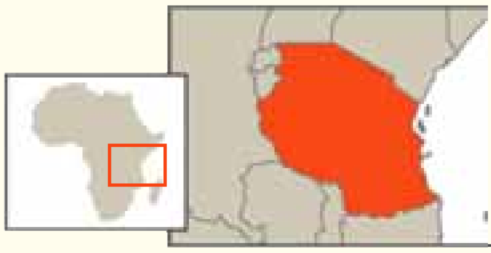
Sugar cane production has become Swaziland's biggest industry as large-scale producers have been joined by hundreds of small-scale farmers. Much of this growth can be attributed to government promotion of sugar cane farming. While this growth has come at the expense of natural flora and fauna, it has brought significant benefits for the eastern province of Lubombo.

Sugar cane plantations are found primarily in northeastern Swaziland where temperatures are optimal. However, this region is also characterized by erratic rainfall with periods of drought; precipitation provides only 25 per cent of the water sugar cane crops need. To meet the sugar



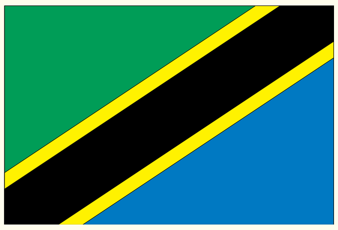
cane industry's remaining water requirements, several dams have been constructed along major rivers, including the Sand River and Mnjoli Dams. These satellite images, from 1979 and 2006, show the dams and how the area devoted to sugar cane plantations has increased over time.

Sugar cane exports bring in roughly US$1 500 million annually to Swaziland. Lubombo Province, in particular, relies heavily on income from sugar cane as well as social services that the industry provides, including medical care, education, housing, and access to clean water. Yet fluctuating sugar prices have prompted the Swazi government to promote the production of other crops. Such a transition, however, is far easier for small-scale farmers than for large-scale producers with extensive plantations.



United Republic of
Tanzania

Total Surface Area: 945 087 km²
Estimated Population in 2006: 39 025 000


Credit: © Flagart.com

United Republic of Tanzania is named after its two principal regions—the large mainland section of Tanganyika and the Zanzibar islands located off its coast. The country is surrounded by several large bodies of water, including 1 300 km of coastline on the Indian Ocean and 2 375 km of shoreline along Africa's three largest lakes; Tanganyika, Victoria, and Malawi (Nyasa) (FAO 2005). Lake Tanganyika, which spans United Republic of Tanzania's western border with Democratic Republic of the Congo, is the deepest lake in Africa (Tanzania National Bureau of Statistics 2005).

Important Environmental Issues

- Water Pollution and Aquatic Ecosystems
- Land Degradation and Deforestation
- Threats to Biodiversity and Ecosystems

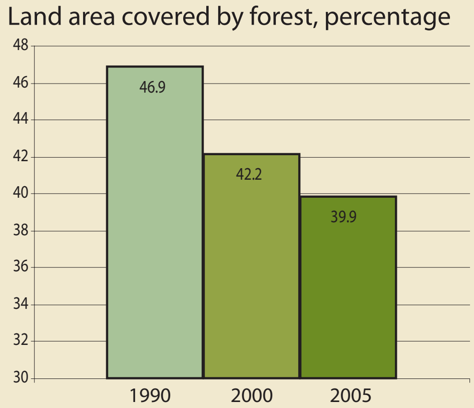
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

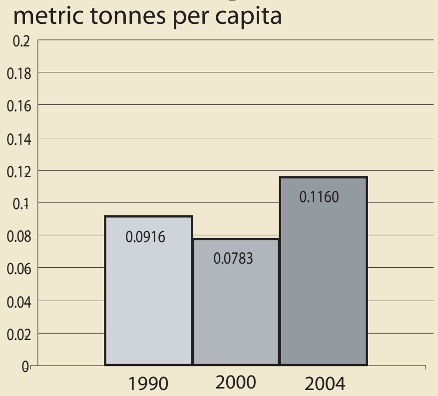
Even though United Republic of Tanzania lost 14.4 per cent of its forest and woodland area between 1983 and 1993, the country is now experiencing a remarkable increase in its forested area. Much of United Republic of Tanzania's environment is protected by a system of national parks. Four of these—Serengeti National Park, Ngorongoro Conservation Area, Kilimanjaro National Park, and Selous Game Reserve—are World Heritage Sites.

★ Indicates progress

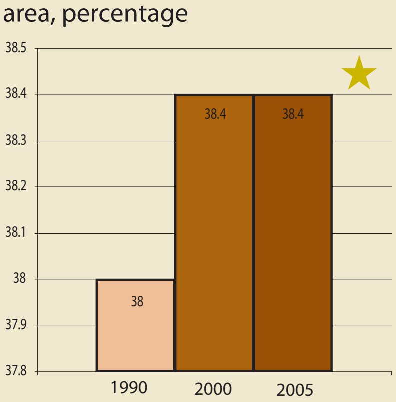
Land area covered by forest, percentage



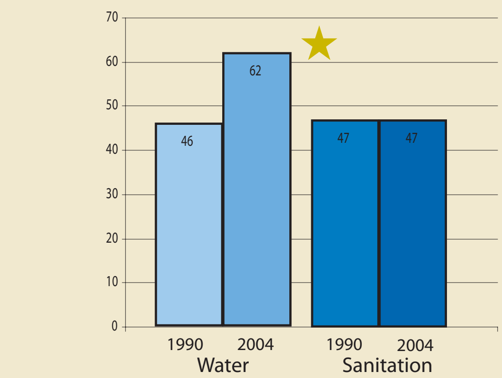
Carbon dioxide (CO_2) emissions, metric tonnes per capita



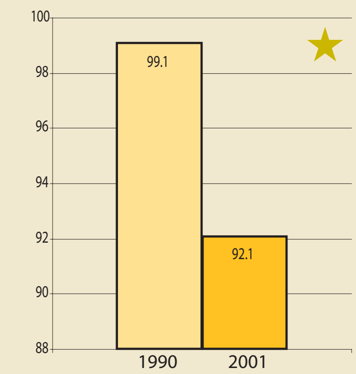
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

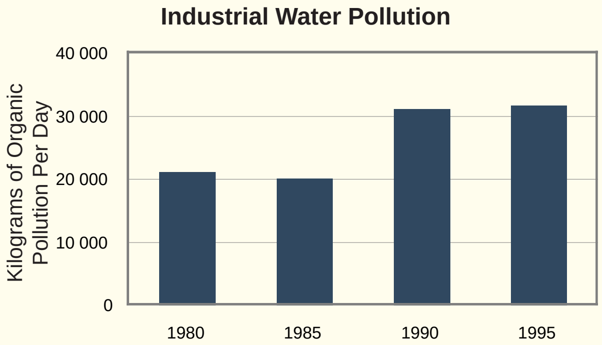


With large numbers of zebra and gazelle and millions of wildebeest, Serengeti National Park is unequalled for its natural beauty and scientific value.

glcom.com (n.d)

Water Pollution and Aquatic Ecosystems

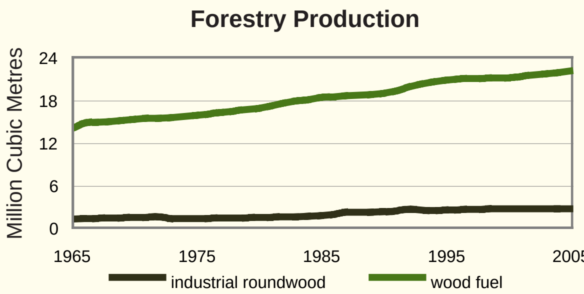
The three largest lakes in Africa—Lake Victoria, Lake Tanganyika, and Lake Malawi (Nyasa)—cover roughly 5.7 per cent of United Republic of Tanzania's total surface area (FAO 2005). Incredibly rich in biodiversity, the lakes are estimated to contain a total of 1 100 endemic fish species (Froese and Pauly 2007). However, pollution from agriculture, industry, mining, and households is threatening the country's water resources. Although the level of industrialisation is low in United Republic of Tanzania,untreated industrial waste causes significant levels of localised pollution. About 80 per cent of the industries, including agro-chemical and chemical industries, breweries and steel manufacturing industries, are located in the coastal Dar es Salaam. It has been estimated that almost 70 per cent of the industries directly or indirectly pollute the Indian Ocean (Mgana and Mahongo 2002). Besides damaging aquatic ecosystems, this pollution also leads to higher incidence of water-borne diseases.



Source: Earth Trends (from World Development Indicators)

Land Degradation and Deforestation

Currently, 25 per cent of land in United Republic of Tanzania is considered severely degraded (FAO AGL 2003), and unsustainable farming practices, overgrazing, and deforestation continue to remove vegetation and sap soil fertility. Despite the creation of large tracts of protected lands and innovative community-based forest conservation projects, United Republic of Tanzania had the third-largest net loss of forest area in Africa (and the sixth largest in the world) between 2000 and 2005 (FAO 2005b). Primary drivers of deforestation include logging for domestic use and export, agricultural conversion, and demand for fuelwood (Tanzania National Bureau of Statistics 2005).

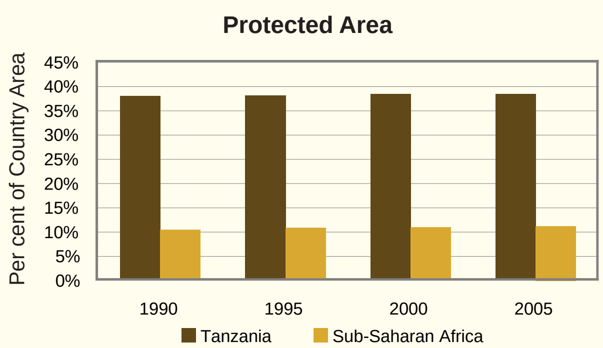


Source: FAOSTAT

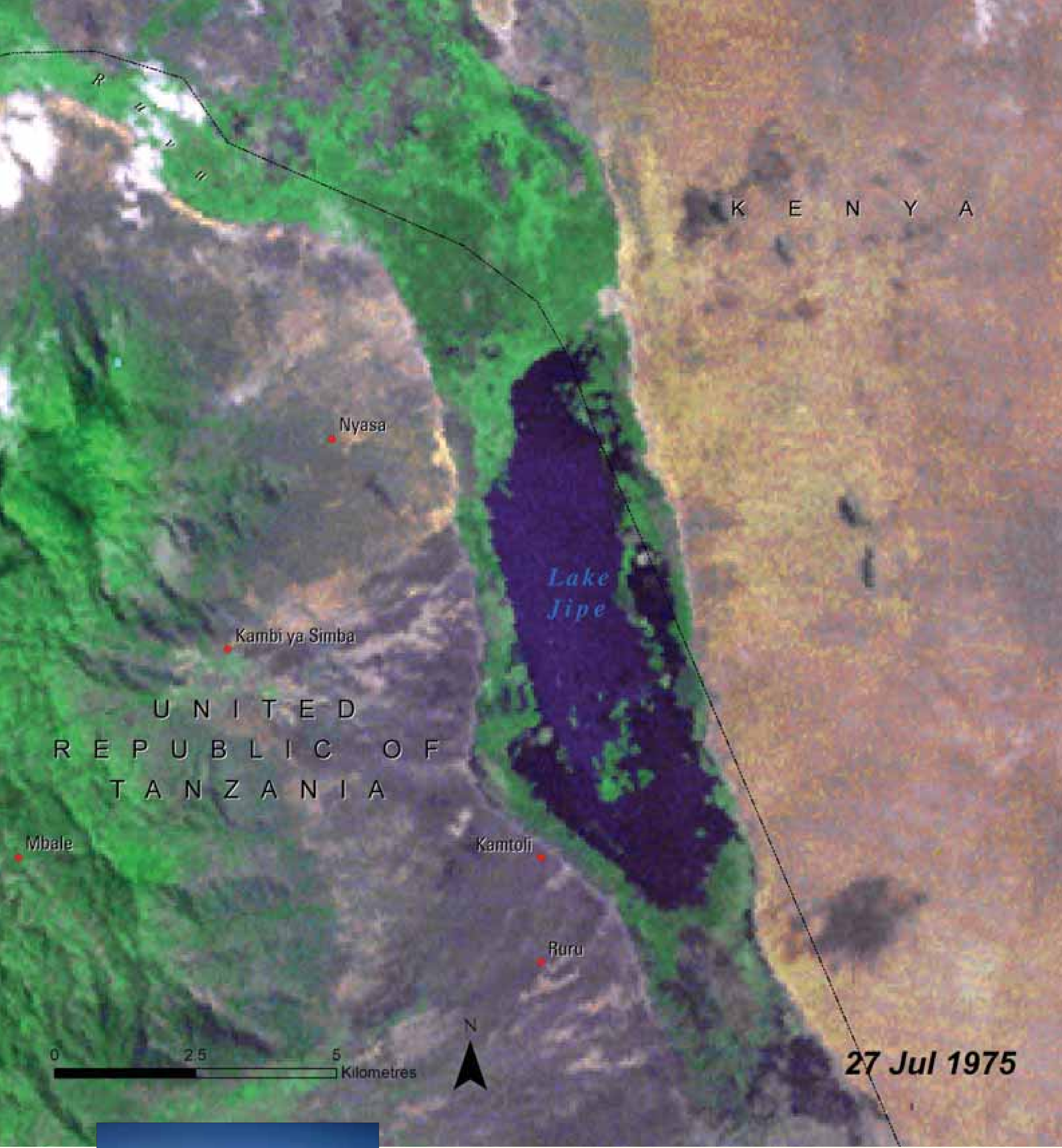
Threats to Biodiversity and Ecosystems

Serengeti National Park is the flagship of United Republic of Tanzania's tourism industry and its ecological and cultural distinction has been recognized by both the World Heritage Commission and the Man and the Biosphere Program. Covering 1.5 million hectares of savannah (UNESCO 2007), the park is famous for the vast herds of wildebeest, gazelles, and zebras that undertake a long and arduous migration to fresh grazing lands each year.

In addition to its terrestrial biodiversity, United Republic of Tanzania's coral reefs are the second largest in Africa, occupying 3 580 km² (Spalding and others 2001) along its coast and nearby islands. The reefs are estimated to contain over 150 coral species (CORDIO 2005), which provide habitat for a host of other aquatic organisms. This rich ecosystem is endangered by over-fishing and anchor damage, increased sedimentation from agriculture and deforestation, and water pollution.



Source: MDG Indicators



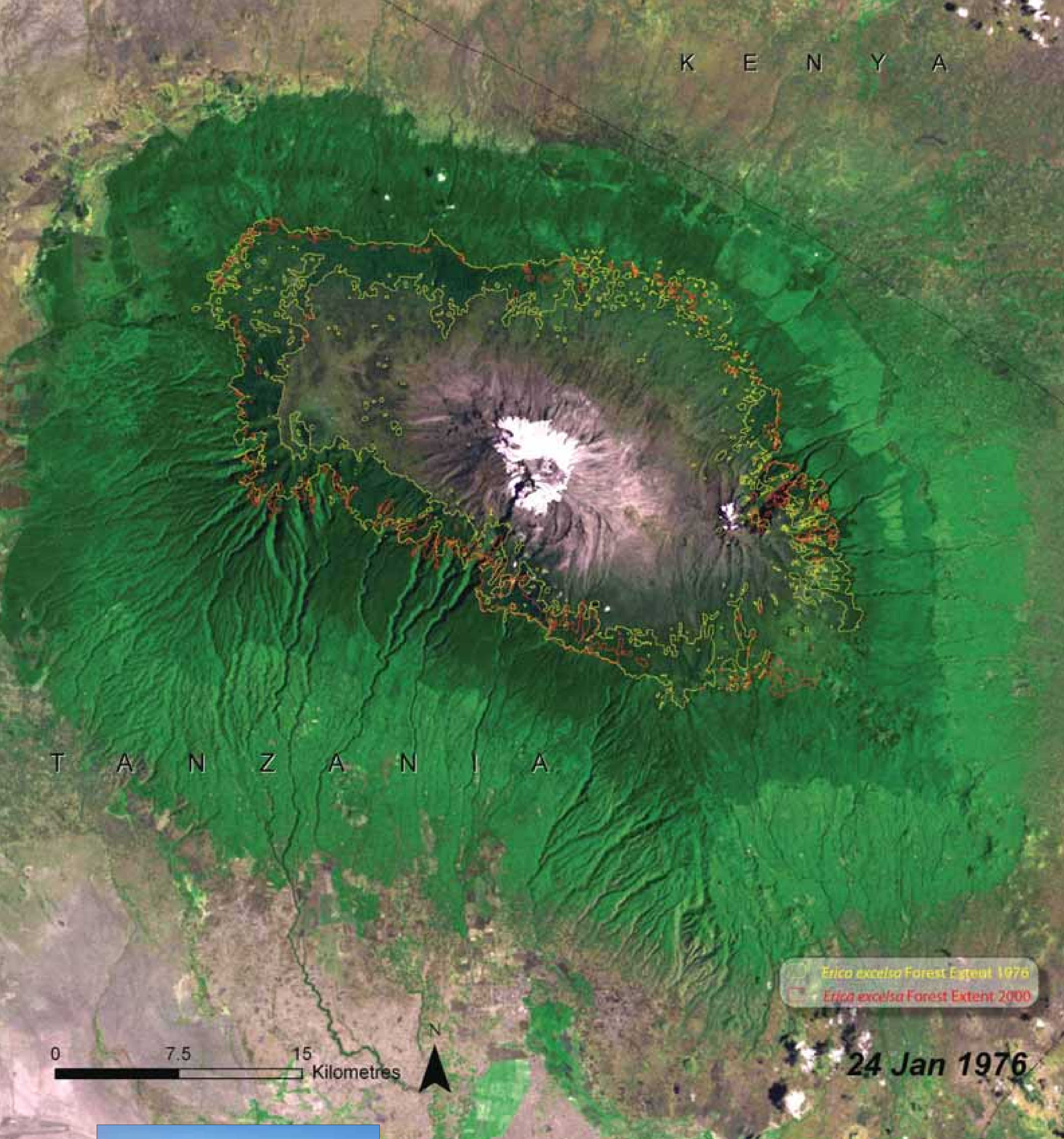
Invasive Plants: Lake Jipe, United Republic of Tanzania

Lake Jipe, along United Republic of Tanzania's border with Kenya, is an important source of the Pangani River. As much of 75 per cent of the lake is infested by invasive aquatic plants, particularly cattails (*Typha domingensis*) and papyrus, or bulrush (*Cyperus papyrus*).

The bright green areas at the waters edge in the 1975 and 2005 images show these invasive plants covering parts of Lake Jipe. Coverage in 2005 is notably more extensive, especially at the northern end of the lake. The greyish patch there is evidence that the lake is actually drying up. Research indicates that if current conditions continue, the lake may dry up completely within the next ten years.

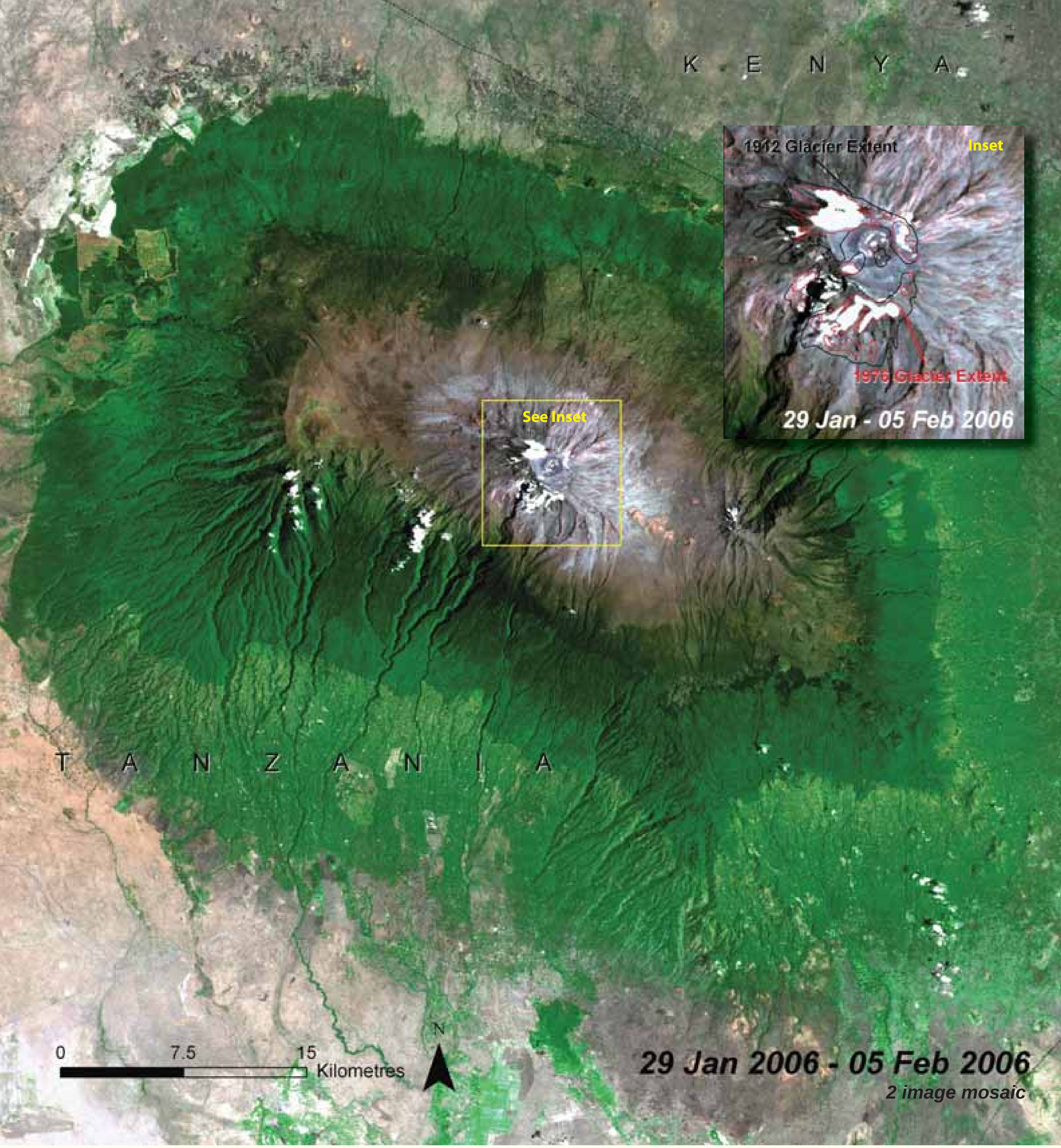
The situation in Lake Jipe is the result of a vicious cycle. Drought reduces water levels in the lake, creating conditions in which the invasive plants flourish. The plants, in turn, encourage siltation and help draw down water levels even further.

The Pangani River Basin provides water for hydroelectric power plants at Nyumba ya Mungu and Pangani Falls, which provide at least 20 per cent of United Republic of Tanzania's electricity. Increasingly low water levels in Lake Jipe and elsewhere have the potential to reduce power production. Low water levels have already affected the local fishing industry, forcing fishermen to move south to the Nyumba ya Mungu Dam. Projected water scarcity may also impact wildlife in Kenya's Tsavo National Park.



Mount Kilimanjaro: United Republic of Tanzania

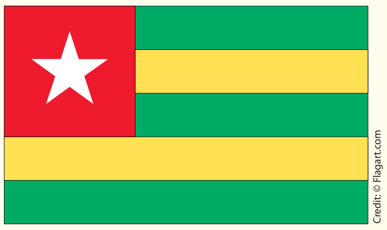
Glaciers on the summit of Mount Kilimanjaro have decreased in area by 80 per cent since the early 20th century. While glacial retreat globally has been linked with rising air temperatures, there is evidence that the decline of Kilimanjaro's glaciers (see inset, above right), along with changes in the boundaries of vegetation zones on the mountain, may be due in large part to a more local trend of decreasing precipitation that began in the 1880s.



It has also been found that water from the melting of Mount Kilimanjaro's glaciers provide little, if any, water to lower elevation streams, as most ice is lost through sublimation; water from the small amount of melting evaporates very quickly. A greater impact on the mountain's hydrology may result from increased burning under the drier conditions since 1880. The upper limit of the forest zone has descended significantly, as nearly 15 per cent of Kilimanjaro's forest cover has been destroyed by fire since 1976. In the 1976 image above, the upper limit of the *Erica excelsa* forest is shown in yellow. By 2000 the upper limit had moved noticeably downslope (red line) as a result of frequent fires. Changes in the hydrological and ecological functioning of Kilimanjaro impact a growing population living on and around the mountain.

Togolese Republic

Total Surface Area: 56 785 km²
Estimated Population in 2006: 6 306 000



Togo is a relatively small country, but its long, narrow shape allows it to span several unique geographic and climatic zones. Half of the population lives in the coastal region, where the climate is tropical and the landscape is dominated by extensive lagoons and marshes. The semi-arid north is characterised by savannah vegetation and is vulnerable to drought.

Important Environmental Issues

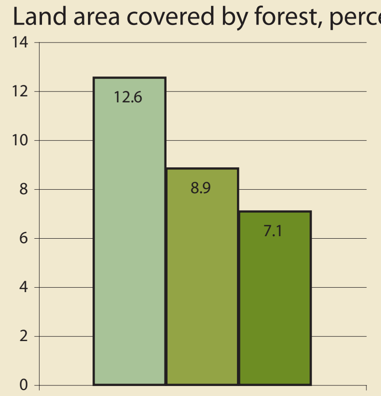
- Land Degradation and Deforestation
- Threats to Aquatic Ecosystems
- Threats to Biodiversity

Progress Towards Environmental Sustainability

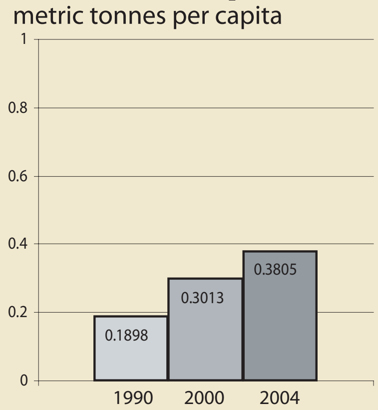
As defined by the United Nations Millennium Development Goal 7 Indicators

Although much of the Togo once was forested, slash-and-burn agriculture and the cutting of wood for fuel have depleted the forest, resulting in the country now having to import wood. Soil and water are threatened by pesticides and fertilizers. The government has taken steps to protect the nation's environment, however, through a comprehensive legislative package.

Land area covered by forest, percentage

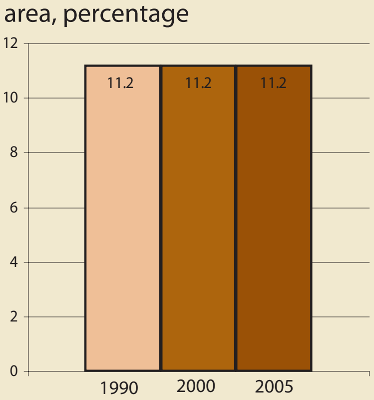


Carbon dioxide (CO_2) emissions, metric tonnes per capita

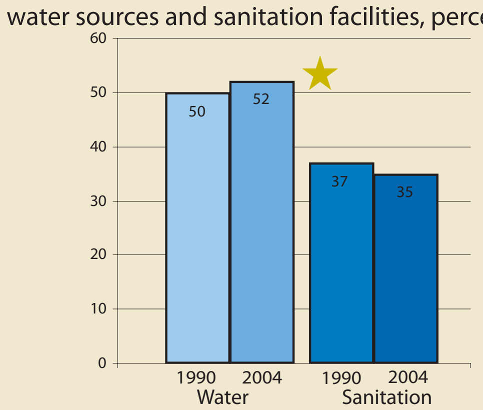


★ Indicates progress

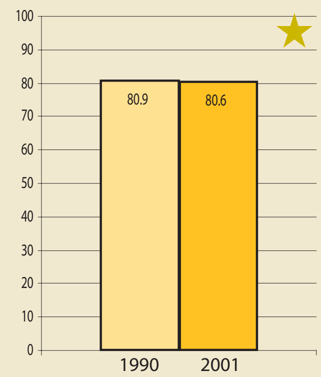
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



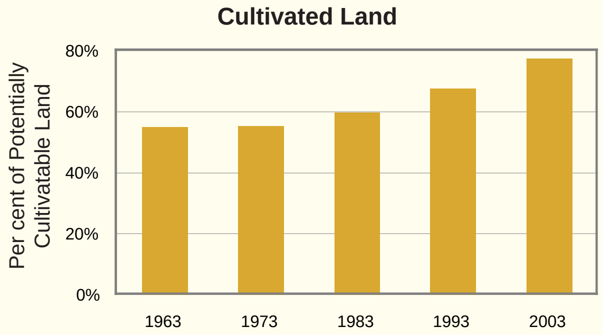
Nearly half of Togo's land is considered arable, making it one of only two countries in Africa with more than 40 per cent of its land suitable for farming.

fao.org (2006)

Land Degradation and Deforestation

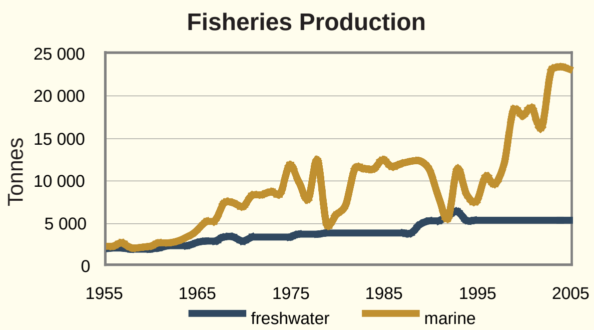
Over half of the total land area in Togo is heavily degraded (FAO AGL 2003). Causes include reductions in fallowing intervals, intensive harvesting of forest resources, and overgrazing. These trends are exacerbated by the country's high population density and the fact that nearly 80 per cent of potentially arable land is already being utilised (FAO 2005).

Forests once covered large areas of Togo, but they now occupy only seven per cent of the country (UN 2007). Forests continue to disappear at a high rate in Africa, causing remaining forest cover to decline by nearly 50 per cent between 1990 and 2005 (UN 2007). Slash-and-burn agriculture and the use of forest products for fuel are the major drivers of deforestation.



Source: AQUASTAT and FAOSTAT

Threats to Aquatic Ecosystems



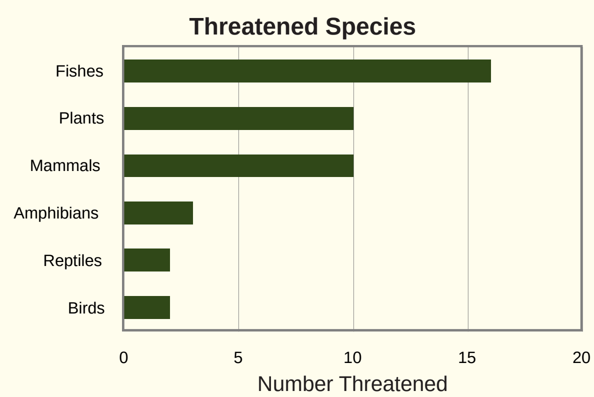
Source: FISHSTAT

Naturally poor soils and agricultural mismanagement have necessitated intensive use of fertilizers, pesticides, and other chemical inputs on farms. Resulting pollution threatens Togo's aquatic environments, which include rivers, lakes, and ocean ecosystems, which harbour over 1 000 aquatic animal species (CBD 2003). Overfishing is another threat to aquatic biodiversity, particularly in the marine sector. Evidence of over-exploitation includes reduced yields and the disappearance of certain species.

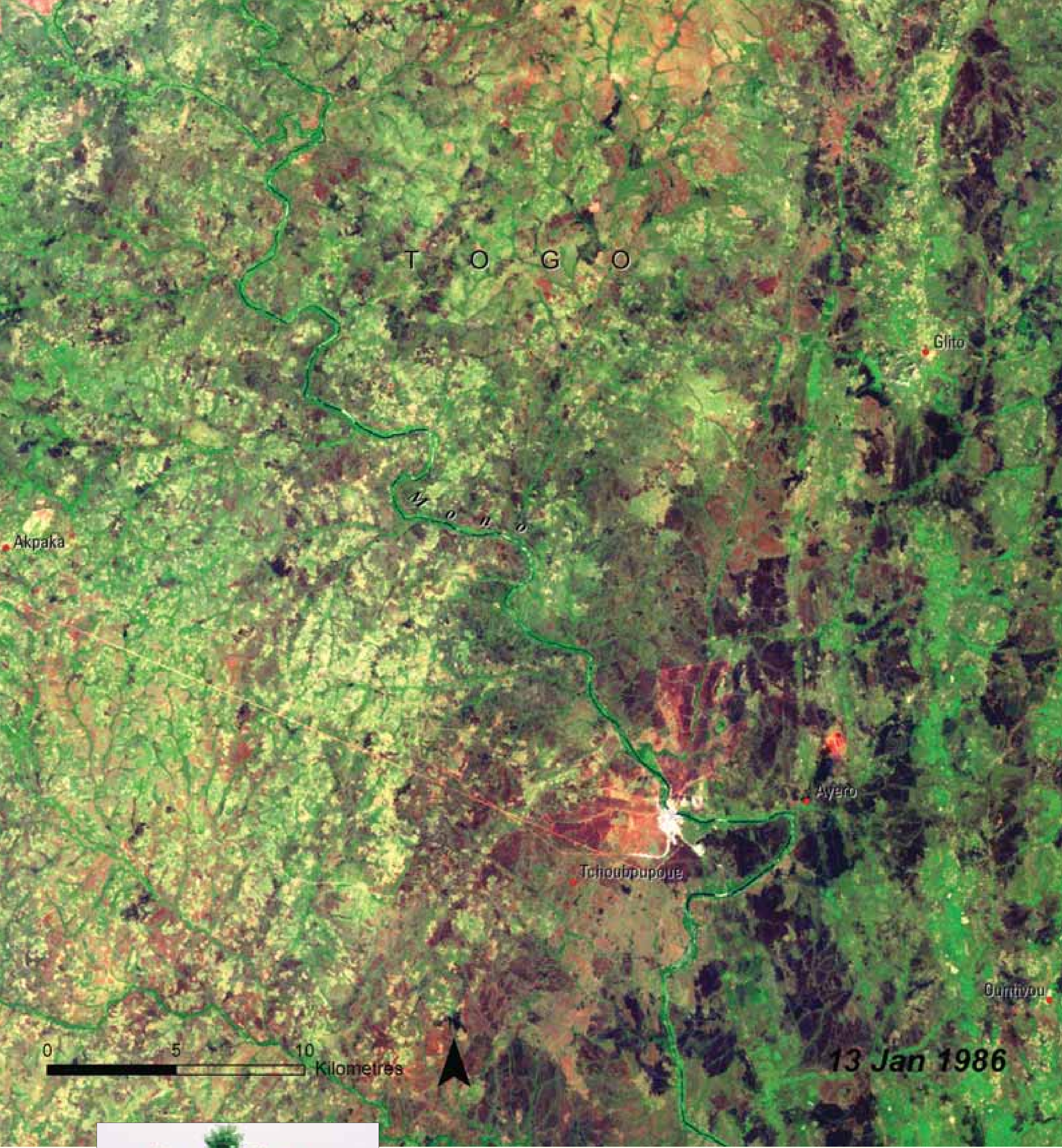
Threats to Biodiversity

Togo is one of the smallest countries in West Africa, but its diverse ecosystems create a land rich in biodiversity. Some 3 472 animal species inhabit the country, including the African elephant, Diana monkey, and West African manatee (CBD 2003).

Protected areas comprise 11.2 per cent of total land area (UN 2007) but are under constant threat from agriculture, poaching, and insufficient institutional and legal enforcement. To address these problems, reserves such as the Missahoè Forest have sought local community involvement to restore and sustainably manage protected lands.



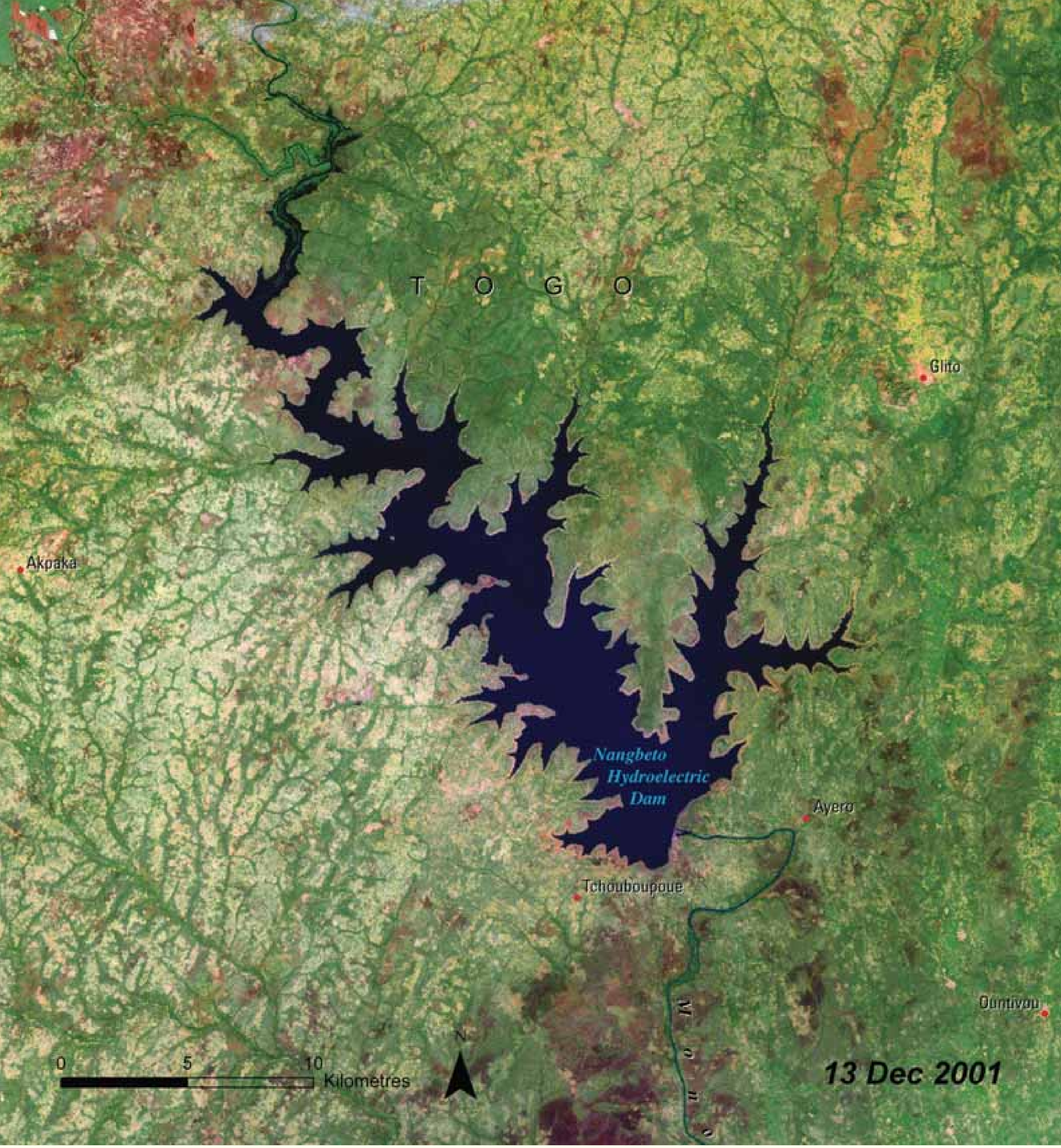
Source: IUCN Red List



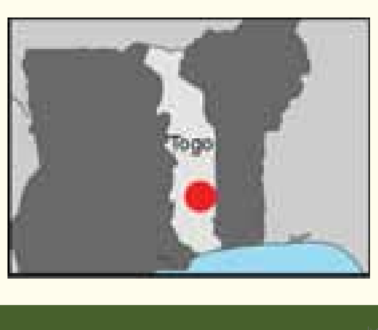
Nangbéto Hydroelectric Dam: Togolese Republic

A feasibility study in the 1960s identified the Nangbéto region as the best location for hydroelectric power development in Togo. The site—160 km upstream from the coast—is the only place where a dam of sufficient volume to regulate the flow of the Mono River was possible. As demand for electricity grew, the decision was made in the 1980s to proceed with the Nangbéto Hydroelectric Dam.

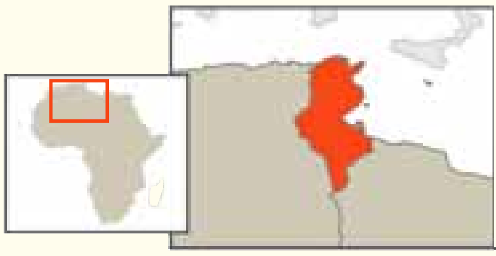
Satellite images from 1986 and 2001 show the region before and after the dam's construction. The completed dam created a reservoir with a surface area of approximately 180



km² and a volume of 1 465 million m³. In addition to generating electricity for domestic and commercial use, the dam also provides water for agricultural irrigation and is a source of commercial fishing and tourism. However, these benefits have been offset by environmental costs.

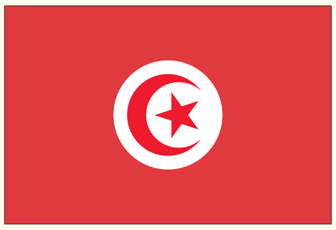


Construction of the dam, creation of the reservoir, and installation of transmission lines resulted in the loss of nearly 150 km² of savannahs and gallery-forests that provided habitat for rare local fauna. The reservoir submerged 1 285 households and 5 500 hectares of agricultural land. Loss of the natural vegetation in the region has altered the climate enough to have had a negative impact on nearly 350 hectares of banana plantations. The creation of the reservoir has also increased the population of two species of aquatic snails that serve as intermediate hosts of the parasite that causes the disease bilharzia.



Republic of Tunisia

Total Surface Area: 163 610 km²
Estimated Population in 2006: 10 210 000



Credit: © Flagart.com

Tunisia is a small country with a relatively long coast sculpted by many natural harbours and inlets. The Atlas Mountain range extends into northern Tunisia and reaches altitudes of 1 500 m. The temperate and hilly regions surrounding these mountains have fertile soils, although irregular rainfall leads to periodic drought. The semi-arid central region merges into the Sahara Desert at the southern tip of the country.

Important Environmental Issues

- Land Degradation and Desertification
- Water Scarcity
- Air and Water Pollution

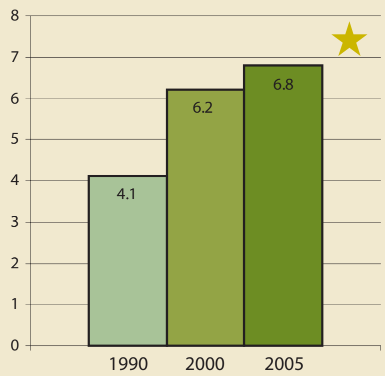
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

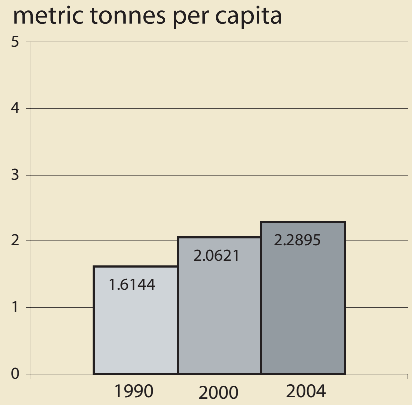
Loss of agricultural land to erosion, which threatens 76 per cent of Tunisia's land area, and degradation of range and forest lands because of overgrazing or overcutting of timber for fuel, are major concerns. Also, pollution from industry and farming activities threatens the nation's limited water supply. Forested lands cover about 510 000 hectares, a large proportion of which is state owned. This may be the reason for a gradual increase in forested area.

★ Indicates progress

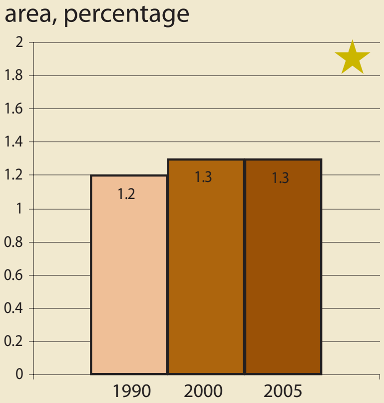
Land area covered by forest, percentage



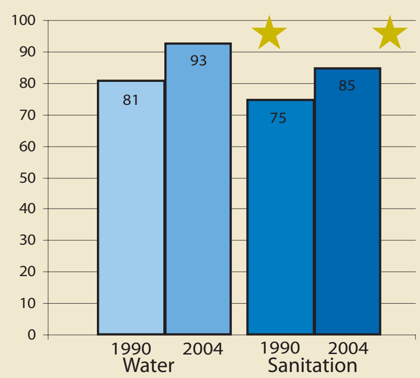
Carbon dioxide (CO_2) emissions, metric tonnes per capita



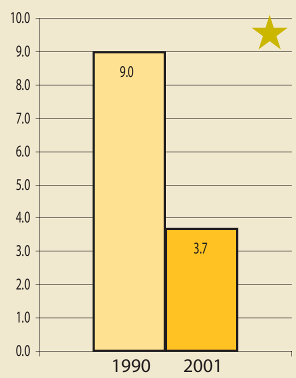
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

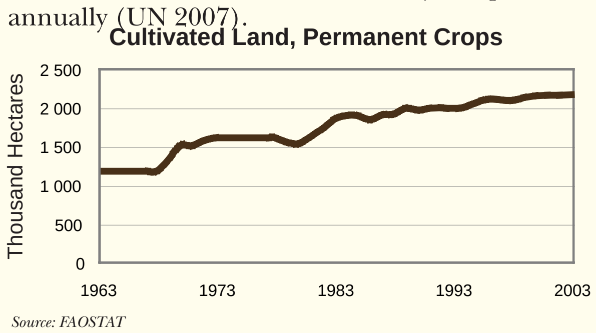


Tunisia's Cape Blanc (Ra's al Abyad) is the northernmost tip of Africa.

fao.org/geonetwork (n.d)

Land Degradation and Desertification

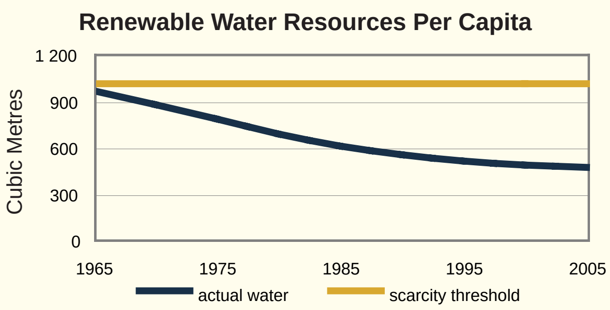
Agriculture is a major driver of land degradation in Tunisia. At least 8 000 hectares of land are lost annually to the encroaching Sahara, costing an estimated US$100 million each year (IUCN and WWF 2003). Approximately one-fifth of Tunisia's land north of the Sahara is affected by salinisation (Mtimet 2004), reducing agricultural productivity and forcing farmers onto rangelands and other marginal soils prone to desertification. Tunisia's forests, currently covering roughly seven per cent of the country, are a critical buffer against continued soil erosion and desertification. Tunisia is one of the few African countries reporting an annual net increase in forest cover, of nearly two per cent annually (UN 2007).



Source: FAOSTAT

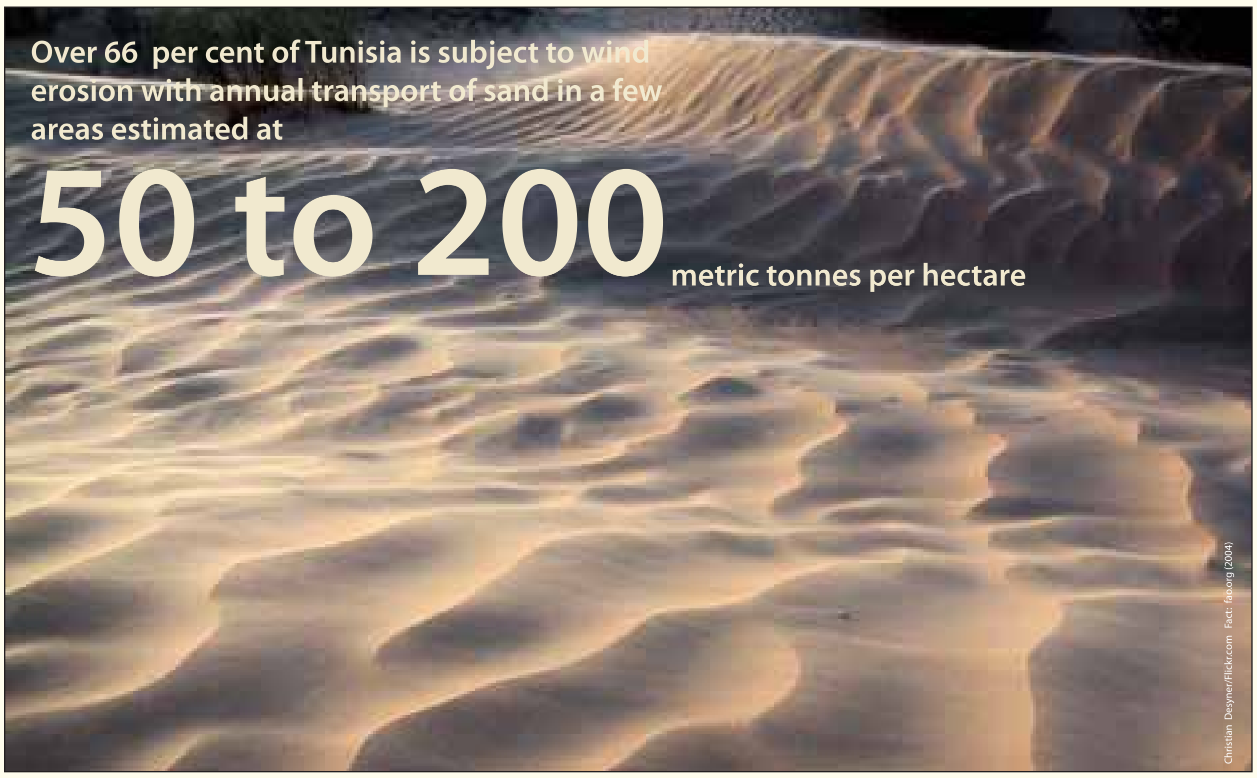
Water Scarcity

Tunisia is one of the most water-scarce countries on the continent, with only 458 m^3 available per person per year (FAO 2007). The north receives the vast majority of rainfall and has over four-fifths of all surface water resources, but even relatively moist regions are subject to drought. Eighty per cent of groundwater resources are already being exploited, primarily for irrigation (Mtimet 2004).



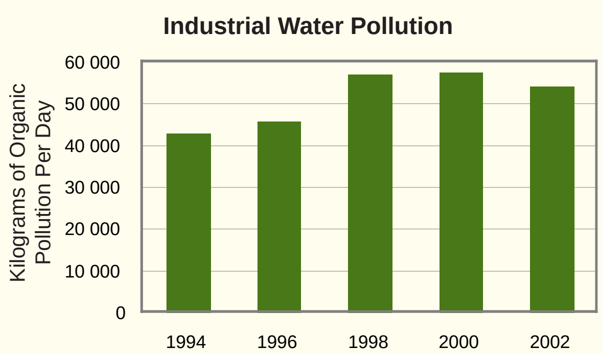
Source: AQUASTAT

Lake Ichkeul, a UNESCO World Heritage Site, is the last remaining freshwater lake in a chain of lakes that once extended along the northern African seaboard. Lake Ichkeul and its marshes are extremely important for migratory waterfowl, but these habitats are threatened by three dams that have substantially reduced freshwater inflow, causing a detrimental increase in salinity (UNESCO-WCMC 2007).



Air and Water Pollution

Tunisia is one of the most urban countries in Africa, with 63 per cent of the population living in cities (UNESA 2006). In the capital, Tunis, air pollution from motor vehicles is a growing issue, although the problem has yet to become severe. In industrial cities, fertilizer manufacturing is a major source of both air and water pollution. Phosphorus mine tailings have contributed to elevated levels of arsenic and heavy metals in Tunisia's only major perennial river, the Madjerda, which eventually feeds into the Gulf of Tunis (Jdid and others 1999).



Source: The World Bank 2006

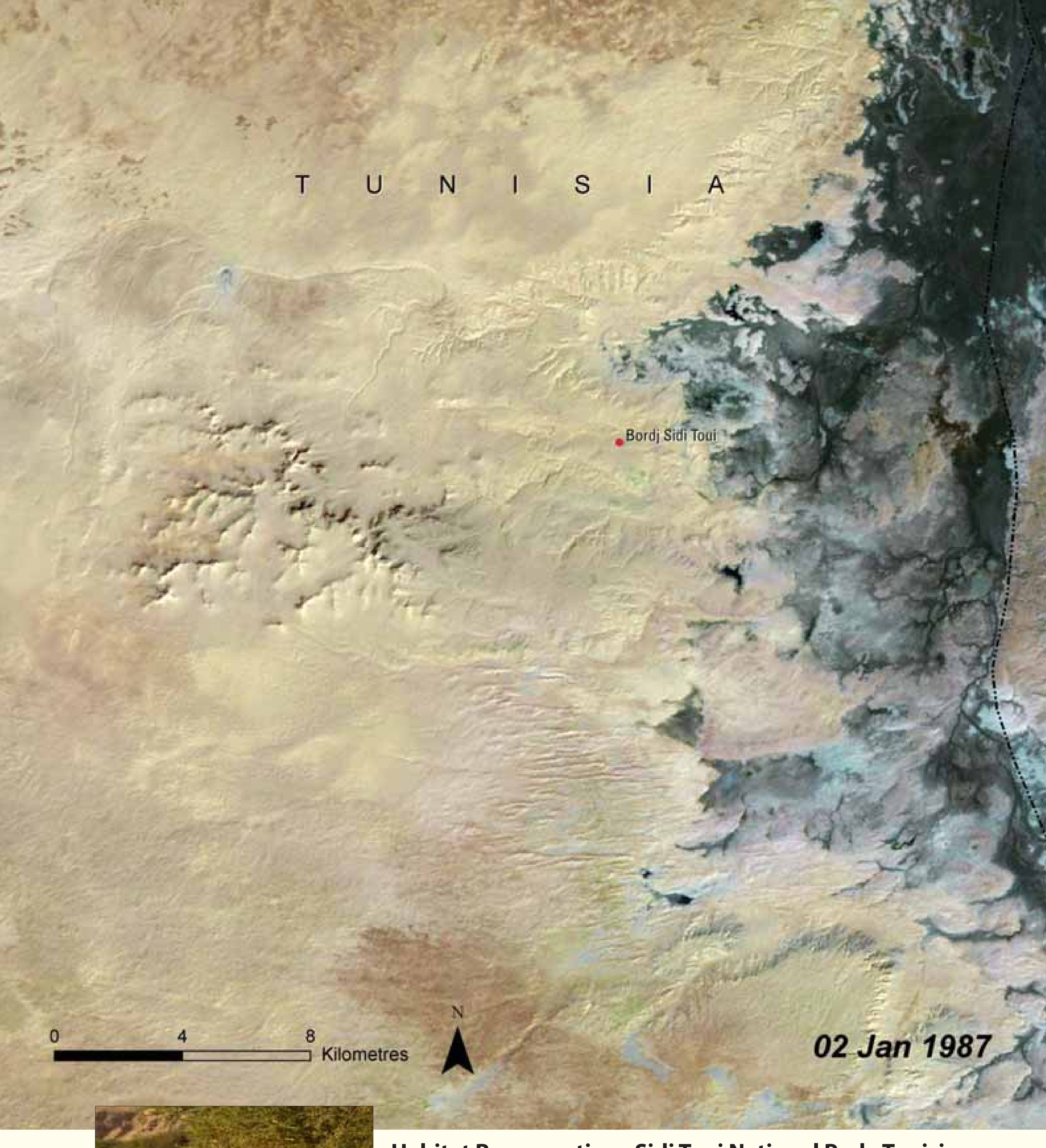
Changes in Lake Ichkeul: Tunisia

Ichkeul National Park includes Lake Ichkeul and surrounding wetlands that form an important wintering and breeding area for migratory birds. It has been designated as a UNESCO Biosphere Reserve and a Ramsar Wetland of International Importance. Lake Ichkeul is fed by seven small rivers but is considered a lagoon because of its connection with the sea via Lake Bizerte (1987 image). During the wet season, Ichkeul fills with fresh water from these rivers. During the dry season, the lake's water level falls, allowing an influx of saltwater from Lake Bizerte. These

alternating conditions create an ideal environment for *Potamogeton pectinatus* (yellow arrows)—a pondweed and principal food source of migratory birds and waterfowl.

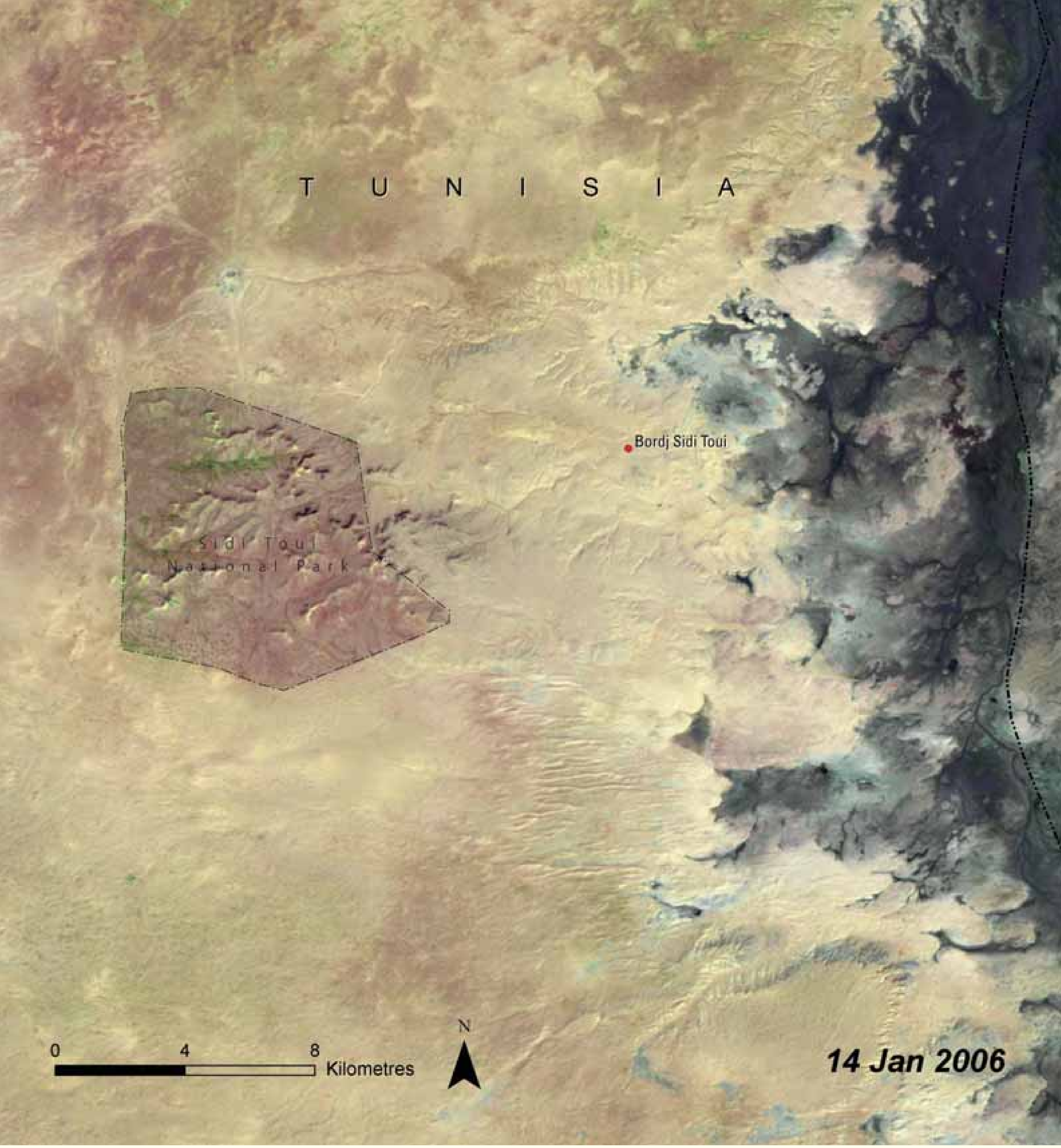
Construction of three dams along rivers that feed Lake Ichkeul modified this fragile ecosystem by decreasing freshwater inflow and increasing salinity during the dry seasons of 1977, 2001, and 2002. Two periods of drought (1993-1995 and 2001-2002) aggravated this trend, leading to a total disappearance of *Potamogeton pectinatus* from 1994 to 2002. In 2002, a mere 10 000 migratory birds came to Lake Ichkeul, the lowest numbers ever recorded.

The Tunisian government responded by increasing water releases from the dams. Helped by favorable rainfall conditions, the *Potamogeton pectinatus* started to recover in 2003, reaching 70 km^2 in 2006 (2005 and 2007 images). Concurrently, migratory birds began returning. In 2004/2005 their numbers had climbed to 30 000.



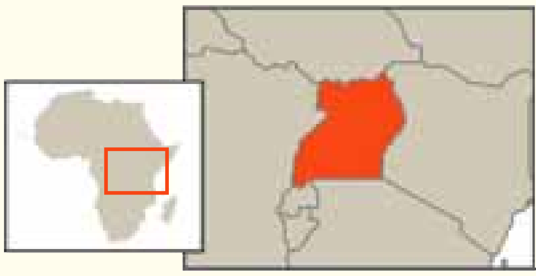
Habitat Regeneration: Sidi Toui National Park, Tunisia

The semi-arid Sahelian grassland and scrub of southern Tunisia has been profoundly altered by human activities during the last century. Located on the northern fringe of the Sahara Desert, this ecosystem is susceptible to erosion and desertification brought on by droughts, overgrazing, and agriculture. In 1993, Sidi Toui National Park was established. Within the bounds of this protected area, natural vegetation began to return. The 1987 image shows the barren condition of the region before the park was created. In the 2006, image the outline of the park, which is protected from



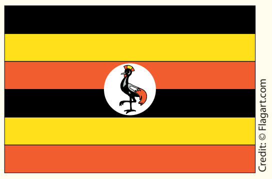
the effects of grazing cattle, contrasts markedly with the surrounding landscape. Protection substantially increased the vegetation density and species diversity, particularly of the grasses.

The Scimitar-horned oryx (*Oryx dammah*) and five other species of gazelles and antelope native to this area had been brought to near extinction by lack of habitat and overhunting throughout the 20th century. Classified as critically endangered in 1996, a small population of Scimitar-horned oryx was introduced into Sidi Toui Park in 1999. If the population inside the park thrives, it may enable future reintroductions of Scimitar-horned oryx elsewhere, Sidi Toui also provides habitat for several native species of antelope, as well as a variety of birds species.



Republic of Uganda

Total Surface Area: 241 038 km²
Estimated Population in 2006: 29 857 000



Uganda is a land-locked country that borders Lake Victoria, the second-largest freshwater lake in the world. Most of the country is fertile and well-watered, with many natural lakes and rivers. Generally, the climate is tropical with one to two thousand millimetre of rain falling annually in two rainy seasons, although roughly seven per cent of the country is classified as arid or semi-arid.

Important Environmental Issues

- Land Degradation and Deforestation
- Habitat Degradation and Threats to Biodiversity
- Water Availability and Pollution

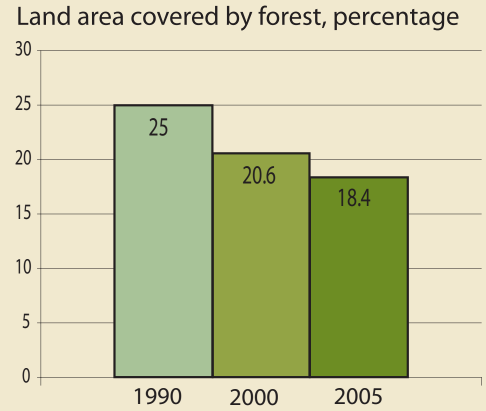
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

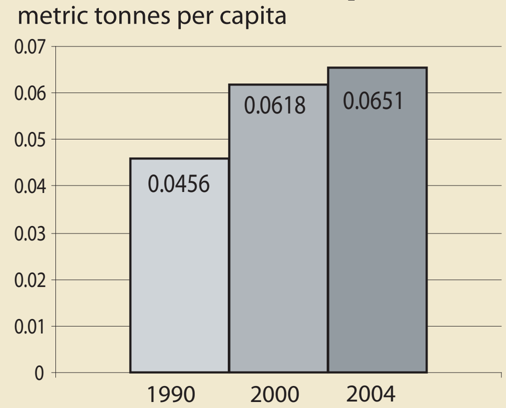
About half of the forested area in Uganda is savannah woodland. Uganda's economy is predominantly agrarian and one-third of the land area is under cultivation. Even wetlands are being drained for agricultural use. Major environmental problems in Uganda include overgrazing, deforestation, and agricultural expansion, all of which lead to soil erosion.

★ Indicates progress

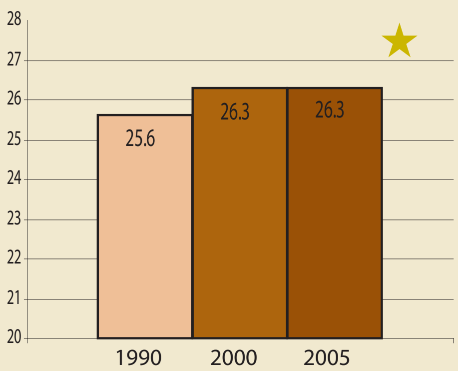
Land area covered by forest, percentage



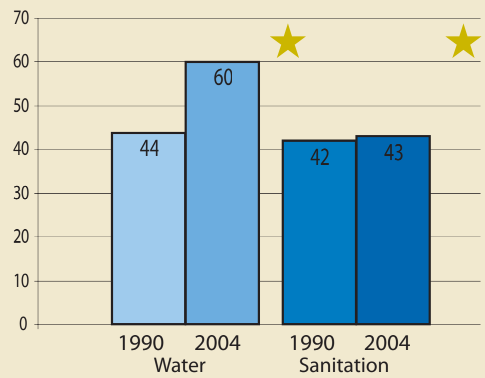
Carbon dioxide emissions (CO_2), metric tonnes per capita



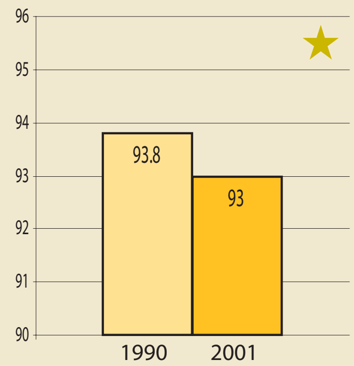
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



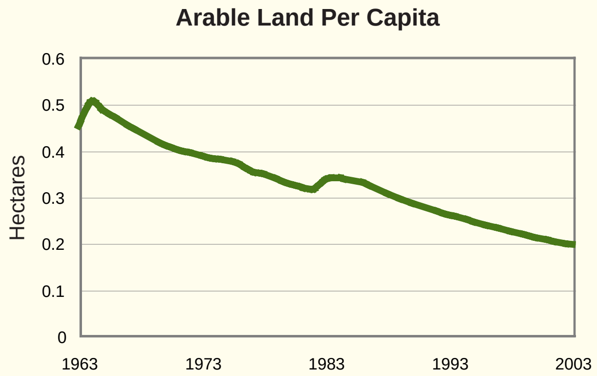
Slum population as percentage of urban



Uganda is home to over half of the World's 720 remaining Mountain Gorilla's (Gorilla beringei beringei). Most of them live in Uganda's Bwindi Impenetrable National Park.

sciencedaily.com (2007)

Land Degradation and Deforestation



Source: FAOSTAT

Seventy-one per cent of Uganda's land area is potentially arable, the largest proportion of any East African country. However, rapid rural population growth, lack of access to improved inputs, overgrazing, and conversion of forests for agriculture have resulted in significant land degradation. Forests are also threatened by harvesting of wood for fuel; over 95 per cent of the population relies on fuelwood as a primary source of energy (WHO 2006). Resulting soil erosion now accounts for over 80 per cent of the total cost of all environmental degradation in Uganda (SoE 2000/2001). In the worst affected districts, over 80 per cent of soil is considered to be severely degraded.

Habitat Degradation and Threats to Biodiversity

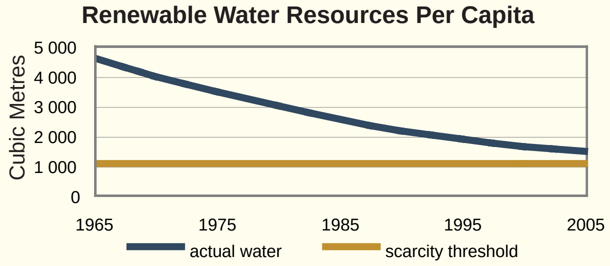
Uganda is home to diverse plant and animal species, reflecting its high variability of landscapes and ecosystems. Threats to biodiversity include poaching, deforestation, conversion and pollution of wetlands, and invasive species.

Bwindi Impenetrable National Park, a UNESCO World Heritage Site, is one of the largest and most biologically rich natural forests in East Africa. Covering 33 000 hectares, it contains over 350 species of birds, 120 species of mammals (including 14 primate species), 200 species of butterflies, and half of the world's remaining 700 mountain gorillas (UNESCO 2007).

	1960	1995/98	% Loss
Antelope	141 300	41 300	70%
Elephant	25 000	1 900	92%
Rhinocerous	600	0	100%
Hippopotamus	26 000	4 000	85%
Rothschild's giraffe	2 500	200	92%
Buffalo	60 000	18 000	70%

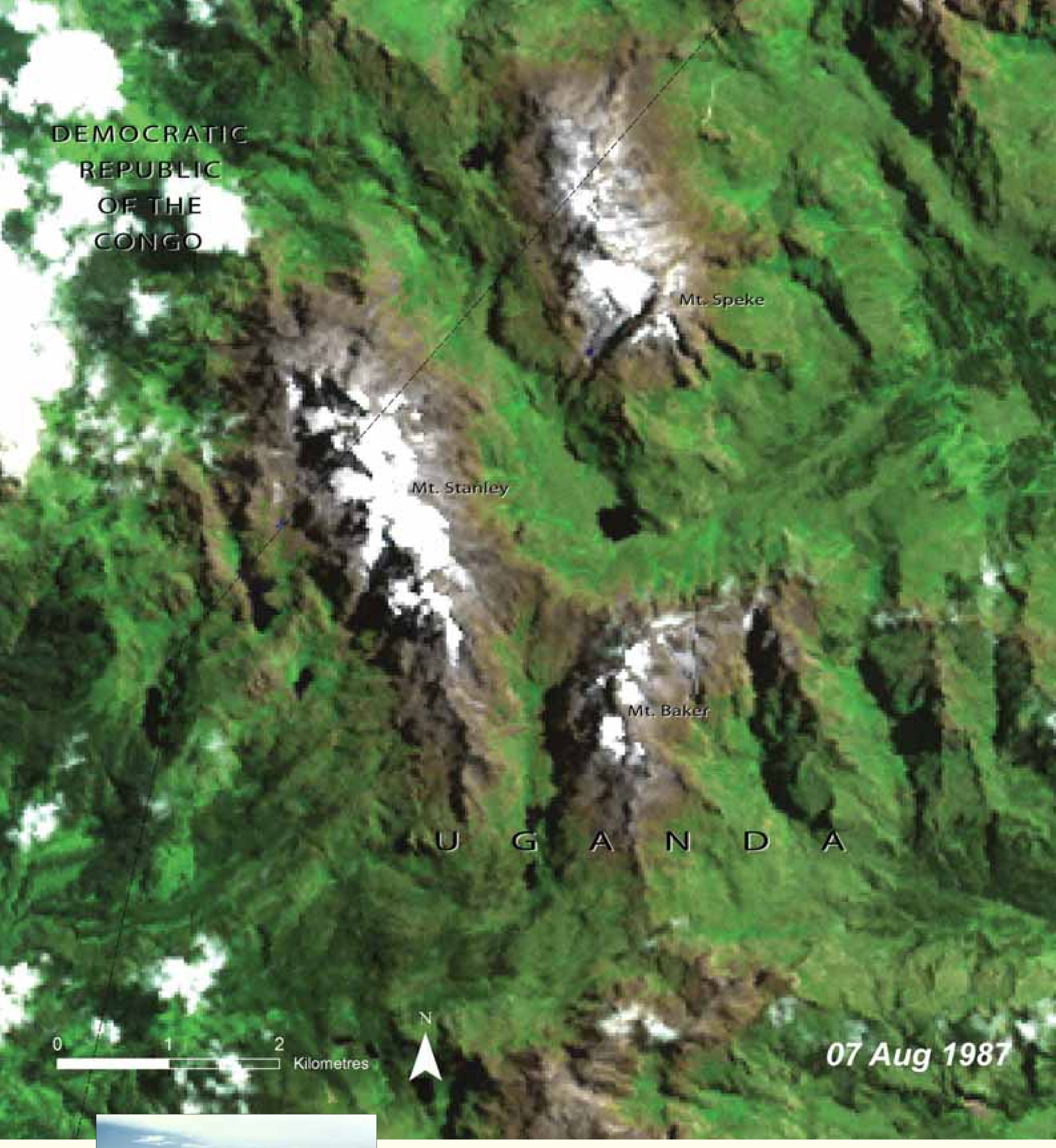
Source: State of Environment Report for Uganda 2000/2001

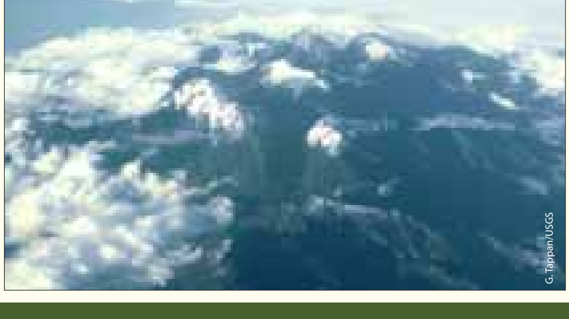
Water Availability and Pollution



Source: AQUASTAT

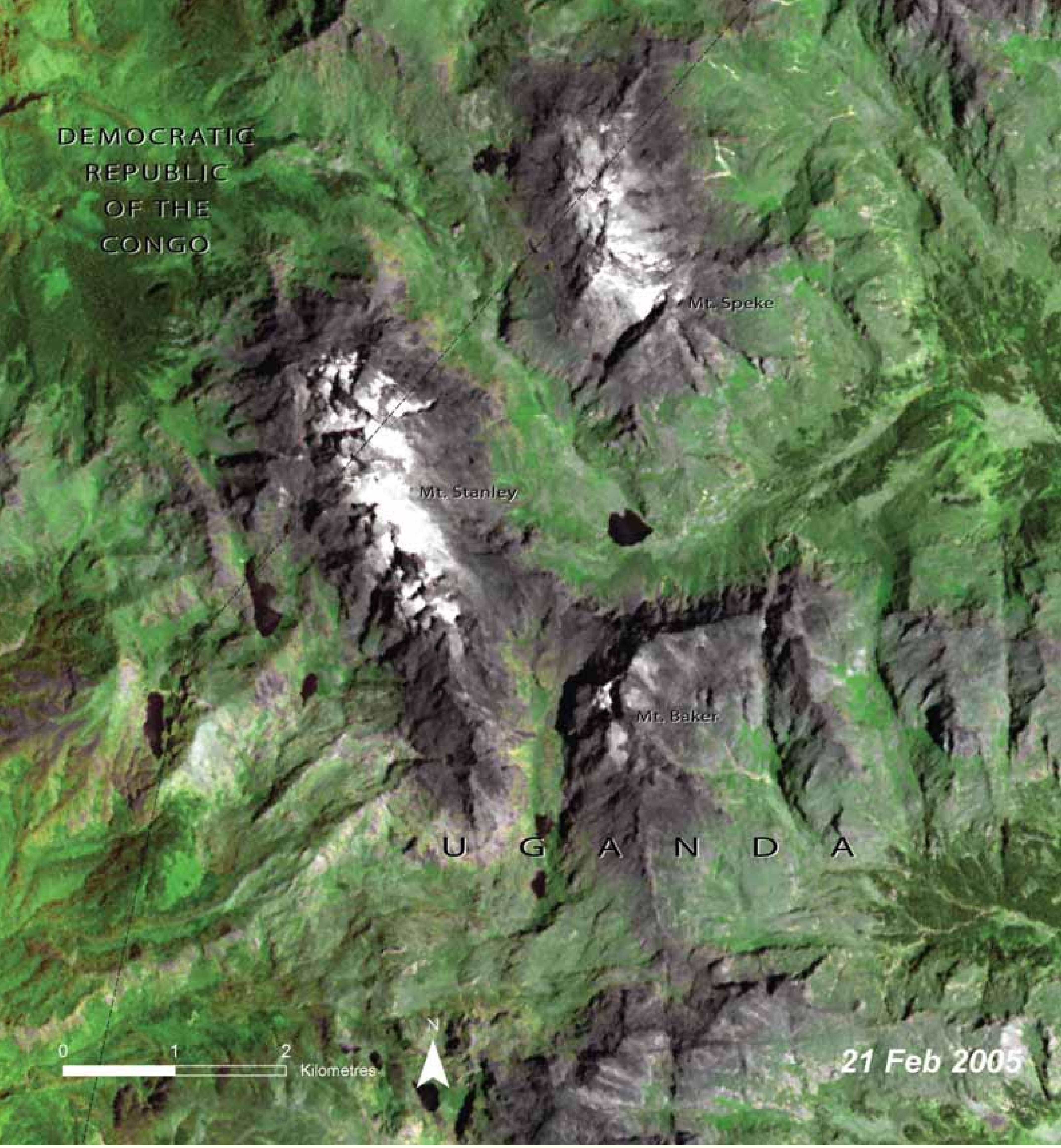
Fresh water accounts for over 15 per cent of Uganda's surface area (FAO 2005). However, rapidly rising demand, uneven distribution of water resources, and pollution have placed Uganda in a state of water stress, with less than 1 500 m^3 of water available per person per year (FAO 2007). Water from available sources principally affected by pollution from residential, industrial, and agricultural discharges into open water bodies is also an area of concern.





Glacial Recession: Rwenzori Mountains, Uganda

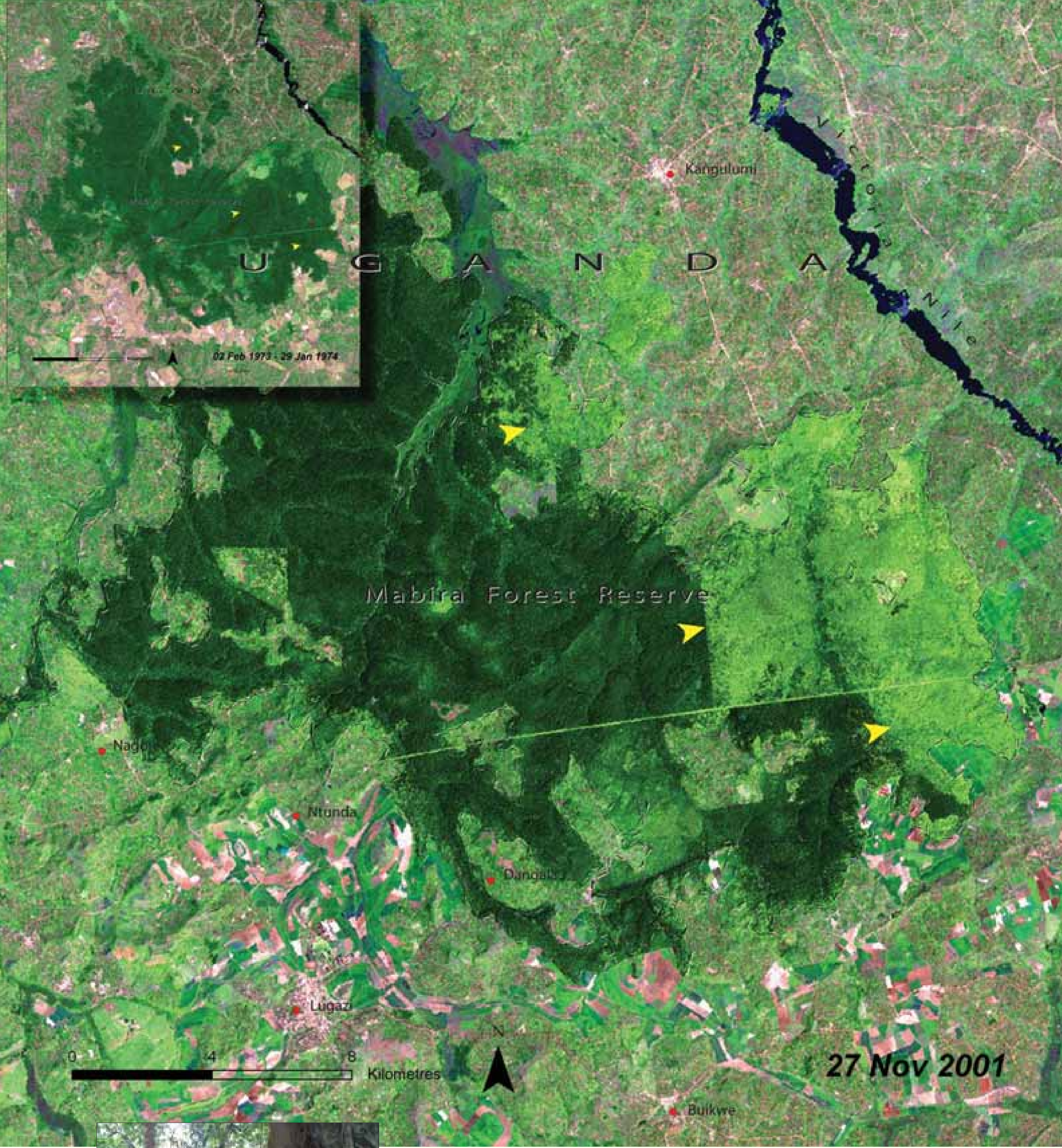
A comparison of satellite images from 1987 and 2005 shows a decrease in the extent of glaciers on Speke, Stanley, and Baker peaks in the Rwenzori Mountains, which lie on the equator between Uganda and Democratic Republic of the Congo, and are a major source of water for the lower plains like Kasese. Seasonal changes in snow and ice cover prevent simple visual analysis from conclusively measuring the decline of these glaciers. However, scientific findings from studies



in 2003 and 2006 show that the glaciers at the tops of the Rwenzori Mountains are rapidly receding. The glaciers declined by 50 per cent between 1987 and 2003.

This glacial recession is generally attributed to increased air temperature and decreased snow accumulation during the 20th century. It has recently been suggested that decreasing cloud cover during that same time period has contributed to a higher rate of sublimation (vaporisation of ice without melting) of these glaciers as well.

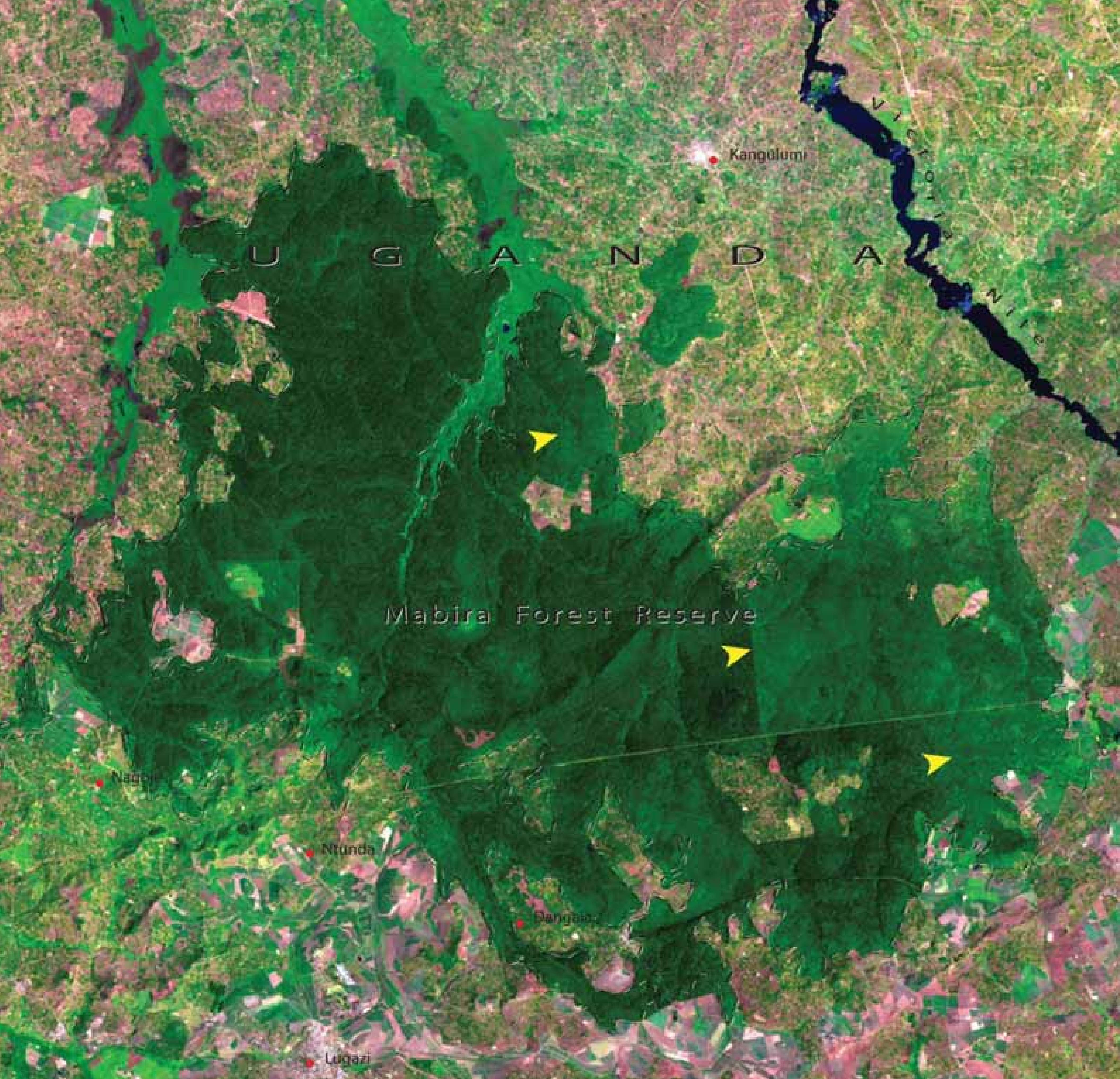
A century ago the glaciers of the Rwenzori Mountains covered nearly 6.5 km². If the glaciers continue to recede, as they have since 1906, researchers estimate they will be gone in the next 20 years.



Secondary Forest Growth: Mabira Forest, Uganda

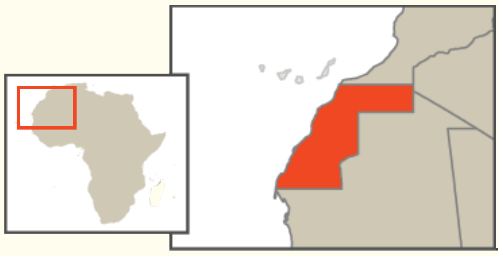
Mabira Forest, located in one of the Uganda's most densely populated districts, is the country's only protected area of medium-altitude, moist, semi-deciduous forest. The forest contains a wealth of biodiversity, provides a variety of services to local inhabitants, and is important to the area's hydrology. The forest is under intense pressure from timber harvesting, charcoal production, fuelwood collection, and agricultural encroachment.

A 1989 study estimated that 29 per cent of Mabira Forest was lost between 1973 and 1988. The report also noted a significant increase in ecological disturbance in the areas of forest that



remained. In the 2001 image, a large portion of the forest described in 1987 still shows the light green colours of young secondary growth (yellow arrows). The 2006 image shows that this secondary forest still remains largely intact and is maturing.

The Ugandan government plans to give much of this portion of Mabira Forest to the Sugar Corporation of Uganda (SCOUL) to expand its sugar plantations. This prospect sparked opposition protests in Kampala, 50 km to the southwest. While the government argues that the need for economic development justifies the loss of the forest, many environmental groups have opposed the move, citing the value lost in biodiversity, ecosystem services, timber production, eco-tourism, and carbon sequestration credits, which can be traded on the world market.



Non-Self-Governing Territory of Western Sahara

Total Surface Area: 266 000 km²
Estimated Population in 2006: 356 000

Western Sahara, a non-self-governing territory in Africa, is highly arid with a long Atlantic coastline. The terrain is mostly low, flat desert with a few small mountains rising in the south and northeast. The territory as a whole is one of the least densely populated areas in Africa with less than two inhabitants per square kilometre. Over 90 per cent of the population is concentrated in urban areas (UNESA 2006). Natural resources on land are limited to phosphate and iron-ore deposits but there are rich offshore fisheries.

Important Environmental Issues

- Land Use and Food Production
- Water Resources
- Marine Fisheries

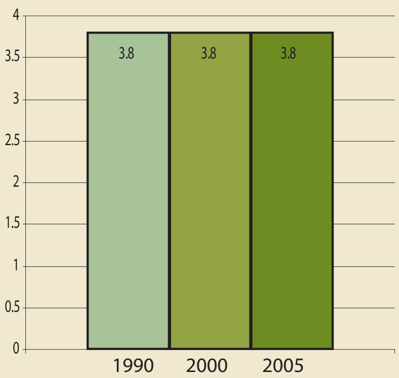
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

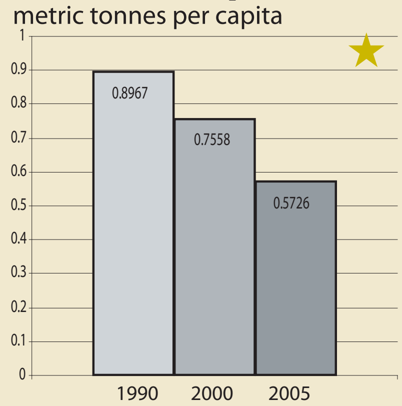
As in all semi-arid and arid regions, annual rainfall in Western Sahara is highly variable, with average rainfall ranging from about 20 mm to just over 50 mm per year. Sparse water and lack of arable land largely limits crops in Western Sahara to fruits and vegetables that can be grown in the territory's few oases. Ninety-four per cent of the population lives in urban areas. Western Sahara has one of the continent's highest urbanisation rates, at 96 per cent.

★ Indicates progress

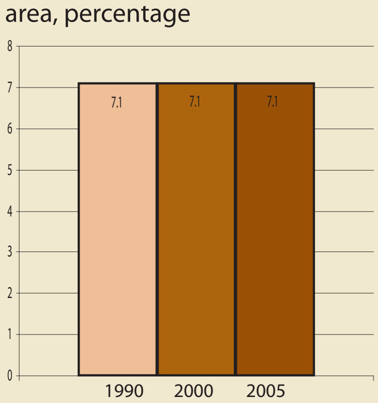
Land area covered by forest, percentage



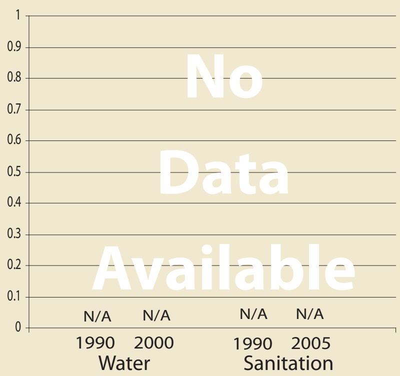
Carbon dioxide (CO_2) emissions, metric tonnes per capita



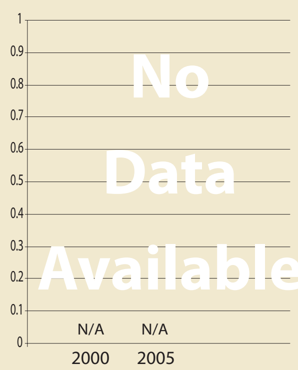
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage

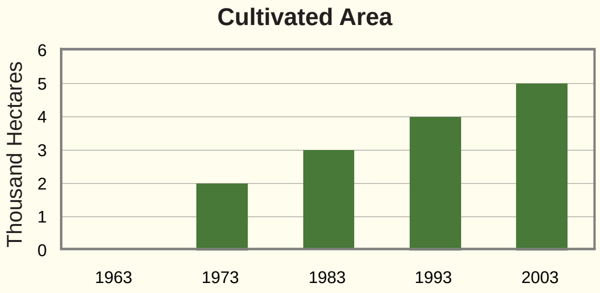


Slum population as percentage of urban



Western Sahara contains one of world's richest phosphate deposits. Saharan phosphate is mineral rich and is of great importance for use as fertilizer.

Land Use and Food Production

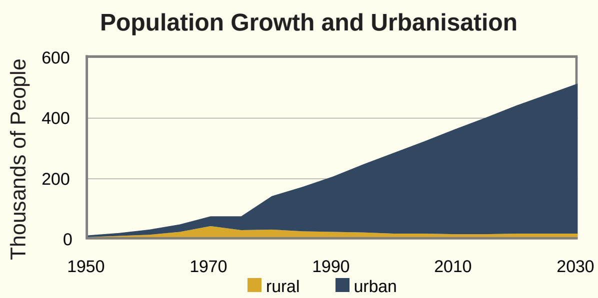


Source: FAOSTAT

Western Sahara has a hyper-arid climate and lacks sufficient and reliable rainfall for agriculture. Crops occupy only 5 000 hectares of land, which is less than half of one per cent of the total surface area (FAO 2006). As a result, most food must be imported to meet the needs of the population.

Water Resources

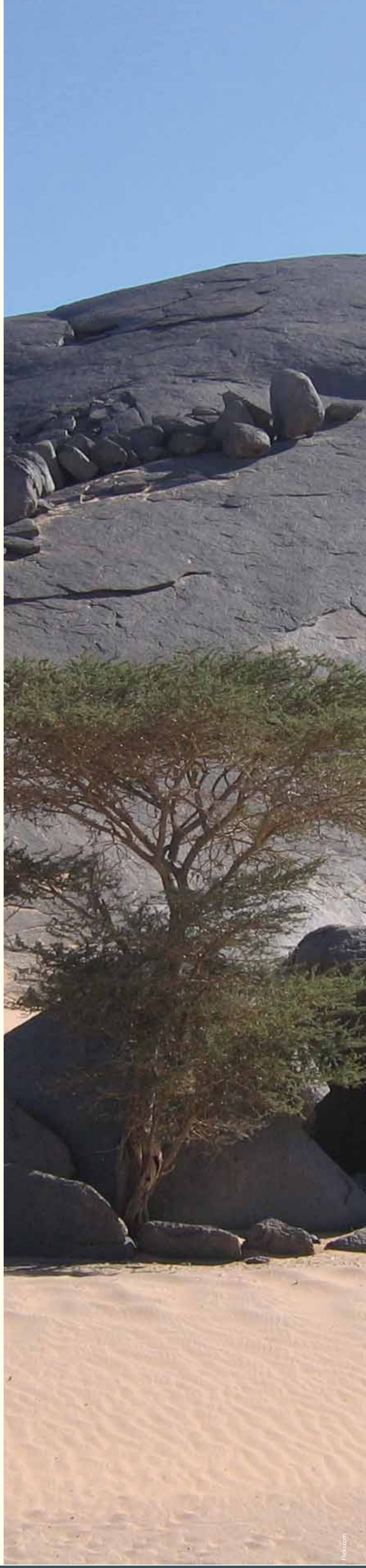
The climatic conditions in Western Sahara are harsh and water infrastructure is underdeveloped. Although official statistics are lacking, access to water and sanitation in Western Sahara is thought to be lower than in neighbouring countries. Occasional flooding brought on by rare, torrential rains disrupts livelihoods, although these temporary floods are important for the territory's fragile desert ecosystems.

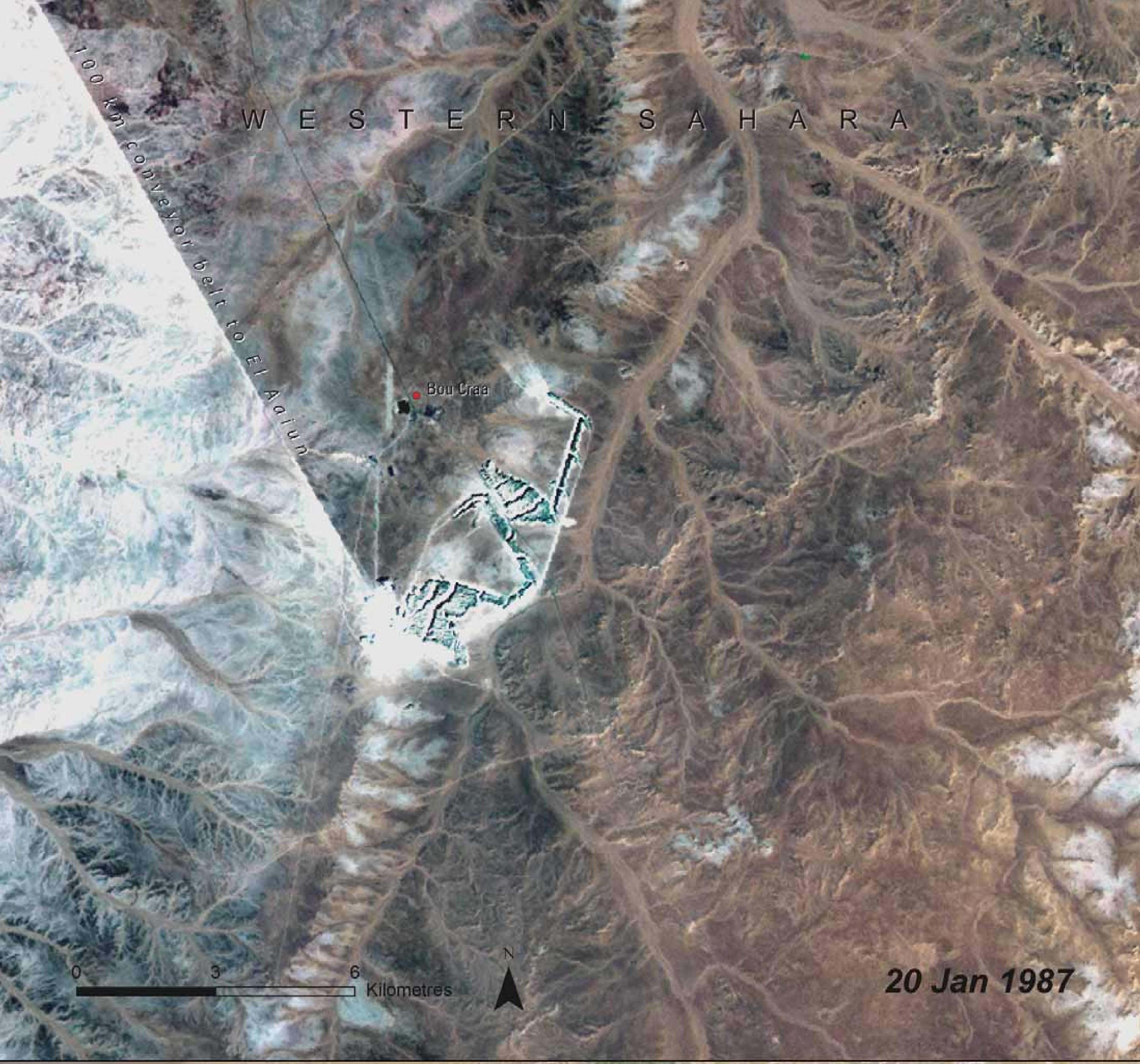


Source: UN Population Division, World Urbanization Prospects 2005 revision

Marine Fisheries

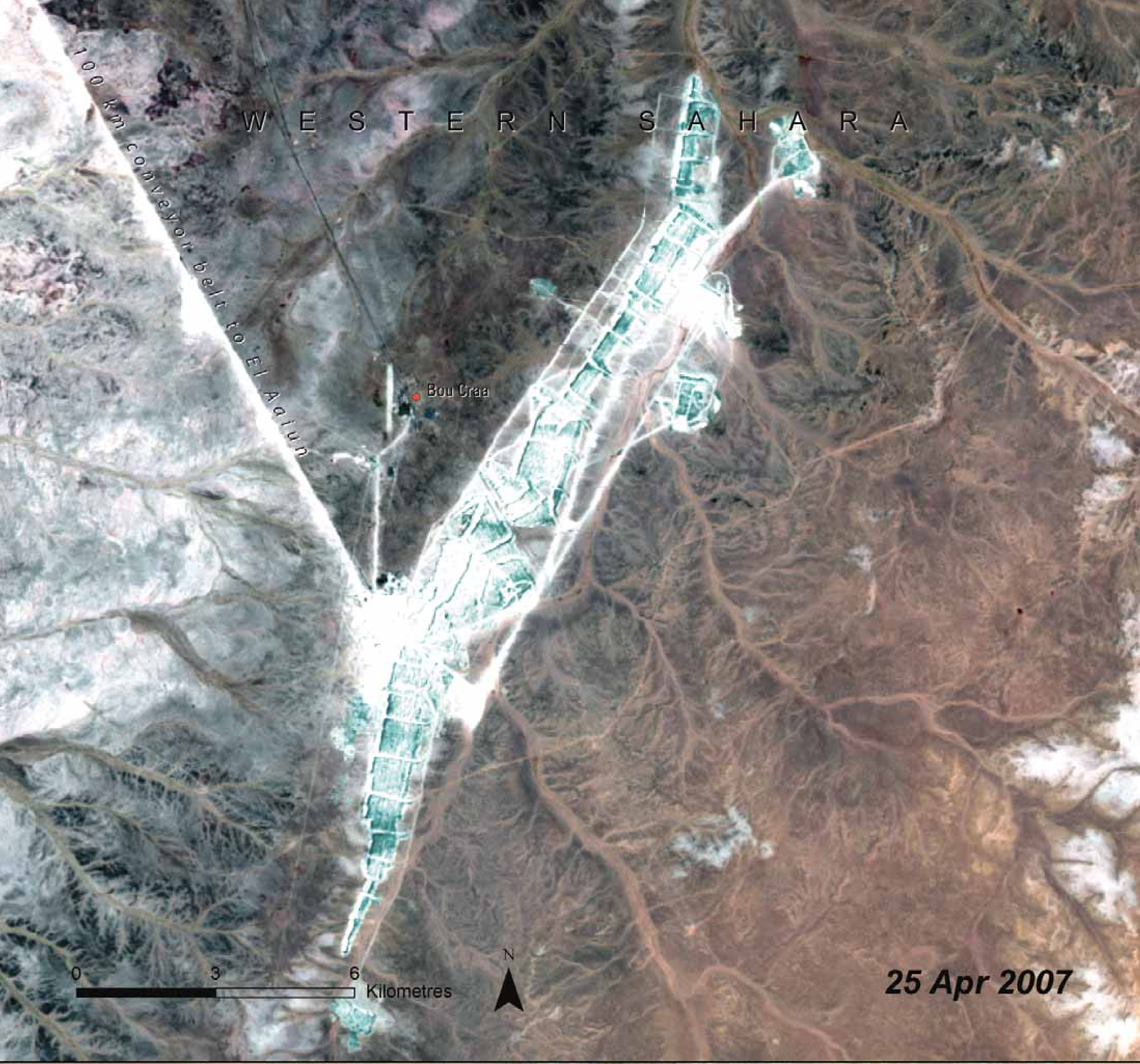
The waters off the coast of Western Sahara are rich in fish and other marine life. These resources are currently exploited by European fishing fleets through an agreement between the European Union and Morocco. Fish caught in Western Saharan waters are thought to account for over half of Morocco's annual fisheries yield of nearly one million metric tonnes. On the other hand, the amount of fish caught by the people of Western Sahara is estimated to be less than 0.5 metric tonnes per year (FAO 2007).

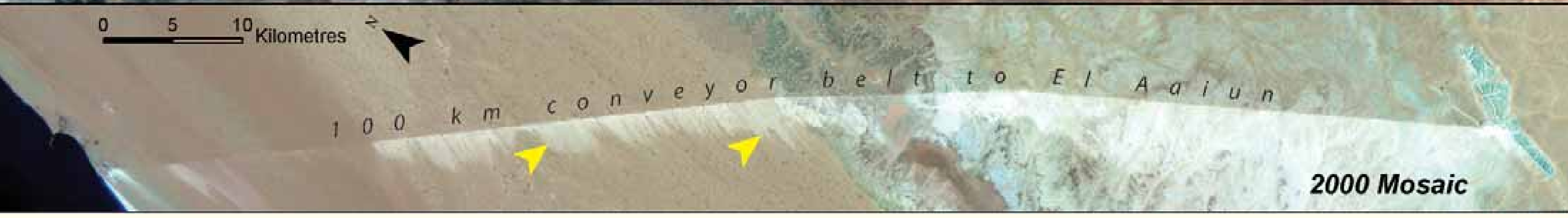




Phosphate Mining: Bou Craa, Western Sahara

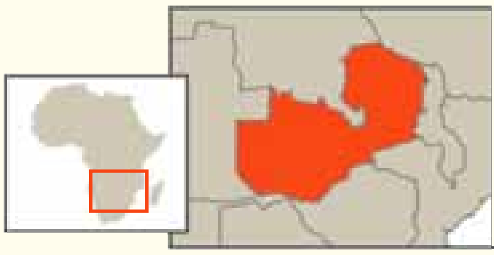
The Bou Craa phosphate mine is located 100 km inland from the capital city of El Aaiun. The Bou Craa area's phosphate resources were discovered by the Spanish in 1947; phosphate deposits are near the surface and are very pure. Phosphate mining, however, did not begin until the 1960s. Since 1974, the Bou Craa mining operation has been growing steadily. In 2000, the mine covered more than 1 225 hectares. In 2001, its output was approximately 1.5 million metric tonnes of phosphate.





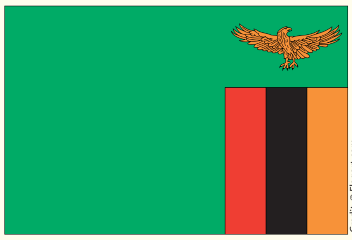
Morocco controls the area of Western Sahara where the mine is located and jointly operates the mine with Spanish interests. While the mine amounts to only two or three per cent of Morocco's phosphate production, the reserves are valuable because of the uranium that can be extracted from them.

The phosphate-containing rock is transported from the Bou Craa mine to the port at El Aaiun via a 100-km-long conveyor belt, which can move 2 000 metric tonnes of rock per hour. The conveyor belt is visible as a straight line from the upper left corner toward the centre of the 1987 and 2007 images above. Below these images are two long, horizontal images, captured in 1972/1973 and 2000. The conveyor belt is visible in the 2000 image running from the mine to the coast. Note the fringe of drifting sand spreading downward from the belt's path (yellow arrows).



Republic of Zambia

Total Surface Area: 752 618 km²
Estimated Population in 2006: 11 861 000



Zambia rests upon a high plateau with a subtropical climate characterised by a single rainy season, a cool, dry winter, and a hot, dry summer. Savannah is the dominant ecosystem and covers the centre of the country, separating the rain forest in the northwest from the semi-desert region in the southwest. Along Zambia's border with Zimbabwe, the Zambezi River flows over the famous Victoria Falls. Both countries also share the Kariba Dam built to generate hydro electric power and is also now a major recreation and fisheries area.

Important Environmental Issues

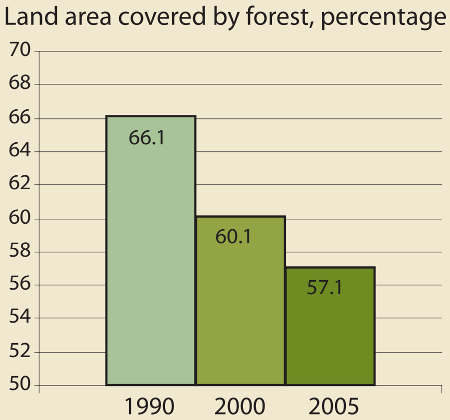
- Copper Mining and Water and Air Pollution
- Deforestation and Wildlife Depletion
- Urbanisation

Progress Towards Environmental Sustainability

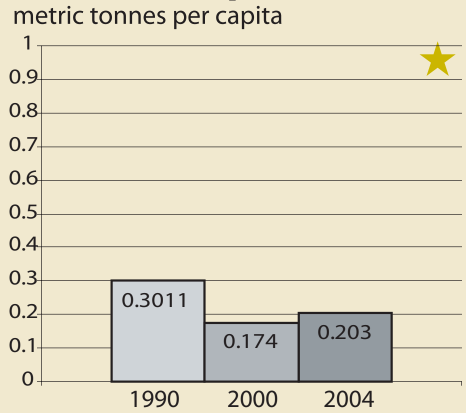
As defined by the United Nations Millennium Development Goal 7 Indicators

In Zambia, traditional and modern farming methods involve clearing large areas of forest. Home to Africa's largest (and the world's second largest) open-cast mine (Nchanga), Zambia is plagued with water pollution arising from contamination by sewage and toxic industrial chemicals. Yet the country shows progress in access to improved water sources and sanitation.

Land area covered by forest, percentage

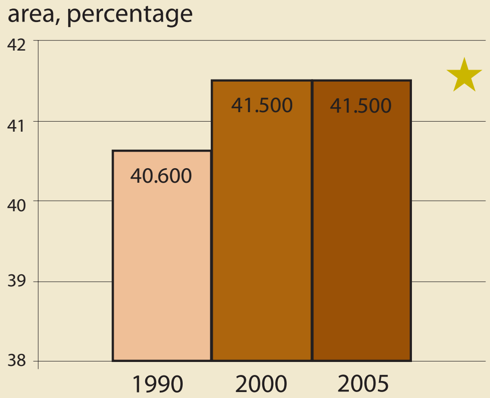


Carbon dioxide (CO_2) emissions, metric tonnes per capita

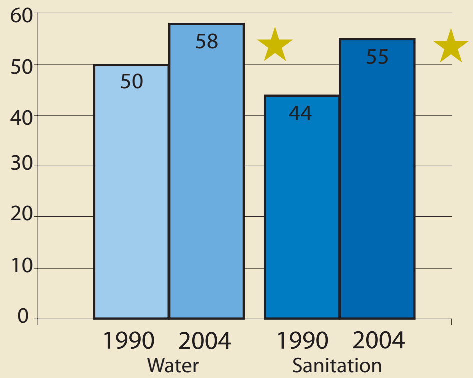


★ Indicates progress

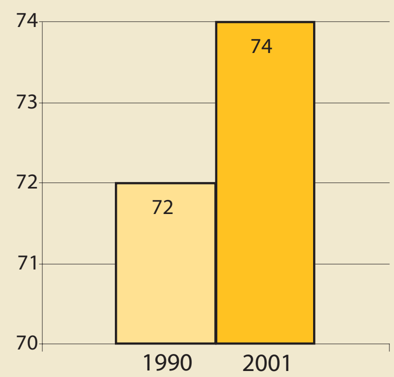
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban

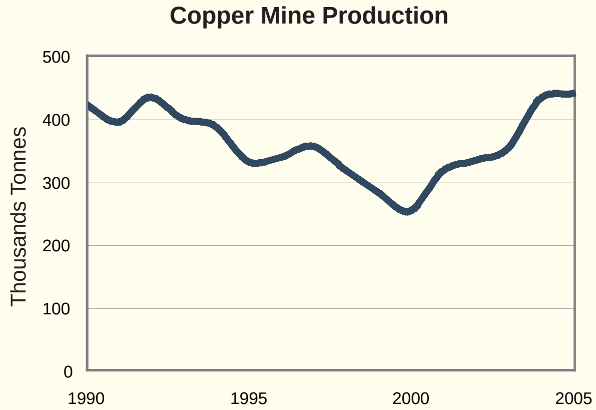


Kafue is Zambia's oldest park and largest park, spreading over 22 400 km².

zambiatourism.com (n.d)

Copper Mining and Water and Air Pollution

Zambia's large copper reserves in the north-central "Copperbelt" region have made it a world leader in copper production. The industry has played a significant role in the national economy since mining began in the late 1920s. Copper mining involves environmentally damaging activities, including open-pit and underground digging, pumping and disposal of large volumes of waste water, and smelting operations that emit sulphur dioxide. Lack of effective environmental regulation of the industry has led to widespread air, soil, and water pollution (World Bank 2002).

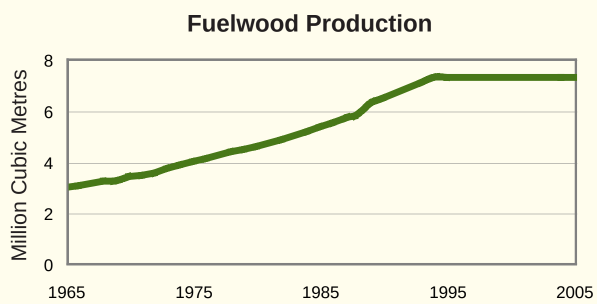


Source: USGS Mineral Commodity Summaries

Deforestation and Wildlife Depletion

Zambia is home to 8 017 different plant and animal species, of which 316 are endemic (UN 2007), 174 are rare, and 38 are endangered or vulnerable (IUCN 2006). The Miombo Savannah woodlands constitute the most biodiverse region in the country, containing elephants, Lichtenstein's hartebeest, lions, and spotted hyenas.

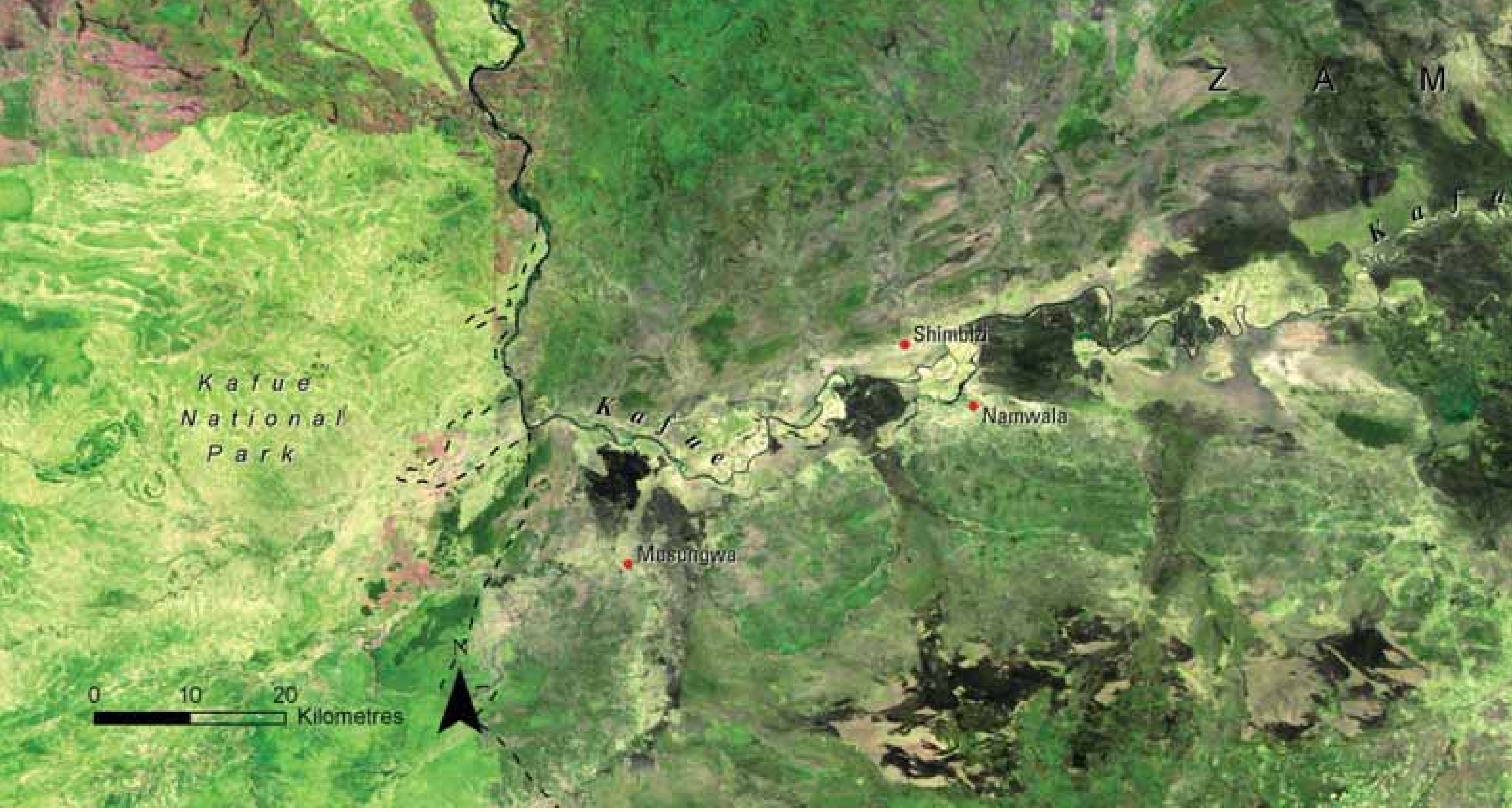
Zambia's wildlife is threatened by illegal hunting and other exploitation, land-use change, dam development, and other human pressures. Between 2000 and 2005, Zambia lost 2.67 million hectares of forest—the second-highest total in Africa and the fifth-highest in the world (FAO 2005). Agriculture is the principal driver of deforestation, but it is also exacerbated by the collection of wood for fuel, the consumption of which is expected to increase by 35 per cent between 2000 and 2020 (FAO 2003).



Source: FAOSTAT

Urbanisation

Africa is the fastest urbanising region in the world and Zambia is the third most highly urbanised country in Sub-Saharan Africa. Zambia experienced high levels of rural-urban migration, as citizens sought to benefit from urban-based employment opportunities and subsidized food and infrastructure. Lusaka, the capital city, was—and continues to be - the main destination for rural migrants, closely followed by the Copperbelt province (World Bank 2002). Lusaka and Copperbelt account for 69 per cent of the total urban population (UN-HABITAT 2007). The major urban areas are faced with serious environmental problems such as soil erosion, loss of soil fertility, and changes to the microclimate resulting from rampant illegal quarrying, illegal development, deforestation, and the over-exploitation of forest resources (UN-HABITAT 2007).



Natural and Managed Flooding: Kafue Flats, Zambia

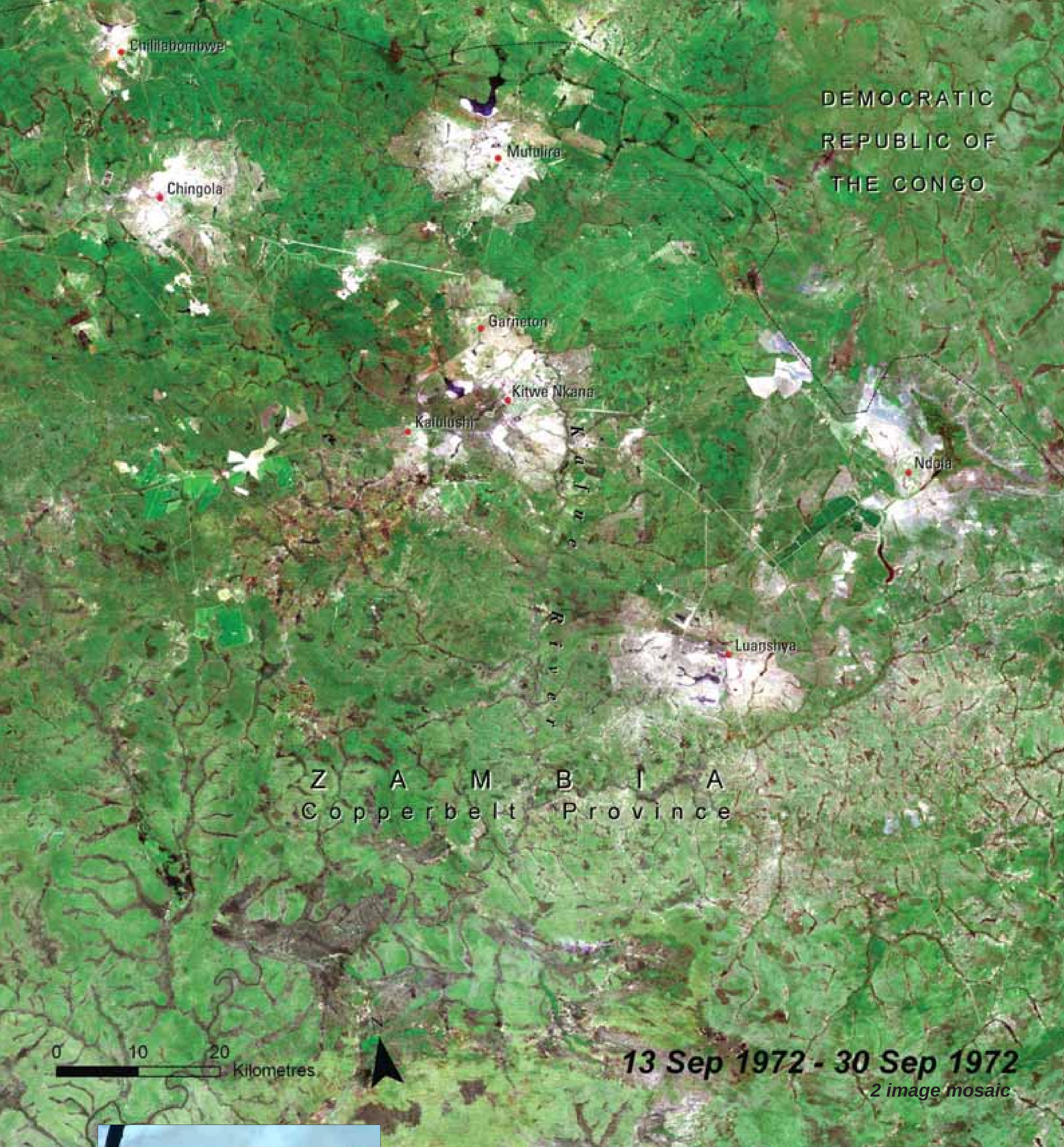
In southern Zambia, the Kafue River crosses a broad floodplain roughly 255 km long. Before the Itezhi-tezhi Dam was built on the river in 1978, flooding beginning in December would cover much of the plain well into the dry season. Although the dam was built to allow the release of sufficient water to cause seasonal flooding, this mimicking of the natural floods has in general not been practised.

The Kafue Flats floodplain provides important habitat for rare and endemic species, including the Kafue lechwe (antelope) and wattled crane, and supports local livelihoods, especially cattle-

Water use across the Kafue Flats is a critical issue. Nearly 1 000 000 m^3 of water is extracted from the Kafue River for commercial agriculture, and most of it goes to the 13 413-hectare Nakambala Sugar Estate.

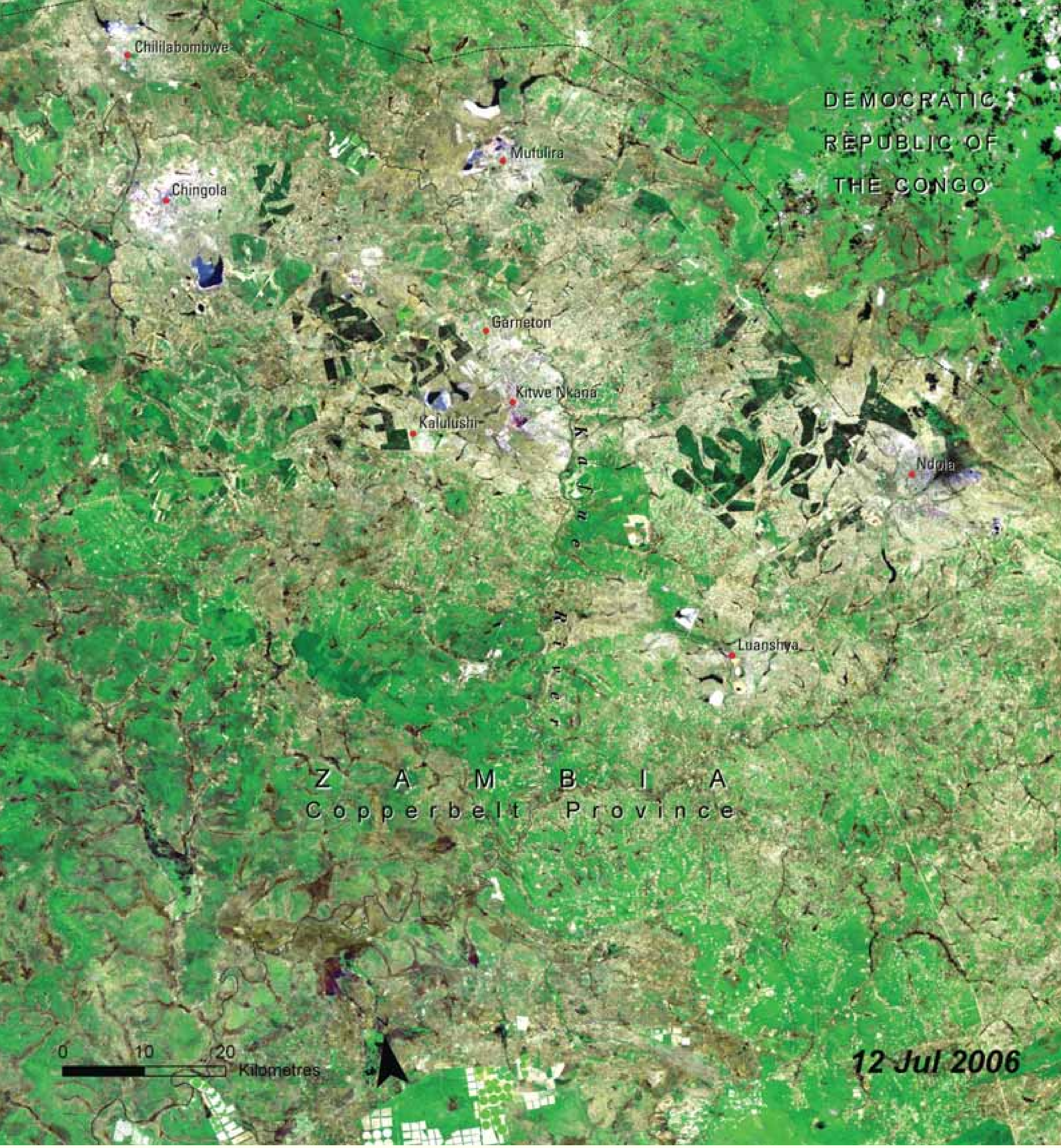
raising and fishing. Limited seasonal flooding following the construction of the dam has been linked to a decline in fish production and in the Kafue lechwe population. The number of lechwe fell from around 90 000 before the dam was built to around 37 000 in 1998. In 2004, a partnership between World Wildlife Fund, the Zambian Ministry of Energy and Water Development, and the Zambian Electricity Supply Company put new rules in place for water releases from the dam to mimic natural flooding patterns more successfully.

The 1970s image shows Kafue Flats in the dry season, with water levels retreating. The Kafue Gorge Dam can be seen in the lower right corner of the image (yellow arrow). Itezhi-tezhi Dam was built a few years later to provide more storage capacity for electricity generation at the Kafue Gorge Dam. The 2007 image shows the Kafue Flats during wet season floods, helped for the first time by the release of adequate water from the Itezhi-tezhi Dam.



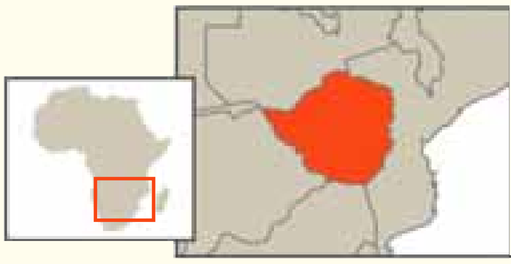
Copper Mines: Copperbelt Province, Zambia

Large-scale copper mining began in north-central Zambia's Copperbelt Province during the 1930s, attracting workers and turning this biologically rich savannah woodland into a heavily populated area with several large cities. Until the 1960s, the mining industry used wood from surrounding lands to generate power for the copper mines; this resulted in the clear-cutting of approximately 127 000 hectares between 1947 and 1956 and selective harvesting of trees in an area of similar size. The mining industry converted to hydroelectric power in the early 1960s, but the growing population continued to rely on wood for fuel.



Copper mining began to decline in the 1970s when oil prices rose and copper prices dropped. By the 1990s, the industry had collapsed, leaving large numbers of workers unemployed. Many of these unemployed miners turned to small-scale agriculture and charcoal production to make a living, putting additional pressure on the surrounding woodlands.

Large urban centres, open-pit mines, and areas of deforestation are already apparent in the 1972 image. These urban areas continued their rapid growth, resulting in the much larger areas of degraded and deforested woodlands visible in the 2006 image. Record copper prices in recent years have revived the area's copper industry. Copper accounted for an average of 67 per cent of Zambia's annual total export receipts between 2002 and 2005.



Republic of

Zimbabwe

Total Surface Area: 390 757 km²
Estimated Population in 2006: 13 085 000

Zimbabwe is a land-locked country bordered by the Limpopo River to the south and the Zambezi River to the north. A high plateau stretches across most of the country, with a sub-tropical climate in an otherwise tropical location. The famous Victoria Falls is located on the border with Zambia, midway along the course of the Zambezi River. During its highest flood stage, the river widens to over 1.6 km directly above the falls before plunging 110 m into the gorge below, forming the largest curtain of falling water in the world (UNEP-WCMC n.d.).

Important Environmental Issues

- Land Degradation and Deforestation
- Water Access and Drought
- Wildlife Poaching and the Black Rhinoceros

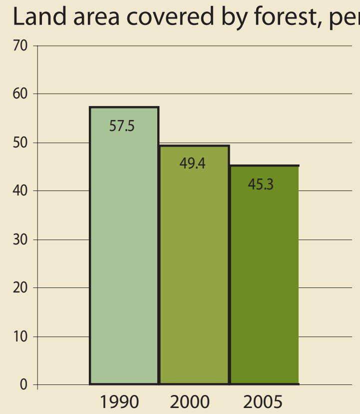
Progress Towards Environmental Sustainability

As defined by the United Nations Millennium Development Goal 7 Indicators

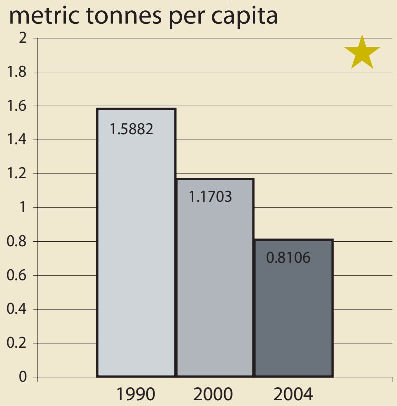
Among the most serious of Zimbabwe's environmental problems are erosion of its agricultural lands and deforestation. Zimbabwe's air is polluted by vehicle and industrial emissions, while water pollution results from mining and the use of fertilizers.

★ Indicates progress

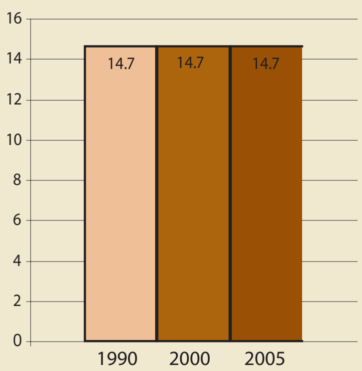
Land area covered by forest, percentage



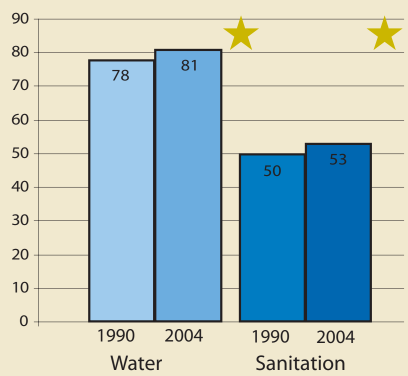
Carbon dioxide (CO_2) emissions, metric tonnes per capita



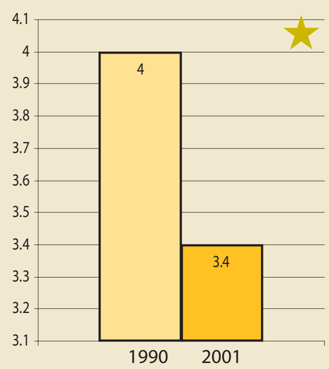
Protected area to total surface area, percentage



Proportion of total population using improved drinking water sources and sanitation facilities, percentage



Slum population as percentage of urban



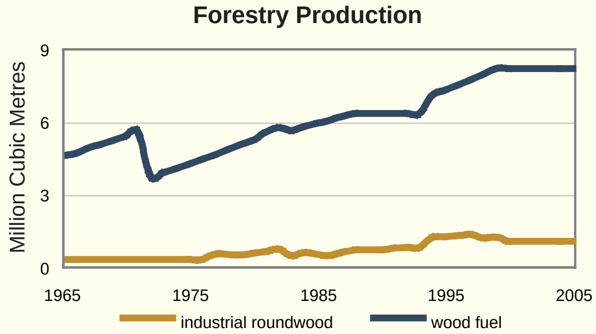
Zimbabwe's population of the critically endangered black rhinoceros has grown from 370 in 1993 to around 500 now.

rhinos-irf.org (n.d)

Land Degradation and Deforestation

Nearly 40 per cent of Zimbabwe's land is categorized as moderately degraded. The regions of greatest concern are in the north and east, where topsoil losses of more than 100 metric tonnes per hectare have been recorded (FAO 2004). The major drivers of land degradation are overgrazing (particularly on communally managed rangelands) and deforestation.

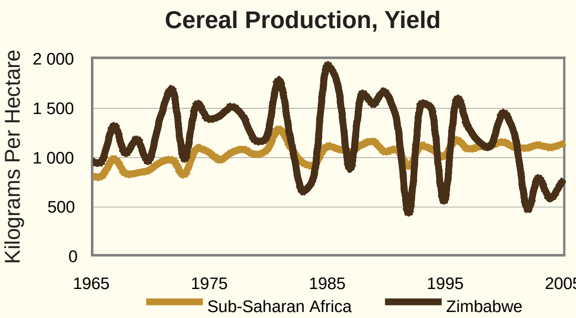
Between 2000 and 2005, Zimbabwe had the sixth highest rate of deforestation in Africa, averaging 3 130 km² per year (FAO 2005). Agriculture is estimated to be responsible for approximately 700 km² (roughly one-quarter) of this annual loss (CBD 1998), while heavy dependence on wood for fuel and commercial logging account for the rest.



Source: FAOSTAT

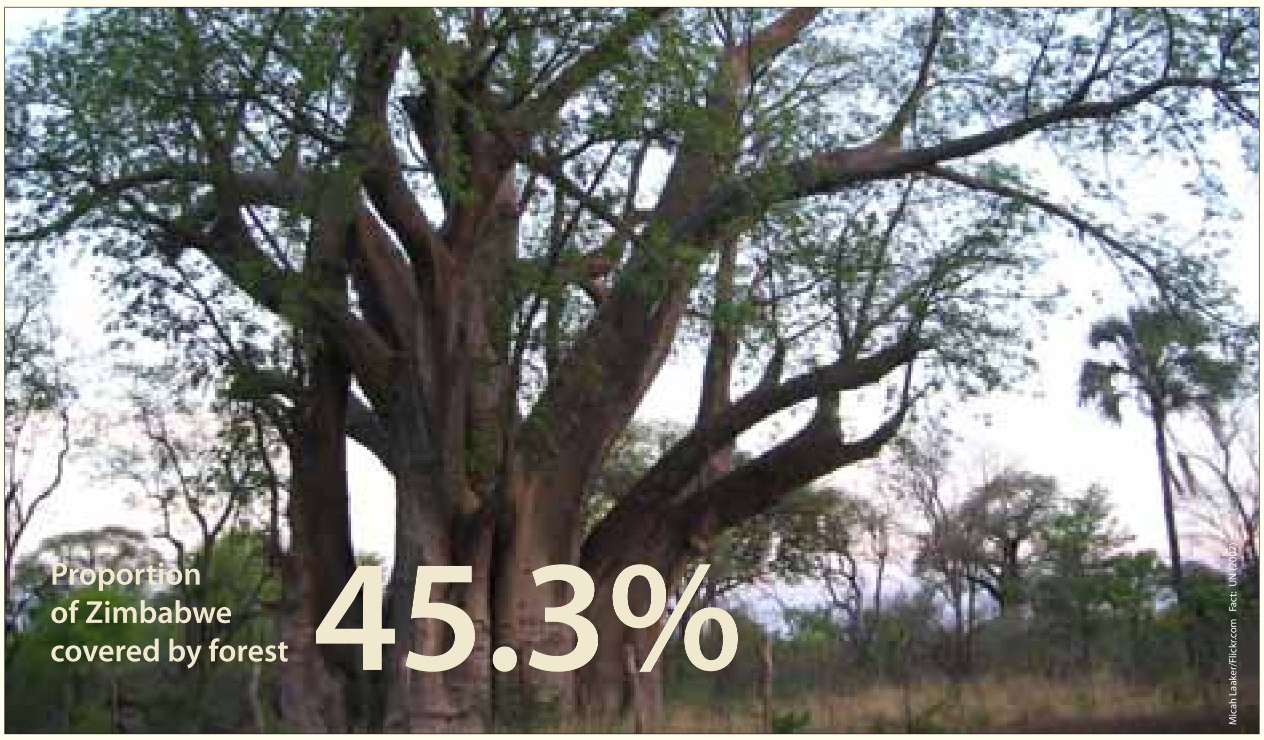
Water Access and Drought

Zimbabwe has few perennial rivers and no natural lakes, so a network of over 8 000 dams makes up the most significant surface water resource. However, siltation has reduced dam capacity and poor infrastructure prevents many people from accessing the water they need. In the major cities of Harare and Bulawayo, residents have gone without water for as long as two weeks during recent years (UN 2006).



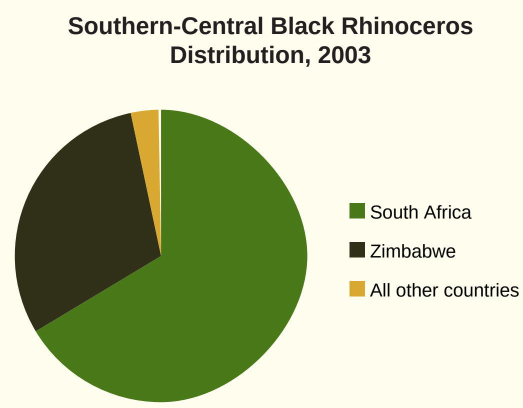
Source: FAOSTAT

In rural areas, highly variable rainfall and drought are a constant threat to social and environmental stability. Between 1991 and 1997 alone, Zimbabwe experienced three major droughts that necessitated the importation of food in order to avert shortages (FAO 2004).

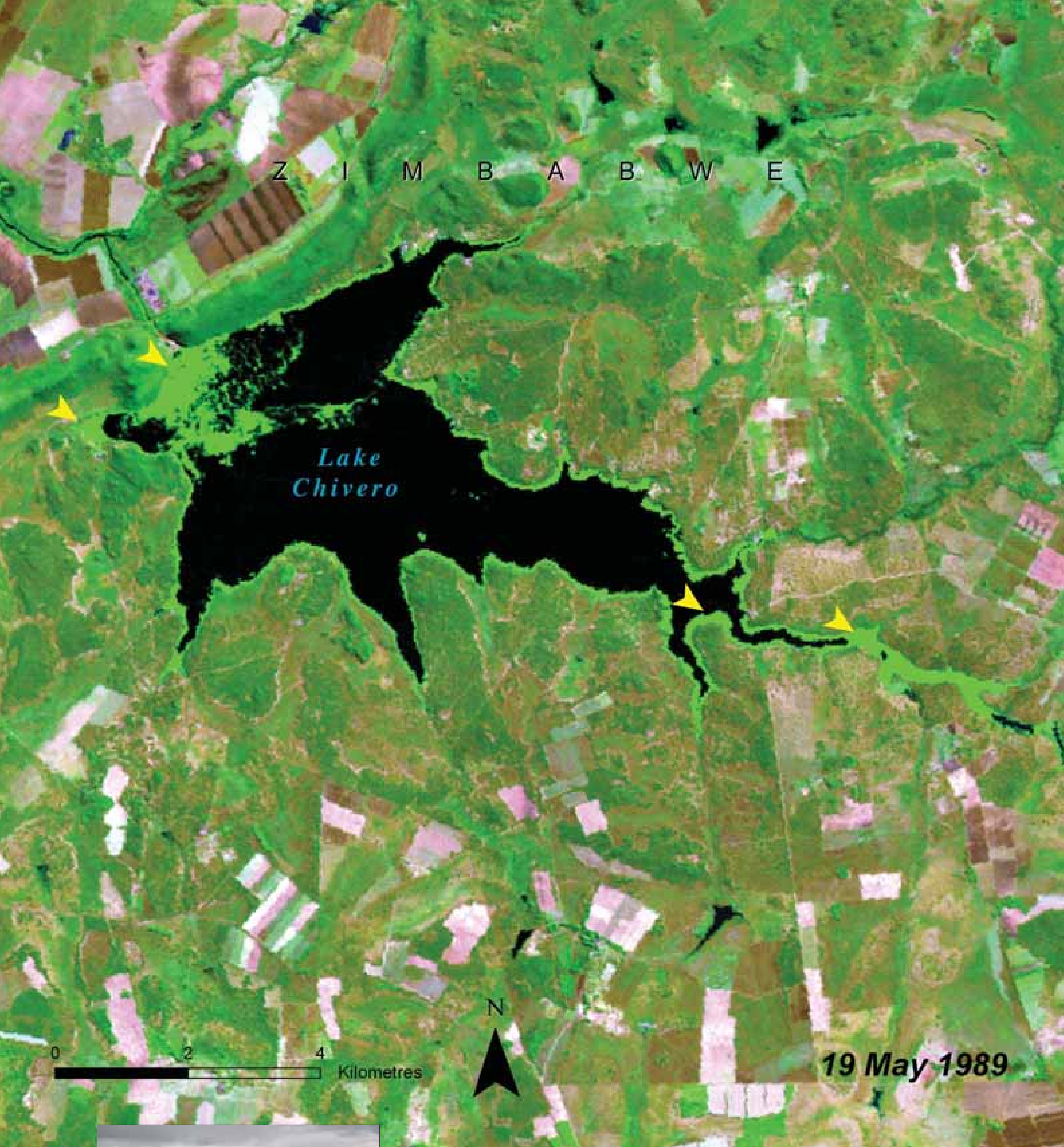


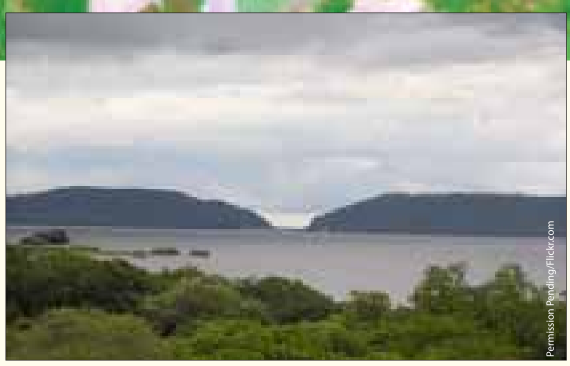
Wildlife Poaching and the Black Rhinoceros

Zimbabwe is home to charismatic megafauna such as the elephant, leopard, black rhinoceros, and giraffe. The black rhinoceros population in Africa declined by over 90 per cent in the last 60 years, reaching a low of 2 410 individuals worldwide in 1995 (IUCN 2007). During the 1980s, Zimbabwe lost over 1 500 black rhinos due to heavy poaching, but enhanced conservation measures have increased the population to an estimated 800 individuals today, making Zimbabwe an important stronghold for this critically endangered species. However, a recent severe economic crisis has reintroduced the threat of poaching, and at least 40 black rhinos have been killed in the past three years alone (Reuters 2007).



Source: International Rhino Foundation

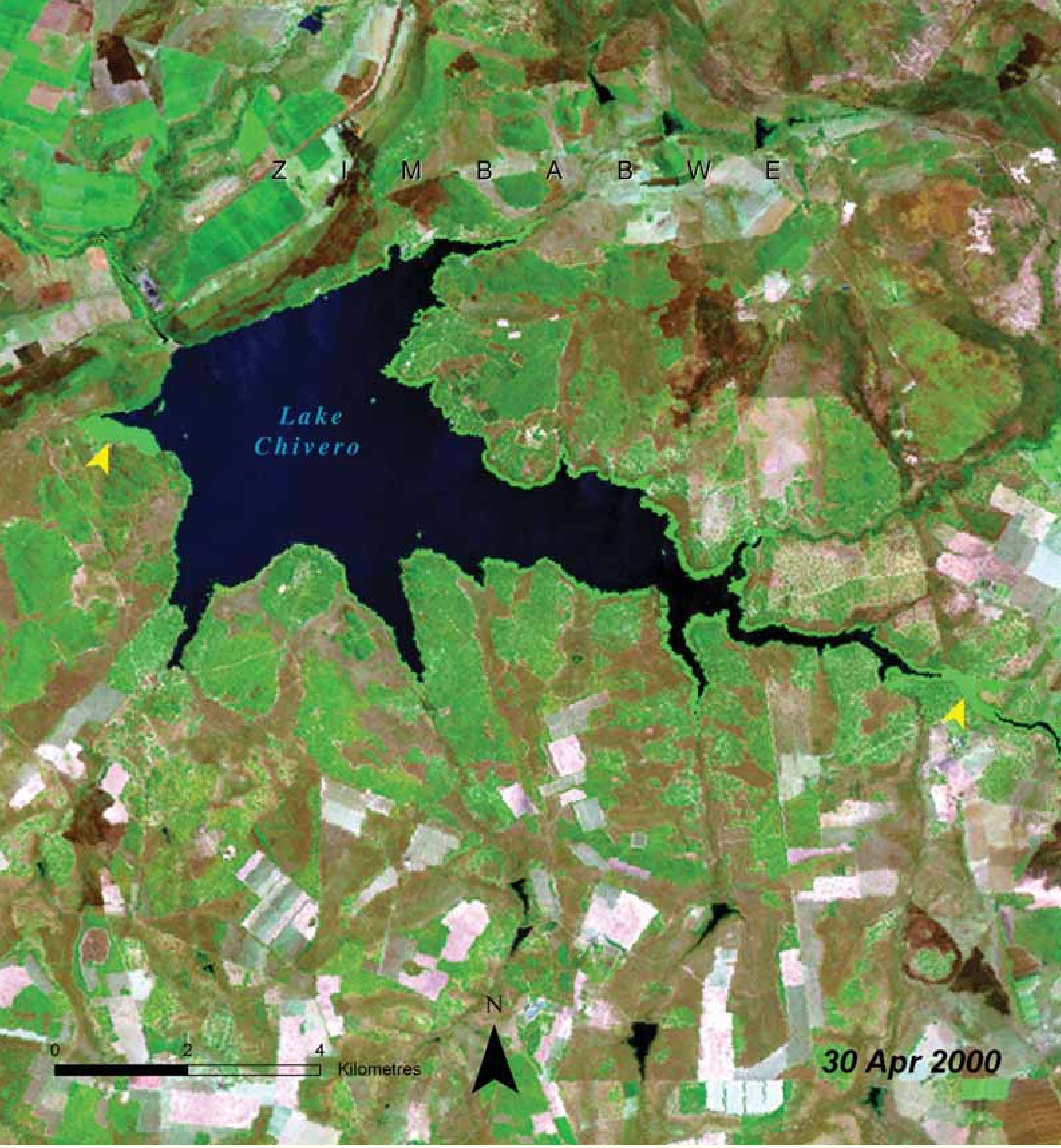




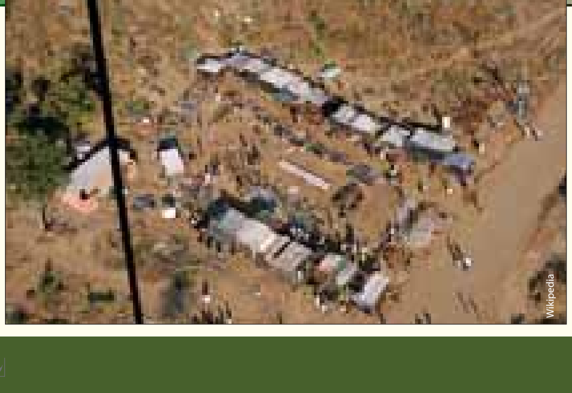
Invasive Plants: Lake Chivero, Zimbabwe

In 1952, the Manyame River was dammed 40 km southwest of Harare, creating Lake Chivero. The Lake was intended primarily as a water supply for Harare, but it is also a source of water for irrigation and industry and serves as a local fishery.

One year after Lake Chivero was created, water hyacinth, an invasive wetland plant, made its first appearance, as a result of the influx of nutrients from nearby agricultural lands and municipal and industrial wastes from Harare. In 1955/1956, the first serious water hyacinth outbreak occurred and was successfully treated with chemical herbicides. The next outbreak



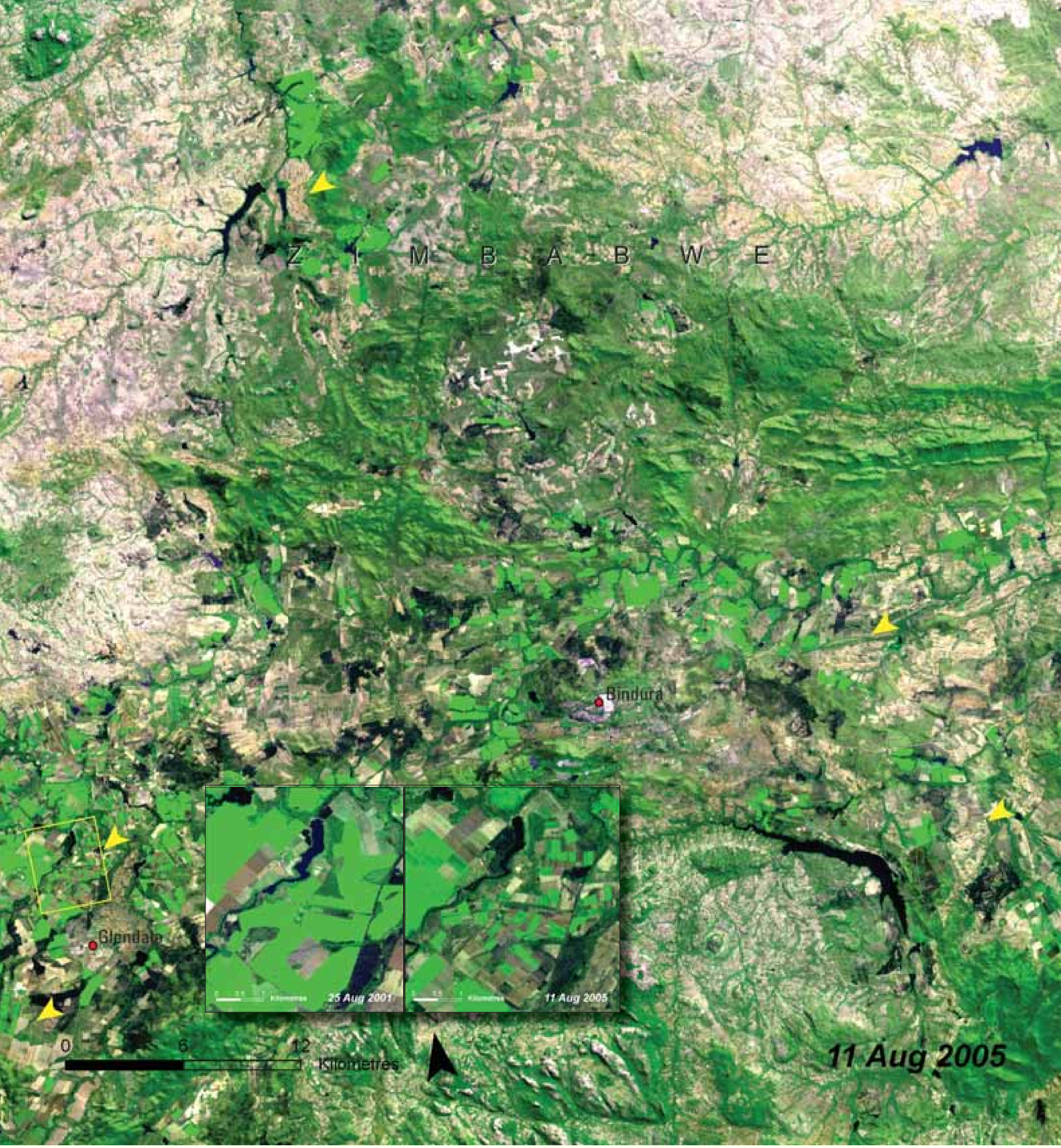
in 1971/1972 covered approximately 25 per cent of the lake. Attempts to end a third outbreak in 1986 used mechanical and chemical controls until public concern about the chemicals brought an end to their use. By 1989, water hyacinth covered 20 per cent of the lake's surface (1989 image, yellow arrows); by 1990, it covered 35 per cent. Weevils that feed on water hyacinth were released as a biological control; mechanical and new chemical controls continued. By 1997, it appeared that water hyacinth had been brought under control (2000 image, yellow arrows). By 2005, however, the invasive plants had returned again, reportedly covering as much as 40 per cent of the lake. In addition to water hyacinth, this most recent infestation includes massive amounts of another invasive plant, spaghetti weed (*Hydrocotyle ranunculoides*).



Agriculture Changes: Mashonaland, Zimbabwe

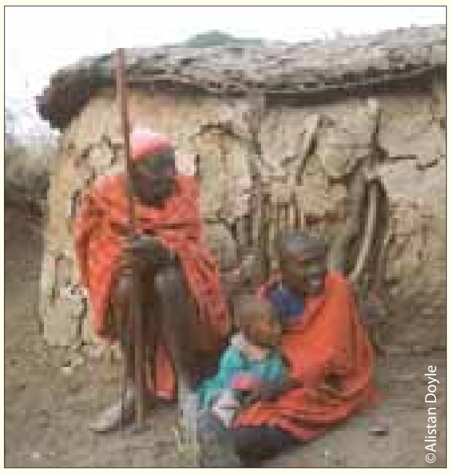
Located in Northern Zimbabwe, Mashonaland Central is a province with a growing population of over one million people. It is in one of the most productive agricultural areas in the country, with maize, a staple in Zimbabwe, as a major crop.

Four different land tenure systems exist in Zimbabwe: communal areas, resettlement areas, large-scale commercial farms, and small-scale commercial farms. In the last decade, the Government of Zimbabwe embarked on an ambitious land reform process that was aimed at redistribution of land, particularly the large scale commercial farms, to previously landless



citizens living in communal areas. This land redistribution effort has had the effect of subdividing previously large commercial parcels into much smaller parcels predominated by subsistence agriculture. This subdivision, coupled with adverse weather conditions, constrained capacities for input acquisition (seeds and fertilizers), and lack of appropriate machinery, is blamed for a drop in food production in Zimbabwe.

The satellite images above show the subdivision of several large commercial farms into smaller farms in a region of Mashonaland Central Province. In the August 2001 image, many large farm fields can be seen as large blocks of bright green. By August 2005, many of these same farms have been broken into smaller fields (yellow arrows).



"The snows are getting smaller year by year..."

- Kinyaol Porboli,
Maasai village chief of Esiteti village

At the foot of Mount Kilimanjaro, an elderly Maasai village chief, Kinyaol Porboli, notes how snows atop Kilimanjaro are shrinking. According to the chief, twenty years ago droughts never killed cattle, because in the old days droughts were short. Longer droughts are becoming a very big problem, increasing poverty and affecting everyday life.

The Maasai village chief squints up at the summit and says only God can explain the shrinking snowcap and worsening droughts. Cattle in the village died in droughts in 2005, 1997 and 1989, said Porboli, who does not know his exact age but reckons he may be 100. This year, some tiny green shoots are coming up through the dust around the village. "It's linked to the mountain," he said, wrapped in a red robe and sitting on a stool outside his village of 70 people who live in windowless huts made from branches and dried cow dung (Excerpted from: Alister Doyle/Reuters 13 November 2006).

The village chief's voice is one of many powerful ones delivering an important message, which we, as stewards of the earth, cannot afford to ignore. Using the universal language of imagery, this Atlas corroborates that very message—putting us on notice that Africa's ecosystems, wildlife, and natural resources are in peril. Scientific measurements of the Millennium Development Goal indicators, such as percentages of forest cover and access to potable water, send us the same alarming prognosis on the environment.

These signs not only show us present conditions in Africa, but also serve as a pointer to the global environment's future. While natural conditions in many of Africa's arid and semiarid regions contribute to some of its environmental problems, most may be attributed to impacts from human activities including pollution, unsustainable agricultural practices, and growing and moving populations.

Despite some attempts by governments to halt and reverse environmental degradation, conditions continue to decline and poverty is worsening. It is here then, that we must also consider the role of each individual in taking action to take back the environment. Whether as a member of a government body holding a nation's resources in trust, or as a citizen beneficiary of the earth's bounty, we can play our part in protecting and restoring the environment.

Looking ahead, more challenges lie before us. Scientists agree that global warming, exacerbated by greenhouse gas emissions, is now changing the climate in many parts of the world. Africa is no exception. In fact, Africa is poised to suffer disproportionately from the consequences of global climate change. New studies confirm that Africa's capacity to adapt to climate change is low, making the continent exceptionally vulnerable to its potential impact. In many regions, even small changes in precipitation and water availability could have a devastating effect on agricultural output and thereby on food security.

As evidenced by Kinyaol Porboli's village, people are adapting as best they can to the effects of climate change that are already being felt, recognizing that the changing conditions around them and the effects are, as the chief said, "linked." However, as climate change intensifies and its impact deepens, adaptation will be much more difficult, as will achieving the Millennium Development Goals at local, regional, and national levels across the vast and wonderfully diverse African continent.

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Acronyms and Abbreviations

AARSE	African Association of Remote Sensing of the Environment
ACOPS	Advisory Committee on Protection of the Sea
AMCEN	The African Ministerial Conference on the Environment
ASAR	Advanced Synthetic Aperture Radar
bbl/d	barrels per day
BCLME	Benguela Current Large Marine Ecosystem
BP	British Petroleum
CAR	Central African Republic
CARPE	Central African Regional Program for the Environment
CBD	Convention on Biological Diversity
CDIAC	Carbon Dioxide Information Analysis Center
CFCs	Chlorofluorocarbons
CI	Conservation International
CIESIN	Center for International Earth Science Information Network
CITES	Convention on International Trade in Endangered Species
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRED	Centre for Research on the Epidemiology of Disasters
DEWA	Division of Early Warning and Assessment
DMS	dense media separation
DOE	Department of Energy
DRC	Democratic Republic of the Congo
EIA	Energy Information Administration, United States Department of Energy
EIS–Africa	Environmental Information Systems – Africa
EM-DAT	Emergency Events Database
ENSO	El Niño/Southern Oscillation
ENVISAT	European Space Agency Environmental Satellite
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GEO	Group on Earth Observations
GIS	Geographic Information Science
GLCF	Global Land Cover Facility
GLTP	Great Limpopo Transfrontier Park
GMMR	Great Man-made River
HABs	Harmful Algal Blooms
HIPC	heavily indebted poor countries
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organization
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature and Natural Resources
IUSSP	International Union for the Scientific Study of Population
kg	kilograms
km	kilometres
km^2	square kilometres
km^3	cubic kilometres
LME	Large Marine Ecosystem
m	metres
m^2	square metres
m^3	cubic metres
MDGs	Millennium Development Goals
METAP	Mediterranean Environmental Technical Assistance Program
mm	millimetres
MODIS	Moderate Resolution Imaging Spectroradiometer
NO_2	Nitrogen Dioxide
N_2O	Nitrous Oxide
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NOSA	National Occupational Safety Association
NP	National Park
NWSA	North-West Sahara Aquifer
ODA	Official development assistance
ODP	Ozone depleting potential
OECD/DAC	Organization for Economic Co-operation and Development/Development Assistance Committee
OMVS	Oganisation pour la mise en valeur du fleuve Sénégal (Organisation for the Development of the Senegal River)
PPP	Purchasing Power Parity
RCMRD	Regional Centre for Mapping of Resources for Development
RS	Remote Sensing
SADC	Southern African Development Community
SADCC	Southern African Development Coordination Conference (Group of nine countries—Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe—surrounding or surrounded by the Republic of South Africa)
SAIC	Science Applications International Cooperation
SCOUL	Sugar Cooperation of Uganda
SDSU	South Dakota State University
SOE	State of the Environment
TWh	terawatt hour (it corresponds to 1 000 000 000 kWh (kilowatt hours) or one thousand Gigawatt hours)
UMD	University of Maryland
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commissions for Africa
UNEP	United Nations Environment Programme
UN ESA	United Nations – Department of Economic and Social Affairs
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USGS	United States Geological Survey
USSP	Uganda Strategy Support Program
UV	Ultra Violet
WAP	W-Arly-Pendjari
WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WIO	West Indian Ocean
WRI	World Resources Institute
WWF	World Wildlife Fund
yr	year

Annex I

Changes in MDG Goal 7: Environmental Sustainability Indicators	Forested Land as % of Land Area		Carbon Dioxide emissions (CO_2), metric tons of CO_2 per capita		Protected area to total surface, area percentage		Access to Improved Water source (% of total population)		Access to Improved Sanitation (% of total population)		Slum Population as percentage of urban population	
Country Names	1990	2005	1990	2004	1990	2005	1990	2004	1990	2004	1990	2001
Algeria, People's Democratic Republic of	**0.8**	**1**	3.0471	5.994	5	5	94	85	**88**	**92**	11.8	11.8
Angola, Republic of	48.9	47.4	0.4413	0.5051	12.1	12.1	**36**	**53**	**29**	**31**	83.1	83.1
Benin, Republic of	30	21.3	0.138	0.2902	23	23	**63**	**67**	**12**	**33**	80.3	83.6
Botswana, Republic of	24.2	21.1	1.5876	2.3693	**29.4**	**30.2**	**93**	**95**	**38**	**42**	59.2	60.7
Burkina Faso	30.6	29	0.112	0.0812	**14.9**	**15.4**	**38**	**61**	**7**	**13**	**80.9**	**76.5**
Burundi, Republic of	11.3	5.9	0.0341	0.0291	**4.4**	**5.6**	**69**	**79**	**44**	**36**	**83.3**	**65.3**
Cameroon, Republic of	52.7	45.6	0.1312	0.2205	**5.4**	**8.9**	**50**	**66**	**48**	**51**	62.1	67
Cape Verde, Republic of	**14.3**	**20.7**	0.2476	0.5553	0	0		80		43	**70.3**	**69.6**
Central African Republic	37.2	36.5	0.0658	0.0614	**15.1**	**15.7**	**52**	**75**	**23**	**27**	**94**	**92.4**
Chad, Republic of	10.4	9.5	0.0234	0.0127	9.3	9.3	**19**	**42**	**7**	**9**	**99.3**	**99.1**
Comoros, Union of the	6.5	2.9	0.1253	0.1132		2.7	93	86	**32**	**33**	**61.7**	**61.2**
Congo, Republic of the	66.5	65.8	0.4844	1.0034	**6.4**	**14.1**		58		27	84.5	90.1
Congo, Democratic Republic of the	62	58.9	0.1047	0.037	**7.2**	**8.4**	**43**	**46**	**16**	**30**	**51.9**	**49.5**
Côte d`Ivore, Republic of	**32.1**	**32.7**	0.4217	0.2825	16.4	16.4	**69**	**84**	**21**	**37**	50.5	67.9
Djibouti, Republic of	0.2	0.2	0.6278	0.4639			**72**	**73**	**79**	**82**		
Egypt, Arab Republic of	**0**	**0.1**	1.369	2.2116	**6.5**	**13.3**	**94**	**98**	**54**	**70**	**57.5**	**39.9**
Equatorial Guinea, Republic of	66.3	58.2	0.3454	11.4748	**4.9**	**14.3**		43		53	**89.1**	**86.5**
Eritrea	16	15.4		0.1735	3.2	3.2	**43**	**60**	**7**	**9**	69.9	69.9
Ethiopia, Federal Democratic Republic of	13.8	11.9	0.058	0.1037	16.9	16.9	23	22	**3**	**13**	99	99.4
Gabonese Republic	85.1	84.5	6.5306	1.0796	**4.7**	**16.2**		88		36	56.1	66.2
Gambia, Republic of the	**39.1**	**41.7**	0.1981	0.1821	3.9	4.1		82		53	67	67
Ghana, Republic of	32.7	24.2	0.2419	0.326	**14.6**	**14.7**	**55**	**75**	**15**	**18**	**80.4**	**69.6**
Guinea, Republic of	30.1	27.4	0.1677	0.1515	**3.3**	**6.1**	**44**	**50**	**14**	**18**	**79.6**	**72.3**
Guinea-Bissau, Republic of	78.8	73.7	0.2056	0.1752	**3.2**	**7.3**		59		35	93.4	93.4
Kenya, Republic of	6.5	6.2	0.2485	0.3054	**12.5**	**12.7**	**45**	**61**	**40**	**43**	70.4	70.7
Lesotho, Kingdom of	**0.2**	**0.3**			0.2	0.2		79	37	37	49.8	57
Liberia, Republic of	42.1	32.7	0.2179	0.1401	12.7	12.7	**55**	**61**	**39**	**27**	**70.2**	**55.7**
Libyan Arab Jamahiriya, Socialist People's	0.1	0.1	8.6612	10.331	0.1	0.1	71		97	97	35.2	35.2
Madagascar, Republic of	23.5	22.1	0.0783	0.1506	**1.8**	**2.6**	**40**	**50**	**14**	**34**	90.9	92.9
Malawi, Republic of	41.4	36.2	0.0637	0.081	16.4	16.4	**40**	**73**	**47**	**61**	**94.6**	**91.1**
Mali, Republic of	11.5	10.3	0.055	0.0501	**1.6**	**2.1**	**34**	**50**	**36**	**46**	**94.1**	**93.2**
Mauritania, Islamic Republic of	0.4	0.3	1.3551	0.8866	1.7	1.7	**38**	**53**	**31**	**34**	94.3	94.3
Mauritius, Republic of	19.2	18.2	1.3844	2.598	**0.5**	**0.9**	100	100		94		
Morocco, Kingdom of	**9.6**	**9.8**	0.9473	1.3654	**0.8**	**1.2**	**75**	**81**	**56**	**73**	**37.4**	**32.7**
Mozambique, Republic of	25.5	24.6	0.0736	0.1079	**7.6**	**8.6**	**36**	**43**	**20**	**32**	**94.5**	**94.1**
Namibia, Republic of	10.6	9.3	0.0052	1.2394	14.6	14.6	**57**	**87**	**24**	**25**	**42.3**	**37.9**
Niger, Republic of the	1.5	1	0.1341	0.0947	6.6	6.6	**39**	**46**	**7**	**13**	96	96.2
Nigeria, Federal Republic of	18.9	12.2	0.4803	0.8263	3.7	6.1	49	48	39	44	80	79.2
Rwanda, Republic of	**12.9**	**19.5**	0.0724	0.0632	**3.9**	**7.6**	**59**	**74**	**37**	**42**	82.2	87.9
Sao Tome and Principe, Democratic Republic	28.4	28.4	0.5683	0.6106				79		25		
Senegal, Republic of	48.6	45	0.397	0.4353	10.8	10.8	**65**	**76**	**33**	**57**	**77.6**	**76.4**
Seychelles, Republic of	88.9	88.9	1.5783	6.4395	1	1	88	88				
Sierra Leon, Republic of	42.5	38.5	0.0816	0.1843	3.9	3.9		57		39	90.9	95.8
Somali Republic	13.2	11.4	0.0027		0.7	0.7		29		26	96.3	97.1
South Africa, Republic of	7.6	7.6	9.0777	9.1927	**5.6**	**6.1**	**83**	88	69	65	**46.2**	**33.2**
Sudan, Republic of the	32.1	28.4	0.2077	0.287	4.7	4.7	**64**	**70**	**33**	**34**	**86.4**	**85.7**
Swaziland, Kingdom of	**27.4**	**31.5**	0.4917	0.8589	3.5	3.5		62		48		
United Republic of Tanzania	46.9	39.9	0.0916	0.116	**38**	**38.4**	**46**	**62**	47	47	**99.1**	**92.1**
Togolese Republic	12.6	7.1	0.1898	0.3805	11.2	11.2	**50**	**52**	37	35	**80.9**	**80.6**
Tunisia, Republic of	**4.1**	**6.8**	1.6144	2.2895	**1.2**	**1.3**	**81**	**93**	**75**	**85**	**9**	**3.7**
Uganda, Republic of	25	18.4	0.0456	0.0651	**25.6**	**26.3**	**44**	**60**	**42**	**43**	**93.8**	**93**
Western Sahara, Non-Self-Governing Territory of	3.8	3.8	0.8967	0.5726	7.1	7.1						
Zambia, Republic of	66.1	57.1	0.3011	0.203	**40.6**	**41.5**	**50**	**58**	**44**	**55**	72	74
Zimbabwe, Republic of	57.5	45.3	1.5882	0.8106	14.7	14.7	**78**	**81**	**50**	**53**	**4**	**3.4**

* Improvements are marked in "**Green and Bold**"

About Remote Sensing Images and Aerial Photographs Used in this Publication

The Landsat satellite program, jointly managed by NASA and the U.S. Geological Survey, has collected and archived images of the Earth's surface for over 35 years. This historical record provides a unique opportunity for identifying and documenting areas of environmental change anywhere on the planet. The majority of the remote sensing images used in this atlas are Landsat images.

The sensors used in the Landsat series are referred to as "multispectral" sensors. They collect reflected electromagnetic energy from the visible range (400 to 700 nanometers) as well as wavelengths that the human eye cannot see (700-2 350 nanometers) and thermal energy. Multi-spectral sensors divide the electromagnetic spectrum into a small number of "bands" or ranges of wavelength. For example Landsat-7 collects electromagnetic radiation in eight different bands or ranges of wavelength (see table). Each of these ranges of "light" can tell us something different about the Earth's surface.

To create viewable images from multi-spectral sensors, three of the available bands are selected and displayed, each through one of the three colours of standard monitor displays—red, green and blue. This can sometimes yield an image that is not intuitive for the non-specialist to interpret (left image). By selecting certain bands and adjusting the distribution of brightness, the overall brightness and the contrast, a more intuitive looking image can be achieved (right image). The images in this atlas have been adjusted so that non-expert readers can interpret these images more easily. The specific sensors and the band combinations used in chapter three can be found the references at the end of the chapter.

In general, the images are displayed so that growing vegetation shows as various shades of green. Conifer forests will generally show as darker shades of green as will mangroves to a lesser degree. Broadleaf forests are typically a slightly brighter shade of green. Agricultural fields with actively growing crops can show as a still brighter shade of green; however this is dependant on the crop and its state of growth. The patterns of brightness are often important clues as to the nature of the vegetation as well. Senescent or inactive vegetation generally appears as shades of gray and brown.

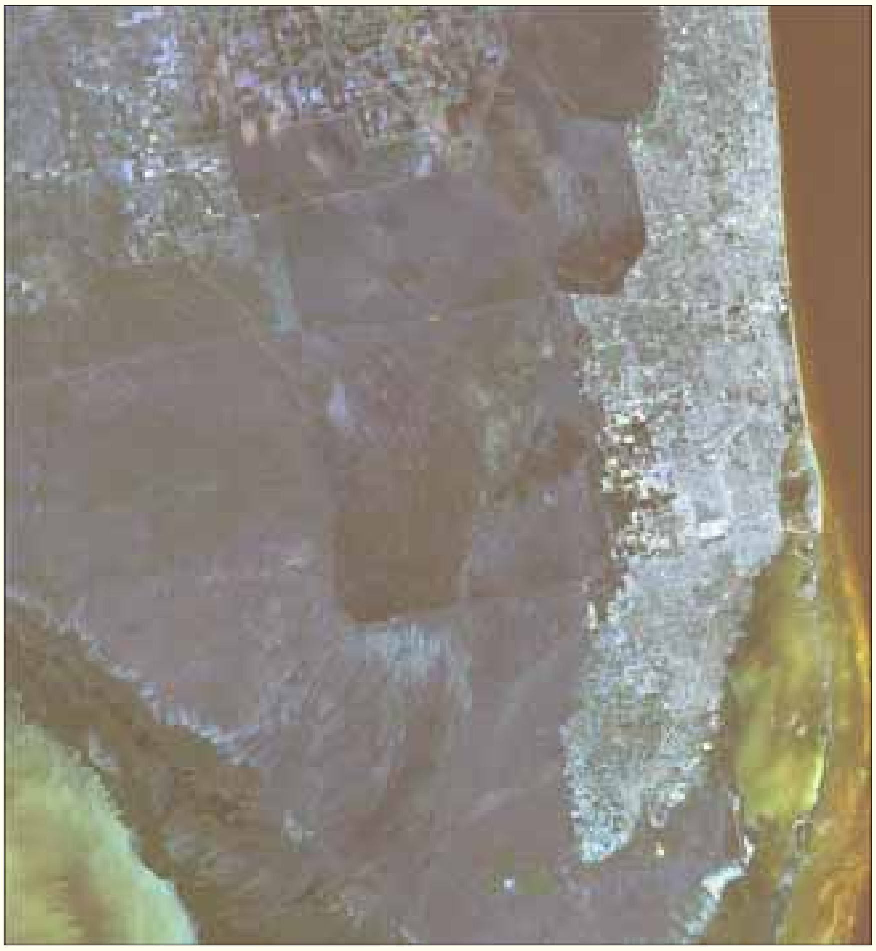
Water bodies will generally be blue to black in appearance, however when sediment is present or the water is shallow it will appear lighter even taking on a pink caste. Areas of bare ground will show as bright usually almost white while urban areas and roads generally appear as a shade of pale purple. Clouds, when they cannot be avoided, will appear as bright white.

In addition to Landsat images, data from other sensors such as ASTER[1] and MODIS[2], have been used as well as the high resolution commercial sensors QuickBird[3] and IKONOS[4], declassified spy satellite images (Corona and Argon)[5] and aerial photography.

Landsat-7 ETM+ Bands

Band	Spectral Range (nm)	Description
1	450 to 515 nm	blue-green light
2	525 to 605 nm	green light
3	630 to 690 nm	red light
4	775 to 900 nm	near-infrared radiation
5	1 550 to 1 750 nm	mid-infrared radiation
6	10 400 to 12 500 nm	thermal-infrared radiation
7	2 090 to 2 350 nm	mid-infrared radiation
8	520 to 900 nm	pan-chromatic

Both of these images are from the same Landsat-7 remote sensing image taken over the Everglades of Florida, USA in March of 2002. On the left bands 1, 2 and 3 are shown as red, green and blue respectively with the contrast and brightness determined by the default settings of a standard Geographic Information System software program. On the right bands 7, 4 and 2 are displayed as red, green and blue and the contrast and brightness have been adjusted.



1 ASTER (The Advanced Spaceborne Thermal Emission and Reflection Radiometer) is a sensor aboard the TERRA satellite is a joint effort between National Aeronautics and Space Administration (NASA) and Japan's Earth Remote Sensing Data Analysis Center (ERSDAC).

2 MODIS (Moderate Resolution Imaging Spectroradiometer) is a sensor carried on NASA's TERRA and AQUA satellites.

3 QuickBird is a high resolution commercial multispectral sensor aboard the QuickBird satellite, operated by DigitalGlobe.

4 IKONOS is a high resolution commercial multispectral sensor aboard GeoEye's IKONOS satellite.

5 Corona and Argon are U.S. photographic surveillance satellites flown from the 1950s through the early 1970s.

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Along the beach in Zanzibar, United Republic of Tanzania

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