Early Warning of Selected Emerging Environmental Issues in Africa:
Change and Correlation from a Geographic Perspective

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Acknowledgments and Disclaimers

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Foreword

I am very pleased to present this analysis of emerging environmental issues in Africa. This report represents a new effort by UNEP to highlight significant emerging environmental concerns confronting the continent so that steps can be taken to resolve them. The study made use of data sets developed by UNEP and its partners by applying reliable scientific methods and has led to some significant conclusions about environmentally sustainable development issues which need immediate attention at national, regional, and global levels.

The study confirms that: (a) natural tropical forests rich in biodiversity still lack adequate protection; (b) increased urbanization and consequent pressure on forest lands and freshwater ecosystems brings to mind an unwelcome prospect of progressive degradation in these life support systems; and (c) the recognized existence of a large number of transboundary river basins could be a potential issue for conflict in the face of a growing demand for water.

Ineffective management of the environment has enormous economic and social consequences. The threat to the maintenance of the well being of human populations will remain as long as scientifically sound methods to preserve environmental quality and, indeed, the entire ecosystem are not in place. Many policy makers remain uninformed about the distribution and extent of pervasive environmental degradation.

The continued degradation of the environment brings us to a crossroads -- a sense of purpose, anchored in a sound understanding of the issues, has never been more important. Studies such as this remind us that we need to be watchful. Recognizing critical environmental conditions, it has addressed the complex relationships and interlinkages between geographic location, environment, and demography in an attempt to support regional policy formulation and decision making.

Human, political, and/or administrative jurisdictions have never been able to contain the impact of environmental issues. More often than not, nature creates its own boundaries; generally involving more than one geopolitical entity. For such shared, transboundary environmental issues, bilateral and multilateral cooperation is the only solution.

The report conveys a sense of urgency about the need to develop suitable long-term strategies, attract investments, and stimulate international cooperation to conserve biodiversity and freshwater resources. My hope is that the holistic view of these problems presented here will help policy makers to make realistic choices about meaningful environmental protection in Africa.

Dr. Klaus Töepfer
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Executive Summary

This study of the world's second largest continent, Africa, focuses on assessing the state of the interconnected nature of population dynamics, land cover distribution, protected areas, and transboundary water resources. By placing human beings at the heart of the environmental protection process, the regional case studies in this report concentrate on identifying some of the emerging environmental issues by critically examining problems over larger areas and by assessing cumulative impacts on natural resources. The study provides an understanding of how conditions at the local level are influenced and constrained by the broader scale conditions of ecoregions and river basins. This type of information can assist policy makers in setting priorities and taking preventive measures. An attempt has also been made to quantify the magnitude of the transboundary nature of river basins as well as protected areas that transcend national boundaries. The impact, real and potential, of natural disasters and climate change was considered to be outside the scope of this study.

One of the main objectives of this analysis is to provide concise, policy-relevant, and credible information about the terrestrial environment of Africa by applying the latest technologies and scientific methodologies. An important feature of this study is the use of globally-consistent and comprehensive geospatial data sets developed by UNEP and its collaborating agencies using remote sensing and other sources. Geographic Information System (GIS) tools have been utilized for analysis, integration, and visualization of results, and for identifying areas at risk or vulnerable otherwise to adverse population-environment-development interactions. Maps and graphs have been used as the primary means of presenting the factual and quantitative data for informing and educating policy makers. Furthermore, baseline information is provided for measuring changes in the environment.

Major Findings of the Study

• The geographic distribution of population in Africa is highly uneven. The most dramatic population changes are occurring around Nigeria and the Great Lakes region of Africa. Continued rapid growth would significantly impact the environmental conditions of these areas and neighboring regions.

• About 11 percent of the African coastal areas (using a 100-km buffer) presently supports nearly 28 percent of the population. Population density is relatively low in most of the region, except around a network of large coastal cities. Coastal areas have registered an increase in population in the same proportion as the rest of the continent. The lack of apparent migration toward the coastal areas is an indication that subsistence agriculture continues to be the mainstay of the African people. The coastal regions of Africa, barring some local exceptions,

do not seem to be experiencing the same level of growth as coastal areas in other regions of the world. However, as the market-based economy expands, the existing conditions are likely to undergo a radical change bringing coastal areas face-to-face with a new set of environmentally stressful conditions.

• About 9 percent of the land under forest cover sustains approximately 10 percent of Africa's population. While 5 percent of forested regions have a high population density, the majority of the people in Africa, 60 percent, live in and around the savannas and grasslands. Increases in population may translate into increasing pressures on land cover; which has social, economic, and ecological consequences. The presence of a sizable population and its rapid growth in and around forested areas are likely to result in further degradation of such lands. The fast dwindling nature of the resources leaves the growing population highly vulnerable, as these resources are vital for their survival.

• About 16 percent of Africa's population lives within 20 km of designated protected areas. The population growth during the period 1960-1990 within these buffer zones was higher than outside the buffer areas. This trend could potentially threaten the resources of such areas.

• Protected areas in Africa account for nearly 7 percent of the continent's 30 million km². Alarmingly, however, only 6 percent of natural tropical forests rich in biodiversity are accorded protection status. The lack of protection status and the relatively ineffective implementation of protection measures in the designated protected areas pose serious threats to forest biodiversity.

• Low population densities in many natural forested areas of high biodiversity provide an opportunity for the protection and conservation of such areas.

• About 63 percent of the total land in Africa lies within transboundary river basins. This unique phenomenon heavily influences Africa's political geography. The growing scarcity of water, increasing population, degradation of shared freshwater ecosystems, and competing demand for shrinking natural resources distributed over such a huge area involving so many countries have the potential for creating bilateral and multilateral conflicts.

• Five major river basins, the Congo, Nile, Niger, Chad, and Zambezi, occupy about 42 percent of the geographical area and sustain over 44 percent of the African population. The high population growth rate and rather low protection status of natural forests of high biodiversity in the Congo Basin are indicators of emerging environmental problems of global significance.

- A low percentage of forest cover and high density of population distribution around Lake Victoria are indicators of increasing pressure on the lake's ecosystem.

- An overwhelming majority of African countries, 33 of them, share 189 protected areas along their national borders. The migratory nature of animals and declining populations in game reserves and national parks could result in loss of tourism revenues. There are also growing requirements for implementing the provisions of the environmental conventions. In light of such developments, transboundary protected areas could be a source of potential tension between the concerned parties.

In conclusion, this study, with the application of the modern information technology tools and consistent data sets, has made it possible to identify and quantify selected emerging environmental issues requiring national and international attention.

Introduction

The Rio Declaration on Environment and Development proclaimed that (Principle 25): "Peace, development, and environmental protection are interdependent and indivisible" (United Nations, 1993). However, the adverse effects of increasing population and human activities on the environment are dramatically accumulating, which is threatening the very foundations of sustainable development. The impact of human activity at the regional scale is receiving increasing recognition as a significant factor in environmental development. Most of the previous studies in this area have generally dealt with "site specific issues" examining only relatively small areas. Consequently, the extrapolation of results of such studies has been limited in scope. A broader geographic perspective of the environment is therefore needed to clearly reveal changes and connections. This perspective, in turn, could provide clues for instituting early warning systems for emerging environmental issues.

In addition, the Nairobi Declaration concerning the "Role and Mandate of the United Nations Environment Program," adopted by UNEP's Governing Council on Feb. 7, 1997, stated that one of the functions of UNEP is:

"To analyze the state of the global environment and assess global and regional environmental trends, provide policy advice, early warning information on environmental threats, and to catalyze and promote international cooperation and action, based on the best scientific and technical capabilities available."

The objectives of this study are: 1) to address some complex relationships between geography and the environment, and 2) to support regional decision making and policy development using consistent and comprehensive geospatial data sets employing modern Geographic Information System (GIS) technology. The focus of these analytical studies is to assess the state of the interconnected nature of population dynamics, land cover distribution, protected areas, and transboundary water resources in Africa which are likely to induce significant environmental changes in the future. Continental data sets are used to derive policy-relevant information regarding the impacts of human settlement patterns on land cover types and protected areas. The study also attempts to quantify the magnitude of the transboundary nature of some of the environmental issues such as transboundary river basins and protected areas, to strengthen cooperative management and enhance intergovernmental cooperation.

In the past, regional analyses have usually been performed by the aggregation of national statistical data derived from a variety of sources. Data sets collected by individual countries or researchers usually vary considerably in quality and geographic coverage. The simple merging of these individual data sets does not meet the needs of a more holistic, regional-scale analysis. Some of these available data sets are often old and based on different definitions and classifications; hence, they are often not comparable and difficult to aggregate. The analysis presented here uses globally-consistent and comprehensive geospatial data sets developed through international cooperation by UNEP and its partners using remote sensing and other sources. Such analyses provide a basis for scientifically credible environmental assessments covering large areas.

This study focuses on Africa, the world's second largest continent. The analysis presented here, however, is not unique to Africa and could be extended to any political or natural region of the world. It is expected that the information derived from such analyses can help in identifying problems in the scientific management of the ecosystem and, more importantly, provide for timely intervention to prevent further degradation of the environment.

This photograph was taken on July 16, 1969, approximately 181,500 km above the earth by an Apollo 11 crew member. It dramatically shows the influences of the Atlantic and Indian Oceans on Africa's climate. The continent's climatic regions are distributed nearly symmetrically about the equator. Warm, moist air moves into Africa from the South Atlantic and Indian Oceans funneling moisture against the western coast, Congo Basin, and Madagascar. The Intertropical Convergence Zone is a band of moist air that shifts north and south of the equator, following the direct rays of the sun. In contrast, the high-pressure cells centered over the tropics of Cancer and Capricorn are primarily responsible for forming the hot and dry Sahara Desert (north) and Kalahari Basin (south).

Two fundamental conditions threaten environmental quality in Africa. First, the very high annual population growth, 2.36 percent, which is nearly double the global rate of 1.33 percent. Second, the general level of poverty impacts the ability to deal with problems on the entire continent. The combination of a high population growth rate and poverty raises concerns regarding the long-term prospects for Africa's environment in general and, more immediately, the high biodiversity-rich forest areas.

Aerial view of Pikine in the suburb of Dakar. Although Pikine was created just 20 years ago with the objective of alleviating congestion of the Senegalese capital, Dakar, it has rapidly grown to a city of more than 800,000 inhabitants. A poor rural economy and drought have increased the rural to urban migration, contributing to Pikine's rapid growth. Its density exceeds 10,322 inhabitants per km^2.

Africans, as a group, are more directly dependent on their environmental and biological resources than most other peoples of the world. A majority of the African population is agrarian; therefore, any increases in population correspond directly to increased pressures on natural resources. Most Africans live by subsistence farming. This agricultural foundation strongly ties them to their land resources. However, soil erosion, salinization, and acidification seriously threaten the land on which they depend. If the deterioration of agricultural lands continues at current rates, experts predict that crop production will be cut in half by the year 2010 and a vicious cycle will ensue (Scotney and Van der Merwe, 1991). As soil degradation increases, productivity decreases, and poverty worsens, the poor will have little alternative but to overuse their already scarce resources. Before their basic needs are met, the people will not be mindful of the sustainability of resources, *inter alia* preservation of natural resources for future generations.

Despite the fact that approximately 57 percent of the African continent is either arid or semi-arid, Africa has a wealth of natural resources. In terms of biodiversity, the

most important regions of Africa are the dense, moist tropical forests of West and Central Africa and Madagascar. In aggregate, Africa has the second largest area of tropical rainforests in the world, totaling over 520 million hectares (FAO, 1997). These forests cover 18 percent of the African continent (FAO, 1995) and are generally considered to be "hot spots" for biodiversity and endemic species. However, deforestation in Africa accounts for over 60 percent of global deforestation. The annual rate of deforestation in Africa during 1990–1995 was 3.7 million hectares, or 0.7 percent of the forested area (FAO, 1997). In an extreme example, Uganda reported a forest and woodland cover of about 45 percent in 1900, but only 7.7 percent in 1995 (Republic of Uganda, 1995).

A view of the densely populated rural area in the Rift Valley, Kenya. The farmers use intensive production methods to grow food crops, such as corn, and millet, and cash crops.

Population and Terrestrial Environment

The priorities set by Agenda 21, the main basis for international organizations' environmental mandates, relevant to Demographic Dynamics and Sustainability (Chapter 5), envisaged "incorporating the demographic trends and factors in the global analysis of environment and development issues." In Agenda 21, among others, the following activities are proposed (United Nations 1993):

(a) "Identifying the interactions between demographic processes, natural resources and life support systems, bearing in mind regional and sub-regional variations deriving from *inter alia*, different levels of development;"

(b) "Integrating demographic trends and factors into the ongoing study of environmental change . . . first, study the human dimensions of environmental change and second, identify vulnerable areas;"

(c) "Identify priority areas for action and developing strategies and programmes to mitigate the adverse impact of environmental change on human population, and vice versa."

The following case studies aim at understanding the magnitude of a population's influence on the terrestrial environment. Population density differences can be used as a surrogate for the pressure of human activities as well as dependence on the environment. By using population data over several decades, the trends in pressure can be identified which can warn policy makers about the extent and location of emerging environmental threats. The case studies presented here are by no means an exhaustive list of possible analyses, but rather samples of what can be done to bridge the gap between science and policy development.

In Africa, large forested areas are cleared annually for agricultural expansion, fuelwood collection, and livestock grazing.

Case 1:
Patterns of Human Settlement and Growth – 1960, 1970, 1980, and 1990

Issue Context: The promotion of sustainable human settlement development is the key for maintaining a scientific balance between man and nature (United Nations, 1993). Population growth is an important factor in estimating the effect of human activities on environmental resources. The Plan of Action, adopted at the International Conference on Population and Development, September 1994, Cairo, states that population is the single largest threat to the world environment. Many significant environmental impacts have their sources in human settlements; these include air and water pollution, waste generation, and the concentration of human population and activities in urban areas exerting immense pressure on the rural areas with which they are linked.

Africa has the highest population growth among all regions of the world (2.36 percent). According to present projections the population of Africa will increase from 0.7 billion persons in 1995 to 1.8 billion in 2050 to 2.8 billion in 2150 (United Nations, 1998). This has to be also examined within the context that Africa has the highest urban growth rate (4 percent annually) on the planet (United Nations, 1997) Such growth is bound to have phenomenal environmental repercussions.

Therefore, it is important to assess human settlement patterns as an early indicator of where and how the impact of growth is likely to affect the state of natural resources.

The analysis assesses geographic distribution of the African population over an approximate area of 30 million km^2 and how the spatial distribution of population dynamics has changed during the decades 1960 to 1990.

Data Used: Population distribution 1960, 1970, 1980, and 1990.

This nighttime view of Africa is derived from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) and is a satellite-based inventory of human settlements. The DMSP-OLS is capable of observing faint sources of visible-near infrared emissions at the Earth's surface, including cities, towns, villages, gas flares, and fires. In this image of Africa, southern Europe, and Saudi Arabia, the coastal outlines of northern Africa from Tunis, Tunisia to Casablanca, Morocco, are readily visible. The developed part of the Nile River, between the Aswan High Dam and the Nile Delta, is shown by the bright string of lights running south-to-north in the upper right-hand part of the image. Johannesburg, South Africa, is the focus of development at the southeastern tip of the continent. Most notably, there is a lack of city or village lights in the interior of the continent, especially in highly populated areas such as the regions around Lagos, Nigeria, and Lake Victoria.
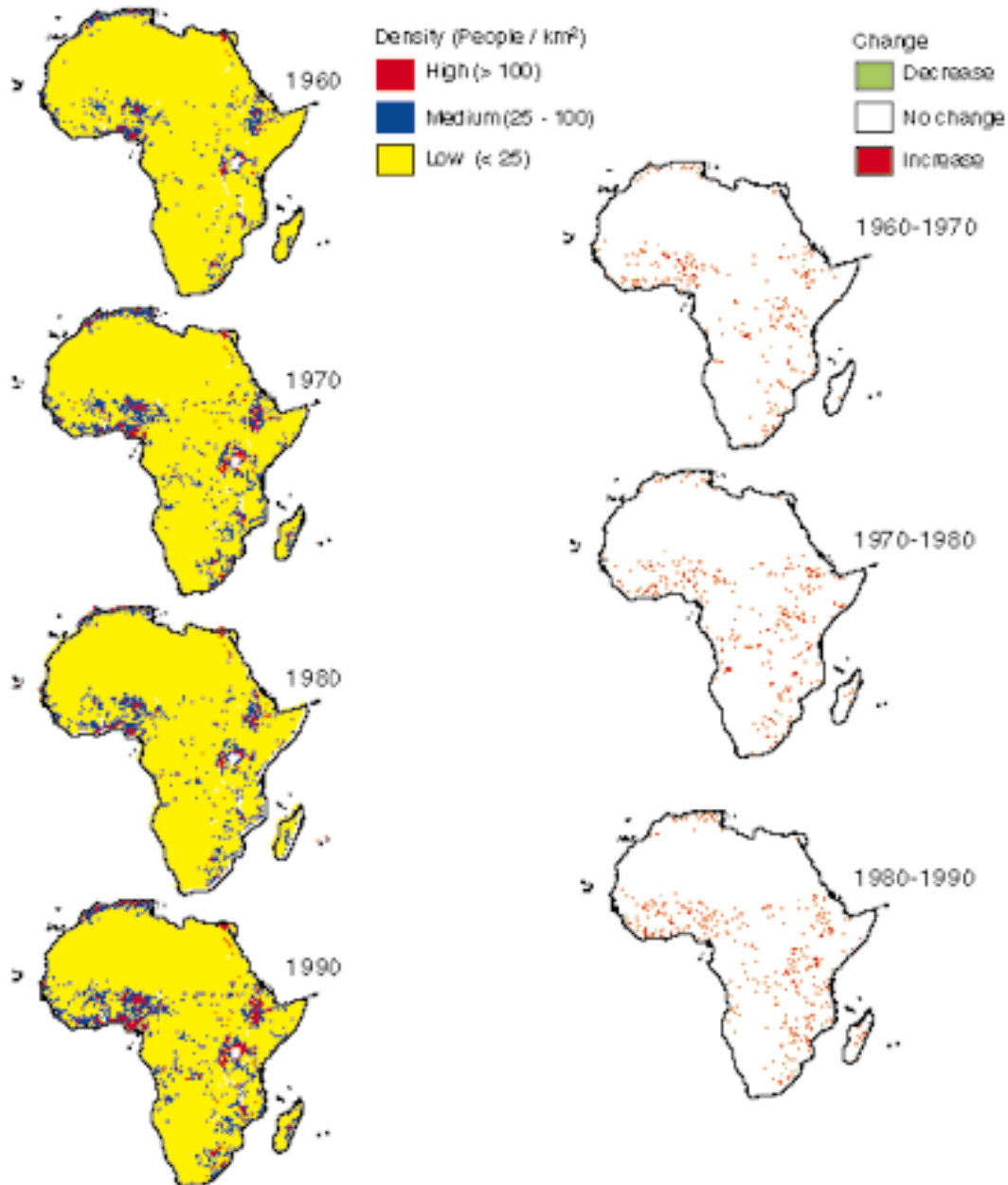
These maps of African population and population change were developed using geographic models that correlate population with the system of highways, roads, and railroads. Using this model, population estimates were produced for a period from 1960 to 1990. The estimated population is broken into high density (greater than 100 persons per km²), medium density (25 - 100 persons per km²), and low density (fewer than 25 persons per km²). The population change maps in the right part of the figure were generated by subtracting the population maps appropriate for the decade of interest (e. g. , 1960's population change is created by subtracting 1960 from 1970 population). These and other cartographic products depict where and when the population has changed in Africa.

Results:

- The geographic distribution of population in Africa is highly uneven. The major populations are concentrated along the northern coast between Tunisia and Morocco, in and around Nigeria, around Lake Victoria, in Ethiopia, and along the Nile River.
- The most dramatic population change has been in the regions around Nigeria and the Great Lakes region of Africa.
- In some areas there is a negative trend in population, presumably due to famine and other disasters, as well as regional and internal conflicts.

Case 2:
Population Growth within 100 km of the Coast

Issue Context: The coastal areas contain diverse and productive habitats important for human settlements, development, and local subsistence. Coastal resources are vital for many local communities and indigenous people. Despite efforts at varying levels, current approaches to the management of coastal resources have not always proved capable of achieving sustainable development while coastal resources and environment are being rapidly degraded and eroded. The coastal states should conduct regular assessments of the state of their environment in the coastal and marine areas (United Nations, 1993).

Rapidly-growing, developing countries usually base their economic success on the export of labor-intensive manufactured products. Large export activities require access to coastal ports. Almost all countries with economic success in the export of labor-intensive products have populations almost completely within 100 km of the coast (Radelet and Sachs, 1988).

In order to develop a suitable strategy for sustainable development of coastal areas, it is vital to assess the population distribution and growth patterns along the coastal regions.

Geographically-referenced data were used to analyze the spatial distribution of population growth. In this case, the interest was in the portion of population living within 100 km of the coast. By definition, for the purposes of this analysis, the coastal areas are all lands within 100 km of the African coast.

Data Used: Population distribution 1960, 1970, 1980, and 1990, and 100-km Coastal Buffer Zone.
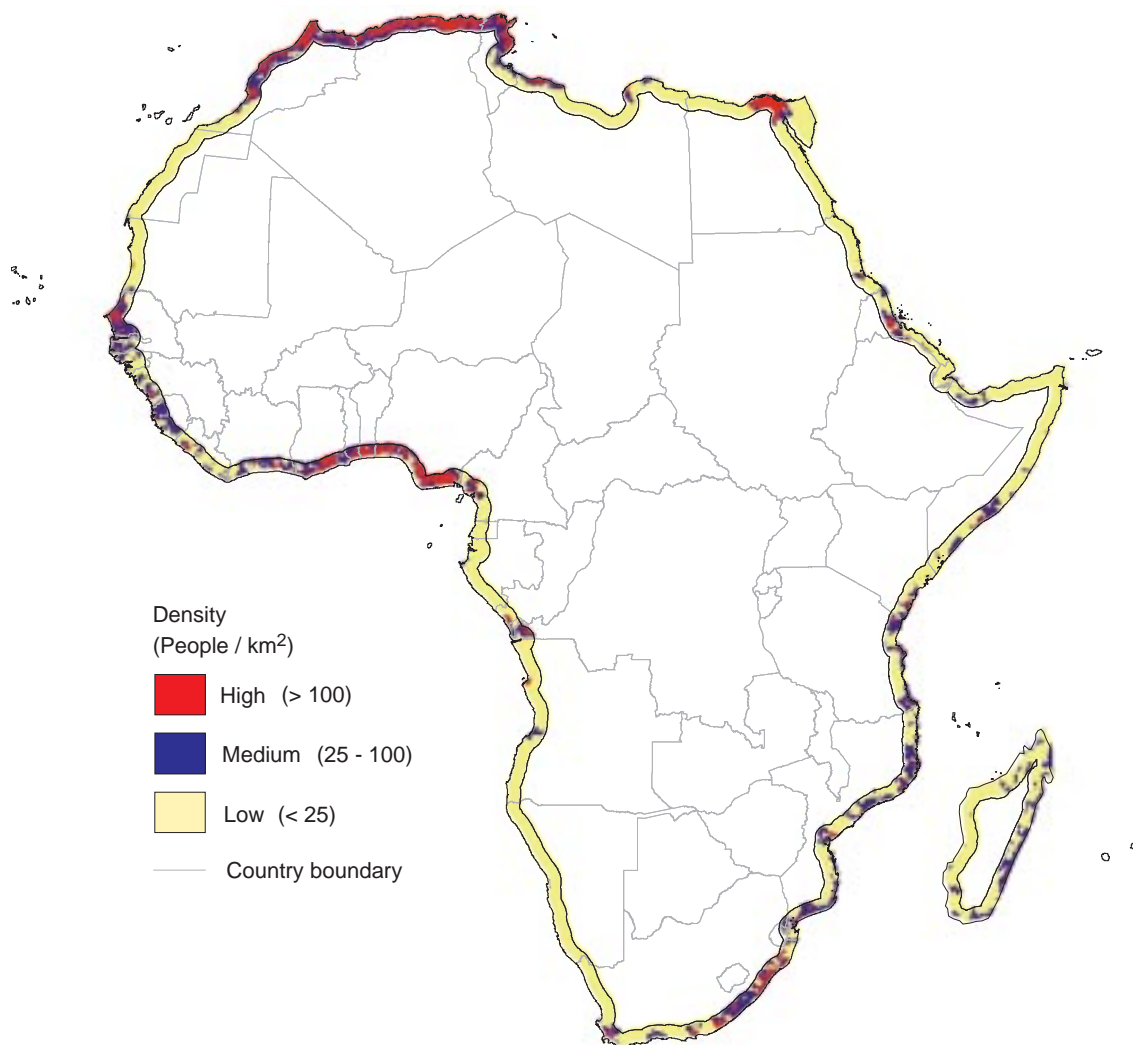
On this map, the interior regions of Africa have been left blank to highlight the 100-km coastal zone population. The population data shown here is from 1990.

Population Growth within 100-km of the Coast
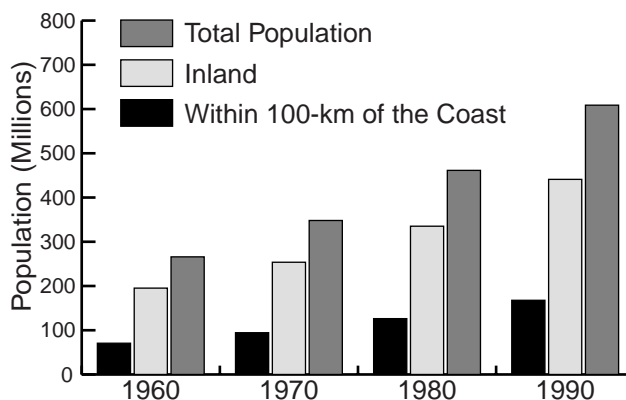
Graph of coastal, inland, and total population from 1960, 1970, 1980, and 1990. The proportionate growth of the coastal regions is evident in this graph.

Population Growth within 100-km of the Coast
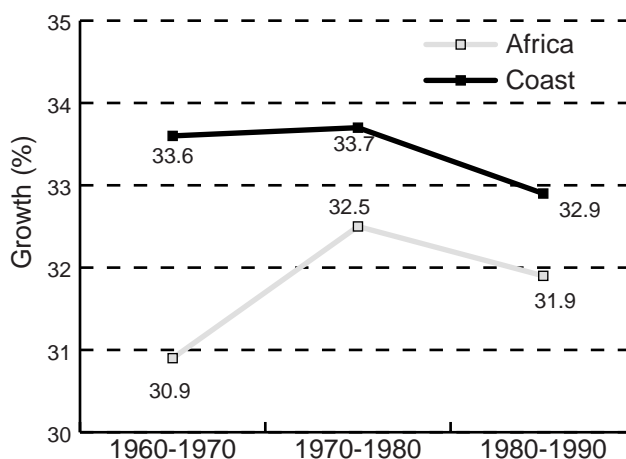
Graph showing changes in the population growth within the coastal buffer compared to the continental trend.

Results:
- Nearly 28 percent of the African population resides within 100 km of the coast. This represents only 11 percent of the continent's land area.
- Africa's coastal population has grown from approximately 70 million in 1960 to approximately 168 million in 1990. Despite this dramatic growth, it is perfectly proportional to Africa's total population growth, which grew from 266 million in 1960 to 609 million in 1990. This lack of migration to the coastal zone is indicative of Africa's historical and continuing base in subsistence agriculture.
- The growth of coastal population during the decade 1980-1990 was slower than in the previous two decades.
- The lack of coastal migration seems to be due to the fact that Africa has remained largely agrarian and, contrary to developments elsewhere, the economic base of the continent has not shifted to the export of labor-intensive manufactured products.
- The proportional growth of population in coastal and non-coastal areas stands as a unique characteristic of this continent's demography when compared with the demographic development worldwide.

Case 3:
Patterns of Land Cover Distribution

Issue Context: In general, land cover resources everywhere are threatened by uncontrolled degradation and conversion to other types of land uses, including agricultural expansion. The impacts of loss and degradation can be seen through the depletion of biodiversity, soil erosion in watershed areas, and options for development. Africa contains the world's largest expanse of drylands accompanied by land degradation. This includes degradation of vegetation cover and soil degradation, both of which have been identified as two major problems in Africa (UNEP, 1997).

Information on the distribution of land cover types is critical for sustainable development planning. The quantity, variety, and spatial distribution of land cover types are important data for the inventory and assessment of changes in ecological conditions. Geographically-referenced information is essential in raising alarms on inappropriate land cover conversions and identifying opportunities to promote suitable land use planning and policy interventions.

In this case study, detailed land cover classes, derived from remote sensing data, were aggregated to form four broad categories of land cover: 1) forest, 2) shrubland or woody savannas, 3) savannas or grasslands, and 4) barren or sparsely vegetated and water.

Data Used: Land Cover distribution.
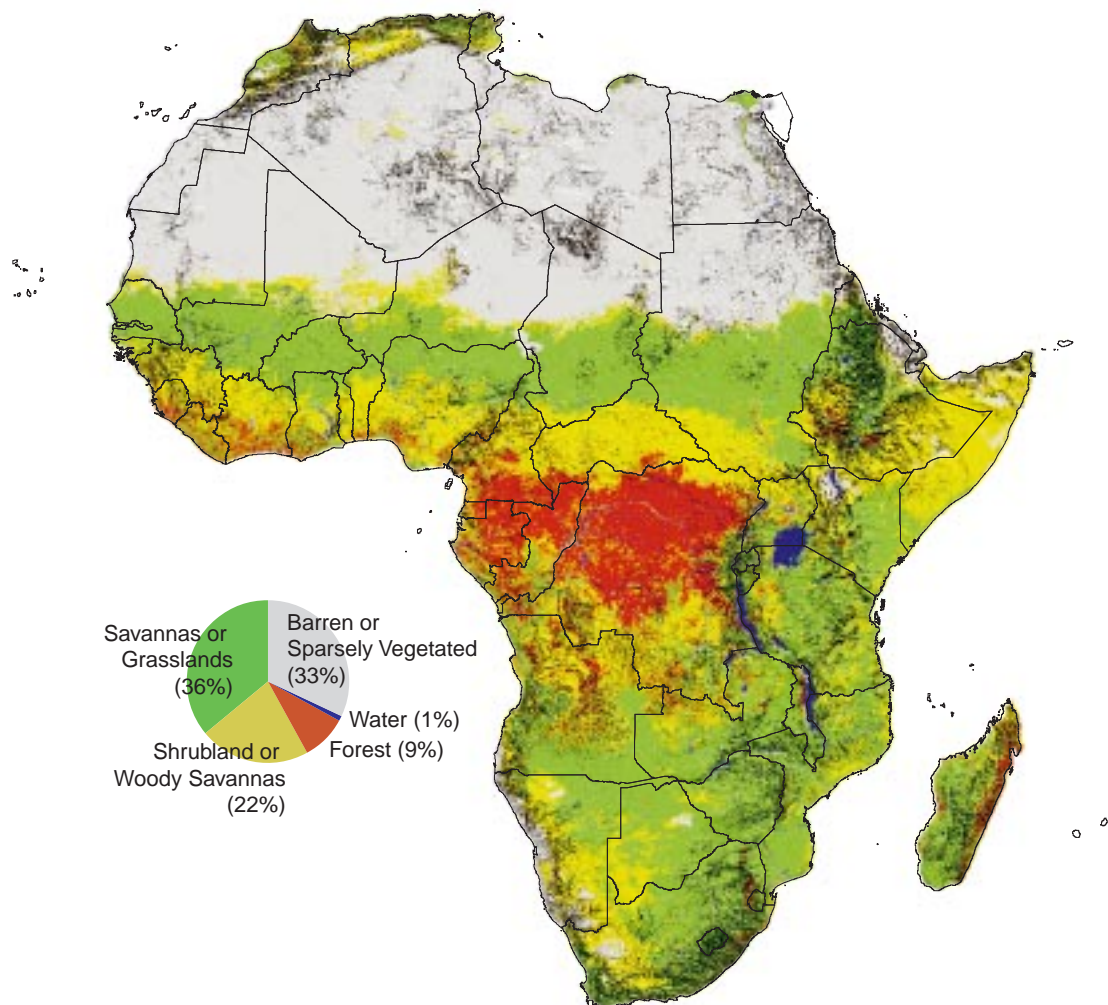
This shaded relief map of Africa shows four broad classes of vegetation cover. Forests, defined as evergreen broadleaf and deciduous broadleaf forests, are concentrated in the Congo Basin, along the western coast, and on the eastern coast of Madagascar.

The open woodlands of the Niokolo-Koba National Park in Senegal remain largely intact, although the animal populations have declined from poaching. However, pressures from cultivation are mounting around the Park's boundaries. Drought and bush fires have also taken their toll.

Rainforest in Côte d´Ivoire with a banana plantation in the foreground. These forests are generally considered as "hot spots" for biodiversity and endemic species. However these forests are retreating as humans convert them to other land uses.

Results:

- Land cover distribution derived from remotely sensed data indicated that only about 9 percent of the continent has forest cover. Shrubland or woody savannas constitutes another 22 percent and the dominant land cover class, savannas or grasslands, makes up 36 percent of Africa's land. One per cent is water and the balance, 32 percent, is barren or sparsely vegetated areas.

- The figure of 9 percent forest cover is significantly lower than the 18 percent reported by the FAO (1995). The discrepancy could be due to differences in real changes in forest cover, assessment methodologies, classification, and definition of "forests."

Case 4:
Population Pressures on Land Cover Types

Issue Context: Increasing population brings about increasing pressure on all kinds of land cover; and with it social, economic, and ecological consequences. Overgrazing, static grazing patterns, encroaching land conversion, and increasing human population densities constitute some of the prevailing threats to grasslands and arid land systems. Despite mounting efforts for the past 20 years, the loss of the world's biodiversity, mainly from habitat destruction, over-harvesting, pollution, and the inappropriate introduction of foreign plants and animals, continues. (United Nations, 1993).

This analysis was carried out to measure the magnitude of population pressures on various land cover types.

Data Used: Population distribution 1990, Land Cover distribution.
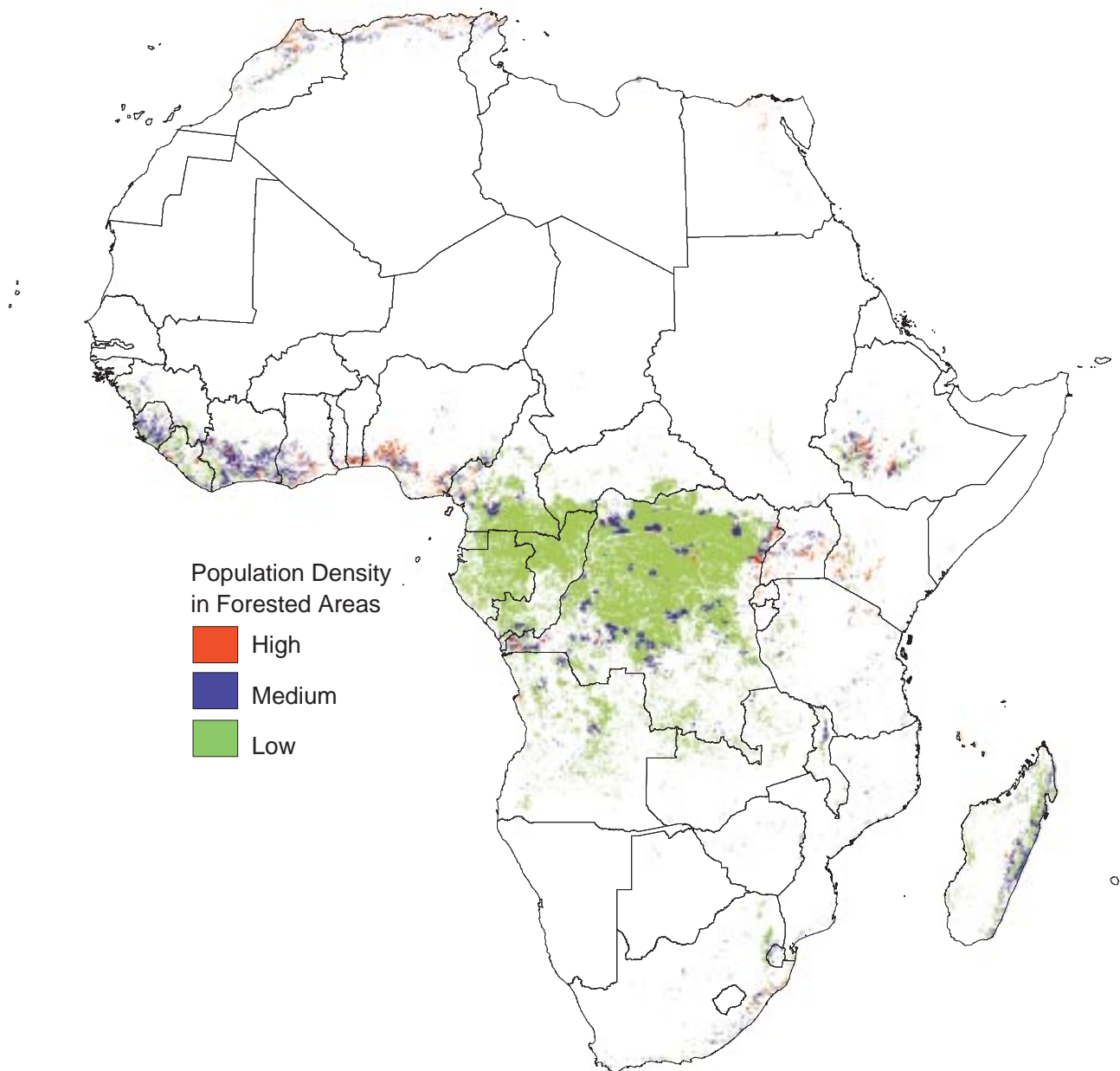
Shown in this map is the correlation between forest lands and population. Areas in white are non-forested. Areas shown in red (high-density population), light blue (medium-density population), and yellow (low-density population) are forested. From this map, three broad areas of population pressure on forests can be seen: the west coast, particularly from Guinea east to Nigeria; the northern coast, including Morocco, Algeria, and Tunisia; and east Africa, predominantly in Ethiopia, Kenya, and Uganda.
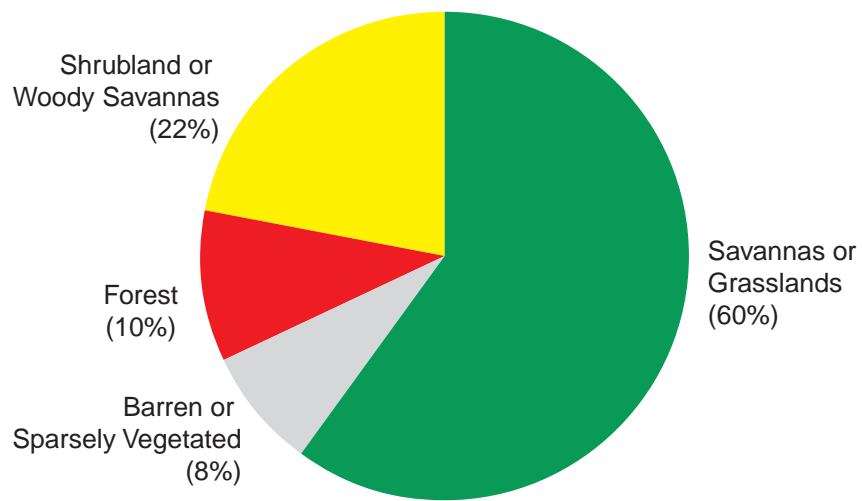
A pie chart shows how the population is distributed by land cover. A majority of the population lives in the savannas or grasslands land cover class.

Results:

- Land under forest cover sustains approximately 10 percent of Africa's population. But the majority of people, nearly 60 percent, live in and around savannas and grasslands.

- About 5 percent of the forested areas are occupied by high-population density, 15 percent by medium-population density, and 80 percent by low-population density.

- Higher population density translates into greater ecological degradation. Rapid population growth in forested areas will inevitably lead to increased deforestation.

Case 5:
Population Pressures within 20 km of Protected Areas

Issue Context: More often than not, the lands surrounding protected areas, for various reasons, become the primary targets of intensive use by humans. The overuse of these limited, yet important, areas is cause for concern as it leads to the degradation of the environment.

The basic issues to be examined here are whether human population pressure and excessive land use threaten the protected areas in Africa.

Data Used: Population distribution 1960, 1970, 1980, and 1990, Protected Areas.
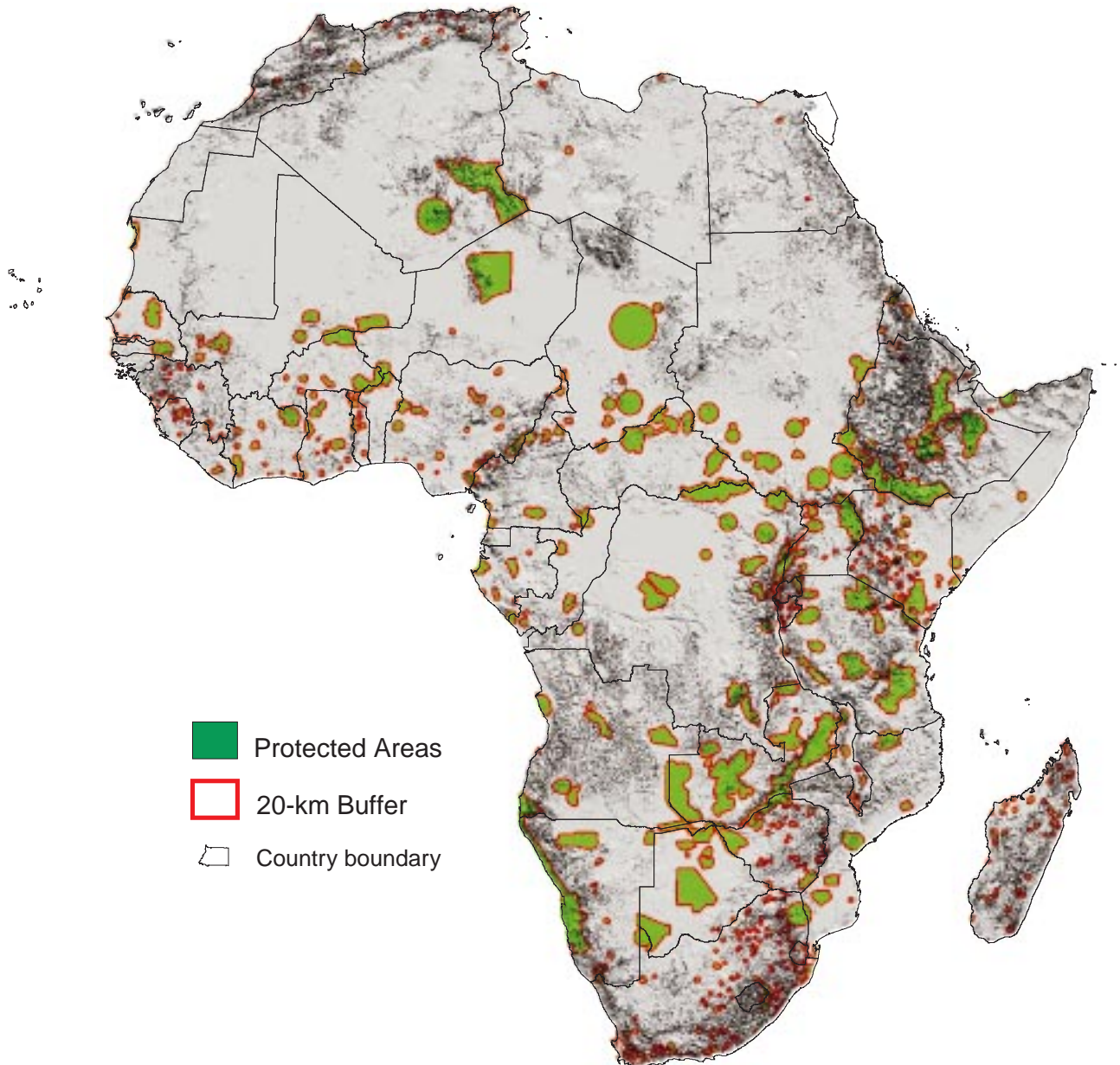
Protected areas in Africa can be found throughout the entire continent. Shown here are the protected areas with a 20-km buffer zone. There is a concentration of protected land along the eastern edge of the continent and a noticeable deficit of protected area on the Mediterranean coast.

Population Density

- 🟥 High
- 🟦 Medium
- 🟨 Low
- Protected Areas & 20-km Buffer
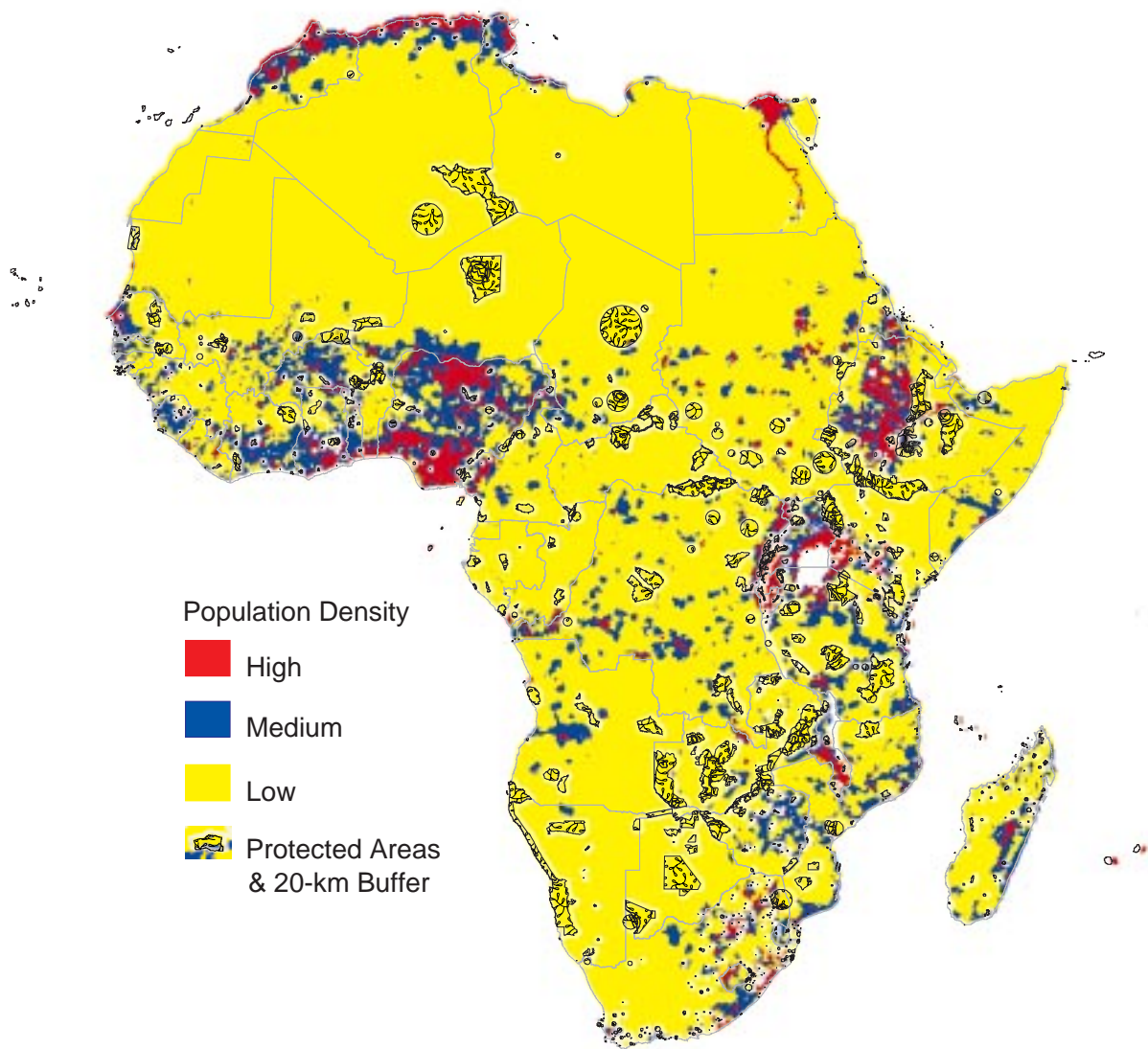
A composite map dramatically shows the juxtaposition and interaction between the population and protected areas. Especially interesting is the evidence of how protected areas affect population. For example, notice how around Lake Victoria the protected areas created barriers to population expansion, but medium- and high-density populations are filling in the gaps between protected areas.

Population within 20 Km of Protected Areas
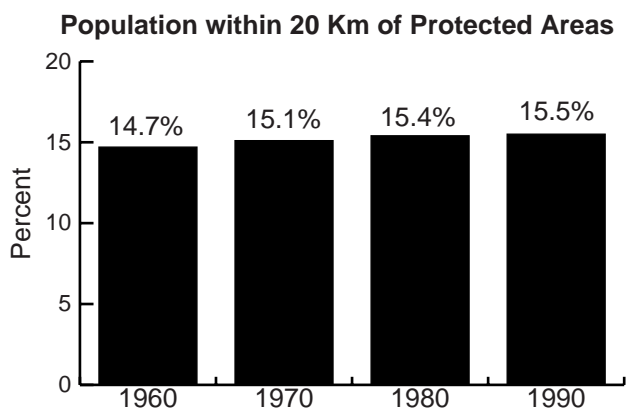
In 1960 approximately 14.7 percent of the population was within 20 km of a protected area; whereas in 1990 the proportion had increased to approximately 15.5 percent.

A view of the Lambaye Forest in Senegal. About 16 percent of Africa's population live within 20 km of protected areas. The population growth during the period 1960-1990 within these buffer zones was higher than outside the buffer areas. This trend could threaten the existence of such areas.

Many countries are raising awareness and are making efforts to increase public participation in natural resources management. Elders, women, and young people all are urged to participate.

Population Density around Protected Areas
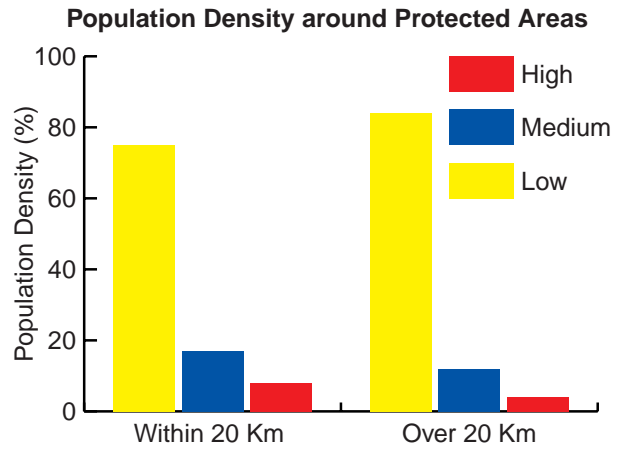
Significant differences between the population density breakdown within the 20-km buffer around protected areas and outside the protected areas. Around 25 percent of the population within the 20-km buffer is either medium or high density. The medium- and high-density values in the buffer are also significantly higher than the area outside the buffer (16 percent medium- and high-density population). These figures are quantitative indications of differential population pressure on Africa's protected areas.

Africa – Protected Areas and Population Increase
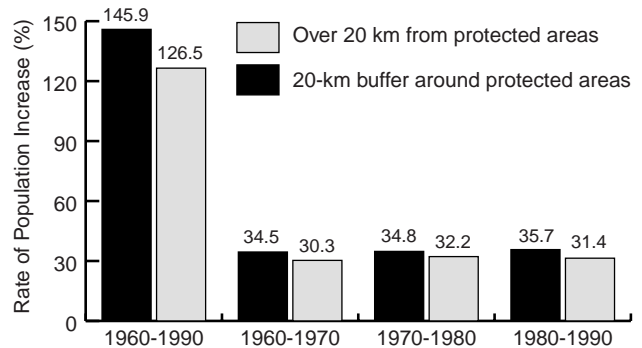
A historical look at how population density has changed in, around, and outside of protected areas highlights the issues between population and protected areas. In the three decades between 1960 and 1990, the continental population increased 129 percent, but in the 20-km buffer regions it increased nearly 146 percent. In addition to being important for environmental purposes, this differential increase in population is indicative of the protected area's economic importance.

Results:

- About 16 percent of Africa's population live within 20 km of protected areas, a number that has grown more quickly than the continental average. Overpopulation and differential population growth near protected areas may be the largest threats to Africa's protected natural resources. Such resources are vital for peoples' survival as well.

- The highest human population densities are found near protected areas in Rwanda, Burundi, and Uganda around Lake Victoria and in scattered areas in Malawi, Zambia, and Kenya.

Case 6:
Protection Status of Land Cover Types

Issue Context: Biological diversity, the variety and variability among living organisms and the environment in which they occur, is important to maintain life-sustaining systems of the biosphere; yet, it is threatened by many human activities. The total number of species that inhabit the planet is unknown and it is feared that the extinction of many of them will occur even before they have been named and described. It is estimated that 85-90 percent of all species can be saved by identifying and protecting areas of high biodiversity before they are further degraded, without having to inventory species individually. Realistically, only a relatively small portion of the total land area is likely to be devoted to biodiversity conservation; hence, it is very important to identify areas rich in species diversity and endemism for priority-setting purposes. In the past, areas have been set aside as protected, often without regard to the biodiversity within their boundaries. As a result, many designated protected areas have little significance in terms of biodiversity, and, conversely, many areas of habitat with significant biodiversity lack protection.

This analysis was carried out to assess the status of protection of biodiversity in Africa to answer the question: Are African land cover types with significant biodiversity adequately protected?

Data Used: Land Cover distribution, Protected Areas.

Land Cover Protected

- 🟥 Forest
- 🟨 Shrubland/Woody Savannas
- 🟩 Savannas/Grasslands
- ⬜ Barren or Sparsely Vegetated
- ⬡ Country Boundary
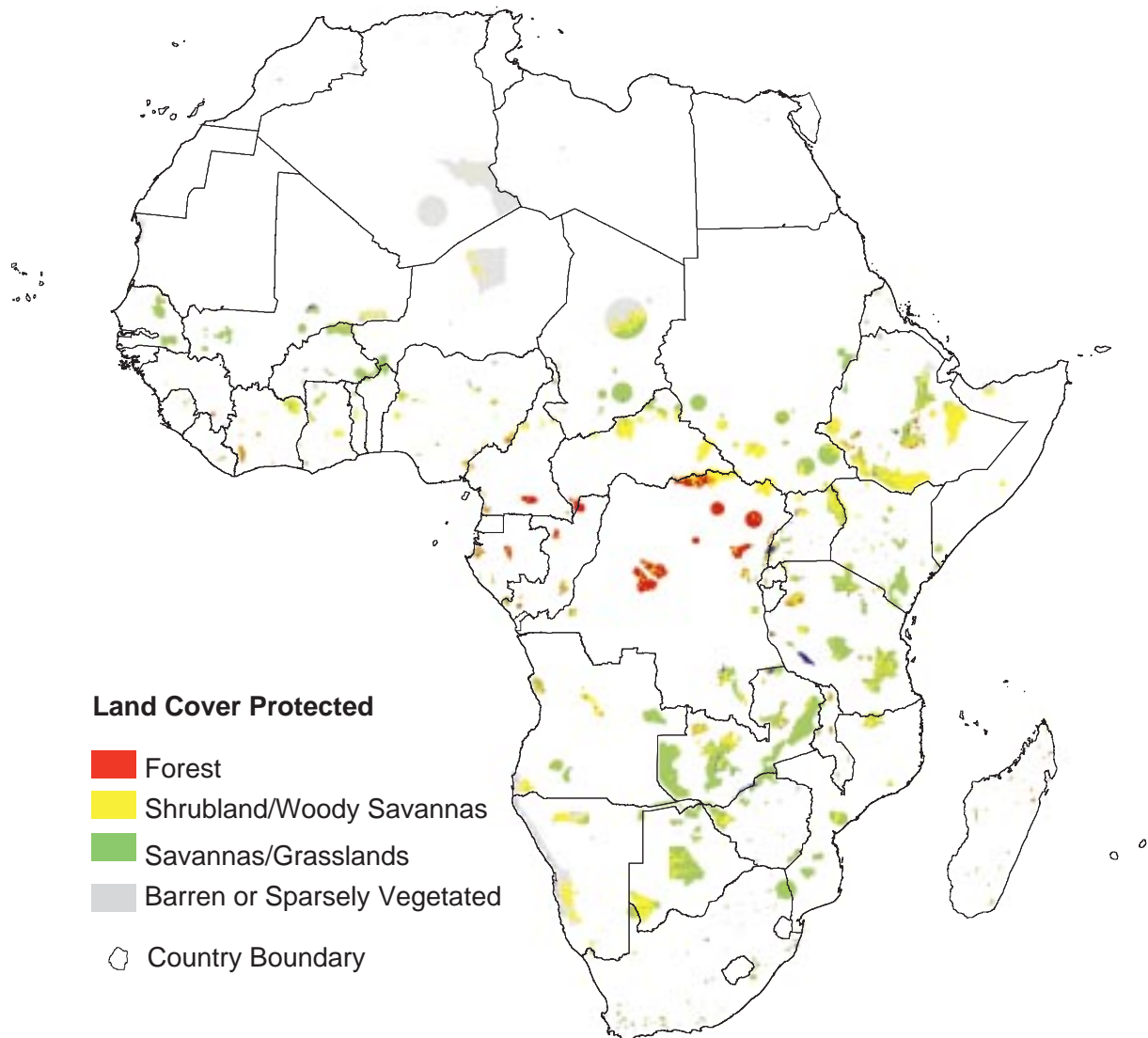
This map highlights the land cover types currently under protection. White areas on the map are unprotected and shaded regions are protected. Protected areas are clustered along the Great Rift Valley and the southeastern highlands of the continent. Noticeably, the Congo Basin, a region with some of the world's highest biodiversity, lacks an equivalent amount of protection.

Percent Protected by Land Cover Type
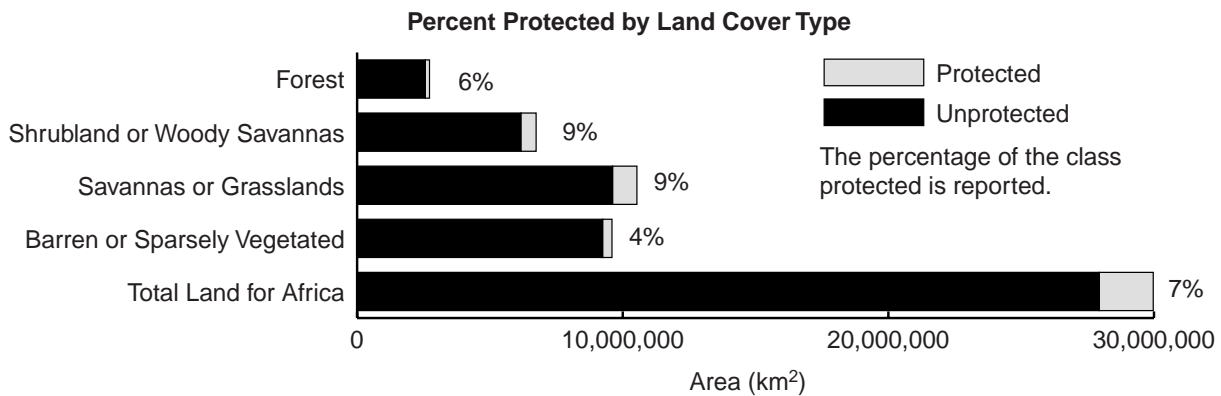
This graph shows the amount and percent protected of each land cover type. Forested lands have the lowest level of protection of any land cover type (6 percent), whereas savannas and grasslands have 9 percent of their land cover protected.

Results:

- Designated protected areas in Africa occupy slightly more than 2 million km^2, or 7 percent, of the continent's 30 million km^2. Of the barren or sparsely vegetated lands, about 4 percent are protected, whereas less than 6 percent of the tropical evergreen broadleaf forests are protected. Savannas or grasslands and shrubland or woody savannas have the largest proportion of protected area, namely, 9 percent each.

- Tropical forests are biologically the most diverse and are home to thousands of endemic species. Geographically, these forests are concentrated in countries like the Democratic Republic of Congo and Madagascar. Such forests lack adequate protection status.

- In Africa, land cover types in drier zones are generally better protected than tropical evergreen broadleaf forests. This is contrary to the widely-held belief that moist habitats, such as tropical rain forests, are generally better protected than drier zones, such as dry forests and grasslands.

Transboundary Resource Issues

Traditionally, environmental analyses have been prepared using political and/or administrative boundaries. There is a great value in using such boundaries as tools because conservation actions are administered within political jurisdictions. However, often many environmental issues transcend political or administrative boundaries. Transboundary issues require intergovernmental cooperation. To provide a basis for such cooperation, it is important to quantify the transboundary aspect of the shared resources, and to characterize the nature and patterns of factors that threaten them.

Water is the world's most vital natural resource and the issues surrounding it are urgent and global in scope. The growing danger to human health from inadequate or unsafe water, the rise of potential conflicts over shared water resources, and the effects of climatic change on water resources are significant environmental threats. Generally, freshwater is very widely shared as manmade political borders rarely coincide with watershed boundaries. In certain regions of the world, water is a scarce resource, and in these regions, shared water gives rise to conflicting politics. The resultant conflicts generate a high probability of water-related disputes (Gleick, 1998).

It has been clearly stated in Agenda 21, Chapter 18, that "transboundary water resources and their use are of great importance to riparian states. Therefore, in conformity with existing agreements and/or other relevant arrangements and while keeping their respective interests in mind, the cooperation among such states becomes crucially important. The overall objective is to satisfy the freshwater needs of all countries for their sustainable development" (United Nations, 1993).

In this connection, the river basins are a convenient and meaningful framework for freshwater assessments as their linkages extend beyond hydraulics. This is because the rivers that reside in the basins create their own economic and social conditions. Rivers are the arteries along which people and goods are transported and inseparably link agricultural activities within the basin. As such, river basins provide a logical holistic view of water resources and related issues.

Another transboundary issue, which has not received much international attention, relates to "Transboundary Protected Areas." For the protection, conservation, and scientific management of these areas, bilateral and multilateral cooperation is *sine quo non*. In the following sections an attempt has been made to quantify and characterize these two transboundary issues.

Issue Context: Transboundary river basin management has a spatial dimension as it involves the sharing of resources among the concerned states. The sharing and management of transboundary river basins require intergovernmental cooperation for resolving the conflicting and competing tendencies between the concerned states. "In the case of transboundary water resources, there is a need for riparian states to formulate water resources strategies, prepare resources actions programs and consider, where appropriate, the harmonization of those strategies and action programs" (United Nations, 1993). It is in this light that a study of shared river basins in Africa and some of the characteristics of five major basins (Nile, Congo, Chad, Niger, and Zambezi) has been carried out.

Data Used: River Basin Boundaries, Political Boundaries.

The river basins shown in this map are those that are multi-jurisdictional. There are 60 shared basins which cover over 63 percent of the total area of Africa.
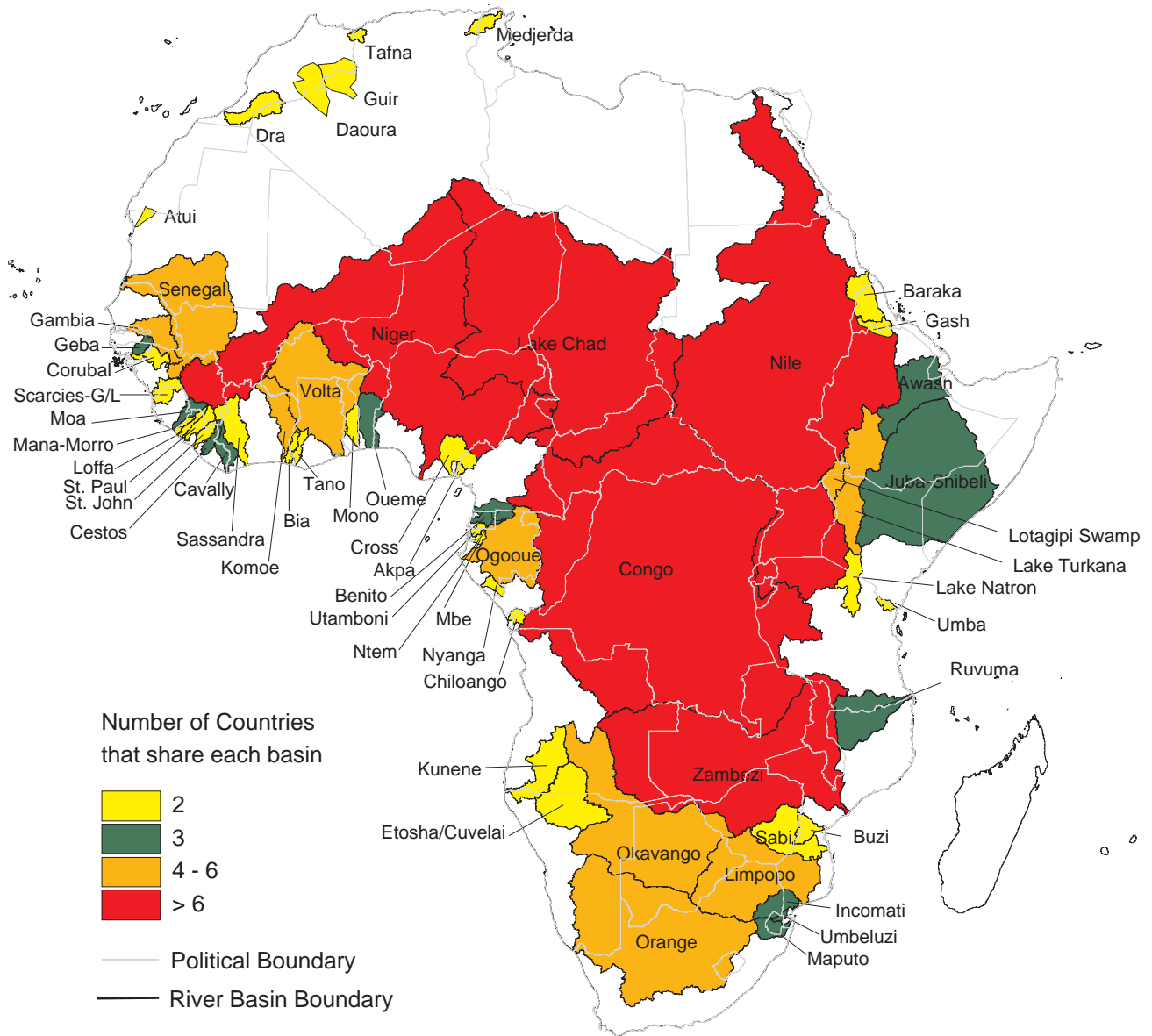
Shading in this map is related to the number of countries that share the basin. There are 30 basins shared by two countries and the balance shared by more than two countries.

Results:

- There are 60 shared basins in the continent covering over 63 percent of the land area of Africa. (See Appendix 1 for details.)

- There are 30 river basins shared by two countries and the remaining are shared by more than two countries. The Congo Basin is shared by the maximum number of countries, which is 13, followed by the Niger and Nile Basins with 11 countries, and the Zambezi and Chad Basins with nine and eight countries, respectively.

Case 8:
A Comparative Analysis of the Congo, Nile, Niger, Chad, and Zambezi Basins

Issue Context: The Congo, Nile, Niger, Chad, and Zambezi are the largest shared basins in Africa. Degradation of freshwater ecosystems in these basins has serious repercussions for a huge population covering a number of countries. Each of these rivers flows through at least eight countries, serving as a constant source of drinking water and providing the basis for agro-economic activity. Population pressure, land degradation, deforestation, and land-based sources of pollution can affect rainfall, reduce productivity, and seriously affect sustainable development in the region.

The resources and soil fertility of these basins have attracted large populations over the decades, resulting in conflicts among nations. For example, there is competition over the use of Nile water among the upper riparian countries, especially Sudan and Ethiopia, which has produced destabilizing tension between the two countries.

This study assesses the current state of land cover distribution, protected areas, and population pressure on water resources by calculating the population growth and number of people living in these river basins. Also, *inter alia* vulnerable populations affected by environmental degradation.

Data Used: Population distribution 1960, 1970, 1980, and 1990, River Basins, Land Cover distribution, Protected Areas.
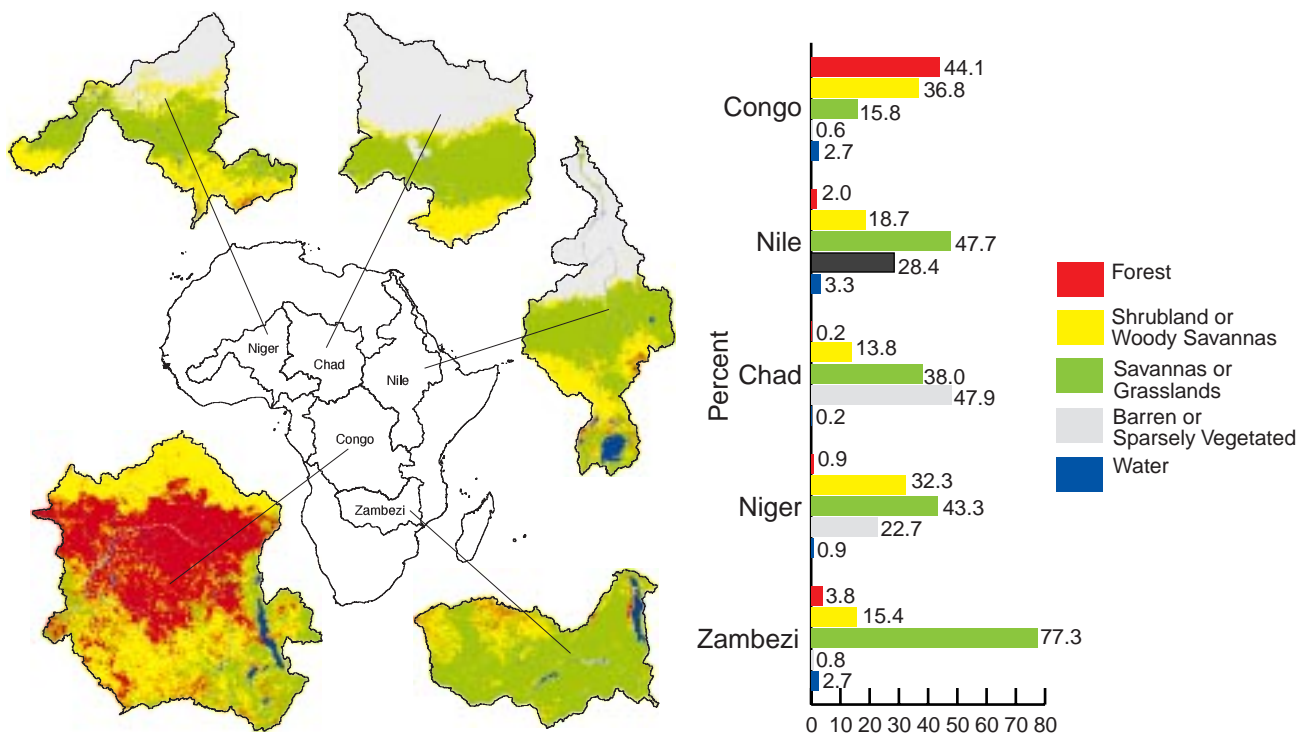
Collage of maps showing the land cover distribution within the five major basins.
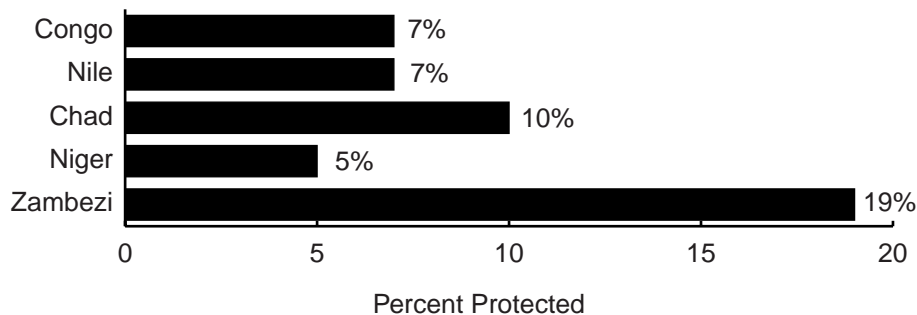
Bar chart showing the difference in percent protected of each basin.

Density
(People / km²)
High (> 100)
Medium (25 - 100)
Low (< 25)

Niger
Chad
Nile
Congo
Zambezi

**Major River Basins
Population Growth**

Congo
18.0
23.7
32.7
45.8

Nile
51.7
66.1
87.8
115.7

Chad
12.4
15.8
20.1
25.5

Niger
26.1
34.3
44.9
58.5

Zambezi
8.9
11.9
16.5
23.5

1990
1980
1970
1960

0   20   40   60   80   100   120
Millions
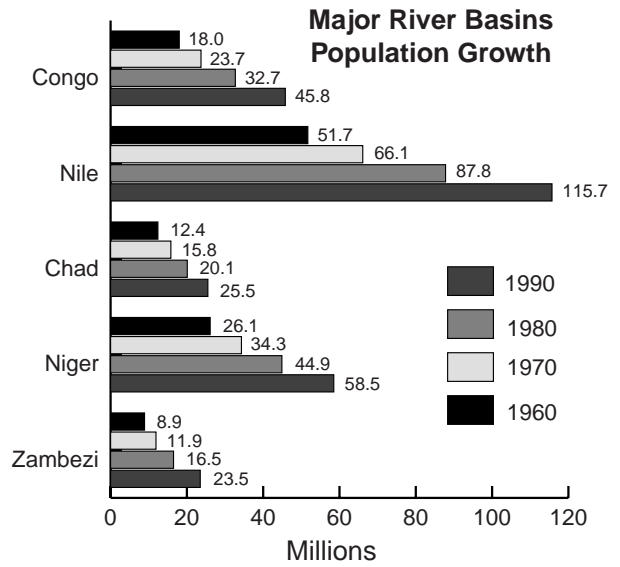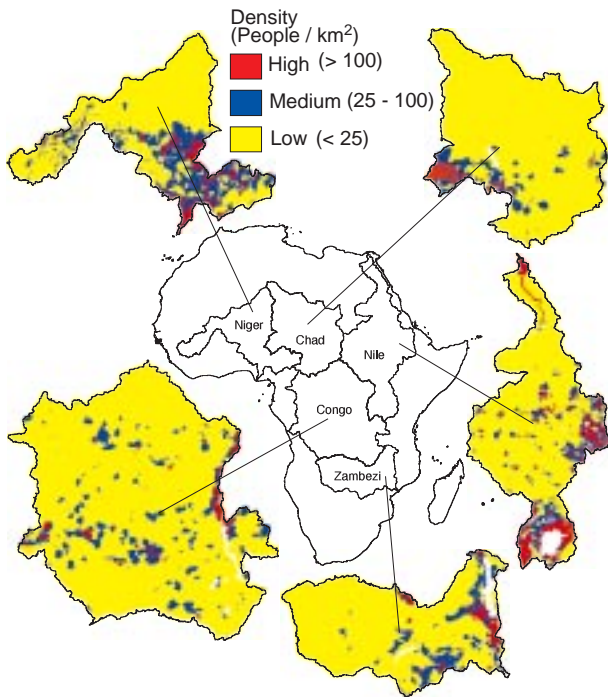
Collage of maps showing the population density (1990) within each river basin.

Graph of population growth by decade for each river basin.

Congo River Basin

Cameroon Other
Tanzania
Zambia
Congo
Angola
Cen. African Rep.
Dem. Rep. Of Congo

Nile River Basin

Kenya Other
Tanzania
Uganda
Egypt
Ethiopia
Sudan

Lake Chad Basin

Cameroon Libya
Sudan
Algeria
Nigeria
Cen. African Rep.
Chad
Niger

Niger River Basin

Ivory Coast
Benin Other
Burkina Faso
Cameroon
Guinea
Algeria
Nigeria
Niger
Mali

Zambezi River Basin

Namibia
Botswana
Tanzania
Malawi Dem Rep. Of Congo
Mozambique
Zimbabwe
Zambia
Angola

Pie charts showing percentage distribution of five major basins by country. Less than one percent is occupied by six countries (Burundi, Rwanda, Sudan, Gabon, Malawi, and Uganda) in the Congo basin, five counties (Eritrea, Democratic Republic of Congo, Rwanda, Burundi, and Central African Republic) in the Nile basin, two countries (Chad and Sierra Leone) in the Niger Basin, one country (Libya) in the Lake Chad basin, and one country (Democratic Republic of Congo) in the Zambezi basin.

Results:

• These five river basins occupy about 42 percent of the geographic area of Africa and sustain over 44 percent of the African population.

• Only the Congo Basin has significant forested areas (44 percent); all other basins have very low forest cover, less than 5 percent.

• The Zambezi Basin has the highest area, 19 percent, designated as protected areas.

• Population density is the highest in the Nile Basin, followed by the Niger Basin. The Chad Basin has the lowest population growth rate (206 percent) between 1960-90. The Nile and Niger Basins grew at 224 percent over three decades, whereas the Congo at 254 percent, and the Zambezi, at 264 percent, outpaced all others.

• High population growth rates and rather low protection status for natural forests of high biodiversity in the Congo Basin are indicators of emerging environmental problems of global significance

Case 9:
Changes in Population and Land Cover around Lake Victoria

Issue Context: Lake Victoria, with a surface area of 68,800 km², is the world's second largest body of freshwater, second in size only to Lake Superior (USA-Canada). Kenya, Tanzania, and Uganda control 6 percent, 49 percent, and 45 percent of the lake surface, respectively. The lake basin is estimated to provide the livelihood of about one third of the combined population of the three countries. The lake basin is used as a source of food, energy, drinking and irrigation water, transport, and as a repository for human, agricultural, and industrial waste. With one of the highest population growth rates in the region, the lake basin ecosystem is undergoing tremendous stress. "The ecological disasters of the Aral Sea, Lake Victoria, and other bodies of water are now in textbooks as examples of how we abuse either intentionally or unintentionally, our aquatic environment" (Gleick, 1998).

Data Used: Population distribution 1960, 1970, 1980 and 1990, and Land Cover distribution.
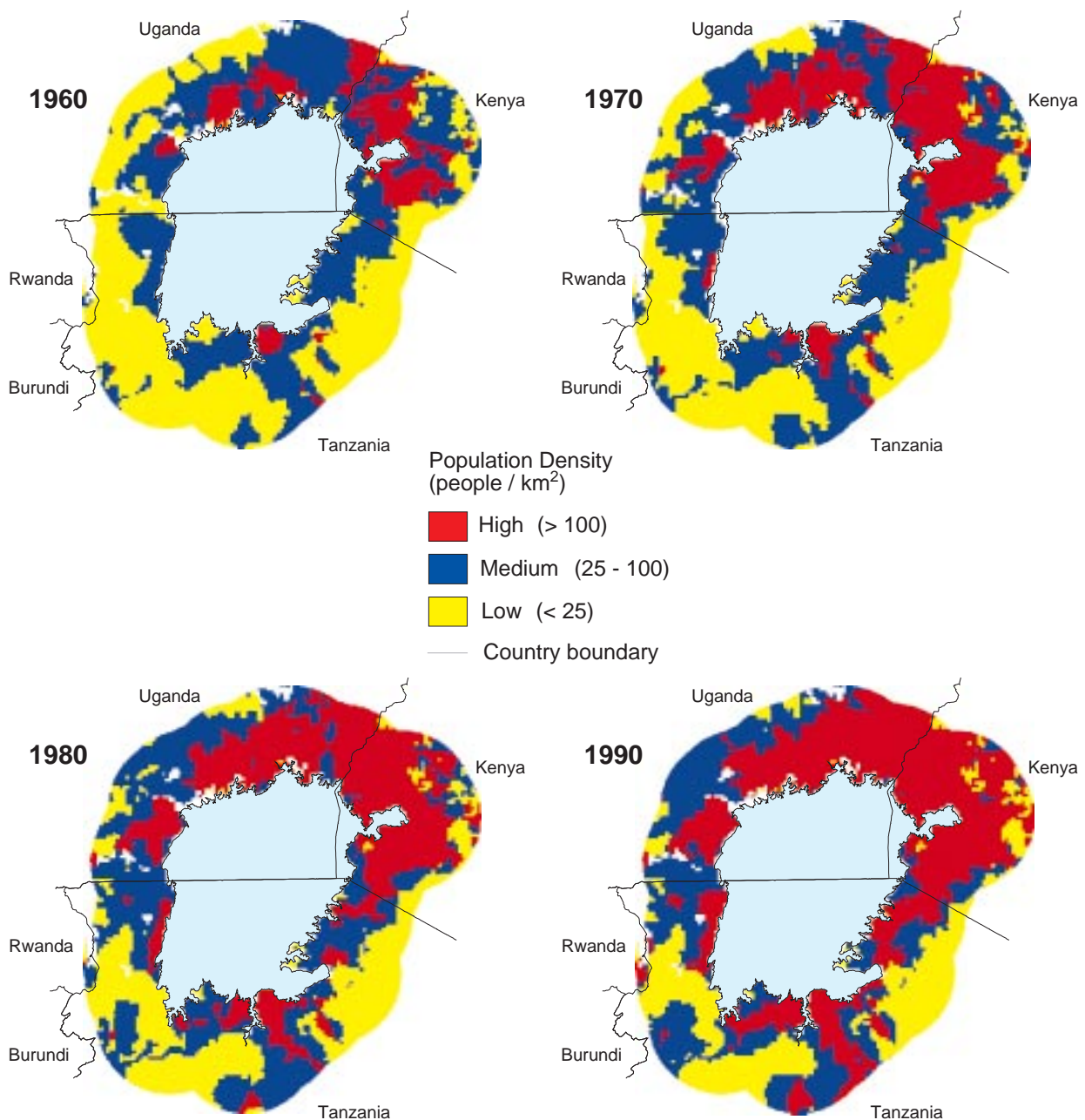
Large-scale map showing 100-km buffer around Lake Victoria, shaded according to population density for the 60's, 70's, 80's and 90's.

Population Growth around Lake Victoria
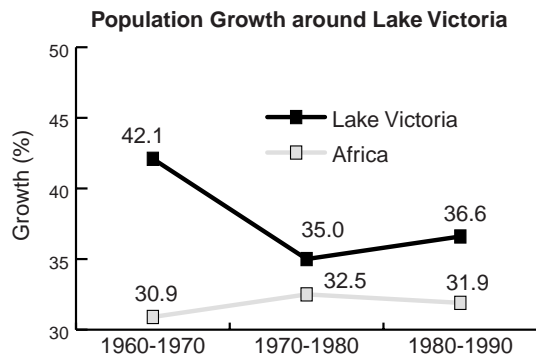
A line graph comparing population growth in the buffer around Lake Victoria to the continent as a whole. Growth around Lake Victoria has steadily outpaced continental population growth by 2.5 to 11.2% per decade.
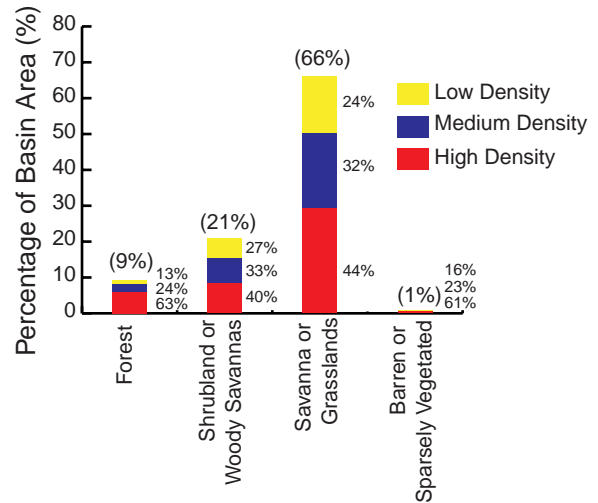
Graph showing land cover types broken down by the population density around Lake Victoria.
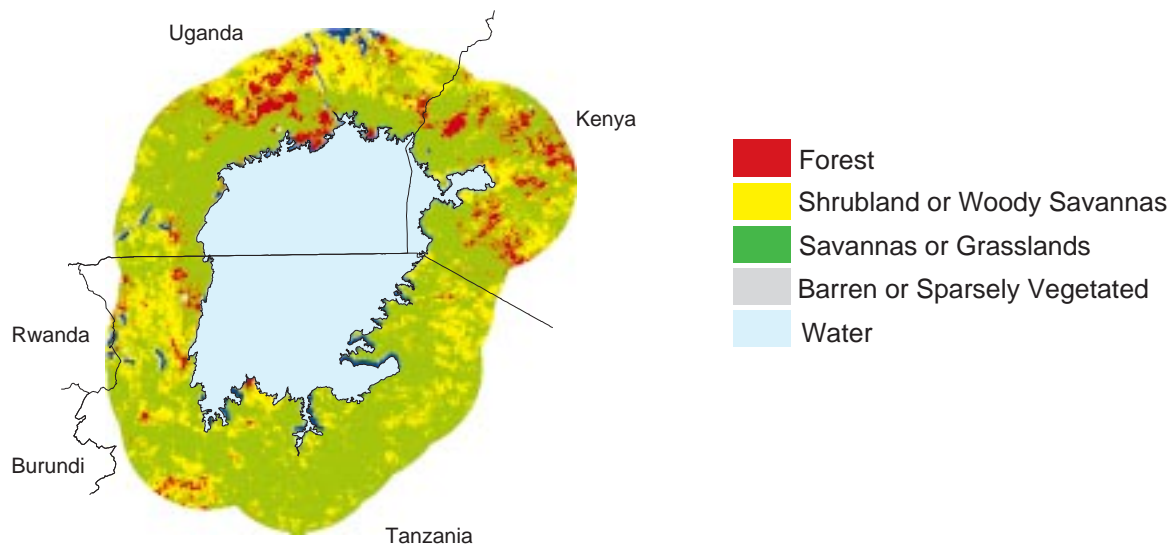
Large scale map showing the 100-km buffer around Lake Victoria and shaded according to the land cover class.

Results:

- Population growth within the 100-km buffer zone around Lake Victoria is significantly higher than that of the rest of Africa. In fact, during each inter-decadal period, the growth inside the 100-km buffer outpaced the continental average. This is expected because of the wealth of natural resources and economic benefits the region offers.

- The 100-km buffer zone has 66 percent under savannas or grasslands, 21 percent under shrublands or woody savannas, 9 percent under forests, and 1 percent under barren or sparsely vegetated land, and the balance under water. The majority of the population, similar to the entire continent, resides in the savannas or grasslands.

- An abnormally large percentage of forest cover types, about 63 percent, has a high-density population. Forty percent of the shrubland or woody savannas and 44 percent of the savannas or grasslands are occupied by high-population density. The low percentage of forest cover and high density of population around Lake Victoria may pose a serious threat to the lake's ecosystems.

Case 10: Protected Areas Located on Political Boundaries: Focus on the Kenya/Tanzania and Benin/Burkina Faso/Niger Borders

Issue Context: The continent offers one of the richest habitats for wildlife in the world. Protected areas are very important centers for the protection and preservation of biodiversity, wildlife, and ecosystems. African wildlife, known as one of the wonders of the modern world, have established a special distinction for this continent. Yet, these enormously rich resources are in jeopardy due to destruction of habitats, poaching, burgeoning rural population, urbanization, and hunger for land.

The geographic distribution of protected areas in Africa is of great significance. The relationship between the political boundaries of sovereign states and some of the national parks (a subset of designated protected areas) in Africa is characterized by their transnational nature in that close to 40 percent of these national parks lie on international frontiers (Griffiths, 1995).

The transboundary and transnational characters of many protected areas pose many challenges requiring innovative strategies and international cooperation for the protection of flora and fauna.

Data Used: Protected Areas, Political Boundaries.
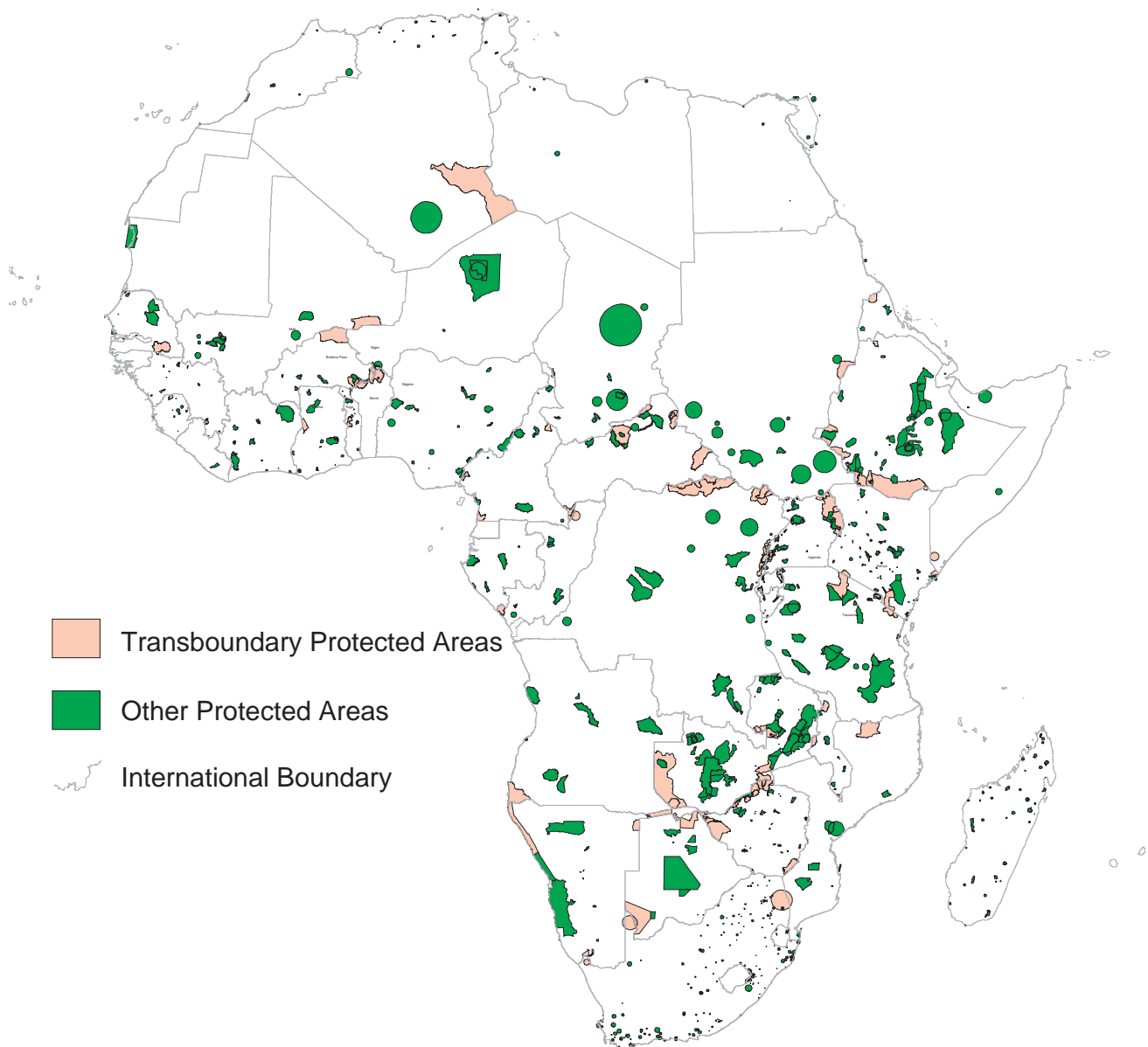
Map of the designated protected areas in Africa. The transboundary areas are those that lie adjacent to national boundaries.
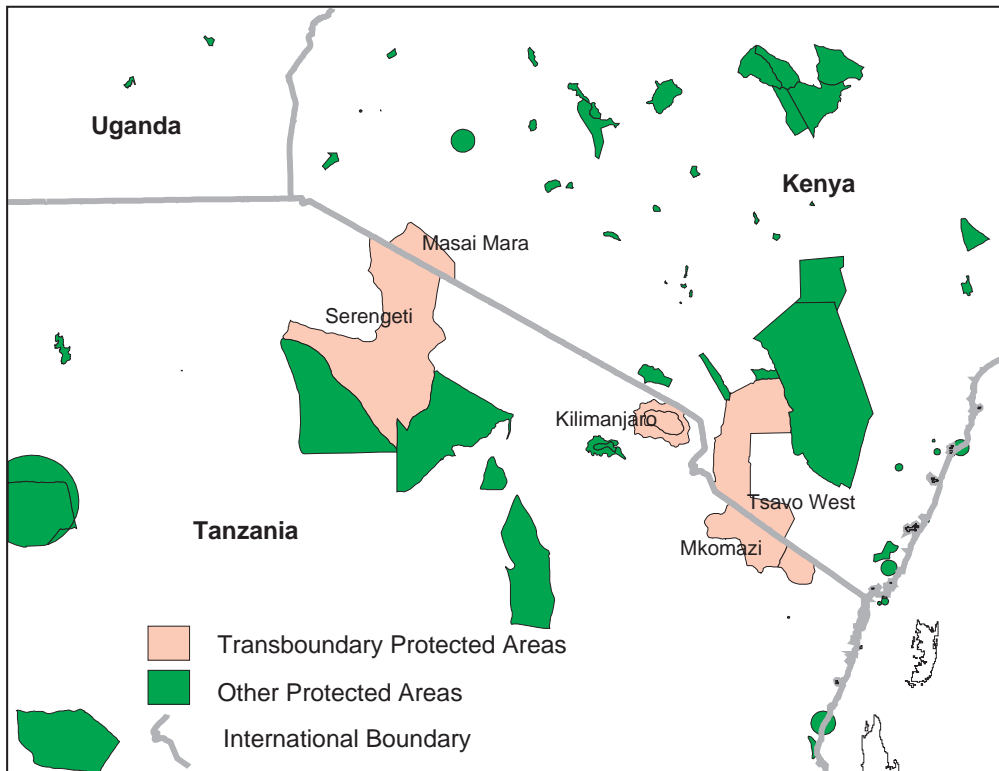
Large scale map focusing on Kenya/Tanzania border. In Kenya, the Masai Mara National Reserve (1675 km^2) and the Tsavo National Park (20,750 km^2), and in Tanzania, the Serengeti National Park (14,700 km^2) and the Mkomazi Game Reserve share political boundaries and animals move freely across the international borders (Source: Griffith, 1995)
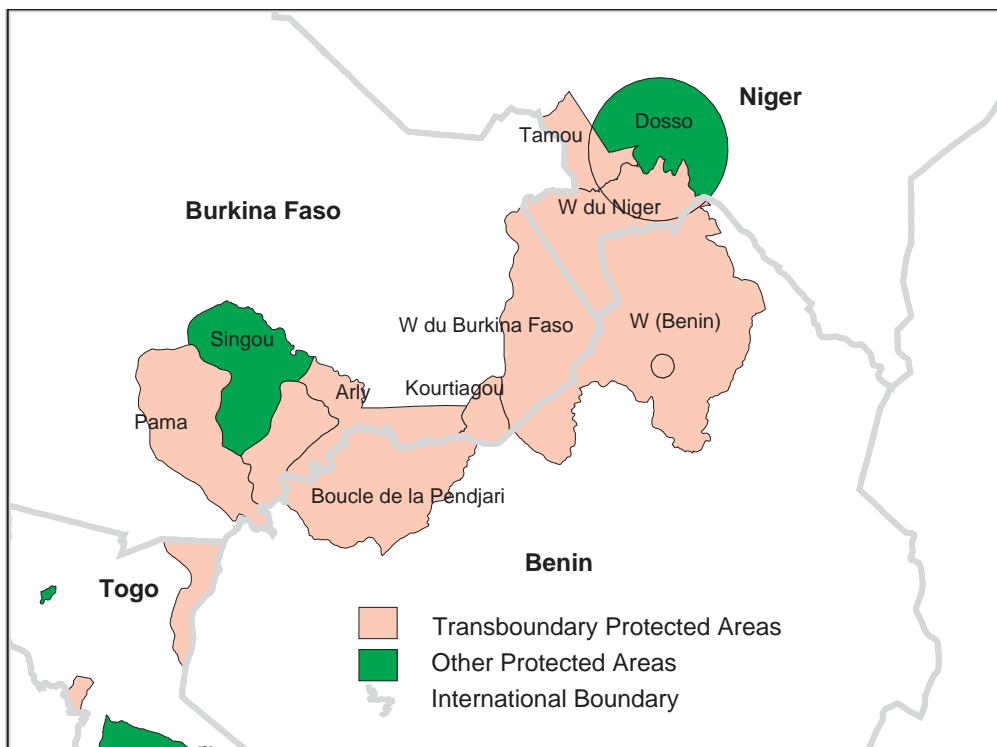
Large-scale map of Benin/Burkina Faso/Niger borders. In West Africa, also 10,720 km^2, a group of national parks and conservation areas is clustered around Le Parc National de W du Niger which shares its ownership and boundary with Niger, Burkina Faso, and Benin (Source: Griffith, 1995).

Countries	Total Shared Border (km)	Border within Protected Areas (km)	Border within Protected Areas (%)
Tanzania/Kenya	763	258	34
Burkina Faso/Niger	636	135	21
Burkina Faso/Benin	311	293	94
Niger/Benin	242	112	46

Table showing shared border lengths for Kenya/Tanzania and shared border lengths for Benin/Burkina Faso/Niger.

Results:

• A large number of designated protected areas in Africa are located along national borders. Of 891 protected areas, 189 are distributed along the borders of 33 countries.

• About 34 percent of the 763 km of international boundary between Kenya and Tanzania is made up of national parks.

• About 21 percent of 636 km shared borders between Burkina Faso and Niger, 94 percent of 311 km shared borders between Burkina Faso and Benin, and 46 percent of 242 km of shared borders between Benin & Niger have trans-boundary protected areas.

Summary of Issues for Policy Makers

Geographic analyses of the relationships between population distribution and growth, distribution of land cover types, protected areas, and transboundary resources revealed that:

• Africa has the highest population growth rate of any region in the world. The abnormally high population growth can severely degrade the resources that sustain the people.

• High population growth in and around natural forests of high biodiversity is an early warning of a threat to the natural system, which is vital for survival of the local population. These ecosystems are likely to be irreparably damaged if a conventional development path, characterized by the over-exploitation of natural resources for economic growth, is followed.

• Only about 6 percent of the biodiversity-rich, tropical evergreen broadleaf forests in Africa are designated as protected areas. The most valuable natural forests, located in the Democratic Republic of Congo and Madagascar, lack adequate protection status. Accordingly, practical action programs that include establishing a network of protected areas should be given high priority.

• The presence of croplands in protected areas is an indication that legal designation alone is not sufficient for the protection of biodiversity in the face of human competition for the same land. Protected status must be accompanied by effective enforcement measures over the long term to ensure protection of biodiversity and endemic and endangered species. Additional resources should be made available to understand socio-economic factors associated with protection of biodiversity. The local stakeholders should be given economic incentives and a role in the conservation of biodiversity.

• A shift in national and international policy and planning processes, based on targeting biodiversity-rich areas, is needed to more effectively protect biodiversity. Geographic targeting and programmatic focus are both needed to conserve ecoregions rich in biodiversity and endemism and to address the socio-economic causes of encroachment and subsequent loss of biodiversity.

• The conservation and management of biological resources that transcend political borders deserve greater attention. These biodiversity reserves located on multiple boundaries and administered under different and, at times, conflicting policies, present unique challenges. Only national authorities can take action for the preservation of protected areas under their jurisdiction but transborder conservation requires cooperation from different sovereign states, regions, and even international organizations. In the interest of developing an effective collaborative management system for the protected areas with multi-party jurisdiction it is imperative that the contradictions in approach and conflicts of interest of the parties concerned be harmonized. Without negotiations, joint management, and enforcement strategies, such a harmony will be difficult to attain. The absence of joint management mechanisms may also become a hurdle in enforcing international conventions.

• Africa is the continent where most of the river systems are international. Of the nine international water bodies shared by six or more countries, five are in Africa. In the interest of sustainable development and avoiding potential conflicts over transboundary river basins, the riparian states should cooperate and develop collaborative infrastructures for the scientific management of their shared ecosystems.

• Information derived from GIS analysis reveals that about 7 percent of the total land area of Africa is designated as protected area. This percentage is substantially higher than the estimate of about 5 percent, compiled from official statistics, which is the normally cited figure in the international sources. Thus, there are considerable differences in protected area statistics derived from actual planar area on the ground, as estimated by calculations of a GIS, and estimates based on official statistics. These differences highlight the need to provide more resources for improving the environmental information infrastructure. Such initiatives are necessary to generate and maintain accurate and up-to-date environmental data for planning and policy formulation.

• Regular assessment of land use/land cover changes using remote sensing technology, smart environmental databases, plus integration, analysis, and visualization of data sets using GIS technology, are needed. The availability of scientifically produced data sets would facilitate informed decision making and measuring performance towards sustainable development.

Data Sources and Methodology

Data Sources

The analysis was carried out using comprehensive and consistent 1-km spatial data sets developed through remote sensing and other source materials. GIS tools were used for analysis, integration, and visualization of results. The following five data sets were used in the analysis.

Africa Land Cover Distribution

The Land Cover Distribution data set was derived from the International Geosphere-Biosphere Program (IGBP) Land Cover Classification developed using the National Oceanic Atmospheric Administration (NOAA) 1-km Advanced Very High Resolution Radiometer (AVHRR) satellite sensor. Regular global coverage by AVHRR imagery offers the opportunity to derive measures of global- and continental-scale land cover classes on a periodic basis. A major derivative product of the Global Land 1-KM AVHRR Data Set, developed at the U.S. Geological Survey's (USGS) EROS Data Center, in cooperation with a number of agencies around the world, is the global seasonal Land Cover Characterization (LCC) database. This database is an improved alternative to conventional land cover maps and a flexible source of tailored data for many varied environmental applications.

Originally, the IGBP land cover classification had 17 classes, which were translated and merged into five classes for the sake of simplification and ease in further analysis.

IGBP Land Cover classes	Classified as
Evergreen Needleleaf Forest	Not applicable for Africa
Deciduous Needleleaf Forest	Not applicable for Africa
Evergreen Broadleaf Forest	Forest
Deciduous Broadleaf Forest	Forest
Mixed Forest	Forest
Closed Shrublands	Shrubland or Woody Savannas
Open Shrublands	Shrubland or Woody Savannas
Woody Savannas	Shrubland or Woody Savannas
Savannas	Savannas or Grasslands
Grasslands	Savannas or Grasslands
Permanent Wetlands	Savannas or Grasslands
Croplands	Savannas or Grasslands
Cropland/Natural Veg. Mosaic	Savannas or Grasslands
Urban & built-up Area	Barren or Sparsely Vegetated
Barren or Sparsely Vegetated	Barren or Sparsely Vegetated
Water Bodies	Water

Africa River Basin Boundaries Database

The Africa River Basin Boundary database is derived from HYDRO1K. HYDRO1K is a geographic database developed at the U. S. Geological Survey's EROS Data Center with international cooperation from the global 30-arcsecond digital elevation model, GTOPO30. HYDRO1K is aimed at providing comprehensive and consistent global coverage of topographically derived data sets. HYDRO1K provides a standard suite of geo-reference data sets (with a 1-km cell size) for users who need to organize, evaluate, or process hydrological information on a continental scale.

Africa Population Database

The Africa Population database is a result of a cooperation between UNEP/GRID-Sioux Falls, the National Center for Geographic Information and Analysis (NCGIA), the University of California, Santa Barbara, and the World Resources Institute (WRI). The African database contains population estimates for 1960, 1970, 1980, and 1990.

Africa Protected Areas

The Protected Areas database is extracted from the 1997 CD-ROM titled "*A Global Overview of Forest Conservation*" published by the World Conservation Monitoring Center (WCMC) and Center for International Forestry Research (CIFOR).

Political Boundaries Data

Political boundary data is extracted from the Digital Chart of the World (DCW) developed by the U. S. National Imagery and Mapping Agency and Environmental Systems Research Institute (ESRI), Inc.

A detailed description of these data sets can be found on the World Wide Web at and through links at http://grid.cr.usgs.gov.

General Considerations about the Data Used

The Land Cover and Population were the best available data sets covering all of Africa. Considerable regional errors are known to exist in the mapped distribution of croplands. The Population data set is generated using a model incorporating many variables, including the location of protected areas. Hence, the areas of intersection between population and protected areas are compromised. This does not invalidate conclusions drawn from the analysis of the proximity of the protected areas to the areas of high population density.

The Protected Area database is not current for all countries. Some of the smaller protected areas may not have been accounted for due to the coarse resolution of data. Where information is not available for the exact extent of

a protected area, a point has been inserted representing the center of the site. Polygons were made for such locations by using the information in the textual databases and drawing a circular polygon of the relevant area around the point location of the site. None of these data sets have been rigorously validated, so local relationships and distributions should be viewed with caution. Availability of high-quality, current data remains a stubborn barrier in such analyses, highlighting the need to support development and updating of such databases.

Methodology

Data processing was performed using software donated by the Environmental Systems Research Institute (ESRI), Inc. Most of the work was done in the GRID module of ARC/INFO. Tabular manipulation of the data was done within the INFO module and Microsoft Excel. Raster and vector data layers are in a Lambert Azimuthal Equal Area Projection. All raster data sets have a cell size of 1,000 meters (1 km).

Population Density

Whenever population is mentioned as high, medium, and low density, the following classification was used:

Low population: <25 people per km^2.

Medium population: 25-100 people per km^2.

High population: > 100 people per km^2.

The data layers were analyzed individually or combined with other data layers in order to see possible interrelations or possible spatial relationships among them. For example, "forest layer" and "population layer" were digitally overlaid in order to assess the population pressure on land cover types. Methodology used in some specific analyses are given below.

Population Growth within 100 km of the Coast

In this analysis, a buffer of 100 km around the African continent boundary defines the coastal zone. The buffer zone was given a value "1" and the rest of the continent (designated here as inland area) a value "2." The output grid was then combined with the population grid data of years 1960, 1970, 1980, and 1990. For each year, the number of population was counted for the coastal and inland areas. The resulting data table was exported as a spreadsheet and combined in one graph showing the evolution of the population of coastal and inland zones.

Population Pressure on Protected Areas

The original data on the CD-ROM are in ESRI Shape file format and were converted to a ARC/INFO vector coverage. Buffers of 20 km were created around protected areas by the following process. First, vector polygons

were converted to raster data. Next, a distance map was created. Then, distance was re-classified into three zones: 1) protected areas, 2) 20-km buffer around protected areas, and 3) remaining area. Population data was combined with the 20-km distance buffer to calculate the number of people living near protected areas.

Population Density within River Basins

The population of a river basin was estimated by combining the river basin grid with the population grid and then summing the population for each basin. The population density was then calculated by dividing total population of the basin-by-basin area; this being the total number of pixels within the river basin. The units are people per km^2.

Percentage of Land Cover within River Basin

The land cover distribution area in each basin was estimated by combining the river basin grid with the land cover distribution grid. Then, for each river basin, the number of land cover type cells was counted and then divided by the basin area with the result being the total number of pixels within the river basin.

Number of Countries Sharing a River Basin

The number of countries that share each river basin was determined by combining the river basin grid with the grid of the countries. Then, a frequency procedure was performed on the data table associated with the output grid using the river basin code as the frequency item.

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Acronyms Used

AVHRR	Advanced Very High Resolution Radiometer
CIFOR	Center for International Forestry Research
DCW	Digital Chart of the World
DEM	Digital Elevation Model
EDC	EROS Data Center
EROS	Earth Resources Observation Systems
ESRI	Environmental Systems Research Institute
GIS	Geographic Information Systems
GRID	Global Resource Information Database
IGBP	International Geosphere-Biosphere Programme
LCC	Land Cover Characterization
NASA	National Aeronautics and Space Administration
NCGIA	National Center for Geographic Information and Analysis
NOAA	National Oceanic and Atmospheric Administration
UNEP	United Nations Environment Programme
USGS	United States Geological Survey
USFS	United States Forest Service
WCMC	World Conservation Monitoring Center
WRI	World Resources Institute

Appendix 1:
Transboundary River Basins of Africa*

	Basin (km²)	Country (%)		Basin (km²)	Country (%)
Akpa	4,905		Cameroon		2.3
Cameroon		62.0	Burundi		0.4
Nigeria		38.0	Rwanda		0.1
			Sudan		<0.1
Atui (1)	10,395		Gabon		<0.1
Mauritania		89.7	Malawi		<0.1
Western Sahara		10.3	Uganda		<0.1
Awash	155,329		**Corubal**	24,097	
Ethiopia		92.7	Guinea		73.0
Djibouti		7.1	Guinea-Bissau		27.0
Somalia		0.2			
			Cross	52,777	
Baraka	66,550		Nigeria		76.4
Ethiopia		62.8	Cameroon		23.6
Sudan		37.2			
			Daoura	34,571	
Benito	16,239		Morocco		52.8
Equatorial Guinea		81.1	Algeria		47.2
Gabon		16.1			
Cameroon		2.9	**Dra**	54,889	
			Morocco		74.0
Bia	11,917		Algeria		26.0
Ghana		60.0			
Côte d'Ivoire		40.0	**Etosha-Cuvelai**	167,559	
			Namibia		68.2
Buzi	27,865		Angola		31.8
Mozambique		88.8			
Zimbabwe		11.2	**Gambia**	70,019	
			Senegal		72.5
Cavally	30,575		Guinea		19.0
Côte d'Ivoire		54.3	Gambia, The		8.5
Liberia		41.5			
Guinea		4.2	**Gash**	40,130	
			Ethiopia		76.0
Cestos	15,011		Sudan		24.0
Liberia		84.5			
Côte d'Ivoire		15.3	**Geba**	12,782	
Guinea		0.1	Guinea-Bissau		67.7
			Senegal		31.9
Chiloango	11,662		Guinea		0.4
Dem. Rep. of Congo		65.9			
Angola		32.1	**Great Scarcies**	12,113	
Congo		2.0	Guinea		75.0
			Sierra Leone		25.0
Congo	3,699,147				
Angola		7.9	**Guir**	79,086	
Dem. Rep. of Congo		62.4	Algeria		77.6
Central African Rep.		10.9	Morocco		22.4
Congo		6.7			
Zambia		4.8			
Tanzania, United Rep.		4.5			

	Basin (km²)	Country (%)		Basin (km²)	Country (%)
Incomati	46,179		**Loffa**	11,422	
South Africa		63.2	Liberia		87.5
Mozambique		31.0	Guinea		12.5
Swaziland		5.8			
			Lotagipi Swamp	38,944	
Juba-Shibeli	805,087		Kenya		52.5
Ethiopia		45.7	Sudan		25.6
Somalia		27.5	Sudan, Admin. by Kenya		8.4
Kenya		26.8	Ethiopia		8.3
			Uganda		5.2
Komoe	78,474				
Côte d'Ivoire		74.5	**Mana-Morro**	6,909	
Burkina Faso		21.7	Liberia		83.7
Ghana		2.9	Sierra Leone		16.3
Mali		0.8			
			Maputo	31,272	
Kunene	110,272		South Africa		59.4
Angola		86.6	Swaziland		35.0
Namibia		13.4	Mozambique		5.5
Lake Chad (2)	2,394,216		**Mbe**	6,996	
Chad		45.2	Gabon		93.0
Niger		28.2	Equatorial Guinea		7.0
Central African Rep.		9.1			
Nigeria		7.6	**Medjerda**	23,145	
Algeria		3.8	Tunisia		67.3
Sudan		3.5	Algeria		32.7
Cameroon		2.0			
Chad, Claimed by Libya		0.5	**Moa**	22,635	
Libya		0.2	Sierra Leone		48.2
			Guinea		38.6
Lake Natron	55,557		Liberia		13.3
Tanzania, United Rep.		67.1			
Kenya		32.9	**Mono**	23,430	
			Togo		95.4
Lake Turkana	207,583		Benin		4.6
Ethiopia		54.7			
Kenya		43.3	**Niger**	2,117,684	
Uganda		1.2	Nigeria		26.6
Sudan		0.7	Mali		25.6
Sudan, Admin. by Kenya		<0.1	Niger		23.6
			Algeria		7.6
Limpopo	415,485		Guinea		4.5
South Africa		44.3	Cameroon		4.2
Mozambique		21.0	Burkina Faso		3.9
Botswana		19.6	Benin		2.1
Zimbabwe		15.1	Côte d'Ivoire		1.1
			Chad		0.8
Little Scarcies	18,918		Sierra Leone		<0.1
Sierra Leone		69.1			
Guinea		30.9			

	Basin (km²)	Country (%)		Basin (km²)	Country (%)
Nile (3)	3,038,137		**Ruvuma**	152,168	
Sudan		63.6	Mozambique		65.4
Ethiopia		11.2	Tanzania, United Rep.		34.3
Egypt		9.0	Malawi		0.3
Uganda		7.9	**Sabi**	116,059	
Tanzania, United Rep.		4.0	Zimbabwe		73.9
Kenya		1.7	Mozambique		26.1
Eritrea		0.7			
Dem. Rep. of Congo		0.7	**Sassandra**	68,176	
Rwanda		0.7	Côte d'Ivoire		87.5
Burundi		0.4	Guinea		12.5
Egypt, Admin. by Sudan		0.1			
Sudan, Admin. by Egypt		<0.1	**Senegal**	437,029	
Central African Rep.		<0.1	Mauritania		50.1
			Mali		34.6
Ntem	29,207		Senegal		8.2
Cameroon		62.4	Guinea		7.1
Gabon		28.8			
Equatorial Guinea		8.8	**St. John**	15,560	
			Liberia		83.5
Nyanga	12,355		Guinea		16.4
Gabon		93.3	Côte d'Ivoire		<0.1
Congo		6.7			
			St. Paul	21,239	
Ogooue	223,429		Liberia		55.5
Gabon		84.9	Guinea		44.5
Congo		11.9			
Cameroon		2.3	**Tafna**	9,453	
Equatorial Guinea		0.9	Algeria		74.2
			Morocco		25.8
Okavango	708,593				
Botswana		50.7	**Tano**	14,329	
Namibia		24.9	Ghana		97.1
Angola		21.2	Côte d'Ivoire		2.9
Zimbabwe		3.2			
			Umbaf	8,238	
Orange	947,715		Tanzania, United Rep.		83.8
South Africa		59.7	Kenya		16.2
Namibia		25.4			
Botswana		12.8	**Umbeluzi**	5,445	
Lesotho		2.1	Swaziland		57.2
			Mozambique		41.6
Oued Bon Naima	514		South Africa		1.2
Morocco		68.9			
Algeria		31.1	**Utamboni**	7,719	
			Gabon		60.0
Oueme	59,517		Equatorial Guinea		40.0
Benin		83.2			
Nigeria		16.0			
Togo		0.7			

	Basin (km^2)	Country (%)
Volta	**413,993**	
Burkina Faso		42.1
Ghana		40.2
Togo		6.2
Mali		4.6
Benin		3.6
Côte d'Ivoire		3.2
Zambezi	**1,388,238**	
Zambia		41.6
Angola		18.4
Zimbabwe		15.5
Mozambique		11.8
Malawi		8.0
Tanzania, United Rep.		2.0
Botswana		1.4
Namibia		1.2
Dem. Rep. of Congo		<0.1
Total Basin Area	**18,688,939**	
Total Land Area	**29,418,206**	

Notes

1) The legal status and sovereignty of Western Sahara is unresolved. The northern area of the territory is contested by Morocco. (The Encyclopedia of International Boundaries, 1995)

2) Lake Chad in extent varies between rainy and dry seasons-from 20,000 to 7000 mi^2 (50,000 to 20,000 km^2). Precise boundaries have been established between Chad, Nigeria, Cameroon, and Niger. The sectors of the boundaries located in the rivers that drain into Lake Chad have never been determined and a number of complications are caused by flooding and the appearance of covering of islands. (The Encyclopedia of International Boundaries, 1995)

3) Egypt and Sudan are in dispute over the Red Sea border area north of the 22nd parallel known as "Hala' ib Triangle" a barren area of 20,580 km^2 (The CIA World Factbook, 1995) The Nile delta is excluded from the area estimate.

*Source: Wolf *et al.*, 1998. (Figures are provisional.)

Appendix 2:
Transboundary Parks in Africa*

Countries with transboundary National Parks	National Parks, etc, on boundaries	Boundary with:
Angola	Mucusso CP	(Namibia)
	Iona NP	(Namibia)
	Luiana CP	(Zambia)
Benin	W NP	(Burkina Faso)
		(Niger)
	Pendjari NP	(Burkina Faso)
	Pendjari ZC	(Burkina Faso)
	Atakora ZC	(Burkina Faso)
Botswana	Chobe NP	(Namibia)
	Gemsbok NP	(Namibia)
		(South Africa)
	Mashatu GR	(South Africa)
		(Zimbabwe)
	Sibuyu	(Zimbabwe)
Burkina Faso	W NP	(Benin)
		(Niger)
	Aril NP	(Benin)
	Aril RPF	(Benin)
	Pama RPF	(Benin)
	Kourtiagou RPF	(Benin)
	Sahel FR	(Mali)
		(Niger)
Cameroon	Korup CMR	(Nigeria)
	Bouba Njida NP	(Chad)
	Kalamaloue CMR	(Chad)
	Campo R	(Equatorial Guinea)
Central Africa Republic	Bamingui-Bangoran NP	(Chad)
Congo	Mont Fouari R	(Gabon)
	Nyanga R	(Gabon)
Gabon	Mont Fouari R	(Congo)
	Nyanga R	(Congo)
Kenya	Masai Mara NR	(Tanzania)
	Tsavo NP	(Tanzania)
	Mount Elgon NP	(Uganda)
Lesotho	Sehlabathebe NP	(Soutn Africa)
Malawi	Lengwe NP	(Mozambique)
	Kasungu NP	(Zambia)
	Nyika NP	(Zambia)
	Vwaza NP	(Zambia)
Mozambique	Niassa GR	(Tanzania)

Countries with transboundary National Parks	National Parks, etc, on boundaries	Boundary with:
Namibia	Skeleton Coast NP	(Angola)
	Kaudam GR	(Botswana
	Caprivi GR	(Angola)
		(Botswana
	Mahango GR	(Botswana
Niger	W NP	(Benin)
		(Burkina Faso)
	Tamou RPF	(Burkina Faso)
Rwanda	L' Akagera NP	(Tanzania)
	Volcans NP	(Dem. Rep. Of Congo)
	Karisimbi	(Dem. Rep. Of Congo)
Senegal	Niokolo-Koba NP	(Guinea)
South Africa	Kalahari Gemsbok NP	(Botswana)
		(Namibia)
	Royal Natal NP	(Lesotho)
	Giant's Castle GR	(Lesotho)
	Mzimkulwana NR	(Lesotho)
	Mzimkulu WA	(Lesotho)
	Kruger NP	(Mozambique)
		(Zimbabwe)
	Ndumo GR	(Mozambique)
	Tembe ER	(Mozambique)
	Richtersveld NP	(Namiia)
Sudan	Dinder NP	(Ethiopia)
Swaziland	Mlawula NR	(Mozambique)
	Malolotja NR	(South Africa)
Tanzania	Serengeti NP	(Kenya)
	Mkomazi GR	(Kenya)
Uganda	Kidepo NP	(Sudan)
	Queen Elizabeth NP	(Dem. Rep. Of Congo)
Dem. Rep. Of Congo	Garamba NP	(Sudan)
	Virunga NP	(Uganda)
Zambia	Sioma ngwezi NP	(Angola)
		(Namibia)
	Lower Zambezi NP	(Zimbabwe)
Zimbabwe	Tuli SA	(Botswana)
	Hwange NP	(Botswana)
	Kazuma FR	(Botswana)
	Kazuma Pan NP	(Botswana)
	Chimanimani NP	(Mozambique)

Countries with transboundary National Parks	National Parks, etc, on boundaries	Boundary with:
	Dande SA Gonarezhou NP	(Mozambique)
	Gonarezhou NP	(Mozambique)
	Mtarazi Falls NP	(Mozambique)
	Malapati GR	(Mozambique)
	Banti SF	(Mozambique)
	Chewore SA	(Zambia)
	Mana Pools NP	(Zambia)
	Matetsi SA	(Zambia)
	Sapi SA	(Zambia)
	Urungwe SA	(Zambia)
	Zambezi NP	(Zambia)

Notes

Abbreviations: Coutada Publica (CP), Forest Reserves (FR), Game Reserves (GR), National Parks (NP), Natural Reserves (NR), Parks (P), Reserves (R), Reserves Partielles de Faune (RPF), Reserves Totales de Faune (RTF), Safari Areas (SA), Safari Forest(SF),Wilderness Areas (WA), Zones Cynegetiques (ZC).
The above list is not exhaustive

*Source: (Griffiths, 1995)