CHAPTER 2

THE STATE OF AFRICA'S ENVIRONMENT AND POLICY ANALYSIS

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INTRODUCTION

The material presented here constitutes the first comprehensive, integrated report on the state of the environment in Africa. Following on from the review and assessment of development policies and progress described in Chapter 1, attention is now turned to the environmental context that underlies policy and forms the background for progress.

Improved understanding of the causes, patterns and consequences of environmental change can contribute to more effective design and implementation of mechanisms to tackle the negative impacts of such change. This report helps to improve understanding by presenting detailed retrospective analyses of Africa's environment, and by describing discernible environmental trends against the backdrop of human activities and management practices of the past 30 years. It thus provides a basis for learning from past experience and lays the groundwork for more effective implementation of Agenda 21 and for sustainable development of Africa's environmental, social and economic resources.

The framework used to assess the state of Africa's environment is called a 'Pressure-State-Impact-Response' framework:

- 'Pressures' are the root causes of environmental change (natural or resulting from human activities).
- 'State' reflects the current situation (and qualitative or quantitative trends over the past 30 years).
- 'Impacts' are the consequences of environmental change on human and ecological systems, and on social and economic development potential.
- 'Responses' include regional agreements and strategies for cooperation, national policies, awareness and education programmes, and community-level projects, aimed at addressing both the causes and impacts of environmental change.

The Pressures, State, Impacts and Responses framework allows analysis of policies and activities relating to specific environmental issues, reveals positive and negative impacts of economic and development policies on the environment, and shows how consideration of the environment can drive policy. Examples and case studies are used to highlight particular issues of concern and instances of good practice, and to illustrate the links between environmental components and issues. Pressures, states, impacts, and responses are discussed in an integrated manner for each issue.

It is not possible to cover all of the environmental issues that have arisen over the past 30 years. Rather, this Chapter aims to draw attention to priority issues for Africa as identified through regional and sub-regional consultations. Hot spots of environmental degradation and potential and emerging issues are highlighted where relevant. The 'bottom-up' means of assessment—in which information comes from national or sub-national activities and is synthesized in sub-regional or regional analyses—and the extensive consultation and review processes ensure that a wide range of perspectives and studies are incorporated, and that the review of the state of the environment is as balanced and objective as possible.

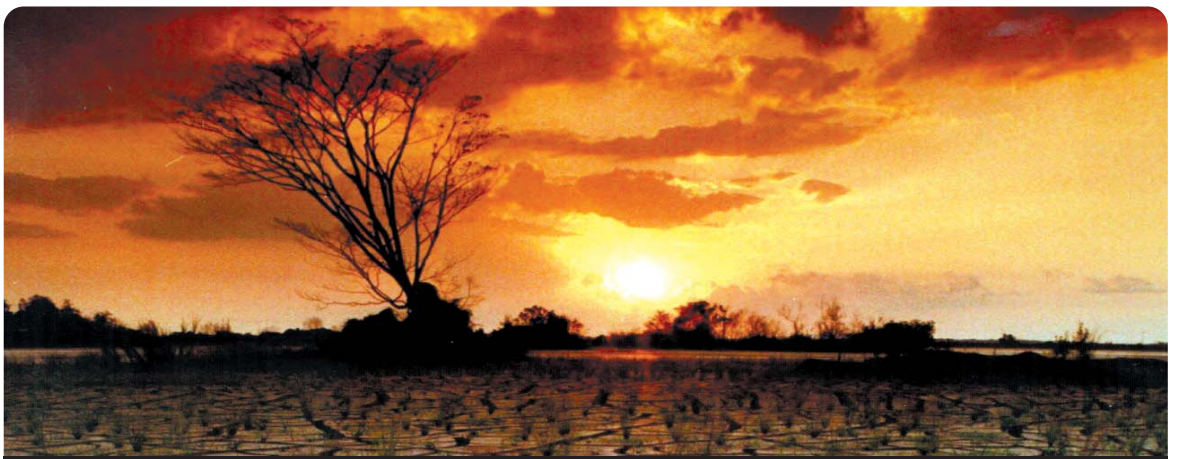
The information is presented under seven environmental themes, namely:

- Atmosphere
- Biodiversity

- Coastal and Marine Environments
- Forests
- Freshwater
- Land
- Urban Areas

Key issues identified for each theme are introduced and regional perspectives presented. Further details are then given for each sub-region. The cross-cutting nature of environmental issues is emphasized at every opportunity with links between issues, themes, sub-regions and causes or impacts of change being highlighted. After this sub-regional analysis, the chapter ends with a *Concluding Summary* which ties together the different themes at regional level and examines both present and future priorities for action.

The breakdown of Africa into sub-regions presented in Chapter 1 is along political and economic lines, its borders do not therefore always coincide with those of an ecological breakdown. There is, therefore, some overlap in the sub-regional analyses presented below.



PART A: ATMOSPHERE

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REGIONAL OVERVIEW

Africa is faced with three major issues where the atmosphere is concerned, namely:

- climate variability;
- climate change; and
- air quality.

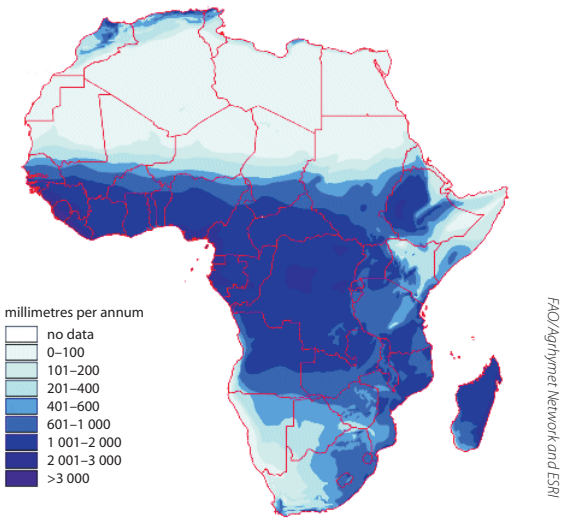
Climate variability

Climate variability means the seasonal and annual variations in temperature and rainfall patterns within and between regions or countries. For Africa, it is determined by prevailing patterns of sea surface temperature, atmospheric winds, regional climate fluctuations in the India and Atlantic Oceans, and by the El Niño Southern Oscillation (ENSO) phenomenon—the natural shift in ocean currents and winds off the coast of South America which occurs every two to seven years. ENSO events bring above average rainfall to some regions and reduced rainfall to others.

Africa is characterized by considerable climatic variations, both spatial and temporal, and extreme events such as flooding and drought have been recorded for thousands of years (Verschuren, Laird & Cumming 2000). The equatorial belt generally has high rainfall, whereas northern and southern African countries and those in the Horn of Africa are typically arid or semi-arid (see Figure 2a.1). All parts of Africa, even those that usually have high rainfall, experience climatic variability and extreme events such as floods or droughts. Most of Eastern, Central and Southern Africa, as well as the Western Indian Ocean Islands, are affected by the ENSO phenomenon. The 1997–8 ENSO triggered very high sea surface temperatures in the south-western Indian Ocean causing high rainfall,

Rainfall records from the early 1900s to mid-1980s show that Africa's average annual rainfall has decreased since 1968, and has been fluctuating around a notably lower mean level, as shown in Figure 2a.2 (UNEP 1985). There is also some evidence that natural disasters have increased in frequency and severity over the past 30 years, particularly drought in the Sahel

Figure 2a.1 Map of rainfall variability in Africa



FAO/Agrhymet Network and ESRI

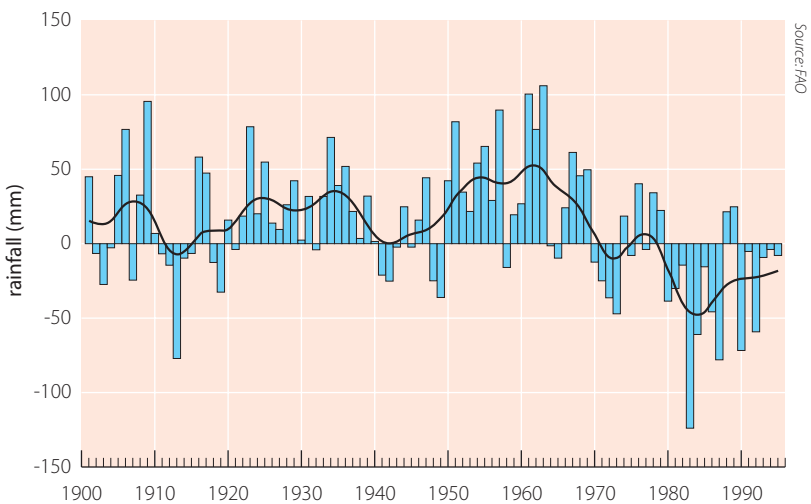
cyclones, flooding and landslides across most of Eastern Africa whereas south-western Africa experienced drier conditions. The higher sea temperatures also caused extensive bleaching of corals on the Eastern African coast and in the Western Indian Ocean Islands (Obura, Suleiman, Motta, & Schleyer 2000, PRE/COI 1998).

Rainfall records from the early 1900s to mid-1980s show that Africa's average annual rainfall has decreased since 1968, and has been fluctuating around a notably lower mean level, as shown in Figure 2a.2 (UNEP 1985). There is also some evidence that natural disasters have increased in frequency and severity over the past 30 years, particularly drought in the Sahel (OFDA 2000). The most prolonged and widespread droughts occurred in 1973 and 1984 (when almost all African countries were affected) and in 1992, although in this case drought was mainly restricted to Southern Africa. The impacts of the 1984 and 1992 droughts were alleviated to some extent by increased preparedness of some countries, even though the droughts themselves were more severe (Gommes & Petrassi 1996). Countries most regularly affected by drought include Botswana, Burkina Faso, Chad, Ethiopia, Kenya, Mauritania and Mozambique (FAO 2001a).

Human activities such as deforestation and inappropriate management of land and water resources can contribute to the frequency and impacts of natural climatic events. For example, clearing of tropical forests in Central and Western Africa alters local climate and rainfall patterns and increases the risk of drought. Clearing of vegetation increases run-off and soil erosion, and damming of rivers and draining of wetlands reduces the environment's natural ability to absorb excess water, increasing the impacts of floods.

Africa's people and economies are heavily dependent on rain-fed agriculture (for commercial export and subsistence) and are therefore vulnerable to rainfall fluctuations. It is usually the poor who suffer most from flood- or drought-induced crop failure, as they are forced to cultivate marginally productive land and cannot accumulate reserves for times of hardship. Malnutrition and famine have resulted from both droughts and floods in Africa and associated food imports and dependency on food aid have contributed to limited economic growth of the countries affected. Additional impacts include loss of infrastructure and disruption of economic activities, outbreaks of disease and sometimes population displacements, both internal and international. Over the past 30 years, millions of Africans have sought refuge from natural disasters, often settling in fragile ecosystems and/or experiencing social tensions with neighbouring communities. Ecological impacts of drought and flooding include land degradation and desertification, loss of natural habitat or changes in distribution of

Figure 2a.2 Rainfall fluctuations in Africa 1900–2000



Source: FAO

biodiversity, increased soil erosion and silting of rivers, dams, and coastal ecosystems.

Strategies for coping with climate variability in Africa

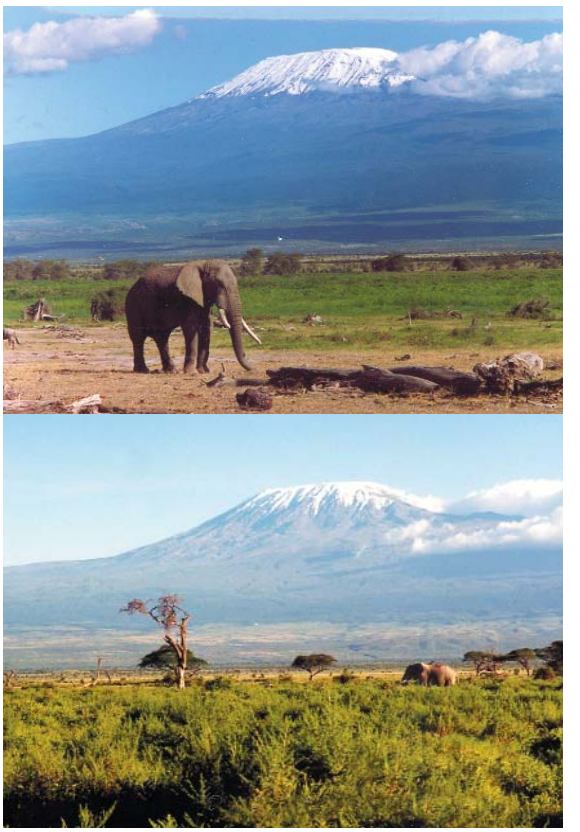
Fifty-two African countries are parties to the United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD). The Convention, signed in 1992, calls for international cooperation and a partnership approach, and focuses on improving land productivity, rehabilitation of land, conservation, and sustainable management of land and water resources. By 2001, sixteen African countries had produced National Action Plans in accordance with the UNCCD, and action plans had been developed for all sub-regions. Food reserve programmes have also been successfully established to provide additional resources for emergencies.

Other African initiatives to predict and cope with rainfall fluctuations include the establishment of early warning systems. These comprise climate-monitoring centres which can assess the likelihood of drought or flood and can alert the relevant departments or agencies as to requirements for food imports, requests to cull livestock, or orders to evacuate vulnerable areas. However, despite significant progress in recent decades in predicting seasonal fluctuations in rainfall (by monitoring interactions between the oceans and the atmosphere), much further investigation will be needed before fluctuations can be predicted accurately or their effects on food production or other human systems fully appreciated.

Longer-term responses include crop research to develop more resistant strains of staple crops, improved housing design and construction, and better urban planning to reduce the vulnerability of human populations.

Climate change

Climate change is now recognized as a pressing global environmental issue. It is the result of higher mean temperatures caused by increased amounts of greenhouse gases (GHG) in the earth's atmosphere, of which the most important is carbon dioxide released during burning of fossil fuels. Since the start of the industrial revolution (around 1750) some 270 billion tonnes of carbon have been released globally from the consumption of fossil fuels and cement production. Half of these emissions have occurred since the mid 1970s, although there was a slight decline of 0.3 per cent between 1997 and 1998 (Marland, Boden & Andres 2000).



Snow cover on Mt Kilimanjaro, Tanzania, April 1993 (top) and 2001 (bottom)

D. Manzolillo Nightingale

It is predicted that, globally, increased temperatures will lead to rising sea levels accompanied by displacement of people living in low-lying areas and loss of some island states, shifts and reductions in agricultural production, the possibility of more frequent and more severe climatic events such as droughts and flooding, and possible shifts in health problems with vector-borne diseases being re-introduced or introduced into different areas.

According to the Intergovernmental Panel on Climate Change (IPCC), global average temperatures have risen by 0.6 °C over the last century and the 1990–99 period was probably the warmest decade since the 1860s (IPCC 2001a). In addition, records indicate that snow and ice cover has decreased, and sea levels have risen by 10–20 cm over the last century.

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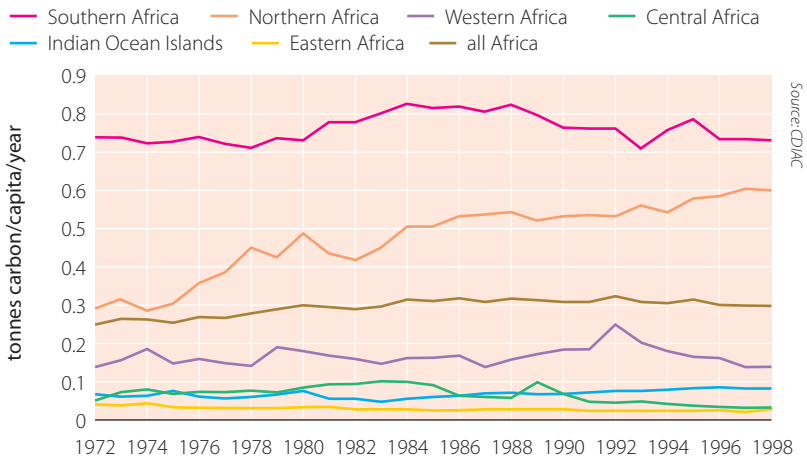
Figure 2a.3 Africa's contribution to global carbon dioxide emissions, 1972 –98

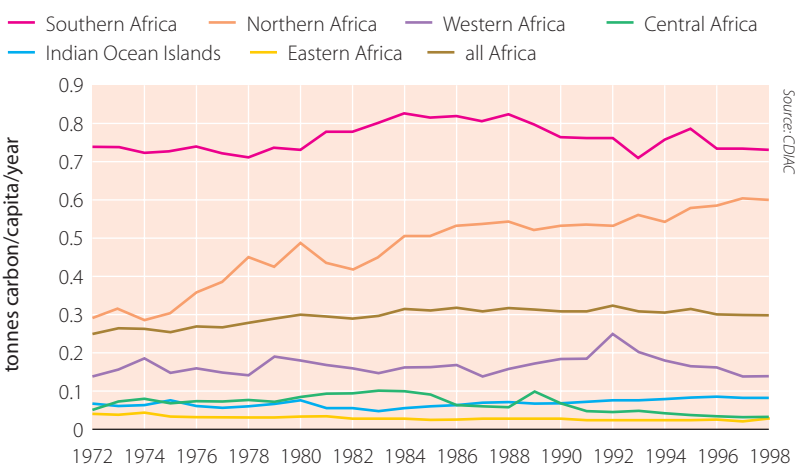


For example, the glaciers of Mount Kilimanjaro have shrunk by over 70 per cent over the last century (WorldWatch Institute 2000).

Africa's carbon dioxide emissions from use of fossil fuels are low in relation to other regions, in both absolute and per capita terms, as shown in Figure 2a.3. Despite the region's total emissions having risen to 223 million metric tonnes of carbon in 1998 (eight times the level in 1950), this is still less than the emissions for the United States, Mainland China, Russia, Japan, India, or Germany. Per capita emissions also increased three-fold over the same period, reaching 0.3 metric tonnes of carbon, only 5.7 per cent of the comparable value for North America.

A handful of African nations account for the bulk of the region's emissions from fossil fuels: South Africa accounts for 42 per cent with another 35.5 per cent coming from Egypt, Nigeria, and Algeria combined. This is illustrated in Figure 2a.4 (Marland and others 2000).

Figure 2a.4: Sub-regional comparison of carbon dioxide emissions 1972–98



Although Africa contributes very little to global GHG emissions the region is highly susceptible to the impacts of climate change because of its dependency on agriculture and limited financial resources for development of mitigation strategies. The IPCC predicts that the greater variability and unpredictability of temperature and rainfall cycles in Africa resulting from climate change would alter the area of suitable land for agricultural or livestock production and increase the frequency of flooding and drought. Grain yields are expected to decline due to increased rainfall variability, especially in the Horn and Southern Africa, and desertification rates may increase (IPCC 2001b). In Central Africa and parts of Eastern Africa increased rainfall and reduced frosts are expected, resulting in an increase in the area suitable for cultivation, possibly at the expense of natural habitat.

Climate change may also have a devastating impact on human settlements and infrastructure development in Africa. Low-lying coastal areas are at particular risk from sea level rise, and many coastal urban developments are of unsuitable design or are inadequately equipped to cope with storms and flooding. In particular, the Gulf of Guinea, Senegal, Egypt, Gambia, the eastern African coast and the Western Indian Ocean Islands are at risk from sea level rise (IPCC 2001b).

Africa's natural environment could also be severely affected by climate change with impacts including changes to forest cover and grassland distribution that would result from temperature rises of 1 ^{o}C or more. These in turn may result in significant changes in abundance and diversity of species. In particular, species living in arid zones will be less able to adapt, as they already exist at the very limits of their environmental tolerance (IPCC 1998). Significant extinction of plants and animals is anticipated, impacting on rural livelihoods and tourism (IPCC 2001b). For example, hartebeest, wildebeest and zebra in the Kruger National Park (South Africa), the Okavango Delta (Botswana), and Hwange National Park (Zimbabwe) could be severely threatened by the anticipated 5 per cent drop in rainfall that would affect grazing distribution (WWF 2000). Marine environments

could also be affected severely—a sea temperature rise of 1–2 ºC could cause extensive coral bleaching in the Western Indian Ocean, affecting the economies of the coastal countries and islands.

Climate change also poses a threat to human health in Africa, through reduced nutrition and possible expansion or creation of new habitats for disease-carrying organisms such as mosquitoes (IPCC 1998). Warmer temperatures and altered rainfall patterns could open up new areas to diseases such as malaria, yellow fever, dengue fever, and trypanosomiasis (IPCC 1998).

Climate change mitigation and adaptation strategies

African countries are faced with the dual challenge of meeting economic development needs without increasing dependence on fossil fuels or inefficient technologies while simultaneously mitigating the diverse and complex impacts of climate change. All African countries, with the exceptions of Angola, Liberia and Somalia, have ratified the United Nations Framework Convention on Climate Change (UNFCCC) and its proposed mechanism for implementation, the Kyoto Protocol, agreed in Bonn, in 2001, by 180 countries from all over the world.

African countries stand to benefit from the Kyoto Protocol and from the funding streams it proposes, namely the Special Climate Change Fund and the fund for Least Developed Countries. Under the Protocol's mechanisms, developed countries will be able to offset some of their emissions by paying for carbon-saving projects such as tree planting and forest conservation schemes in developing countries. Funds will also be available to help developing countries to convert to cleaner technologies such as solar and wind power or fuel-cell-operated vehicles, currently too expensive for many African nations. Additional funds will be available to assist developing countries in adapting and mitigating the impacts of climate change by means, for example, of flood defence systems and appropriate infrastructure design. Many countries (including Algeria, Botswana, Cape Verde, Côte D'Ivoire, Egypt, Ghana, Lesotho, Mali, Mauritius, Niger, Senegal, Seychelles, South Africa and Zimbabwe) have embarked on National Communications Strategies to provide detailed inventories of emissions and carbon dioxide 'sinks' and programmes to mitigate the impacts of climate change. In both Northern and Southern Africa, options for further exploitation of alternative sources of energy (for example, solar, wind, micro-hydro, geothermal and biomass) are being explored as additional means to combat climate change.

Air quality

Air quality in Africa is an issue that has emerged over the last few decades, particularly in large urban centres. It has been identified as a priority issue for action because rates of urbanization in Africa are the highest in the world, and there are enormous economic pressures for continued industrial growth.

The air in Africa's urban centres is polluted by emissions from industry, households and vehicles. Major air pollutants from these sources include sulphur dioxide, carbon monoxide, carbon dioxide, particulates, lead, and organic compounds. In most countries, economic pressures to increase industrial output have contributed to rising levels of pollution, and this trend is likely to continue if current development patterns persist (SEI 1998). Policy measures such as high taxes on fuel and on importation of new vehicles have also contributed to emissions, by encouraging the use of dirty fuels and a prevalence of old and more polluting

Air quality is an issue in large urban centres.

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... particulate matter emitted from diesel exhausts is small enough to reach deep into the lungs and contains toxic substances such as arsenic, benzene, formaldehyde, nickel, and polycyclic aromatic hydrocarbons that have been shown to cause cancer in humans and animals

vehicles. Studies in the United States have shown that a car manufactured today produces 70 to 90 per cent less pollution over its lifetime than a car made in the 1970s (CARB 2001a). Conversion to cleaner vehicles is therefore a priority for improvement of urban air quality. Diesel is a commonly used fuel in Africa, especially in commercial trucks and public vehicles, because it is cheaper than petrol. However, the particulate matter emitted from diesel exhausts is small enough to reach deep into the lungs and contains toxic substances such as arsenic, benzene, formaldehyde, nickel, and polycyclic aromatic hydrocarbons (PAHs) that have been shown to cause cancer in humans and animals (CARB 2001b). The use of leaded fuel in Africa is also of concern, as very few countries have promoted conversion to unleaded fuel.

In both urban and rural areas, air pollution from domestic combustion of wood, coal, paraffin, crop residues and refuse is a major health issue. Use of these traditional energy sources is driven by lack of investment in rural electrification and high costs of electricity and electrical appliances. These traditional fuels emit toxic pollutants including sulphur dioxide, carbon dioxide, nitrogen oxides, aldehydes, dioxin, PAHs and respirable particulate matter. Exposure to such emissions is associated with acute respiratory infections, chronic obstructive lung diseases (such as asthma and chronic bronchitis), lung cancer and pregnancy-related problems. Women are particularly susceptible because of their traditional roles as cook which means that they spend more time indoors and close to the pollution sources. Children are also at risk if they spend long periods indoors with their mothers. Other environmental impacts of air pollution include accelerated corrosion rates of buildings and toxicity to water, soil and vegetation.

Towards improving air quality in Africa

Recent responses to try to improve air quality in Africa include the establishment of air quality standards and guidelines and monitoring of ambient air quality. In addition to promulgation of laws and standards, the 'polluter pays principle', which advocates fines for companies exceeding certain emission levels, has been adopted, in theory, by many African governments. However, most countries lack the capacity and resources to enforce regulations or to enter into lengthy and costly legal proceedings with offenders.

In 1998, the Air Pollution Impact Network for Africa (APINA) convened a meeting to discuss the prevention and control of transboundary air pollution. APINA is a network of scientists, policy makers and NGOs established to provide information on air pollution, methodologies and databases, and to bridge the gap between information and policy making. It also provides training courses and workshops with specific groups such as the mining sector. Both APINA and NGOs have been instrumental in promoting the use of more efficient stoves, although with mixed results.

The City of Cairo, where only unleaded fuel has been sold since 1997, is a notable exception to the general use of leaded fuel in Africa. Other urban centres in Egypt are scheduled to follow suit by 2002. Some countries are upgrading public transport systems and have imposed age limits on private and commercial vehicles or are subsidizing the conversion to unleaded fuels. The World Bank's Clean Air Initiative in sub-Saharan African Cities is one such programme, involving phasing out of leaded petrol, and revision of transport policies. Responses to address traffic congestion have included upgrading of roads and incentives for car-share schemes.

Adoption of cleaner technologies to reduce industrial emissions is planned in most parts of Africa, but has, until now, been too expensive to adopt. With funding under the Kyoto Protocol mechanisms, cleaner technologies should become more widely accessible to African countries.

NORTHERN AFRICA

Northern Africa is one of the most arid areas of the world, with rainfalls that vary widely in terms of both temporal and geographical distribution. Northern African countries are also the most urbanized in Africa and are heavily dependent on fossil fuels for energy. The major issues of concern in the sub-region are therefore climate variability, climate change, and air quality in urban centres.

Climate variability in Northern Africa

Northern Africa experiences highly variable rainfall and recurrent droughts. The sub-region receives only 7 per cent of Africa's total precipitation and this is not evenly

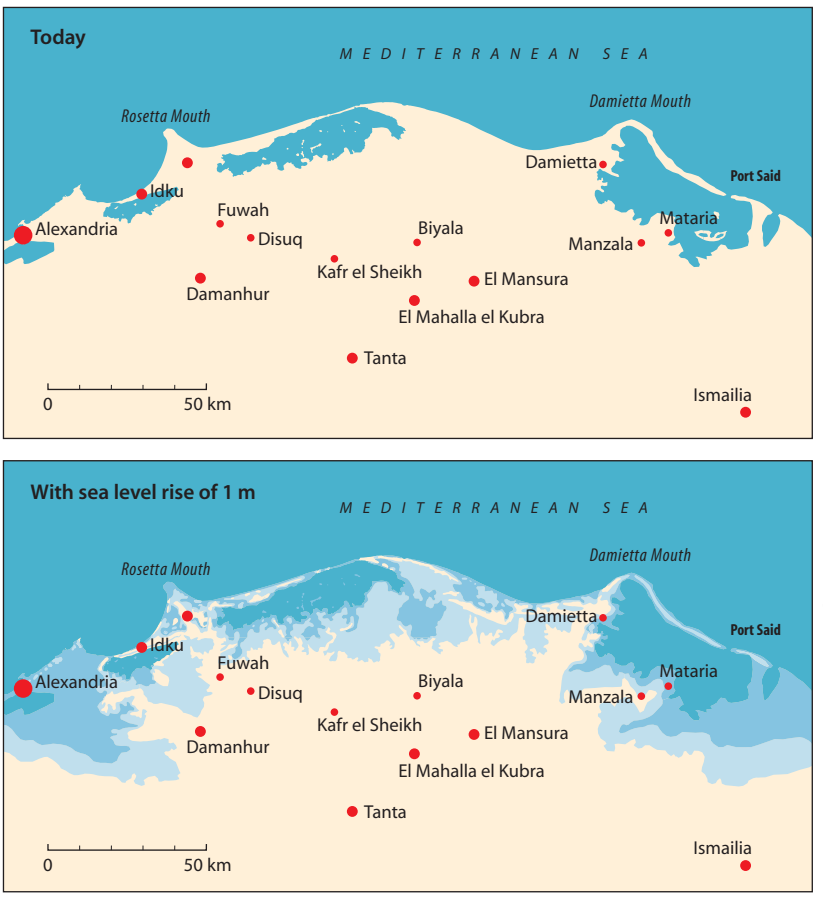
distributed. Egypt, for example, receives just 18 mm/yr of rain (FAO 1995), Algeria, Morocco and Tunisia experienced 6–7 years of drought between 1980 and 1993, and Morocco has experienced a drought in one year out of every three over the last century (Swearingen & Bencherifa 1996).

Flash floods—short-lived but very rapid rises in the level of water courses or filling of dry beds—are a typical feature of several African countries. Often following a brief downpour, flash floods rapidly erode soils, particularly where natural vegetation cover has been cleared from slopes (Swearingen & Bencherifa 1996). In Egypt, flash floods are often accompanied by mudflows which can be more disastrous than the floods themselves (Nemec 1991). Prior to the building of the Aswan High Dam, Egypt was also subject to frequent floods during the rainy season in the Ethiopian plateau (August through October) and to water shortages in years with below normal rainfall.

Swearingen and Bencherifa (1996) have suggested that the hazard of drought in Northern Africa has increased mainly as a result of expansion of cereal cultivation to drought-prone rangeland and reduction of fallow systems. This process was fostered during the colonial period by large-scale land expropriation and by displacement of peasants to marginal lands. It was also influenced by incentive-raising policies for cereal production, mechanization of agriculture, and by increased demand for food associated with rapid population growth.

Drought has major socio-economic significance in Northern Africa because rain-fed cereal cultivation is predominant. In 1997, for example, Algeria's cereal harvest decreased sharply as a result of severe drought. In Morocco, agricultural output recorded losses in 1992, 1995 and 1997. Drought also aggravates the effects of overgrazing, increasing degradation of natural vegetation and soils. The Nile River and Delta were much affected by the drought in the 1980s which resulted in loss of output from agriculture and fisheries and a drop in water level in Lake Nasser which exacerbated the country's existing irrigation problems (Abdel-Rahman, Gad & Younes 1994). In the Sudano-Sahelian area, hundreds of thousands of people were affected by famine, infectious diseases, and displacement (OFDA 1987).

Figure 2a.5 Predicted inundation of the Nile Delta



Sources: adapted from Otto Simonett, UNEP/GRID Geneva; Prof. G. Sestini, Florence; Remote Sensing Center, Cairo; DIERCKE Weltwirtschaftsatlas

Strategies for coping with climate variability in Northern Africa

All countries of the Northern Africa sub-region have ratified the UNCCD. Tunisia has produced a National Action Programme, and the Union du Maghreb Arabe has produced a sub-regional Action Plan for the Arab countries of Northern Africa (UNCCD 2001). Additional government policies to avoid or mitigate drought include changing agricultural practices and technology and rearranging land use patterns through reduction of cultivation in marginal areas and reduction of fallow periods.

Long-term solutions include an initiative by the Moroccan government to finance job-generating projects in rural areas to keep farmers from abandoning their lands. Officials are also working on expanding irrigation systems to cultivated areas and the use of supplementary irrigation in rain-fed areas (PEACENET 2000). However, policies are needed to improve the

Maintenance of wetlands, vegetation cover (especially riparian vegetation) and flood plains improves the ability to soak up excess water and thus reduce the intensity of flooding

ability of societies to understand and detect drought as well as to improve their ability to cope with its effects.

Improved monitoring and forecasting systems, such as modern remote sensing technology, are also required. For example, the impacts of the 1980s drought could have been alleviated if more effective detection and mitigation methods had been available (White 1992).

Improved integrated water resource management can assist in mitigating the intensity and impacts of flooding. Maintenance of wetlands, vegetation cover (especially riparian vegetation) and flood plains improves the ability to soak up excess water and thus reduce the intensity of flooding. Mitigating measures of the research and planning type, such as mapping of hydrological, hydrogeological and land-use patterns, could help to avoid urbanization in areas where there is a risk of flash floods.

Climate change in Northern Africa

Northern African countries account for a large proportion of all of Africa's GHG emissions, although emissions are lower than those of most European or North American countries. In 1996, Northern African countries emitted a total of 280 million metric tonnes of carbon dioxide, 37 per cent of Africa's total (African Development Bank 2001). The highest total emissions were from Algeria and Egypt, although Libya had the highest per capita emissions of any country in Africa (8 tonnes). Northern Africa is also responsible for about 20 per cent of Africa's anthropogenic methane emissions (African Development Bank 2001).

Predicted impacts of climate change for Northern Africa include decreased run-off water, increased desertification, and increased frequency of flooding and drought (IPCC 1998). In the drylands, predominant throughout the sub-region, population growth will push people into marginal lands which are highly vulnerable to desertification.

Management of changes in water resources resulting from climate change will be very difficult, as the sub-region is already suffering from problems of water availability and distribution. However, the most dramatic impacts will be seen in the coastal zone as a result of sea level rise. For example, studies have shown that a sizeable portion of the Nile Delta will be lost through inundation and erosion, with consequent loss of agricultural production, damage to infrastructure, and displacement of people. A one metre rise in sea level would inundate large areas of land in the Nile Delta area, and the Egyptian city of Alexandria would also be severely affected (see 'Coastal and marine environment').

Climate change mitigation and adaptation strategies in Northern Africa

All countries in the Northern Africa sub-region are parties to the UNFCCC and, by October 2001, Egypt had signed the Kyoto Protocol. Northern African countries are investigating the application of stricter efficiency measures, improved quality of fuels, and advances in the use of higher efficiency engines and industrial plants to reduce emissions including GHGs (Unified Arab Economic Report 1999). Improved energy efficiency, brought about through energy-pricing reforms and technological adaptations, could also make a substantial contribution to curbing of carbon dioxide emissions. Alternative sources of energy—such as solar energy which is abundant in the region—are being explored, especially in the rural areas that are home to about 50 per cent of the region's population. With international assistance, solar power could increasingly become a commercially viable option for many applications.

Northern African countries are also benefiting from Global Environment Facility (GEF) funding for climate change mitigation. For example, Sudan has projects for rangeland rehabilitation to enhance carbon sequestration and reduce GHG emissions, and Tunisia has received funds for renewable energy development (GEF 1999).

Air quality in Northern Africa

Declining air quality, especially in urban centres, continues to be one of the most serious local environmental problems in Northern Africa and a continuing threat to human health. The three principal anthropogenic causes of declining air quality are energy generation, emissions from vehicles, and industrial production, all of which have increased in the past 30 years.

Much of Northern Africa's industrial base was developed in the 1960s and the capital stock of most

industries is therefore old and highly polluting. The situation is further complicated by protective trade regimes, foreign exchange constraints, and by dominance of the public sector in industry, all of which provide little incentive for adopting more efficient and cleaner industrial technologies. Few enterprises have air emission controls, and a lack of maintenance and spare parts impairs the performance of existing systems (World Bank 1995).

In many cities in Northern Africa—especially those close to refineries and oil-fired power plants using high-sulphur fuel—sulphur dioxide levels reach more than 100 micrograms/m^3, double the World Health Organization (WHO) standard (World Bank 1999). Industry and the power sector are the sub-region's major sources of sulphur dioxide and total suspended particulates, and are large contributors to nitrogen oxide emissions (90, 80 and 60 per cent respectively). Sulphur dioxide, either dry or dissolved in rain water, causes erosion of infrastructure and monuments as well as soil and water acidification. For example, studies in 1985 and 1995 concluded that sulphur dioxide is a major factor contributing to corrosion of metallic structures in central Cairo and to deterioration of the Sphinx (Hewehy 1993).

Atmospheric concentrations of lead and particulates in Northern Africa often exceed WHO guidelines by a multiple of two to five in large cities. The cement and steel industries produce 50 per cent of the total particulate emissions (World Bank 1995). In Egypt, the Cairo Air Improvement Project (CAIP) reported greatly increased concentrations of lead in industrial districts during 1998, because of excessive lead emissions from smelters. It has been estimated that, prior to 1997, lead emissions from motor vehicles in Cairo were about 700 to 1000 tonnes per annum.

The number of motor vehicles in most countries in the sub-region has nearly doubled in the past 10 to 15 years and many vehicles are of older types. Older vehicles emit 20 times more hydrocarbons and carbon monoxide and four times more nitrogen oxides than new vehicles. Particulate emissions from poorly maintained diesel-fueled buses and trucks are five to seven times higher than those from similar but well-maintained vehicles (World Bank 1995, Larsen 1995).

City dwellers in Northern Africa, particularly those in congested metropolitan centres, are exposed to a variety of toxic and carcinogenic compounds including heavy metals and PAHs which contribute to the incidence of respiratory diseases such as asthma, bronchitis and emphysema. If combined with other pollutants such as sulphur dioxide, suspended particulates can cause bronchitis and other lung diseases. For example, statistics from Egypt's Ministry of Health indicate that, in the areas of Ma'adi and Helwan, chest diseases are the second cause of death after communicable diseases.

Towards improving air quality in Northern Africa

In 1991, having identified the major sources and established levels of emissions of the major air contaminants, the Council of Arab Ministers Responsible for the Environment (CAMRE) adopted the concept of sustainable development as the basis for development in the 21st century. Control of air pollution, especially in urban centres, was identified as one of the main objectives in Algeria, Libya and Morocco. More liberal trade policies and the increased production of more affordable vehicles will lead to the gradual replacement of highly polluting, older vehicles. Another target that is expected to be of higher priority is the reduction of the sulphur content of fuels. Algeria, Morocco and Tunisia have included electrified railways in their transportation infrastructures and Egypt has built an underground metro system that has made a considerable contribution to reducing surface mass public transit thus reducing emissions from vehicles.

Industrial pollution abatement initiatives have been introduced in Northern Africa and have begun to reduce carbon dioxide emissions. For example, conversion of industrial enterprises to natural gas has been financed. In Tunisia, a solar water-heating project will promote commercialization of solar water heating technology in the residential sector. A repowering project in Morocco has also been approved but is awaiting construction of a natural gas pipeline from the Algeria-Portugal pipeline. Other projects at the preparation stage include solar, wind, and waste-to-energy projects in Algeria, Egypt and Morocco.

In Egypt, the Cairo Air Improvement Project (CAIP) aims to initiate and implement measures to reduce air pollutants that have the most serious impacts on human health in Greater Cairo, especially suspended particulates and lead (see Box 2a.1). The CAIP will also

Atmospheric concentrations of lead and particulates in Northern Africa often exceed WHO guidelines by a multiple of two to five in large cities

Box 2a.1 The Cairo Air Improvement Project

Recognising the seriousness of air pollution, the Egyptian government has embarked on a comprehensive programme to improve air quality throughout Egypt. In 1993, the country's Ministry of Petroleum introduced unleaded fuel as a part of this programme and within two years 85 per cent of the country's fuel supply was converted. The Cairo Air Improvement Project (CAIP), set up in 1997 and tasked with monitoring ambient air quality, reported that levels of airborne lead in Cairo had decreased by up to 88 per cent in just one year. Other initiatives under the project include testing of compressed natural gas as an alternative to diesel for public buses, and running a public awareness campaign.

Source: USAID 2001a

monitor the effectiveness of pollution abatement schemes implemented by the Egyptian Environment Affairs Agency, CAIP, and other organizations.

EASTERN AFRICA

Large parts of Eastern Africa are arid and semi-arid, and annual rainfalls below 500 mm are common. Amounts of rain and its distribution are highly unpredictable, both from year to year and in terms of distribution within a given year (FAOSTAT 2000). These conditions make the sub-region particularly vulnerable to the impacts of climate change on food production and security of livelihoods. These are accordingly priority issues.

Air pollution is not currently a major problem in the sub-region, as rates of urbanization and industrial production are relatively low at present. However, these rates are rising rapidly in comparison with other parts of Africa and effective long term development plans are needed to prepare for potential increases in emissions.

Climate variability in Eastern Africa

Eastern Africa has experienced at least one major drought in each decade over the past 30 years. There were serious droughts in 1973/74, 1984/85, 1987, 1992–1994, and in 1999/2000 and there is some evidence of increasing climatic instability in the sub-region, and increasing frequency and intensity of drought (FAOSTAT 2000). For example, records of dry and wet years for Uganda between 1943 and 1999 show a marked increase in the frequency of very dry years over the past 30 years (Department of Meteorology 2000). Rainfall records also indicate that, in some parts of the sub-region, the drought in 2000 was worse than that experienced in 1984 (DMC 2000).

Persistent deficits in rainfall in Eastern Africa have had serious impacts including total crop failure which has led to increasing food prices and dependency on food relief in Burundi, Ethiopia, Kenya and Uganda (DMC 2000). In Ethiopia, the 1984 drought caused the deaths of about 1 million people, 1.5 million head of livestock perished, and 8.7 million people were affected in all. In 1987, more than 5.2 million people in Ethiopia, 1 million in Eritrea and 200 000 in Somalia were severely affected (DMC 2000). Severe water shortages and rationing, continued reductions in water quantity and quality, increased conflicts over water resources, and the drying up of some rivers and small reservoirs have contributed to death of livestock from hunger, thirst and disease, and increased conflicts over grazing belts.

Additional impacts in the sub-region include persistently low water levels in rivers, underground aquifers and reservoirs, impacting on hydrology, biodiversity and use of water for domestic, industrial and irrigation purposes. Low reservoir levels have also reduced the potential for hydropower generation leading to the introduction of power rationing in the domestic and commercial sectors which has caused

Drought impacts on soil

UNEP

interruptions of economic activities and declines in manufacturing output. This was the case in Kenya where low rainfall between 1998 and 2000 led to reductions in hydropower generation and the need for drastic rationing schedules. The Kenya Power and Lighting Company was estimated to have lost US$20 million (IRI Climate Digest 2000) and there were additional losses to the economy resulting from the enforced closure of industrial facilities.

By contrast, some areas have experienced above-average rainfall, triggered by the ENSO phenomenon. The very warm ENSO event during the rainy season of 1997 resulted in record rainfall in some areas (averaging 5 to 10 times more than normal in many areas) and disastrous flooding. Thousands of people were displaced and extensive damage to property was caused. In Uganda, about 525 people died and another 11 000 were hospitalized and treated for cholera which broke out after flooding and landslides. About 1 000 more people were reported to have died in flood-related accidents and 150 000 were displaced from their homes (NEMA 1999). About 40 per cent of Uganda's nationwide 9 600-km feeder road network was destroyed and the country experienced widespread crop failure resulting in dependency on food imports and aid.

Strategies for coping with climate variability in Eastern Africa

All Eastern African governments except Somalia have signed and ratified the UNCCD. Djibouti, Ethiopia and Uganda have produced National Action Plans, and the Intergovernmental Authority on Development (IGAD) (see Chapter 1) has produced a sub-regional action plan for the countries in the Horn of Africa (UNCCD 2001). All Eastern African countries (except Rwanda and Burundi) belong to IGAD. Monitoring and early warning systems have been put in place, through IGAD, to improve the ability to cope with climate variability. ENSO-related events can also now be detected, as a result of research conducted under the World Meteorological Organization's (WMO) Tropical Ocean and Global Atmosphere programme. The WMO issues monthly statements (*El Niño Update*) to provide effective, accurate, and timely information to all concerned, to allow them to take mitigatory action. However, most of the national institutions in the sub-region are under-resourced making adequate early warning dependent on donor support.

In April 2000, an Inter-Agency Task Force on the UN Response to Long Term Food Security, Agricultural Development and Related Aspects in the Horn of Africa was launched. The Task Force has produced a strategy for the Elimination of Hunger in the Horn of Africa aimed at broadening opportunities for sustainable livelihoods, and formulating and implementing country food security programmes. In Kenya, research into traditional methods of coping with climate variability is also underway, with the aim of applying traditional knowledge to commercial enterprises (see Box 2a.2).

Box 2a.2 Traditional strategies for coping with drought

Drought is extremely difficult to predict and the variable duration and extent of the phenomenon make its effects difficult to manage. For pastoralists, following the rains and pasture is a natural part of their system, and setting aside of areas for grazing reserves and splitting of herds to minimize risk are part of their coping mechanisms. However, exclusion from some traditional grazing areas has compromised their ability to cope during dry periods and drought.

A project conducted by the African Centre for Technology Studies (Kenya) aims to identify traditional means of reducing vulnerability to environmental change in dryland Africa, and incorporate them into commercial food production systems. Field studies were conducted to gather information on ways in which rural households use indigenous plants in responding to drought, and how national environmental policies affect their practises.

Source: ACTS 2001

Climate change in Eastern Africa

Low levels of industrialization and urbanization in Eastern Africa mean that the sub-region's contribution to global carbon dioxide emissions is negligible—less than 2 per cent of Africa's total emissions in 1996 (African Development Bank 2001). However, the impacts of climate change, particularly on food security, are a priority concern for this sub-region.

Climate change impacts include reduced rainfall (a reduction of 10 per cent by 2050 is anticipated for the

Horn of Africa), increased temperatures, and increased evaporation (IPCC 1998, IPCC 2001b). Resulting shifts in vegetation zones will be felt particularly in the areas of agriculture, tourism, energy, industry and commerce (Ottichilo and others 1991).

ENSO events may also be influenced by climate change, but it is not known at this stage whether flood frequency and intensity in Eastern Africa will increase. Increased rainfall intensity, together with degraded vegetation cover, would make the sub-region more prone to landslides associated with flooding.

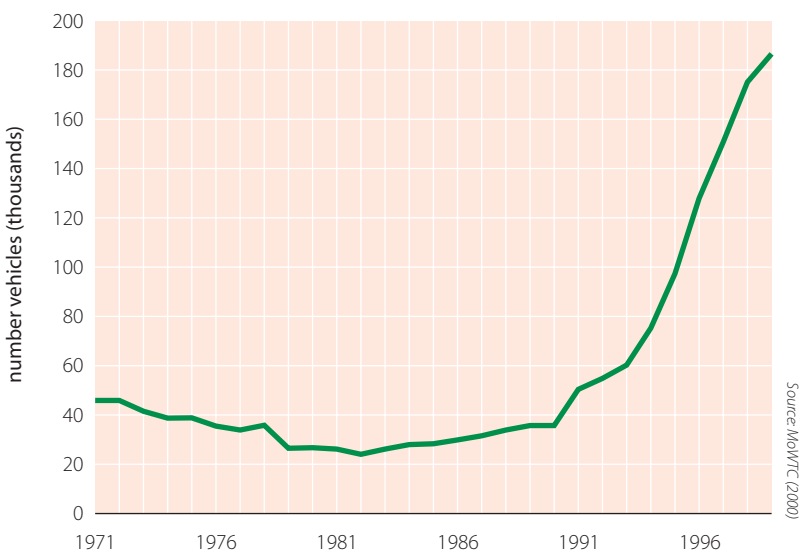
Rises in sea levels and sea temperatures could have devastating consequences on the Eastern African coast with risk of inundation of many important commercial centres, loss of infrastructure, and population displacement. For example, port activities at Dar es Salaam and Mombasa may be interrupted, and tourism activities and potential activities foreclosed. The coral reefs in the Western Indian Ocean are particularly at risk from sea temperature rise—almost 90 per cent of the sub-region's corals suffered bleaching during the 1997/8 warm ENSO event (Obura and others 2000).

Climate change mitigation and adaptation strategies in Eastern Africa

In response to growing concern over climate change in the sub-region, almost all governments have ratified the UNFCCC and Burundi has ratified the Kyoto Protocol. The Kenyan government has established a National Climate Change Activities Coordinating Committee, with members drawn from the ministries of agriculture and forestry, energy, planning, finance, and industry, and from research institutes, municipal councils, public universities, the private sector, and NGOs. The Council will coordinate and facilitate research, response strategies, policy options, public information and awareness, and liaison with the IPCC.

Several countries have developed national strategies for disaster prevention, preparedness, and management. In Ethiopia, this was followed by the establishment of a five-year plan for the Federal Disaster Prevention and Preparedness Commission, in 1998. Successes of the plan's implementation include a ten-fold increase in food reserves (WFP 2000).

Figure 2a.6 Number of vehicles registered in Uganda in 1971–99



Air quality in Eastern Africa

Emissions from vehicles, manufacturing, mining and industrial activities (including diesel-powered generators, copper smelters, ferro-alloy works, steel works, foundries, and cement and fertilizer plants) contain carbon, sulphur and nitrogen oxides, as well as hydrocarbons and particulates, causing localized smog.

Domestic combustion of 'biofuels' poses a risk for human health. Figures since 1980 show that the traditional use of biomass as a source of energy still accounts for over 70 per cent of total energy consumption in Eastern Africa (UNDP 2000) and consumption of biomass is predicted to increase over the next 20 years (FAO 2001b).

Demand for vehicular transport is on the increase in Eastern Africa and many of the vehicles presently on the road are old and inefficient. For example, as shown in Figure 2a.6, Uganda had around 44 500 vehicles on the road in 1971; by 1998 this number had climbed to over 182 400, a more or less four-fold increase in less than 30 years (MoWTC 2000). In Ethiopia, the capital, Addis Ababa, accounts for 41 per cent of all of the country's petrol consumption, indicating the concentration of vehicles and their emissions in Addis. Many of these vehicles are old and do not therefore have filtering systems (NESDA 2000).

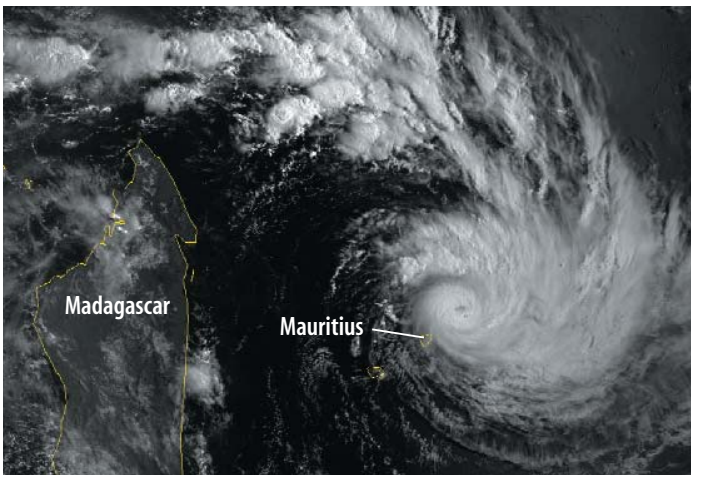
Additional sources of air pollutants include both legal and illegal waste dumps. For example, in 1998, methane emissions from the municipal dump in Addis

Ababa were estimated to be more than 9 Gg (1 Gg = 1 x 10^9 grams) (NESDA 2000).

Towards improving air quality in Eastern Africa

Air quality standards for all major pollutants have now been established for most countries in Eastern Africa, but lack of resources renders enforcement less than optimum.

Addis Ababa has recently acquired a new pollution-measuring laboratory, costing US$286 000, which will help to identify the type and amount of pollutants emitted by factories in the city, assess the impacts on soil and water, and recommend measures to prevent further environmental pollution (PanAfrican News Agency 2001).



Tropical cyclone *Ando* in the Indian Ocean

EUMETSAT

WESTERN INDIAN OCEAN ISLANDS

The Western Indian Ocean Islands lie between the tropics, with the exception of a small part of Madagascar which falls south of the tropic of Capricorn. They are subject to about ten tropical storms or cyclones each year in the period between November and May (four per year in Madagascar). The sub-region also experiences inter-annual variations in rainfall as well as periodic flooding and droughts.

Although early warning systems are well developed in the Western Indian Ocean Islands, the threat of increased climate variability and of sea level rise, arising from climate change, are issues of priority and concern.

Air pollution in urban areas is emerging as a problem for human health and for the sub-region's ecology. Preventive action is required.

Climate variability in the Western Indian Ocean Islands

Cyclones—with high winds gusting at over 200 km/hour—demolish lightweight buildings, damage overhead cables, uproot trees, and are a threat to life and property. Cyclones also cause heavy swells in the Western Indian Ocean which in turn cause significant rises in sea levels that affect coastal infrastructures such as roads and settlements, undermine beach stability, and cause vertical scouring of up to two metres (Ragoonaden 1997). The heavy rains resulting from cyclones cause destruction of crops and vegetation, flooding, soil erosion and contamination of freshwater supplies, with risk to humans and to animal life. At the height of a cyclone most outdoor human activity comes to a halt, schools and workplaces close down, emergency shelter has to be found for those whose homes are destroyed or damaged, and calls are issued for community aid programmes.

In the aftermath of a cyclone, communities may be temporarily prevented from returning to normal activity because people, domestic animals, crops, services and buildings have been lost (UNEP 1999). In some cases the damage may be so severe that countries are obliged to seek international relief aid. Madagascar is an example of this (FAO 1984, UNDHA 1994).

The ENSO phenomenon is also a major factor in climate variability in the sub-region, causing floods and droughts. Mauritius, for example, is prone to drought, especially in the dry season, while Madagascar is most affected by desertification, with sandstorms that cause sand dunes to invade the interior along the coast, covering houses and crops (UNEP 1999). In these countries and elsewhere in the sub-region, the pressure of an increasing population is resulting in the use of marginal land close to rivers, of sand dunes and of land reclaimed from the sea for residential and industrial purposes. Conditions in these marginal or reclaimed lands are more precarious than in other areas, and such

encroachment puts more people and jobs at risk from the effects of climate change and natural disasters.

Coral reefs in the sub-region are also at risk. In 1997 and 1998, the ENSO phenomenon caused abnormal increases in sea and air temperatures that led to bleaching and death of coral reefs. In Seychelles, more than 80 per cent of coral reefs were lost and, in the same period, a prolonged drought caused temporary closure of the Seychelles Breweries and the Indian Ocean Tuna Company (UNEP 1999).

Strategies for coping with climate variability in the Western Indian Ocean Islands

Cyclones cannot be controlled, but their impacts on lives, livelihoods, crops and infrastructure can be minimized through adequate preparation and efficient, accurate warnings by meteorological services. For example, Mauritius has a cyclone warning system that was established in the 1950s, at a time when the island's economy was dominated by sugar production (a crop highly vulnerable to the wind and rain damage associated with cyclones). The subsequent rapid growth in the country's population and its economic and agricultural development mean that more people and infrastructure are now at risk from cyclone impacts and the system is used to give a series of warnings allowing for preparations or evacuation (see Box 2a.3). The regional Tropical Cyclone Warning System in the southwest Indian Ocean is also being upgraded and observation and telecommunications systems are being enhanced. Meteorologists and hydrologists are being given advanced training on early warning systems.

Cyclones cannot be controlled, but their impacts on lives, livelihoods, crops and infrastructure can be minimized through adequate preparation and efficient, accurate warnings by meteorological services

Box 2a.3 Cyclone warnings and preparation in Mauritius

Mauritius' Meteorological Office rates cyclones on a four-point scale of likelihood that the cyclone will hit the island. Warnings are issued to indicate that the cyclone is heading towards the island between 6 and 12 hours before it hits, and once the windspeed reaches 120 km/hr. There are fully equipped shelters and emergency procedures that are tested regularly. Plentiful advice on stocking up with provisions and water is also given.

Source: US Embassy in Mauritius 2001

Cyclone-proof buildings are becoming a common feature in the sub-region (incidentally creating a demand for building sand which, as it is often dug from beaches, exacerbates erosion and damage to the delicate reef ecology). Wind resistant crops are also being developed on the islands.

Regional programmes can contribute to better protection from and response to crises, but effective intra-regional collaboration is vital to ensure sharing of technical skills, training, information, research, and collaboration in response.

Climate change in the Western Indian Ocean Islands

The contribution of the Western Indian Ocean Islands to global climate change is small (less than half of one per cent of Africa's total carbon dioxide emissions in 1996), but vulnerability to the impacts of change is high, as is the case for other Small Island Developing States (African Development Bank 2001).

Seychelles has the highest per capita emission rate for carbon dioxide emissions in the sub-region (2.2 tonnes of carbon dioxide per inhabitant per year in 1996), but the country's natural capacity for removal of the gas from the atmosphere is estimated to be four times higher than the levels it emits (African Development Bank 2001, UNDP 2000).

Energy production and industry are important sources of GHGs and commercial energy consumption is increasing in Madagascar by 1.6 per cent per year and in Mauritius by 2.6 per cent per year. Per capita consumption of electricity has more than doubled in Mauritius and Seychelles since 1984, while in Comoros and Madagascar it has remained constant or fallen. Between 1991 and 1995, total carbon dioxide emissions from industrial processes increased by 5 per cent in Madagascar and by 23 per cent in Mauritius (UNEP 1999).

The sub-region is particularly vulnerable to the impacts of global climate change because of its low lying flat lands, narrow coastal strips, atolls, reefs and sandy beaches, and the concentration of human populations, tourism, infrastructure, transport and industrial activities in coastal zones (Leatherman 1997). It is estimated that a one-metre rise in sea level would submerge most of the Seychelles islands with a loss of

Coral sand beaches with unique granite formations are unique to the Seychelle islands.

W. Norbert/Still Pictures

70 per cent of their land area (Shah 1995, Shah 1996). The same rise would result in a loss of 5 km^2 of land in Mauritius, 0.3 per cent of its surface area (IPCC 1995). For the sub-region as a whole, it has been estimated that, in total, 22 per cent of the population of the islands would be at risk from ocean rises and that rises would affect fishing and tourism, and jeopardize economic viability.

Climate change mitigation and adaptation strategies in the Western Indian Ocean Islands

Responses to climate variability and climate change include ratification of the UNFCCC and, in the case of Seychelles, the Kyoto Protocol. This has been supported at the national level by the development of National Communications Strategies, as well as National Environment Action Plans. Mauritius has also undertaken studies of GHG sources and sinks.

The Western Indian Ocean Marine Applications Programme is a regional branch of the Global Ocean Observing System (GOOS), a permanent global system for observation, modelling and analysis of marine and ocean variables to support operational ocean services world-wide. The GOOS provides information on the current state of the oceans and forecasts on future conditions as the basis for climate change modelling.

In May 1991, the Mauritius Meteorological Services established a National Climate Committee (NCC) involving all parties with an interest in climate change. The Committee was tasked with monitoring progress on the scientific understanding of climate change, and evaluating the possible economic impacts on agriculture, coastal zones, energy and water resources, and human health and welfare.

Air quality in the Western Indian Ocean Islands

The Western Indian Ocean Islands are well ventilated and have yet to experience levels of air pollution with lasting effects on ecology and human health. However, concerns are growing about air pollution from industry and transport, especially in Seychelles and Mauritius. Traffic density is increasing alarmingly and the transport sector, the largest energy user in the sub-region as a whole, currently accounts for 43 per cent of total energy consumption. Vehicles also tend to be older—in Madagascar the average age of buses is 11 years, that of cars 7–8 years (ONE 1997). In Mauritius, urban pollution, caused largely by vehicle exhaust emission, often exceeds WHO guidelines (UNEP 1999). Government subsidies for public transport and import duties on vehicles have failed to stem the growth in numbers of private vehicles and have resulted in a fleet that is increasing both in age and inefficiency. Lack of policies and of incentives to use cleaner fuels has also added to the burden of pollution.

Increasing disposable income in the sub-region will continue to drive up both energy use and numbers of vehicles. In Mauritius, for example, accelerated industrial development has resulted in increased industrial emissions and commercial road traffic, even though the capital, Port Louis, escapes concentrations of urban pollution because of its coastal position. In Madagascar, more than 70 per cent of industrial enterprises—principally agro-processing, textiles, clothing, leather, wood, paper, chemicals, mineral and metal products and industrial boilers—are located around the capital, Antananarivo, causing pollution problems. Air quality and pollution in Antananarivo are also influenced by strong sunshine and an absence of air movement, putting additional pressure on human respiratory health (ONE 1997).

The domestic use of wood and charcoal for cooking is causing concern over air pollution in Comoros and

It is estimated that a one-metre rise in sea level would submerge most of the Seychelles islands with a loss of 70 per cent of their land area

Madagascar (UNEP 1999). In Mauritius, where this problem also exists, its impacts are compounded by cigarette consumption which is at significant levels among males (UNDP 2000).

The practice of burning sugar cane before harvesting, in Mauritius and elsewhere in the sub-region, causes severe, though often localized, air pollution with release of fly ash, ozone, carbon dioxide, carbon monoxide, methane and volatile organic compounds. Pollutants such as these can have an impact on respiratory health and can acidify ecosystems thereby affecting the quality of soil, land and water.

The sub-region has no heavy, power-intensive industrial sector, but odours from the fish processing industry are a source of complaint.

Environmental quality is the key factor on which the sub-region's tourism and other inward investment depend. The main priority is therefore to avoid further deterioration of air quality and to reduce current sources of pollution.

Towards improving air quality in the Western Indian Ocean Islands

Even though natural ventilation in these islands disperses much of the pollution, there is still a need for additional control measures. Some steps have been taken, including:

- Monitoring of pollution along main roads and the introduction of public awareness and school programmes highlighting the risks of air pollution to the environment and to human health.
- Use of some renewable energy sources including hydro-electricity in Madagascar and Mauritius and solar power in most countries of the sub-region. Bagasse from sugar cane is used to produce electricity in Mauritius (UNEP 1999).
- Environmental protection legislation is in place in each country, but its application is at the 'educational' rather than the enforcement stage.

In general, establishing the nature of the problem in the sub-region and quantifying it are difficult because monitoring tools are inadequate. In addition, control of sources of pollution is weak and there is a general laxness in regulation of the industrial sector. Social costs and impacts on health have not been studied, public sensitivity to environmental issues has yet to be stimulated and the sub-region is characterized by a general lack of awareness of the threats to the ecology and to human health.

SOUTHERN AFRICA

The main issues of concern regarding the atmosphere in Southern Africa are the occurrence of flooding and droughts arising from climate variability, impacts of climate change on vegetation systems, biodiversity, freshwater availability, food production and localized air quality problems associated with emissions from industry, vehicles and use of domestic fuels.

Climate variability in Southern Africa

Rainfall in Southern Africa is strongly influenced by the Inter-Tropical Convergence Zone (ITCZ), a zone close to the equator where massive rain-bearing clouds form when the South East Trade Wind (from the south east of the continent) meets the North East Monsoon Winds. The ITCZ changes position during the year, oscillating between the Equator and the Tropic of Capricorn, and its southward movement usually marks the beginning of a rainy season. The further south the zone moves, the more promising this is

Maize rotting in the fields after the Feb/March 2000 floods in Mozambique

Pieternella Pieterse/Still Pictures

considered to be for the rainy season. In a normal season, the ITCZ can exert an influence between mid-Tanzania and southern Zimbabwe and is associated with favourable rainfall. Another system, the Botswana High, often tends to push the ITCZ away, resulting in periods of drought.

The ENSO also influences Southern Africa's climate, tending to bring either heavy rains often accompanied by severe floods (as in 1999/2000 when Mozambique was exceptionally hard hit), or drought (as in 1982/83 when much of Southern Africa was severely affected) (National Drought Mitigation Center 2000).

In the wet season, normal rainfall in Southern Africa ranges from 50 mm to over 1000 mm. Recent weather patterns have, however, been erratic with severe droughts recorded in 1967–73, 1981–83, 1986/87, 1991/92 and 1993/4. Floods have also been observed, most notably across most of Southern Africa in 1999/2000 (Chenje & Johnson 1994, WMO 2000).

The drought of 1991/2 was the severest on record, causing a 54 per cent reduction in cereal harvest and exposing more than 17 million people to risk of starvation (Calliham, Eriksen and Herrick 1994). Zimbabwe alone imported an additional 800 000 tonnes of maize, 250 000 tonnes of wheat, and 200 000 tonnes of sugar (Makarau 1992). Water and electricity shortages resulted in a 9 per cent reduction in manufacturing output and a 6 per cent reduction in foreign exchange (Benson & Clay 1994).

Cyclone Eline, which hit south-eastern Africa in 1999/2000, affected 150 000 families and wreaked havoc in Mozambique where it caused US$273 million worth of physical damage, and cost US$295 million in lost production, and US$31 million in food imports (Mozambique National News Agency 2000).

A combination of dry spells, severe floods, and disruption of farming activities between 1999 and 2001 has left Southern Africa with meagre food reserves. Several of the sub-region's countries have faced food shortages (FAO 2001a).

Strategies for coping with climate variability in Southern Africa

The Southern African Development Community (SADC) has developed a Sub-Regional Action Programme to Combat Desertification in southern Africa, in line with the UNCCD. All of the countries in the Southern African sub-region are party to the UNCCD, and Lesotho, Malawi, Swaziland, Tanzania, and Zimbabwe have also produced National Action Plans (UNCCD 2001).

Early warning and response strategies for mitigating the impacts of climate variability are relatively well developed in the sub-region (see Box 2a.4) and a drought fund is in place to mitigate the effects of poor rainfall (Chimhete 1997). However, monitoring, research, and preparedness strategies need further strengthening. This is evidenced by the response to cyclone Eline—according to some sources, the early warning systems did not supply sufficient information about the extent of the impacts of the cyclone, resulting in the loss of many lives that could have been saved (CNN 2000).

Box 2a.4 Early warning in Southern Africa

The SADC Regional Early Warning Unit, the Regional Remote Sensing Project, the Drought Monitoring Centre and the Famine Early Warning System Project all advise governments on drought preparedness. During the 1991–1992 drought, the unit altered national agencies and donors in time to increase food imports and request food aid.

Source: Masundire, 1993. Photo: UNEP

Climate change in Southern Africa

Emissions of GHGs by Southern Africa (in particular South Africa) are higher than those for other sub-regions of Africa, although they represent only 2 per cent of the world total. The sub-region's emissions are, however, projected to rise as countries develop, including a threefold increase in Zimbabwe over the next 50 years (Southern Centre 1996). South Africa already has a net positive GHG emission level—it accounts for the majority of emissions from the sub-region and 42 per cent of all emissions from Africa (World Bank 2000a, Marland and others 2000).

The majority of Southern Africa's primary energy comes from fossil fuels, in the form of coal and petroleum, and its level of industrialization is high compared to other parts of Africa. It is therefore imperative that the sub-region adopt a two-pronged approach, introducing cleaner technologies and

It is predicted that the malaria-carrying Anopheles female mosquito will spread to parts of Namibia and South Africa where it has not been found before

renewable sources of energy production while simultaneously improving coping capacities to deal with the anticipated impacts of an increasingly variable and unpredictable climate.

Southern Africa's background of climate variability, food insecurity and water stress makes it one of the most vulnerable areas to climate change (IPCC 1998, IPCC 2001b). The sub-region is expected to experience a mean temperature rise of 1.5 ºC and increased rainfall variability and insecurity (Hulme 1995). The expected impacts of these changes include reductions in the extent of grasslands and expansion of thorn savannas and dry forest, together with a general increase in the extent of desertification across the sub-region. This will in turn affect the distribution of wildlife and some of the major national parks could suffer economic losses through reduced tourism potential (IPCC 2001b). Crop yields are also expected to vary, dropping by as much as 10–20 per cent in some parts of the sub-region (GLOBE 2001). It is also predicted that the malaria-carrying *Anopheles* female mosquito will spread to parts of Namibia and South Africa where it has not been found before (IPCC 1998).

According to the IPCC, global sea levels are expected to rise by between 10 and 100 cm by 2100, due to snow and ice melt. This could inundate up to 2 117 km^2 and erode up to 9 km^2 of the coast of Tanzania, with a cost of more than US$50 million (IPCC 1998). The economies of most Southern African countries are highly vulnerable to a changing climate because of their dependence on commercial agriculture. In addition, over 50 per cent of the sub-region's population is based in rural areas and is directly dependent on small-scale cultivation and rearing of livestock.

Climate change mitigation and adaptation strategies in Southern Africa

To date, all of the 11 countries of the Southern African sub-region have signed and ratified the UNFCCC, signalling the importance with which they regard climate change. Several countries have embarked on the production of National Communications Strategies to document GHG emissions and sinks, and have developed strategies for mitigating climate change.

A sub-region-wide initiative is also underway to develop a strategy for GHG reduction in Southern Africa. Tanzania's Centre for Energy, Environment, Science & Technology, in collaboration with Zimbabwe's Southern Centre for Energy and Environment and Zambia's Centre for Energy, Environment and Engineering are coordinating studies for this initiative.

South Africa, the sub-region's largest contributor to GHG emissions, has established a National Committee for Climate Change to advise its Minister of Environmental Affairs on the implications of climate change and policy options for reducing emissions. In 1996, the government of Zimbabwe reviewed the country's environmental legislation and incorporated climate change issues. A climate change office was set up within the then Ministry of Mines, Environment and Tourism to coordinate activities on the subject (Government of Zimbabwe 1999).

In Mozambique, plans are underway for a tree-planting scheme which should qualify for funds from the Cleaner Development Mechanism of the Kyoto Protocol. This project aims to restore native Miombo woodlands in Gorongosa National Park and to provide economic opportunities to local communities through sales of timber and development of eco-tourism.

Air quality in Southern Africa

Although GHG emissions for Southern Africa are generally low, emissions of toxic air pollutants, especially in urban

Smog over Cape Town, South Africa

Jonathan Kaplan/Still Pictures

centres, are cause for concern. Examples include the heavy metals mercury and lead, synthetic chemicals such as polychlorinated biphenyls (PCB), polycyclic organic matter (POM), dioxins and benzene. These pollutants arise from industrial and domestic sources and from use of vehicles and because Southern Africa lacks affordable cleaner technologies and fuel sources. Weather conditions in cities in the sub-region also aggravate the levels of pollution observed so that air pollution levels observed in certain cities in winter exceed WHO levels (Chenje & Johnson 1994).

Traditional fuels also cause pollution problems. For example, a study in Tanzania found that children under five who died of acute respiratory infections were almost three times more likely to have been exposed to burning of traditional fuels in the home than healthy children in the same age group (World Bank 2000b).

In South Africa, sulphur dioxide emissions from power stations travel significant distances and acidification of water and forests has been recorded in the north-eastern part of the country.

Towards improving air quality in Southern Africa

Actions to improve air quality in Southern Africa include air quality monitoring and establishment of air quality guidelines, as well as requirements for environmental impact assessments to be made for any new development with potentially damaging effects on air quality. Botswana, South Africa, and Zimbabwe have air pollution legislation, although it is enforced to varying degrees, being limited by lack of resources. Tanzania's National Environment Management Council commissioned a study of air quality in Dar es Salaam, to assess emissions from traffic as well as noise pollution, sulphur dioxide levels, and particulate concentrations, measured against national and international standards. The purpose of the study was to find ways of reducing emissions and improve transport systems. In August 2000, the United Nations Motor Vehicle Emissions Agreement came into force, to develop globally uniform regulations, promoting energy efficiency and vehicle safety. South Africa was the first country to sign this agreement, other Southern African countries are encouraged to follow suit.

CENTRAL AFRICA

Central Africa is faced with similar challenges to other sub-regions in terms of climate variability: periodic extreme weather events, impacts of climate change on food production, sea level rise, and localized air quality problems in urban areas. These challenges are partly natural and require effective impact mitigation strategies but they are, in some cases, also exacerbated by human activities and thus require an integrated environmental management approach.

Climate variability in Central Africa

Rainfall and temperature patterns in Central Africa vary considerably, with unpredictable seasonal variations. Rainfall is relatively high and reliable over the central and coastal parts of the sub-region but tends to diminish and become more variable towards the north. For example, Douala, in coastal Cameroon, has an average rainfall of 3 850 mm/yr while Djamena, in Chad, receives only 500 mm/yr, and suffers periodic drought. Temperatures in the low-lying coastal forests vary little because persistent cloud keeps mean annual temperatures between 26 °C and 28 °C. In the high-relief mountainous areas, mean annual temperatures are low, between 19 °C and 24 °C. In the semi-arid zone of Cameroon and Chad, clear skies lead to strong insolation during the day and massive heat losses by emission of longer wavelength radiation at night.

Droughts in the Central African Sahelian zone have become more frequent since the late 1960s, and food security is declining, particularly among the poor who are forced to cultivate marginal lands and are unable to accumulate food reserves (IPCC 1998). Flooding is common in the more humid areas of Central Africa, especially where forests and natural vegetation have been cleared for cultivation or human settlements.

In the past 30 years, development policies and activities such as commercial logging, commercial or subsistence agriculture, and collection of firewood have led to extensive clearing of forests in Central Africa. These changes have disturbed the sub-region's microclimate, increasing vulnerability to rainfall fluctuations. Furthermore, the dense humid tropical forests of the sub-region are important sinks for

atmospheric carbon dioxide (more so than forests of equal area in temperate zones). Reduction in their area therefore limits carbon sequestration and thus contributes to global climate change. Reduction of vegetation cover also exposes the soil and worsens the impacts of drought and flooding.

Strategies for coping with climate variability in Central Africa

Central African countries have ratified the UNCCD, and Chad has also produced a National Action Plan. The Permanent Inter-State Committee for Drought Control in the Sahel (CILSS) has developed a sub-regional action plan to combat desertification (UNCCD 2001). CILSS and the Club du Sahel have also developed a new vision for food security in the Sahel, and have established a Food Crisis Prevention network to improve coordination between countries.

Climate change in Central Africa

GHG emissions are minimal in Central Africa, contributing just 2 per cent of Africa's total emissions in 1996. They form a negligible part of global emissions (African Development Bank 2001). Emissions of gaseous pollutants such as carbon monoxide, carbon dioxide and methane result from a variety of sources, including dumping of gas-producing garbage, use of traditional fuels in domestic energy production, and from slash and burn agriculture. The occasional eruption of Mount Cameroon also contributes to gaseous emissions.

Large scale logging of hardwood in Cameroon

J. C. Vincent/Still Pictures

However, global atmospheric and climatic changes will impact on Central African countries, increasing rainfall and temperature fluctuations and thus affecting security of food and water resources. Most of Central Africa will experience increased precipitation, soil moisture and run-off. This could result in a net increase in forest cover, although increased suitability of land for agriculture may lead to accelerated rates of forest clearance. Shifting distribution of natural habitat could also have important consequences for the unique biological resources of the Central African forests, such as the endangered Mountain Gorilla. Other perturbations of hydrological systems may change flooding patterns, increase the risk of contamination of freshwater supplies and encourage outbreaks of water-borne diseases. Malaria and trypanosomiasis may spread to new areas, particularly to areas at higher altitudes where their presence was previously limited by low temperatures, and to drier areas where increased rainfall is predicted (IPCC 1998).

Freshwater availability may decrease in the arid and semi-arid parts of Cameroon, Central African Republic and Chad because of decreased rainfall and increased evaporation. Over the past 30 years the level of water in Lake Chad has dropped greatly under the combined pressures of rainfall fluctuations and continued withdrawals and the water level today is around only one-twentieth of what it was 30 years ago (NASA GSFC 2001). The millions of people currently dependent on the lake's resources could suffer enormous economic and food security losses if its level decreases further.

Sea level rise and increased vulnerability to inundation and storm surges will render some of the coastal areas of Central Africa uninhabitable, displace millions of people and threaten low-lying urban areas, such as Douala in Cameroon (IPCC 1998, IPCC 2001b).

Climate change mitigation and adaptation strategies in Central Africa

In response to the challenges of adverse climatic variations, all countries in Central Africa have joined the international community in signing and ratifying the UNFCCC. At the national level, capacity building amongst stakeholder groups and revision of policies

Box 2a.5 The role of Central African forests in mitigation of climate change

Central Africa's extensive tropical forests are important carbon sinks and can assist in mitigating GHG emissions. In the Republic of Congo a research study has been launched to evaluate the carbon sink potential of the tropical forests and develop strategies for forest conservation. Additional studies are underway as part of the Central African Regional Programme for the Environment (CARPE) to develop and implement means of reducing deforestation and biodiversity loss in the Congo Basin.

The Conference on Ecosystems of Dense Humid Forests in Central Africa (CEFDHAC) is another initiative linked to CARPE, established to improve sub-regional cooperation on issues of forest management in the Congo Basin.

Source: USAID 2001b

and legislation for enhanced environmental protection is underway, including protection of the sub-region's important forest reserves (see Box 2a.5). Although this action demonstrates political commitment across the region to addressing the problem, Central African countries emit negligible amounts of GHG and—because they are classed as developing countries under the Kyoto Protocol—they are not yet required to reduce emissions. Climate variability and the impacts of climate change are also being tackled through the establishment of climate modelling programmes and early warning of rainfall variations. These are, however, in the early stages of development and little information on their effectiveness is available.

Air quality in Central Africa

There have been few studies of the ecological impacts of air pollution in Central Africa, as emission levels are generally low. However, generic studies of urban air quality have linked pollutants arising from domestic combustion of traditional fuels to increased rates of respiratory diseases, particularly among children. Industrial emissions, although currently below international averages, must be considered a potential threat as the needs of economic development continue to exert a pressure for greater industrial output. Of particular concern are the extensive oil and gas reserves in the sub-region which could be exploited for domestic energy production and export to other regions. Exploitation would involve clearing of forests and disturbance of marine ecosystems, as well as considerable increases in the sub-region's GHG emissions.

Towards improving air quality in Central Africa

It is clear that cleaner technologies are required urgently if Central Africa is to meet its energy requirements and satisfy its economic development needs without increasing pressure on the environment and human health. The sub-region has abundant renewable energy resources including solar, hydro, and wind which have not yet been fully exploited. The transport sector consumes the greatest proportion of energy and strategies for improving fuel efficiency of vehicles and public transport systems are therefore priorities for action. The World Bank's Sub-Saharan Africa Transport Policy Programme, launched in 1998, provides a framework for phasing out leaded fuel and improving transport infrastructure. It could be instrumental in improving air quality in Central African countries.

WESTERN AFRICA

Western Africa faces challenges arising from climate variability—especially in the arid Sahelian zone where drought is recurrent—and from the predicted impacts of climate change on food production, freshwater availability, and desertification. Localized problems of air quality have also been identified as priorities for action.

Climate variability in Western Africa

The climate of the Western Africa sub-region varies greatly from north to south and is mainly governed by the seasonal movements of the ITCZ. Desert and semi-desert regimes, characterized by annual precipitation of 100–300 mm, prevail along the border of the Sahel covering Mauritania, northern Senegal, Mali, and Niger. There is substantial inter-annual variability in precipitation with no perennial run-off and flash floods occurring in small basins during rainy periods. In addition, evaporation rates are very high (more than 4 m/year). Further south, temperatures and evaporation

Desert landscape, Mali

Romano Cagnoni/Still Pictures

rates are lower, although widespread flooding occurs because of the marked hydrological degradation, relatively high run-off and large areas of flat land. The coastal zone experiences warmer, wetter conditions, with annual rainfall in excess of 1 000 mm/yr, and greater reliability of rainfall, although floods are not uncommon.

Drought is a recurrent problem in the Sahelian zone of Western Africa, although the equatorial zone is rarely affected. The last Sahelian drought, one of the worst on record, persisted for a whole decade from 1972–84, and reduced precipitation was even noted in the equatorial zone. During this period, more than 100 000 people died, and more than 750 000 people in Mali, Niger and Mauritania were totally dependent on food aid in 1974 (Wijkman & Timberlake 1984). The drought also resulted in power shortages in Benin, Chad, Mali, and Nigeria because of hydropower failures at the Kainji Dam on the River Niger (IPCC 1998). Desertification is also a problem in the region, especially in the arid and semi-arid zones, but it also affects the sub-humid zones. For example, as in Central Africa, the falling level of Lake Chad could have major economic implications for the millions of people in Western Africa who depend on its resources.

The last Sahelian drought, one of the worst on record, persisted for a whole decade from 1972–84; during this period, more than 100 000 people died, and more than 750 000 people in Mali, Niger and Mauritania were totally dependent on food aid in 1974

Strategies for coping with climate variability in Western Africa

All the countries of Western Africa have ratified the UNCCD. Benin, Burkina Faso, Cape Verde, Gambia, Mali, Niger, and Senegal have produced National Action Plans, and The Economic Community of Western African States (ECOWAS), together with the CILSS, has produced a Sub-regional Action Plan (UNCCD 2001).

Other recent projects in the sub-region include an assessment of the vulnerability of production systems in Burkina Faso, Mali, Niger and Senegal. A Sahel Sahara Observatory has been set up, within the framework of the UNCCD, to act as a sub-regional coordinating body and to provide improved access to and sharing of information, and to implement scientific and technical capacity-building projects in land and water resource management. Areas of specific interest for this project include development of data banks, preparation of manuals and handbooks, facilitating of north-south exchanges of experience and knowledge, and provision for the transfer of know-how between the various areas of Africa.

Climate change in Western Africa

The pressures resulting in climate variability and climate change originate outside of Western Africa, given that the sub-region contributes little to global emissions of carbon dioxide and other GHGs. Nigeria is the largest contributor in the sub-region accounting for 11 per cent of Africa's total emissions in 1996 (African Development Bank 2001). Gas flaring in Nigeria consumes large amounts of natural gas every day during oil extraction. This not only contributes to atmospheric pollution by releasing considerable quantities of carbon dioxide, but also wastes important resources. The Nigerian gas reserves are estimated to be sufficient to provide power to the whole of Western Africa (United Nations 1999). Overall, however, it is the transport sector which contributes the most to carbon emissions in the sub-region, followed by the industrial sector. Widespread use of biomass for energy results in fewer emissions from electricity generation than in Northern and Southern African countries.

Equatorial zones are expected to experience a 5 per cent increase in annual rainfall and temperature rise of 1.4 ^{o}C as a result of climate change. Although parts of the Sahel could receive increased rainfall, the Sahel in general will be more prone to desertification because of increased evaporation and run-off (IPCC 1998, IPCC 2001b). In addition, increased intensity of rainfall may increase soil erosion, nutrient leaching and crop damage. Loss of rainfall in marginal and vulnerable areas would exacerbate drought and desiccation problems and increase the risk of bushfires, in turn threatening forest

margins. Changes in timing and length of growing seasons may lead to planning problems for agriculture. The recent history of droughts in this zone has reduced national food reserves, and people in the sub-region are now more than ever vulnerable to food shortages. Changing patterns of distribution of forests and other natural habitat may place more animal and plant species under threat of extinction, and inland fisheries are at risk from changing rainfall and flood regimes. In addition to increasing vulnerability in the Sahelian zone, there is increased vulnerability of the equatorial zone to sea level rises as a consequence of climate change. Côte d'Ivoire, The Gambia, Nigeria, and Senegal are among the most vulnerable countries in Western Africa (IPCC 1998).

Climate change mitigation and adaptation strategies in Western Africa

In response to climate variability and climate change, all of the countries of Western Africa (with the exception of Liberia) have ratified the UNFCCC. Ratification of the Kyoto Protocol—under which countries stand to benefit from funds for forest conservation and adoption of cleaner technologies—is expected shortly.

The need for coping strategies to mitigate the impacts of climate variability and drought is equally important, and significant progress has been made in this area in the past 30 years. The AGRHYMET Regional Centre was established in 1974 by the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS) following the Sahelian drought of the 1970s. Its primary function is to act as regional producer of raw data and analysed information, and to provide training in agrometeorology, hydrology, monitoring and evaluation, and plant protection. The nine member states of CILSS participating in the AGHRYMET activities are Burkina Faso, Cape Verde, Chad, Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal. AGRHYMET's Major Programme on Information aims to produce information relating specifically to food security, the fight against desertification, and livestock management.

Air quality in Western Africa

Rapid urbanization and concentration of economic activities in Western Africa's urban centres is leading to air pollution from industry, vehicle emissions and quarrying activities. Combustion of traditional fuels for domestic energy needs is another major source of air pollution in both urban and rural areas. For example, children in the Gambia exposed to smoky stoves were six times more likely to develop acute respiratory infections than unexposed children (World Bank 2000b). Inadequate urban planning is a significant driving force behind rising emission levels, because residential and commercial centres are often far apart, forcing mass movement of workers on a daily basis. Poor economic development has also contributed to air pollution by creating dependence on old vehicles and dirty fuels.

Smoke from fires can cause or enhance respiratory diseases

Ron Giling/Still Pictures

Pollutants such as sulphur oxides, nitrogen oxides, hydrocarbons and heavy metals, together with particulate matter, form dense concentrations of smog in urban centres, causing respiratory diseases, contamination of vegetation and water resources, and corrosion of buildings.

Towards improving air quality in Western Africa

Most countries in Western Africa have introduced standards and regulations to control the atmospheric pollution in cities, but lack of resources makes enforcement of these emission standards and regulations weak.

In Accra, Ghana, a project is underway to analyse and monitor sources of air pollution and to compare ambient pollution levels in commercial and residential areas, affluent suburbs and slums (Accra Mail 2001). A recent study of transport in Dakar, Senegal, estimated

Box 2a.6 Tackling vehicle emissions in Senegal

Senegal has become a major importer of used cars in recent years and these now represent 84 per cent of all vehicles in the Dakar region where they constitute a major source of air pollution. The average age of vehicles in Dakar is approximately 15 years for cars and 20 years for buses. More than 40 per cent of the cars have diesel engines, which have particularly toxic emissions. The high level of diesel use results from a combination of many diesel engine cars being imported and many owners replacing petrol engines with diesel engines after importation, because diesel is cheaper than petrol.

The Senegal Ministry of Environment has proposed a new law to provide new clean air standards to limit emissions from vehicles. The law also re-introduces a requirement for customers to lodge request for cars before they are imported, a measure which was scrapped in 1996. It also rules that imported cars must be under five years old.

Air quality monitoring stations are to be set up around Dakar, to record ambient pollution levels on a daily basis. The ministry also intends to establish an environmental police force, backed up by the national police force, to impose compliance with the regulations and track down polluting vehicles.

Source: Abdourahmane Ndiaye, Advisor to the Ministry of the Environment (quoted in Africa Online News, 21 January 2002)

the costs associated with death or injury, hours wasted through congestion, and health costs relating to air pollution to be equivalent to 5 per cent of GDP (World Bank 2001). This study recommended that planning should be improved to ease the traffic flow and that mass transport should be re-organized. The small French locomotives known as 'Petit Train Bleu' have recently been rehabilitated and this has helped to alleviate urban congestion and pollution as well as providing reliable, secure, affordable mass transit and creating jobs (UNCHS 2001). Other measures to improve air quality include tighter controls on importation of second hand cars from Europe (see Box 2a.6).

Africa's limited economic and infrastructure resources for mitigating or coping with shifting patterns of food production, increased frequency and severity of natural disasters and rising seal levels make the region one of the most vulnerable to climate change

CONCLUSION

Climate variability is common throughout Africa and it is increasingly limiting development. Extremes of rainfall are the most damaging aspect of climate variability and Africa frequently suffers the devastating impacts of floods and drought. Lives, livelihoods, crops, livestock and infrastructure are lost during these events and the financial cost is well beyond the means of African countries, meaning that they are neither prepared for such events nor able to afford to repair the damage caused. It is the poor who are the most vulnerable as they have no alternative source of income to their direct, subsistence level dependence on natural resources (either through cultivation, livestock rearing, or harvesting resources from natural habitats). Most countries have developed and implemented strategies for coping with climate variability, including ratification of the UNCCD, and development of National Action Plans. There are also effective climate and hazard monitoring programmes and early warning systems in many sub-regions. However, given the additional impacts of climate change, these systems may need additional trained staff, financial resources and equipment. The main priorities for action are therefore to strengthen coping strategies for effective management of the impacts of extreme events, increase food security, and maintain healthy ecosystems.

Africa's limited economic and infrastructure resources for mitigating or coping with shifting patterns of food production, increased frequency and severity of natural disasters and rising seal levels make the region one of the most vulnerable to climate change. Although many African countries have ratified the UNFCCC and the Kyoto Protocol, most countries (with the exception of those of Northern Africa and South Africa) have negligible GHG emissions. Developing countries such as those in Africa stand to gain from the proposed mechanisms for emissions trading, reforestation schemes, and cleaner development. Emphasis in the global arena should therefore be placed on their implementation as soon as possible, to assist in meeting development objectives through sound environmental management.

Above all, it is critical that action be taken immediately. Further delays in curbing the trend of increasing atmospheric pollution will only add to the uncertainties and insecurities that natural climate variability causes. Developing countries also need to invest in disaster preparedness strategies in the short term, and to diversify their economies away from the heavy dependence on agriculture in the long term.

Ambient air pollution, particularly in urban centres, is emerging as an issue of concern for human health in

many African countries. Increasing levels of toxic pollutants such as sulphur dioxide, nitrogen oxides, lead, and particulates are a result of industrial emissions and vehicle exhausts (particularly from older vehicles) as well as burning of coal, wood, or other fuels to meet domestic energy requirements. Population growth over the past 30 years has increased the demand for energy and industrialization, thus raising emissions of pollutants. Population growth and the pattern of human settlements have also put pressure on transport systems, increasing vehicle exhaust emissions. Radical changes in technology are required if economic development is to proceed without adding to the existing environmental challenges and if stringent emission controls are to be avoided. Removal of subsidies, expansion of electrification programmes, promotion of unleaded fuels, and conversion to cleaner fuels are measures that have been implemented successfully in parts of Africa recently. In particular the energy industry, manufacturing industries, and transport systems will have to undergo fundamental changes in order to supply sustainable energy, material and mobility to future generations.

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François Suchel/Still Pictures

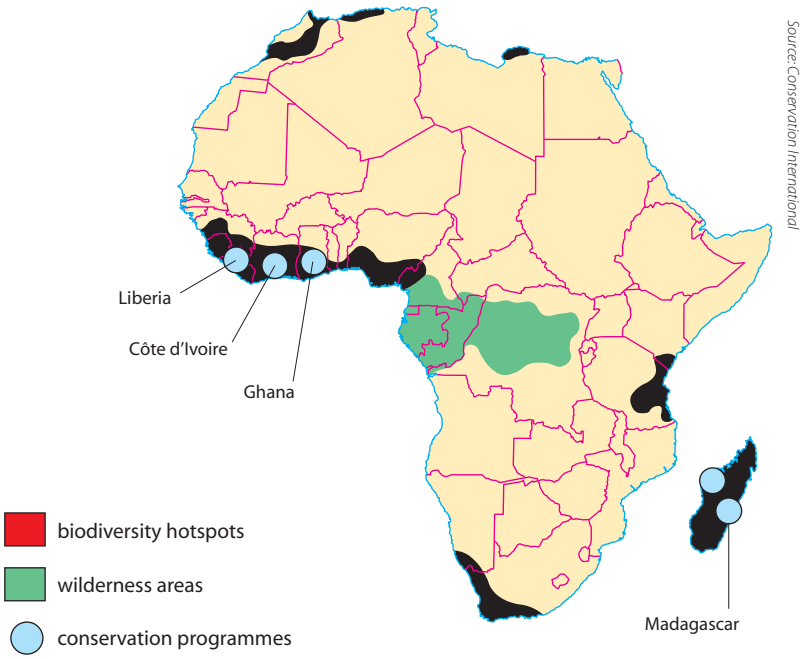
PART B: BIODIVERSITY

REGIONAL OVERVIEW

Biological diversity or 'biodiversity' means the variety of plant and animal life at the ecosystem, community or species level, and even at the genetic level. Biodiversity is most commonly measured and reported at species level with characteristics such as species richness (number of species), species diversity (types of species), and endemism (uniqueness of species to a certain area) being the most useful elements for comparison.

Only a fraction of the species inhabiting the earth have been identified and studied to date and the roles they play in influencing the environment are still often poorly understood. Studies have tended to concentrate on higher plants and mammals and such species have also been the focus of most conservation efforts. This can give a misleading impression of the importance of 'lower organisms' such as bacteria, insects, and fungi which play vital ecological roles—for example, in nutrient cycling, and regulation of water, soil and air quality. Lack

Figure 2b.1 map of Africa showing biodiversity hotspots and potential hotspots



of understanding of the role of such organisms can lead to their being 'sidelined' when conservation efforts or commercial utilization are being considered. It is worth noting that around 1 million of the 1.75 million species described so far are insects and myriapods, and that the total number of such species is estimated to be around 8 million. In other words, only one-eighth of insect and myriapod species have been identified and recorded to date. It is also estimated that there are 1.5 million species of fungi, of which 72 000 have been described, and 1 million species of bacteria, of which a mere 4 000 have been described (WCMC 2000).

Africa has rich and varied biological resources forming the region's natural wealth on which its social and economic systems are based. These resources also have global importance, for the world's climate and for the development of agriculture or industrial activities such as pharmaceutics, tourism or construction, to name but a few of the most important areas.

Africa is also a continent of extremes, both in terms of physical features and climatic conditions, and therefore in terms of the life it supports. The humid tropical forests of equatorial Africa are among the most productive ecosystems in the world with Net Primary Productivity (NPP)—the net flux of carbon from the atmosphere into green plants—greater than 800 gCarbon/m^2/yr). They also support an estimated 1.5 million species. By contrast, Africa's arid areas are among the harshest environments in the world. The Sahara and Namib deserts and the Sahel, for example, have NPP of just 100 gCarbon/m^2/yr (WCMC 2000). But even under these conditions many plant and animal species manage to thrive.

The designation of some areas as 'biodiversity hotspots' is a useful concept developed in recent years as a means of prioritizing habitats for conservation (Myers 1990). Hotspots are areas where species diversity and endemism are particularly high and where there is an extraordinary threat of loss of species or habitat. There are 25 internationally recognized hotspots, six of them are in Africa (Mittermeier, Myers, Gil & Mittermeier 2000). These are shown in Figure 2b.1 and are described below:

- **The Mediterranean Basin Forests** constitute just 1.5 per cent of the world's forests, yet are home to 25 000 plant species and 14 endemic genera (Quézel, Médail, Loisel, & Barbero 1999).
- **The Western Indian Ocean Islands** have extremely high levels of endemism due to their isolation. This is especially true for Madagascar which has the highest number of endemic species in Africa (including 700 endemic vertebrate species), and ranks 6th in the world (UNEP 1999).
- **The Cape Floristic Region**, in South Africa, is the smallest and richest of the world's floral kingdoms with 68 per cent of the 8 700 plant species endemic to the region (Low & Rebelo 1996).
- **The Succulent Karoo**, shared between South Africa and Namibia, is the richest desert in the world—40 per cent of its 4 849 species are endemic (Low & Rebelo 1996).
- **The Guinean Forest** hotspot is a strip of fragmented forest running parallel to the coast of Western Africa through 11 countries from Guinea to Cameroon. It has the highest mammalian diversity of all of the world's 25 hotspots (551 species out of the 1 150 mammalian species on the African continent) and contains 2 250 plant species, 90 bird species, 45 mammal species and 46 reptile species found nowhere else (Conservation International 2002, Mittermeier and others 2000).

- **The Eastern Arc Mountain Forests** of Eastern Africa are 30 million years old and are thought to have evolved in isolation for at least 10 million years. As a result, more than 25 per cent of the plant species are endemic (Lovett 1998).

Africa also has several areas where both species richness and degree of threat are high but endemism is lower. These 'potential hotspots' include the highlands of Ethiopia; the forests of the Albertine Rift in eastern Congo, Rwanda, Burundi and adjacent parts of Uganda and Kenya; the western escarpment of Angola; and the Miombo Woodlands of interior Southern Africa (Mittermeier and others 2000).

Africa also has a range of aquatic habitats with very high levels of biodiversity. Marine ecosystems tend to be more diverse than terrestrial ones and reach even higher levels of diversity in warmer tropical waters than in cooler seas. The coasts of many African countries have rich ecosystems such as coral reefs, seagrass meadows, mangrove forests, estuaries and floodplain swamps (Martens 1995). Rivers, lakes (freshwater and soda) and riverine edge swamps, valley swamps, seasonal floodplains, ponds and high altitude peat-forming wetlands all contribute to a wide variety of aquatic ecosystems in Africa that support an extensive range of resident as well as migratory species (Harper & Mavuti 1996).

The national and sub-regional boundaries that characterize present day Africa are the result of geographical and human activities often determined by political or economic factors, they therefore seldom reflect the boundaries of ecological systems. This difference between political and ecological units is significant—when the boundaries of ecosystems extend beyond territorial boundaries, the protection of the natural resources within those ecosystems requires management strategies that are coordinated jointly between nations or sub-regions (Westing 1993). The disparities between political and ecological boundaries also imply some overlap in discussion of biological systems in the sub-regions referred to in this report. For example, Tanzania forms part of the Southern African sub-region but shares major ecological systems with Kenya and Uganda. It is therefore discussed in both the Southern Africa and Eastern Africa analyses.

Ecological, economic and social values of biological resources

Biological resources are the backbone of the African economy as well as the life-support system for most of Africa's people. A variety of resources, both plant and animal, are used for food, construction of houses, carts and boats, household utensils, clothing, and as raw materials for manufactured goods. Many resources such as timber and agricultural produce are traded commercially and others are used in traditional crafts such as basket weaving and carving. In addition, many species with medicinal properties are harvested by local communities and pharmaceutical multinationals alike. These include the African potato (*Hypoxis rooperi*) in Southern Africa (Natures Truth 2001), the rosy periwinkle (*Catharanthus roseus*) from Madagascar and Mozambique, and prunus (*Prunus africana*) from Cameroon, Democratic Republic of Congo (DRC), Kenya and Madagascar (Sheldon, Balick & Laird 1997). Other species provide the genetic resources for improved agricultural products such as disease- or drought-

Madagascar: picking rosy periwinkle, *Catharantus roseus*, used to make drugs to treat cancer

D. Halleux/Still Pictures

resistant crops. For example, an African species of rice has been used in the development of a high-productivity, drought-resistant variety (Science in Africa 2001) and the native Mauritian caffeine-free *Coffea* species could be used to develop coffee cultivars with low caffeine content (GOM/ERM 1998). The richness and diversity of ecosystems in Africa also provide opportunities for tourism which many African countries have successfully exploited. The coral reefs of the Red Sea, Eastern African coast, and Western Indian Ocean Islands, for example, are among the most famous in the world, and the savannas of Eastern and Southern Africa are popular destinations for safari-goers.

Africa's biodiversity is under threat from four main sources, described below. These are:

- natural habitat loss;
- loss of species or subspecies;
- invasion by alien (non-native) species; and
- lack of recognition of indigenous knowledge and property rights.

These issues, individually and in combination, constitute forces that are restricting full realization of the value of Africa's biodiversity and use of the resources it provides for Africa's own development.

In some cases, protected areas have been established without consultation of local people, without their consent and, frequently, without being based on rigorous biological inventory studies. This has led to protected areas which are not only less effective in their contribution to conservation but which have also failed to earn the respect of local communities

Natural habitat loss

Natural habitats in Africa are being degraded or lost owing to a number of 'proximate' and 'ultimate' (or root) causes. Proximate causes include clearing for alternative land uses (mainly agriculture and human settlements) and overharvesting of resources (most notably timber in the forests of Central and Western Africa). Over 211 million hectares of African forest have been lost since 1970, amounting to almost 30 per cent of the original extent. In the same period, the land area under cultivation has increased by 36 million hectares, or 21 per cent (FAOSTAT 2000). Other threats to terrestrial habitats include bush fires which are commonly used in agriculture to prepare the soil but which can get out of control and destroy large areas of forest or woodland. On the other hand, fire (along with grazing) is also considered to be one of the most important factors determining the structure of savanna ecosystems (Gichohi, Gakahu & Mwangi 1996).

Coastal habitats are being reduced by proximate causes such as overharvesting of resources, physical alterations and urban and industrial developments, siltation, pollution, introduction of alien species, and global climate change (Martens 1995). Inland wetland areas have suffered in the same way, with additional problems stemming from drainage for conversion to agriculture and salinization of soils due to irrigation, as well as overextraction of water from lakes or the rivers feeding them (Harper & Mavuti 1996).

The ultimate causes of habitat loss in Africa are human population growth and the resulting demand for space, food and other resources; widespread poverty; a dependence on natural resources; and economic pressures to increase exports, particularly of agricultural produce, timber and mineral products. A lack of awareness of the value of wild biological resources, lack of knowledge of biodiversity and of how to apply that knowledge, and failure to enforce conservation policies have also contributed to a decline in area of natural habitat. For example, development and expansion of settlements, infrastructure and logging activities have not, until recently, been coordinated with respect to natural habitat or sensitive ecosystems and were not subject to environmental impact assessment requirements. In some cases, protected areas have been established without consultation of local people, without their consent and, frequently, without being based on rigorous biological inventory studies. This has led to protected areas which are not only less effective in their contribution to conservation but which have also failed to earn the respect of local communities. In some cases, communities have encroached on the protected areas, in others they have deliberately raided resources (FAO 1995, Fay, Palmer, & Timmermans 2000). Weak legal and institutional structures, corruption, conflict and civil strife, as well as market factors, can also contribute indirectly (or even directly) to habitat degradation and loss (Martens 1995, Rodgers, Salehe & Olsen 2000).

Loss of habitat threatens biodiversity at all levels, from the 'ecosystem' to the 'genetic'. Three main processes are at work, namely:

- reduction in the total size of habitat;
- fragmentation of habitat; and
- change in the structure or characteristics of the habitat.

Plant and animal communities need habitats that are of sufficient size to provide food and water and to

Table 2b.1 protected areas in Africa, 1999

	Nationally Protected Areas				Internationally Protected Areas					
	Terrestrial			Marine	Biosphere Reserves*		World Heritage Sites		Ramsar Sites	
	No	*Area (000 ha)*	*% Land area*	*No.*	*No.*	*Area (000ha)*	*No.*	*Area (000ha)*	*No.*	*Area (000ha)*
Central	69	31 161	33.1	10	11	3 034	7	9 121	8	4 228
Eastern	119	11 981	N/A	16	7	1 126	5	454	5	105
Northern	72	15 862	7.8	50	13	N/A	2	>13	22	>2 000
Southern	578	65 014	N/A	44	8	N/A	10	7 850	27	12 026
Western	123	28 724	68.2	25	15	31 112	10	1 2003	37	3 674
WIOI	89	N/A	N/A	3	3	N/A	3	N/A	4	53
Total	**1050**	**N/A**	**N/A**	**148**	**57**	**N/A**	**37**	**>29 441**	**103**	**>22 086**

Source: Ramsar 2002, UNDP and others 2000, UNEP 1999, UNESCO 2002 Data not available for Burundi, Cape Verde, Comoros, Djibouti, Sao Tome & Principe, Seychelles & Swaziland
**Some Biosphere Reserves are also World Heritage Sites or Ramsar sites*

find a mate or nesting site. If the total size of a habitat is reduced, the sizes of the populations of many species, particularly large mammals and top predators, are forced to decline. In some cases, population sizes have reached the minimum viable population, that is to say the lower limits beyond which the species will not be able to breed successfully (Gilpin & Soule 1986).

Fragmentation of habitats is a particular problem for large animals and top predators which require extensive ranges. Even if the total area of a natural habitat is large, some species may still be threatened if it is divided into fragments that are too small or are lacking in some vital components (Harris 1984, Gilpin & Soule 1986, Skole & Tucker 1993). This factor has not always been taken into account when creating protected areas, and migration routes of large herbivores have been cut off, preventing them from finding adequate food or water resources in times of stress.

Fragmentation and selective harvesting can also change the nature of a habitat, making it unsuitable for certain species. Forests, for example, have distinct 'edge species' and 'interior species'. Edge species are those that are suited to conditions at the edge of the forest (where there is typically more exposure to light, wind, and predation), interior species are more suited to conditions inside the forest. Reduction of forest area or size of forest patches increases the ratio of edge to interior, and thus changes the species composition (Lovejoy, Bierregaard, Rylands, Malcolm, Quintela, Harper, Brown, Powell, Powell, Schubart & Hays 1986). Too much edge threatens interior species and natural forest dynamics can collapse.

Mitigation of natural habitat loss

The typical response to warnings of loss of natural habitat in the past 30 years has been to increase the number and extent of protected areas. Although initially the establishment of protected areas was not always based on biodiversity assessments or threats to certain habitats, in recent years tools such as Geographic Information Systems (GIS) have been used to identify areas of particularly high conservation priority such as unique habitats or especially species-rich habitats (Burgess, de Klerk, Fjeldså, Crowe & Rahbek 2000). Protected areas in Africa are shown in Table 2b.1

Only six African countries (Botswana, Burkina Faso, Namibia, Rwanda, Senegal, and Tanzania) have more than the international target of 10 per cent of their land area under protection (World Bank 2001). Absolute percentage area is not, however, the only important consideration in conservation efforts. International efforts and regional partnerships have contributed to

biological conservation both within and outside of protected areas. Wetlands, for example, have received much attention through the signing of the Convention on Wetlands of International Importance, Especially as Waterfowl Habitat, signed in Ramsar, Iran, in 1971 (and known as the 'Ramsar Convention'). The Convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Thirty-three African countries are party to the Ramsar Convention (February 2002), and there are 103 'Ramsar sites' in Africa with a combined area of over 20 million hectares.

In recent years the concepts of World Heritage Sites, Biosphere Reserves, and Transborder Parks have also been influential in establishing conservation priorities. World Heritage Sites are sites considered to be of global ecological and cultural significance. There are 35 of these in Africa, totalling 37 million hectares (UNDP, UNEP, World Bank & WRI 2000).

The concept of Biosphere Reserves—developed in 1971 by the United Nations Educational, Scientific, and Cultural Organization (UNESCO), together with Conservation International—established biosphere reserves to protect whole ecosystems rather than selected species. Biosphere reserves include areas in which various types of human activity are allowed. There are currently 50 such reserves in Africa covering a total of 52 million hectares (UNDP and others 2000).

Transborder parks are protected areas that overrun national boundaries and in which the relevant countries share the conservation activities, as well as the benefits. The first of these, the Kgalagadi Transfrontier Park, was established in 1998, between Botswana and South Africa, allowing free migration of species within the Kalahari Desert. Table 2b.1 shows protected areas in Africa.

Protected areas do not, however, meet all of Africa's needs in terms of conservation of natural habitat. In some countries war, poaching, and encroachment by refugees or local communities claiming traditional ownership of the land have contributed to loss and degradation of vegetation, water, and species composition. Lack of resources to enforce protection of protected areas also constitutes a major barrier to their effectiveness. In addition, concern has been expressed at the potential loss of species (or local extinctions) within such areas if they become too insularized. One study has shown that six species of large diurnal mammals have become locally extinct in Tanzanian parks in the last 80 years. This problem could be alleviated by the establishment of corridors, or through protection outside of parks, to facilitate recolonization (Newmark 1999). Furthermore, the purpose of conserving habitats is to allow present and future generations to benefit from the resources and services they provide. Programmes of sustainable use of natural resources should therefore also be considered in addition to exclusion of human activities from some areas. To this end, Community Based Natural Resource Management Programmes (CBNRM) have been implemented in parts of Africa such as Zimbabwe, Kenya and Uganda, with varying degrees of success in terms of socio-economic development of surrounding communities and protection of threatened habitat (Hulme & Murphree 2001).

Private reserves have also been created as a means of promoting habitat protection. Although there are few assessments of the effectiveness of this approach, surveys carried out in 1989 and 1993 in Latin America and Africa concluded that private reserves were generating substantial employment and that their profitability was increasing. They also noted that African reserves were larger than those in Latin America (with an average size of 11 436 ha). A follow-up study concluded that the effectiveness and profitability of private reserves were sufficient for them to warrant greater support as agents of sustainable development and conservation (Alderman 1991, Langholz 1996).

Fifty-two African countries are party to the Convention on Biological Diversity and most have shown their commitment at the national level through the development of National Environmental Action Plans (NEAPS) and National Conservation Strategies. Financial assistance through the World Conservation Union (IUCN), the World Bank, UNEP and UNDP's Global Environment Facility (GEF) offer opportunities to overcome some of these barriers and to promote sub-regional cooperation in conservation.

Species loss

Individual species are under threat from a variety of pressures in addition to loss of their natural habitat. Recent estimates show that a total of 126 recorded

Bushmeat trader, Abidjan

Anna Giovenito

animal species have become extinct (or extinct from the wild) in Africa, and that there are 2 018 threatened animal species across the region. One-hundred and twenty-three plants are recorded as extinct and 1 771 are threatened (IUCN 1997).

The reasons for such high rates of species loss or endangerment include:

- habitat loss;
- illegal hunting for food;
- medicinal, or commercial use; and
- national and international trade.

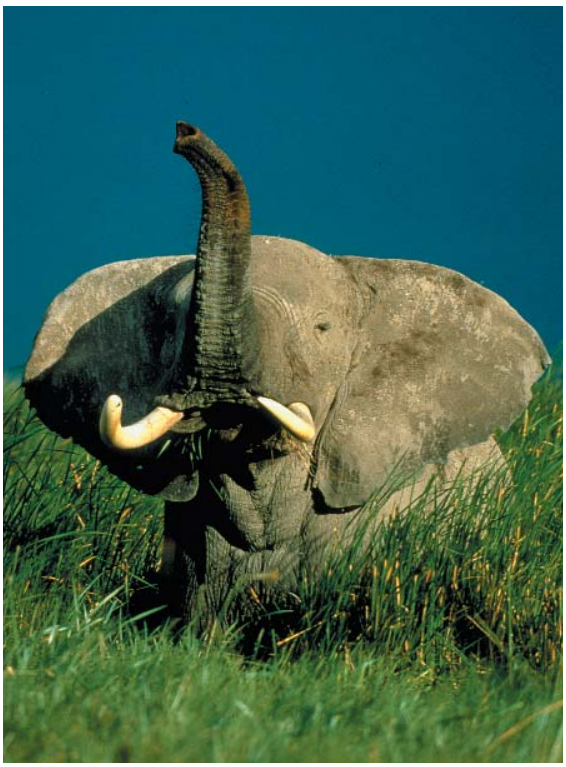
A recent study found that the bushmeat trade in Central and Western Africa is contributing significantly to the decline in populations of gorillas, chimpanzees, elephants, bush pigs and forest antelopes. Bushmeat is a traditional supplement to the diets of many African communities, but the increasing human populations and commercial trade are pressurizing these species to the extent of a million tonnes of bushmeat a year (Greenwire 2001). Bushmeat is now a major source of animal protein in many towns and cities in tropical Africa (Fa, Garcia Yuste & Castello, 2000). In addition, activities such as logging and mining are improving access to previously remote areas, making collection from the wild more profitable. A recent study showed that road density is linked to habitat fragmentation, deforestation, and intensified bushmeat hunting (Wilkie, Shaw, Rotberg, Morelli & Auzel 2000).

Selective harvesting of medicinal plants is also taking its toll on species diversity and abundance. The World Health Organization (WHO) has estimated that 80 per cent of people in the developing world are reliant on traditional medicines. Eighty-five per cent of these medicines use plant extracts, so it is estimated that around 3 000 million people around the world rely on plants for traditional health treatments. The number is even larger if plant-derived commercial drugs are included (Sheldon and others 1997). In Africa, 80 per cent of both rural and urban populations depend on medicinal plants for their health needs (and those of their livestock) either because they prefer them for cultural or traditional reasons, because such remedies are effective in treating certain diseases, or because there is a lack of affordable alternatives (Baquar 1995, Ole Lengisugi & Mziray 1996). Overharvesting of these plants from the wild and loss of their habitat are threatening many species (as well as human and livestock health) and alternative strategies such as cultivation of medicinal species in nurseries are being considered (Dery & Otsyina 2000). The *Acacia senegal* tree is another highly sought-after species because of the high economic value of the gum arabic which it produces. The species has been commercially exploited, particularly in Sudan (Abu-Zeid 1995).

The exotic pet trade is another powerful international driving force for species reduction, as is demand for animal products such as ivory, rhino horn, skins, furs, and other trophies. Many species are protected by restrictions on international trade, but a thriving black market creates a demand, and extreme levels of poverty tempt local people to meet it (CITES 2002).

Loss of species means loss of economic opportunities, both now and in the future. For example, the possibility of developing new strains of drought- or disease-resistant crops, crops with higher protein content, or synthetic manufacture of pharmaceutical products of plant origin may be lost. Different breeds of livestock are also important components of global biodiversity because they have genes that are or may be useful for agricultural production. Locally adapted strains of livestock often have greater potential for increased productivity, due to their ability to thrive under specific conditions. For example, Botswana and Namibia have the greatest proportional diversity of breeds but these indigenous breeds could be

Recent estimates show that a total of 126 recorded animal species have become extinct (or extinct from the wild) in Africa, and that there are 2 018 threatened animal species across the region. One-hundred and twenty-three plants are recorded as extinct and 1 771 are threatened



African elephant *(Loxodonta africana)* at Amboseli National Park, Kenya

M. & C. Denis-Huot/Still Pictures

threatened if the livestock husbandry systems under which they have been developed are replaced or changed, or if exotic breeds or their semen are imported under aid programmes or livestock development policies. Loss of traditional livestock management regimes and the genetic diversity that they provide could result in increases in the cost of food production in those areas (Hall & Ruane 1993, Hall & Bradley 1995). On the other hand, properly planned and managed *in situ* conservation of livestock breeds could satisfy demands for intensified production without the need for massive external inputs and foreign aid (Hall & Bradley 1995).

Species loss or extinction can also affect local and regional communities either because opportunities for tourism are lost or because of security problems arising from heavy poaching. Local communities also lose valuable sources of food and other raw materials, as well as losing irreplaceable cultural and spiritual assets.

Ecological communities are impacted by species loss, as this affects predator/prey relationships, and removes agents of pollination, seed dispersal or germination such as insects, elephants, primates or other animals. Species loss reduces the integrity of ecosystems in ways that are still far from being fully understood and reduces the environment's capacity to regulate climate, water and soil quality.

Combating species loss

Forty-eight African countries are party to the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) which regulates trade in endangered species or products through trade prohibitions or suspensions. This has had varying degrees of success in Africa. For example, there has been significant growth in national herds of elephant in Botswana and Zimbabwe in recent years after a ban was introduced on trading in ivory, although it is argued in some quarters, that this has more to do with good conservation measures than trade restrictions on ivory. Southern African countries now want to resume some level of trade in order to capitalize on economic opportunities from successful conservation. In Kenya, however, the decline in poaching of elephants (from 3000 deaths a year to under 50) which followed a dramatic drop in prices in ivory (from US$60 to US$5 a kilo in Somalia) indicated direct links between the ivory trade, prices and criminal activities (Western 1997). East African countries feel that any relaxation of restrictions will further endanger their elephant populations which have not recovered so quickly. The black rhino, another endangered species, is still threatened throughout Africa by illegal hunting and populations have not recovered to pre-1960s levels.

Species re-introduction and *ex-situ* plant propagation in nurseries are some of the additional efforts underway to counteract the recent rapid loss of species in Africa. In the Western Indian Ocean Islands, successful conservation measures resulted in growth of populations of the Mauritian Kestrel and the Pink Pigeon.

Alien invasive species

A further threat to biodiversity comes from invasion by non-native, or alien, species of plants and animals. These are species that have been introduced both accidentally and intentionally and that are free from their natural

predators or other natural limitations to their population growth. They are thus able to dominate plant and animal communities either by out-competing native species for space, light, or nutrients, or through predation.

Southern and Eastern Africa and island nations have been particularly affected by the introduction of alien species. The Nile perch (*Lates nilotica*), introduced into Lake Victoria 30 years ago to stimulate the fisheries of Uganda, Kenya and Tanzania, is a striking example. In the 1960s, the Nile perch accounted for about 1 per cent of fish catch; it is now dominant in the lake, representing close to 80 per cent of annual fish harvests, and its introduction is believed to have caused the loss of more than 200 endemic species (MoFPED 2000). Lack of control on introduction of species has also led to the rapid spread and domination of the water hyacinth (*Eichornia crassipes*) in freshwater bodies across Africa, including Lake Victoria and Lake Kariba. This weed blocks water channels, alters hydrological regimes, and renders surrounding areas more vulnerable to flooding.

Islands are particularly vulnerable to invasions by alien species, particularly predators, because many island species have evolved in isolation from predators such as cats and rodents. The Western Indian Ocean Islands have experienced dramatic changes to their ecology through the introduction of a range of species, including monkeys, pigs, rats, mice, rabbits, privet, Chinese guava, and wild pepper (UNEP 1999).

Lake Victoria: dense mats of water hyacinths accidentally introduced from Latin America

Hartmut Schwarzbach /Still Pictures

Invasion by alien species reduces biodiversity either through predation, competition, or smothering. In some cases alien plants form such dense infestations and produce so many seeds that are dispersed so widely that it is virtually impossible to control them. They also change the dynamics of the natural system and may produce toxic chemicals, inhibiting the growth of native species. In other cases they threaten native species and functioning of ecosystems through an excessive consumption of resources such as water. In Southern Africa, pines, eucalyptus and acacias have been introduced for commercial forestry, but have invaded natural habitats where they threaten ecological integrity by using many times more water than native species (Working for Water 2000).

Prevention and control of invasion by alien species

Options to control the introduction and spread of alien species include tightening controls on importation of products of animal or plant origin. However, lack of resources to police borders and entry points and to enforce fines for breach of regulations results in continued threats to biodiversity.

Infestations of alien plants can be physically removed by hand, by mechanical or chemical means, or by a combination of these. Such approaches have been adopted in Lake Victoria and in parts of Southern Africa. Biological control is gaining in popularity as a means of containing populations of alien plants and animals, as it is less harmful to other species and to the surrounding environment. However, it is a more lengthy process, because release of control organisms into an environment has to be rigorously tested to ensure that release has no adverse effects.

Indigenous knowledge and property rights

Efforts to protect and conserve Africa's biodiversity are constrained by a lack of research into and documentation of the continent's biodiversity. This is especially true regarding indigenous knowledge of, for example, the properties of selected species and their traditional uses and of natural resource management and conservation practices. The relatively low level of knowledge in the science of biodiversity has resulted from a lack of investment in research and development, compounded in some cases by a failure to assign

monetary values to the ecological functions of plant and animal species, thus fostering the belief that natural resources are free and in unlimited supply.

Lack of knowledge has two main results:

- conservation efforts are constrained by lack of understanding of species and ecological systems; and
- opportunities for commercial exploitation and economic gains are missed or are taken up by international companies without the benefits returning to the original holders of the knowledge.

Some efforts have been made to address this situation. In recent years, influential publications have increasingly helped to improve understanding by emphasizing the links between cultural diversity and biological diversity, by describing how indigenous peoples use their knowledge to manage their natural resources, including plants and animals (Warren 1995). Studies on the value that indigenous people place on forest and wildlife resources indicate that they ascribe a high value to their resources and understand that—in addition to being sources of food, fuel, medicine, and building materials—these resources can also provide ecosystem services (Ntiamoa-Baidu 1995, Olsen, Rodgers & Salehe 1999).

Increasing efforts are therefore being made to understand indigenous knowledge systems and to promote their continued application, thereby mainstreaming such knowledge and knowledge-holders and bringing them into new development projects. This new form of partnership includes the application of indigenous knowledge to environmental assessment and to project implementation (Croal 2000, Emery 2000).

The second result mentioned above—missing of commercial opportunities by communities—relates to the right of control over traditional lands and resources, intellectual property, and accommodation of customary laws and practices. Article 14 of the International Labour Organization's Convention 169 on Indigenous and Tribal Peoples (1989) states that '*the rights of ownership and possession of the peoples concerned over the lands which they traditionally occupy shall be recognized. In addition, measures shall be taken in appropriate cases to safeguard the right of the peoples concerned to use lands not exclusively occupied by them, but to which they have traditionally had access for the subsistence and traditional activities. Particular attention shall be paid to the situation of nomadic peoples and shifting cultivators in this respect.*'

The Convention on Biological Diversity also recognizes the value of traditional knowledge. Its Article 8(j) states that parties should, as far as possible, '*…respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge innovations and practices.*'

Many Governments are now in the process of implementing this principle through their national biodiversity action plans, strategies and programmes. The means employed include adoption of relevant legislation, policies, and administrative arrangements for protecting traditional knowledge through prior informed consent. Although such means are usually applied to medicinal plants, cultivars, and some traditional practices, it has been pointed out that protection of traditional knowledge should also include traditional stock raiser rights and the protection of animal genetic resources (Kohler-Rollefson & McCorkle 2000). It has been suggested that livestock projects should be required to present 'genetic impact statements' to anticipate the effect on the local gene pool of the introduction of exotic livestock breeds. If a negative impact is anticipated, the projects could perhaps include a provision for maintaining a purebred population of the indigenous livestock breed (Hall & Bradley 1995).

The World Bank's programme on Indigenous Knowledge in Africa has established 15 resource centres across Africa focussing on identification and dissemination of indigenous or traditional knowledge and practices. Policies have also been developed under this programme to protect indigenous knowledge, and to apply it in agricultural, medicinal, and conservation practices.

Given the many and diverse pressures on Africa's biological resources, and the enormous untapped potential for economic and social development, implementation of strategies for effective conservation

and sustainable use of these resources is of paramount and immediate importance. Such strategies must be activated on a number of fronts and existing measures at national, sub-regional and regional levels will have to be reinforced, upgraded and opened up to further innovative measures to deal with changes in the status of habitats or species. Compliance with regional and international agreements must be strengthened through enforcement of legislation, policies, and plans, and through institutional reform. Further research and application of research findings is required to strengthen *in-situ* and *ex-situ* conservation systems, particularly those involving local and indigenous innovations and interventions. Systematic valuation of resources and incorporation of those values into national accounting systems and development policies are also required. Capacity building and awareness programmes are critical components for each activity, and at each level (Mugabe 1998).

A view over Haute Atlas, Morocco

Michael Gunther/Still Pictures

NORTHERN AFRICA

Northern Africa's extreme climatic conditions and physical features greatly influence the sub-region's biological elements. Most of Northern Africa falls within arid and semi-arid environments, but there is also a range of geomorphological features and sub-climatic zones which have created diverse ecosystems and extremely rich communities of flora and fauna. For example, long shores with vast areas of coastal land, oases in the Sahara and varying landforms create diversity of habitat and remarkable biological diversity, including a large number of varieties and strains of field crops. Morocco, for example, has 3 675 recorded species of higher plants, and Sudan has 267 recorded species of mammals and 938 recorded species of birds. The sub-region's reptiles and amphibians are still under assessment in most countries, but Egypt has already recorded 83 species of reptile and 6 species of amphibians. The sub-region has 1 129 endemic species, 22 endemic species of mammals, one endemic bird species, 20 endemic species of reptiles and 4 endemic species of amphibians, with Morocco having the greatest level of endemism (WCMC 1992). Northern Africa also encompasses the biota of the semi-closed Mediterranean and Red Seas. The Mediterranean Basin is one of the 25 internationally recognized biodiversity hotspots, with extraordinary plant diversity and endemism.

There are also five regionally recognized hotspots in Northern Africa, these are:

- The Imatong Mountains and surrounding lowlands on the border between Sudan and Uganda. This area has nearly half of the total flora of Sudan and 12 endemic species of plants.
- The isolated Jebel Marra volcanic massifs near the Sudan border with Chad, with about 950 plant species.
- Jebel Elba, a mountainous ecosystem bordering the Red Sea between Egypt and Sudan. This is a transitional area between Afrotropical and palaearctic biogeographic realms and has an estimated three to four times as many plant species as desert areas further north.
- Tassili d`Ajjer, a highland area in Algeria, where several plant species are recorded as near endemic and one is strictly endemic.
- The High Atlas Mountains which extend along the northern part of Morocco and into Tunisia, home to more than one-third of all endemic species in Northern Africa.

Ecological, economic and social values of biological resources in Northern Africa

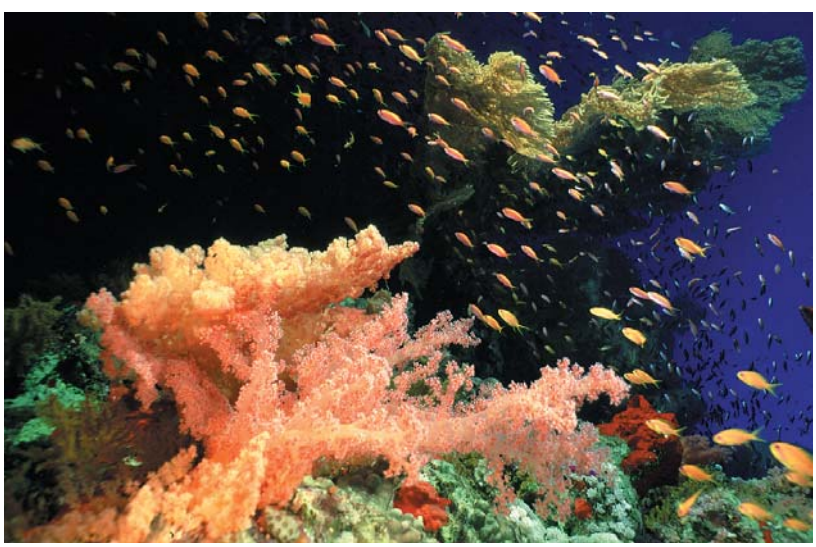
The richness and diversity of species in Northern Africa constitutes a wealth of biological resources (Hegazy 2000a, 2000b). Plant biodiversity in the region has supported the grazing herds of camels, sheep and goats led by nomadic pastoralists for millennia, and agricultural advances have promoted the use of many high yielding cultivars adapted to the arid environment that predominates in the sub-region. Some species offer opportunities for biotechnological modification to improve agricultural, medicinal and industrial applications. About 70 per cent of wild plants in the region are known to be of potential value, over 10 per cent have the potential for commercial exploitation, and 35 per cent of useful plants are either under-utilized or can be used for more than one purpose. These under-utilized and multipurpose species have potential value as sources of food, forage for livestock, medicine and pharmaceuticals and for agro-forestry (Ucko & Dimbleby 1969, WWF & IUCN 1994, UNESCO/UCO 1998).

Threats to biodiversity in Northern Africa

Threats to Northern Africa's natural habitats include rapid population growth with a consequent demand for space and resources, agricultural and urban expansion, poverty and unsustainable use of biota. Depletion of groundwater resources is also a problem in many countries and has led to the deterioration and loss of unique wetland habitats with their associated biota.

Coral reef life in Egypt's Red Sea

Rafel Al Ma'ary / Still Pictures



Natural, macro-scale stresses such as drought also have the potential to change ecosystem dynamics and species composition over time.

Some specific threats have been recorded in the sub-region. For example, the Imatong Mountains have been threatened by the civil war in Sudan, bush fires, fuelwood collection and by conversion of land to agricultural plantations. There are also threats to individual species from overharvesting, as evidenced by the deforestation of the *Acacia senegal* tree in Sudan. The *Acacia senegal* is the source of gum arabic, and Sudan is the world's main producer. In the 1970s, the Sudanese government set up a company to control prices and exports of the gum. However, flawed pricing policies led to low producer prices and farmers cut down their trees for sale as firewood. In an attempt to slow the rate of deforestation, the government responded by allowing the price to rise by 300 per cent over the next two years. Producers, realizing that they could now make large economic gains rapidly, increased their production to such an extent that 80 per cent of the remaining trees were overtapped and died (Larson & Bromley 1991). Other threats to species in Northern Africa include pollution from industrial emissions and agricultural chemicals, and pressure from hunting. The cheetah (*Acinonyx jubatus*) is endangered in Northern Africa because of hunting and of reductions in populations of its prey caused by recurrent drought.

Marine habitats are also threatened—by over-fishing, intensive tourism and invasion by alien species. Species common to the Red Sea have recently been found in the Mediterranean, where it is feared that their introduction (probably through discharges of ballast water by ships) could disturb the ecological balance. Exotic algae species such as *Caulerpa taxifolia* have also been found in the Mediterranean and Red seas where they have formed toxic algal blooms.

A further, emerging threat to biodiversity is the introduction of genetically modified species, which may result in lowered genetic diversity through hybridization, competition, or predation (Hegazy, Diekman & Ayad 1999).

As a result of the pressures outlined above, a total of 139 species of mammals, birds, reptiles, invertebrates and plants are currently threatened with extinction in Northern African, and each country in the sub-region has witnessed the extinction of at least one

Table 2b.2 threatened species in Northern Africa, 2000

Country	Mammals	Birds	Reptiles	Amphibians	Fishes	Inverts	Plants	Total
Algeria	13	6	2	0	0	11	2	34
Egypt	12	7	6	0	0	1	2	28
Libya	9	1	3	0	0	0	1	14
Morocco	16	9	2	0	0	7	2	36
Sudan	24	6	2	0	0	1	17	50
Tunisia	11	5	3	0	0	5	0	24

Source: IUCN 2000a

animal species (IUCN 2000a). This situation is summarized in Table 2b.2.

The numbers of extinctions and of threatened species are set to rise over the next 30 years. Up to 5 per cent of plant species will disappear from Algeria and Morocco, 16 per cent of mammals are expected to disappear from Libya, and 13 per cent of mammals from Tunisia. About 12 per cent of bird species in Egypt and Libya and 8 per cent in Morocco and Tunisia are threatened with extinction. It is also expected that Egypt will lose 2 per cent of its reptile species (WCMC 1992, WWF & IUCN 1994, World Bank 1996).

Towards sustainable management and conservation of biodiversity in Northern Africa

Arab cultures have traditionally practiced biodiversity conservation, as evidenced by 'Hema', the traditional Bedouin practice of rangeland conservation and management of grazing areas. Return to traditional control of rangelands has proven successful as a conservation and rehabilitation strategy, for example in Syria, where a programme of cooperatives was implemented over several years. Applications by tribal units for control over their former traditional grazing lands were granted by the government, and now approximately two thirds of Syria's Bedouin population are member of *hema* cooperatives and associated schemes. The members benefit from greater security and incentives for conservative practices, and the natural resource base benefits from reduced pressure (Chatty, D. 1998). Other traditional conservation measures include the forest reserves, known as 'Harags', dating from Mediaeval Egypt, and protection of oases in Morocco and Andalusia (Draz 1969, Kassas 1972, Ghabbour 1975, UNESCO 1996). In Islam, hunting is prohibited during certain months of the year, 'Al-Ash-hur Al-Hurum'.

In more recent times, schemes have been introduced to establish protected areas and biosphere reserves such as those set up under the Arab Man and Biosphere (ArabMAB) Network. ArabMAB reserves are areas of terrestrial and coastal ecosystem in which solutions are promoted that reconcile the conservation of biodiversity with its sustainable use. There are 12 such reserves in Northern Africa, covering an area of around 13 million hectares.

At present there are 72 terrestrial protected areas in Northern Africa, with a combined area of more than

Table 2b.3 nationally protected areas in Northern Africa

	Terrestrial			Marine
Country	*Number*	*Area (000 ha)*	*% land area*	*Number*
Algeria	18	5 891	2.5	8
Egypt	16	794	0.8	18
Libya	8	173	0.1	5
Morocco	12	317	0.7	10
Sudan	11	8 642	3.4	2
Tunisia	7	45	0.3	7
Total	**72**	**15 862**	**7.8**	**50**

Source: World Bank 2001a

Table 2b.4 internationally protected areas in Northern Africa

Country	Biosphere Reserves*		World Heritage Sites		Ramsar Sites	
	Number	*Area (000 ha)*	*Number*	*Area (000 ha)*	*Number*	*Area (000 ha)*
Algeria	3	N/A	1	N/A	13	1 866
Egypt	2	2 577	0	0	2	106
Libya	0		0	0	2	N/A
Morocco	2	N/A	0	0	4	14
Sudan	2	1 901	0	0	0	
Tunisia	4	32	1	13	1	13
Total	**13**		**2**	**>13**	**22**	**>1 999**

Source Ramsar 2002, UNDP and others 2000, UNESCO 2002.

**Some Biosphere Reserves are also World Heritage Sites or Ramsar sites*

15 million hectares and 50 marine protected areas (World Bank 2001a). Details of nationally protected areas are given in Table 2b.3, internationally protected areas are shown in Table 2b.4. Many more sites are proposed for protection (Hegazy, Fahmy & Mohamed 2001). However, in spite of such efforts, the total area officially declared as protected in Northern Africa remains less than the international target of 10 per cent, although some countries are aiming to increase their protected areas to more than 15 per cent within the next three decades.

Between 1993 and 1999, more than 30 regional meetings were convened to promote inter-Arab cooperation on biodiversity conservation, with regular participation by most of the countries involved. In 1996, the IUCN sponsored a regional programme for Northern Africa and, the Arab League produced a comprehensive policy programme for the Council of Arab Ministers of the Environment meeting, in November 1997. Trans-border conservation is an issue that has received recent attention, and plans for protection are underway between Egypt and Sudan, and between Morocco and Algeria.

Conservation measures through sustainable use of resources include four pilot projects by Algeria's National Agency for the Conservation of Nature. One project aims to protect, document, and establish nurseries for medicinal plants, another aims to conserve and manage cheetah populations and two are designed to raise awareness among local farming communities in and around protected areas. Working with communities has resulted in more widespread use and cultivation of hardy species, and less intensive harvesting of endangered species from the wild.

In Egypt, researchers and conservationists have been working with Bedouins to document and conserve medicinal plants. So far, they have published a book on the wild Medicinal Plants of Egypt and have established nurseries with the Bedouins to provide a source of income from sustainable use of these resources (IUCN 2000b).

The Moroccan Association for the Protection of the Environment has established a project with women in rural areas, to relieve the pressure on the environment from fuelwood collection and to lessen the burden on women of searching and collecting firewood. As an interim measure, all women in a village have been provided with cookers, and regular workshops are held to showcase their traditional knowledge and promote the apprenticeship of their skills (IUCN 2000b).

A recent GEF-funded project in Dinder National Park, Sudan, aims to preserve biodiversity by encouraging species conservation and the sustainable use of resources through the integration of local communities in the utilization and management of natural resources. Dinder National Park lies along Sudan's border with Ethiopia and serves as a vital habitat for terrestrial migratory species which spend the dry season in the park. The park's extensive wetlands

also provide refuge for a large number of migratory birds. The project will develop and implement an integrated management plan, in partnership with the impoverished surrounding communities and with equitable sharing of conservation benefits (IUCN 2000b). The fauna and flora of the park will receive protection and there are plans to re-introduce certain species which have been exterminated, such as the Nile Crocodile.

It is imperative that biodiversity conservation efforts in Northern Africa incorporate modern knowledge as well as traditional protection systems if they are to be acceptable and successful. The pressures of urbanization, industrialization, growing population, abuse of agrochemicals, and uncontrolled fishing and hunting are expected to increase in Northern Africa over the next decade. Protection of critical sites and creation of national parks are therefore needed urgently, together with more sustainable agricultural, forestry and fisheries practices.

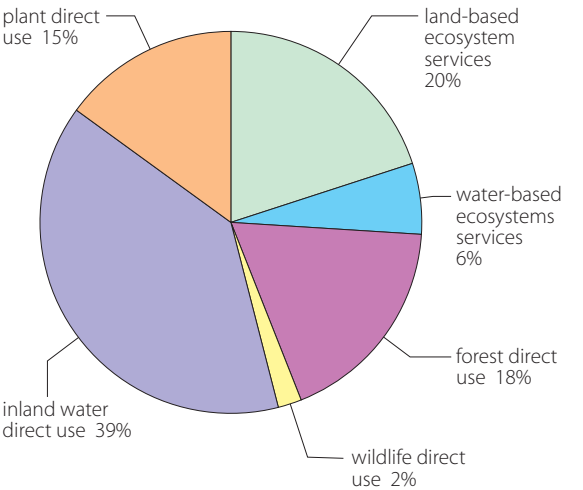
EASTERN AFRICA

Eastern Africa is well known for its rich and diverse biological resources and for its variety of habitats which range from high montane forests and afroalpine ecosystems to dense tropical lowland forests, plains and savannas, freshwater and soda lakes, coastal forests and mangroves. Eastern Africa is also home to the world's population of 320 Mountain Gorillas (*Gorilla beringei beringei*) and to other critically endangered primates in Kenya, Uganda and Rwanda (Moyini & Uwimbabazi, 2000, Mbora & Weizckowski 2001, Butynski 2001). The sub-region's grassland savanna parks have large populations of antelope, buffalo, and other ungulates, as well as elephant, rhino, hippos, crocodiles, and large cats. The coral reefs along Eastern Africa's coasts are among the most spectacular in the world, and the sub-region's freshwater lakes have remarkable levels of species richness and endemism.

Mountain gorilla feeding, East Zaire.

Phil Ward/FLPA

Figure 2b.2: economic benefits of biological resources, Uganda



Source: Emerton & Muramira 1999

ECOLOGICAL, ECONOMIC AND SOCIAL VALUES OF BIOLOGICAL RESOURCES IN EASTERN AFRICA

Many of Eastern Africa's biological resources are used for agricultural, pharmaceutics, construction, clothing and ornamental products and have high local, national and global economic value. For example, the economic benefits of biological resources in Uganda have been estimated at about US$741 million annually (Emerton and Muramira 1999). The breakdown of economic benefits to Uganda is illustrated by Figure 2b.2.

The agricultural biodiversity of the sub-region is also rich as evidenced by Ethiopia, one of the world's 12 centres of genetic diversity known as 'Vavilov Centres'. Ethiopia is the sole or the most important centre of genetic diversity for arabica coffee, tef, enset (Ensete ventricosum) and anchote (Coccinia abyssinica), and for sorghum, finger millet, field pea, chickpea, cow

pea, perennial cotton, safflower, castor bean, and sesame. Genetic erosion in other parts of the world has led to Ethiopia now also being the most important centre of genetic diversity for durum wheat, barley, and linseed. The Plant Genetic Resources Centre of Ethiopia has been entrusted with safeguarding this wealth of genetic resources and, by 1994, had a collection of 53 625 specimens of 100 crop types in its gene bank. The Centre also keeps substantial *ex-situ* collections of arabica coffee and is involved with a number of farming communities in promoting the in situ conservation of crops (EPA/MEDC 1997).

Eastern Africa's biological resources also make the sub-region a desirable destination for tourists and makes a significant contribution to economic development. For example, Kenya's tourism industry is the country's second largest earner of foreign exchange, contributing 19 per cent to the country's GDP (World Bank 2000).

Threats to biodiversity in Eastern Africa

Natural habitats in Eastern Africa are under threat from a rapidly increasing human population and from the accompanying demands for space, agricultural produce, and economic gains from commercial and industrial exploitation. With the sub-region's population growing at about 3 per cent per annum (World Bank 2001a), the pressures on biological resources are likely to increase in the near future.

Destruction of natural habitat in Eastern Africa is a threat to wildlife and to the biological resources that are both the basis of survival for local communities and the mainstay of the economy for many countries. Clearing of natural habitat forces wildlife to invade human settlements; the invading species become crop pests, predators on livestock, and a danger to humans and, in turn, become threatened with trapping, shooting and poisoning. Wild animals may also cross-breed with domesticated species, which can alter their genetic make-up and thus affect their status as a species. Ethiopia, for example, is witnessing the hybridization of the Ethiopian Wolf (*Canis simiensis*) with domestic dogs (EPA/MEDC 1997). The Ethiopian Wolf is the most endangered canid in the world and, in addition to the problem of hybridization, is threatened by exposure to canine pathogens prevalent among domestic dogs (Laurenson, Sillero-Zubiri, Thomson, Shiferaw, Thirgood & Malcolm 1998, Vigne 1999). Conversely, wildlife-related diseases can be transmitted to domestic animals. A regional research effort covering Kenya, Tanzania and Uganda is underway to model wildlife, livestock and human interactions.

Loss of natural habitat and species could have a negative impact on tourism and on the foreign exchange earnings this generates. However, in the short run, tourism is more likely to be affected by issues such as bad publicity, lack of security and poor infrastructure. Such issues can lower the amount of income earned from the sub-region's substantial natural assets, meaning that less investment goes back into the areas supporting concentrations of biodiversity on which the tourism industry depends.

The lack of an adequate legal framework for protection has also contributed to the problem of biodiversity loss in Eastern Africa. For example, of the 38 wildlife conservation areas in Ethiopia, only two are 'gazetted', meaning they have legal protection (EPA/MEDC 1997). Human settlements are encroaching on protected areas such as national parks and forest reserves, as a result of weak law enforcement and low monitoring capacity resulting from inadequate funding. In some cases, critical ecosystems have been damaged

• *Clearing of natural habitat forces wildlife to invade human settlements; the invading species become crop pests, predators on livestock, and a danger to humans and, in turn, become threatened with trapping, shooting and poisoning. Wild animals may also cross-breed with domesticated species, which can alter their genetic make-up and thus affect their status as a species* •

Ethiopian Wolf—a highly endangered species

Michel Gunther/Still Pictures

Table 2b.5 threatened species in Eastern Africa 2000

Country	Mammals	Birds	Reptiles	Amphibians	Fishes	Inverts	Plants	Total
Burundi	5	7	0	0	0	3	2	17
Djibouti	4	5	0	0	0	0	2	11
Eritrea	12	7	6	0	0	0	3	28
Ethiopia	34	16	1	0	0	4	22	77
Kenya	51	24	5	0	18	15	98	211
Rwanda	8	9	0	0	0	2	3	22
Somalia	19	10	2	0	3	1	17	52
Uganda	19	13	0	0	27	10	33	102

Source: IUCN 2000a

beyond repair. For example, most parts of the Gambella National Park have been converted to irrigated agricultural land and another part has been settled by refugees from Sudan (EPA/MEDC 1997).

Although the countries of Eastern Africa are signatories to the Convention on Biological Diversity and have ratified it, their individual efforts at meeting the provisions of the Convention are clearly inadequate, as is their strategic planning for protected area management. There are exceptions to this situation such as Uganda's Protected Area System Plan, described below. However, even where plans exist, their implementation is often hampered by lack of funds, and the high revenues from tourism—even though this is based on conservation—tend to be absorbed by other government activities rather than being invested in further conservation. Funding requirements for effective conservation include well-trained, well-remunerated and equipped staff, security equipment, monitoring and assessment equipment, and maintenance of infrastructure.

Threatened species in Eastern Africa include the African Wild Dog, Grevy's Zebra, Lion, Dugong, the Black Rhinoceros, the Imperial Eagle, the Greater Spotted Eagle, The African Green Broadbill, the Turkana Mud Turtle, the West African Dwarf Crocodile, and the Kyoga Flameback (IUCN 1997). Critically endangered species include the Ethiopian Wolf (*Canis simiensis*) and several primates: the Mountain Gorilla (*Gorilla beringei beringei*) in the Virungas, the Tana River Red Colobus (*Procolobus rufomitratus*) and the Tana River Crested Mangabey (*Cercocebus galeritus*) in Kenya (Butynski 2001, Mbora & Weiczkowski 2001). In Uganda, the Northern White Rhino and the Black Rhino have been poached to extinction (NEIC 1994), and populations of large mammals were reported to have decreased from 141 300 in the 1960s to about 41 000 by 1995 (MUIENR 2000). This situation is summarized in Table 2b.5.

Loss of biodiversity in Eastern Africa is being further exacerbated by changes in institutional mandates, and by political instability. In Uganda and Ethiopia, protracted civil wars destroyed a lot of infrastructure necessary for management of protected areas. For example, four Ethiopian national parks lost all their facilities including ranger camps and equipment. In Uganda, two parks are currently closed to both management operations and tourism.

Many non-native animal and plant species that have been introduced to Eastern Africa and have become invasive or problematic. These include Tonna ciliate, Cassia spectabilis and Cedrella mexicana, Broussonetia papyrifera, and various eucalyptus species. As already mentioned, introduction of the Nile perch into Lake Victoria is believed to have led to the disappearance of more than 200 endemic species of fish. Some of the ameliorative measures that have been suggested include the reduction of eutrophication in the Lake and the establishment of 'fish parks'. Water hyacinth, Eichornia crassipes, is another introduced species causing havoc on Lake Victoria. It forms dense mats on the surface of the Lake, creating a hazard to boats and impeding flow of water, reducing sunlight and

Table 2b.6 nationally protected areas in Eastern Africa

Country	Terrestrial			Marine
	Number	*Area (000 ha)*	*% land area*	*Number*
Eritrea	3	501	4.3	
Ethiopia	21	5 518	5.0	
Kenya	50	3 507	6.0	14
Rwanda	6	362	13.8	
Somalia	2	180	0.3	2
Uganda	37	1 913	7.9	
Total	**119**	**11 981**		**16**

Source:World Bank 2001

Data not available for Burundi and Djibouti.

nutrient availability to species below the surface, and when it dies, releasing compounds into the water that are toxic to other species. Water hyacinth infestations also threaten to block the turbines of the Owen Falls Hydroelectric Facility in Uganda, to interrupt shipping and commerce, and disrupt artisanal fisheries (Olal, Muchilwa & Woomer 2001). The Lake Victoria Environment Management Programme (LVEMP), a regional conservation management programme funded by the GEF, is contributing to development of income from profitable fisheries and to control of the water hyacinth through manual, chemical, and biological control methods.

Towards sustainable management and conservation of biodiversity in Eastern Africa

In 1994, the combined size of the 95 protected areas in East Africa was about 12 million hectares, bigger than the combined areas of Djibouti, Rwanda, Burundi and Eritrea (UNDP 2000), although this calculation included the sizeable reserves of Tanzania. In 1999 another assessment was undertaken, which excluded Burundi and Djibouti (due to lack of information), and Tanzania (now placed in Southern Africa). This survey found 119 nationally protected terrestrial areas and 16 marine protected areas (World Bank 2001a). The slight change in overall size results from the exclusion of Tanzania from this calculation and the increase in number of terrestrial protected areas in the other countries. There are now also 17 internationally protected areas, although Burundi, Eritrea and Somalia have yet to designate any internationally important sites. National protected sites in Eastern Africa are shown in Table 2b.6, internationally protected ones in Table 2b.7.

While policies, laws and regulations are putting greater emphasis on community participation in biodiversity conservation in Eastern Africa, the results have been less than satisfactory in some areas. For example, in Ethiopia, weak law enforcement has resulted in encroachment of protected areas by neighbouring communities and refugees. Areas that are suffering include the Abijatta-Shalla Lakes National

Table 2b.7 internationally protected areas in Eastern Africa

Country	Biosphere Reserves*		World Heritage Sites		Ramsar Sites	
	Number	*Area (000 ha)*	*Number*	*Area (000 ha)*	*Number*	*Area (000 ha)*
Burundi	0		0	0	0	
Eritrea	0		0	0	0	
Ethiopia	0		1	22	0	
Kenya	5	891	2	300	4	90
Rwanda	1	15	0	0	0	
Somalia	0		0	0	0	
Uganda	1	220	2	132	1	15
Total	**7**	**1 126**	**5**	**454**	**5**	**105**

Source UNDP and others 2000, Ramsar 2002

*Data not available for Djibouti. *Some Biosphere Reserves are also World Heritage Sites or Ramsar sites*

Park, one of the most heavily settled protected areas in Africa now completely overrun by people who are now permanently settled. Awash National Park is being severely degraded as a result of illegal occupancy, especially in the northern part where nomadic pastoralists contribute to over-grazing (WCMC 1991).

A successful example of protection is the Mgahinga Bwindi Impenetrable Forest Conservation Trust (MBIFCT), a GEF-funded endowment, which supports communities around the two parks of Uganda, the Mgahinga Gorilla National Park and the Bwindi Impenetrable National Park. The Trust is intended to convey management responsibility and long-term proprietorship to the Government of Uganda and local communities, and provides a chance to pilot test conservation and development partnerships between multiple stakeholders. The Trust funds community development projects, research projects and park management activities, and these have been successful so far (MBIFCT 1994).

Uganda has also recently completed a Protected Area System Plan (UWA 2000). This was developed in recognition of the fact that protected areas were neglected during the wars and conflicts of the 1970s and 1980s and that wildlife populations were reduced or almost wiped out in some areas and large areas settled by displaced communities. The plan was developed with the active participation of these communities, and various types of management were agreed for different areas, including Community Wildlife Management Areas, forestry reserves managed by the Forestry Department, and animal sanctuaries managed by the Uganda Wildlife Authority. The plan is currently awaiting approval by Uganda's parliament.

In 1999, Kenya enacted a very comprehensive Environmental Management and Co-ordination Act. Under this Act, the new guidelines for environmental impact assessment (EIA), will contain a provision for the inclusion of traditional holders of knowledge in a technical advisory committee for the EIA process. The EIA will take into account the potential impacts of projects on local cultures and the views of local communities in the assessment process as well as in the review process (Berger & Mugo 2001). Uganda has also formulated a national policy on Indigenous Knowledge, under the World Bank's Programme on Indigenous Knowledge in Africa.

Little Bee Eaters, Masai Mara, Kenya

Gunter Ziesler /Still Pictures

Kenya has established a wide range of institutions for the managemnt of biodiversity. These research institutions specialise in areas such as agriculture and livestock, as well as monitoring and research in forestry, fisheries, wildlife and rangelands. The National Museums of Kenya (NMK) houses a Centre for Biodiversity, as well as the East Africa Natural History Society, and the Kenya Research Centre for Indigenous Knowledge. NMK is also affiliated with the Institute for Primate Research. The Kenya Wildlife Service is the major body whose madate is the conservation and management of wildlife and Kenya's National Park system.

Because most of Kenya's wildlife exists outside of its National Parks, Kenyans have been experimenting with a range of community and private initiatives to set up tourism or ecotourism enterprises on their land. These ventures may involve the setting aside of game viewing areas on large private ranches, or on group ranches, and sometimes collaboration between groups and individual ranchers to increase the total area of land available for conservation and ecotourism activities. Il Ngwesi, a 16 500 acre group ranch in the

northern area of Kenya, opened a small lodge in 1996, grossed US$40,000 in 2000 and is expecting more than double that in 2001 (Johnstone, 2001). The Mara Conservancy, in the Trans Mara area of Kenya, is a new initiative aimed at ensuring that the local community actually receives the proceeds from tourism activities carried out in their area. Several group ranches have subcontracted a private company to manage their game viewing area, collect entry fees, reinvest a proportion into the infrastructure of the reserve, and pay the rest into the community (Daily Nation, 13 December 2001).

Ecotourism and conservation enterprises can be part of an effort by pastoral communities to stop the sub-division, sale and subsequent encroachment of settlement onto their common grazing land, which interferes with their traditional livelihood activities. Some of the Maasai residents of a former conservation area located next to Nairobi National Park (and part of the wildlife dispersal area) are attempting to re-integrate use of the riverine forest and grazing land to attract tourists and dissuade members of the scheme from selling off small plots of land for settlement (Ole Kaasha 2001). On a different tack, the Loita Maasai of Kenya responded firmly to attempts to include the sacred Loita Forest as part of the Maasai Mara game reserve, to be developed for tourism. As part of a series of efforts to prevent the alienation of this forest and the loss of its biodiversity, the Loita Maasai went to court to seek legal entitlement, invoking Article 8(j) of the Convention on Biological Diversity (Stephenson 1999).

Other conservation measures include the re-introduction of species to areas from which they had formerly been eradicated, and management of wildlife-livestock interactions. For example giraffes were successfully re-introduced from Kenya into Kidepo Valley National Park, Uganda, and there are plans underway to re-introduce black rhino to Uganda. In July 2001, the Kenya Wildlife Service translocated 56 elephants from the Sweetwaters Rhino Sanctuary in Laikipia district, to Meru National Park. Meru's elephant herds were decimated during the 1960s and 1970s. This is the sixth major operation of this kind in Eastern Africa since 1996, and is one way that the KWS is handling wildlife-human conflicts (Situma 2001). The Ethiopian Wolf Conservation Programme, the IUCN/SSC Canid Specialist Group and the Ethiopian Wildlife Conservation Organization have started a programme to vaccinate dogs against rabies, canine distemper and canine parvovirus in and around the Bale Mountains National Park. The programme will not only help curb the spread of diseases that are a threat to this critically endangered species, but it will also benefit local communities, by reducing the number of deaths of humans and their livestock from rabies. Another initiative is to encourage responsible dog ownership, and the neutering of both male and female dogs (Laurenson and others 1998, Vigne 1999).

WESTERN INDIAN OCEAN ISLANDS

The importance of conservation within oceanic islands is perhaps best expressed by the fact that they are home to around one-sixth of all plant species, and that one in three of all known threatened plant species are island endemics. The Western Indian Ocean Islands, uninhabited until the 16th and 17th centuries, are a typical example where rich land based flora and fauna have evolved in isolation from human intervention and from the intrusion of other alien species that the human presence so often brings

Madagascar has the highest number of endemic species of any country in the Africa region, and ranks

Ring-tailed lemurs, Madagascar

M&C Denis-Huot/Still Pictures

sixth in the world. Up to 8 000 of the 9 500 species of higher plants and over 50 per cent of all vertebrate species found in the island are known or are thought to be endemic (UNEP 1999). In Mauritius, around 50 per cent of all higher plants, mammals, birds, reptiles and amphibians are endemic to the island, and the Seychelles has the highest level of amphibian endemism of any island in the world (11 of the 12 species are found nowhere else) (WCMC 1992).

Ecological, economic and social values of biological resources in the Western Indian Ocean Islands

This extraordinary biodiversity of the Western Indian Ocean Islands not only contributes to their unique ecological conditions, it also provides valuable raw materials for local and commercial use. In addition to use for food, construction, clothing and shelter, many plant species are used medicinally and several species are being researched for commercial agricultural or pharmaceutical use. For example, the native *Coffea sp.* is being investigated for commercial production of naturally caffeine-free coffee (GOM/ERM 1998).

The Islands' internationally renowned coral reefs support a booming tourism industry and subsistence and commercial fisheries. There are also ten species of mangroves providing stabilization of the coastal zone, creating spawning and nursery grounds for many fish species, mitigating storm impacts, and providing resources for construction, weaving, and food.

Threats to biodiversity in the Western Indian Ocean Islands

Human population growth, the selective and accidental introduction of alien species, urbanization, rapid change in use of land for cultivation, hunting, pollution and degradation of soil have all taken their toll on endemic species of plants, mammals, birds, reptiles and amphibians and the Islands' biodiversity is now seriously under threat. All of the West Indian Ocean Islands are important endemic bird areas and four islands in Seychelles are bird sanctuaries. The greatest threat to their biodiversity is habitat destruction resulting from expansion of agriculture and of human settlements, with additional threats from natural processes such as coastal erosion, bush fires and seawater intrusion. The continued extension of agriculture into the natural forest and woodland areas exerts a continuous pressure on already endangered species of flora and fauna in the islands. Grazing by introduced species of animals such as deer, goats and cattle has diminished plants not adapted to grazing and has led to a predominance of exotic grasses. In addition, sugar cane, coffee, and tea estates now use large areas of land for these imported species, and the high dependency on wood and charcoal for household use has further depleted forest and woodland areas (UNEP 1999).

In Madagascar, grassland fires are commonly used to clear land at the end of the dry season, and this is contributing to the destruction of woodlands and threatening the habitat of birds, insects and mammals which depend on the forest cover for survival. In 1995, more than 1.2 million hectares of Madagascar's forest were destroyed by grassland fires (4 900 ha of natural forest and 10 287 of plantation forest) (Republic of Madagascar, 1997). In Mauritius burning of sugar cane is a common cause of habitat destruction for insects, birds and reptiles, as well as a source of air pollution.

Modification of freshwater habitats through pollution is another cause of reductions in biodiversity on the islands, as are selective harvesting and overharvesting. For example, collection of fuelwood is a form of selective harvesting that is contributing to loss of quality of habitat and to reduction of species diversity. Overharvesting of land tortoises and marine turtles over the past three decades has contributed to their decline (RFIC 1998).

Western Indian Ocean Island coastal and marine habitats and species are under threat from destructive fishing practices, overharvesting, and intense tourism. Mangrove clearance means loss of buffering against ocean swells and is accelerating coastal erosion and saltwater intrusion. Nursery grounds for shrimp, crab and other species are also being lost as mangroves are reduced. Mining of coral and sand for use in construction is also damaging habitats, and threatening the biodiversity they support. Intensive tourism is thought to be damaging the coral reef habitats by pollution from boats, hotels and other infrastructure and facilities, and by excessive walking on coral or its removal for souvenirs.

Island species are particularly vulnerable to competition and predation by invasive alien species. Animal species introduced to the Western Indian Ocean Islands include rats and mice, rabbits, pigs, and the long-tailed macaque (*Macaca fascicularis*). This latter species is a problem for farmers as it regularly damages crops. It is also contributing to the extinction of many wild bird species through predation on their nests. Rodents are also problem predators and have contributed to the demise of birds and reptiles. The two most prolific alien plant species in Mauritius are the Chinese guava (*Psidium cattleianum*), from South America, and the privet (*Ligustrum robustrum*) from Asia. Neither species is kept in check by natural consumers or competition and they therefore form dense thickets in the upland forests, preventing other species from regenerating. Lowland forests are being invaded by liane cerf, wild pepper, and aloe.

As a result of these pressures, a significant number of plant and animal species in the Western Indian Ocean Islands are threatened with extinction or have become extinct—the most notorious case being that of the Dodo of which the demise is attributed to overhunting and the introduction of alien species. Throughout the Western Indian Ocean Islands, populations of endangered marine species such as the Green Turtle, the Hawksbill Turtle, the Coelacanth and the Dugong have declined in recent years. In Mauritius 62 animal species—mainly birds, reptiles and a large number of molluscs—have become extinct and several species now only survive in small populations under protection schemes. Mauritius and Seychelles are ranked second and third in the world in terms of the percentage of native plants threatened (UNEP 1999). The numbers of threatened species in the sub-region are given in Table 2b.8.

Mauritius and Seychelles are ranked second and third in the world in terms of the percentage of native plants threatened

Table 2b.8: threatened species in the Western Indian Ocean Islands (percentage of known species)

Country	Higher plants	Mammals	Birds	Reptiles	Amphibians
Comoros	1	18	6	8	0
Madagascar	5	28	10	5	1
Mauritius	71	100	37	55	27
Seychelles	8	8	7	27	33

Source: UNEP 1999, UNDP 2000

In response to the threats to natural habitats in the Western Indian Ocean Islands, protected areas have been established inland and in the coastal and marine zones. In 1999, there were: 1 reserve in Comoros; 44 protected areas covering 2.9 per cent of the land area in Madagascar; 18 reserves covering 3.7 per cent of the land area in Mauritius; and 26 sites covering 47 per cent of the land area in Seychelles (UNEP 1999). The Andringitra Reserve, newly created in Madagascar with the assistance of WWF, is thought to be one of the world's most biologically rich areas, and to be most representative of the island. The Andohahela National Park, Bexa Mahafaly Special Reserve and Lac Tsimanampetsotsa are areas designated as reserves with the specific aim of protecting the dry forest and spiny thicket habitats which are unique to Madagascar.

The sub-region also has two Biosphere Reserves in Madagascar and one in Mauritius, three World Heritage sites (two in Seychelles and one in Madagascar), and four Ramsar sites (one in Comoros, two in Madagascar, and one in Mauritius) (Ramsar 2002, UNESCO 2002, UNEP 1999). Mauritius has also signed the Ramsar Convention, but has not yet designated a site. All of the Western Indian Ocean Islands are parties to the Convention on Biological Diversity, and efforts are underway to develop a conceptual framework for coral reef conservation. The Indian Ocean Commission has initiated a regional project with a view to achieving sustainable management of natural resources. This aims to protect resources and integrate management in the coastal zone, and to protect and conserve endangered endemic flora.

More than 20 endangered species in the Western Indian Ocean Islands, are protected by official programmes within national protected areas. Madagascar has 10 programmes for conservation of species in protected areas and there are 8 in Mauritius and 3 in Seychelles. Particular success has been achieved in the Seychelles with the protection of the Aldabra Tortoise through an Australasian Species Management Programme—there are now 155 000 specimens in the wild. In Mauritius, the Pink Pigeon has been successfully conserved through a Jersey Wildlife Preservation Trust project and some 300 are now surviving in the wild. In Seychelles, populations of the Brush Warbler, a species that was critically threatened, have grown to 250 and, in Mauritius, the Rodrigues

Flying Fox has successfully recovered under the North American Species Survival Plan. There are now 350 flying foxes surviving in the wild (UNEP 1999).

Eradication of introduced problem predators such as rats, mice and macaques has been achieved in some of the smaller islands, by means including poison pellets, wax blocks, and trapping. Infestations of alien plants are being controlled within conservation management areas by manual weeding and by erecting barriers to pigs and other animals that may disperse the seeds. Airports and seaports are also carefully monitored and incoming traffic is sprayed with insecticides and herbicides to reduce the risk of accidental introductions. There are also strict regulations on animal and plant products entering the country. Reducing populations to manageable levels will, however, take a long time and will require considerable resources.

All of the West Indian Ocean Islands have ratified the CITES, and Madagascar, Mauritius and Seychelles have established Management and Scientific Authorities to regulate the granting of import and export permits. National programmes have also been established to encourage sustainable use and trade in certain wildlife products (including shells, turtle products, seabirds and their eggs, and certain plants), but these frequently suffer from insufficient resources to properly implement the restrictions. A major sub-region-wide policy giving highest priority to conservation of endangered species is an immediate requirement. Alternative strategies to individual species conservation programmes and creation of protected areas are also required. Local communities and national economies need alternative resources or means of support, and a culture of sustainable harvesting needs to be implemented.

SOUTHERN AFRICA

Southern Africa has rich biological resources in a variety of ecosystems which range from moist tropical forests in Angola and Zambia to savannas, coastal forests and mangroves, deserts and semi-deserts, and to the extraordinary diversity of plants of the Cape Floral Region, in South Africa. The sub-region boasts an average of 57 mammalian species and 136 breeding bird species per 10 000 km^2 (UNDP and others 2000). South Africa ranks as the third most biologically diverse country in the world, mainly because of the richness of its plant life—over 18 000 species of vascular plants of which over 80 per cent are endemic. In terms of numbers of endemic species of mammals, birds, reptiles and amphibians, South Africa is the fifth richest country in Africa and the twenty-fourth richest in the world (DEA&T 1997).

Ecological, economic and social values of biological resources in Southern Africa

Southern Africa's rich biological resources play an important role in ensuring long-term food security. Access to genetic resources for crop and animal breeding purposes is also seen as a critical factor. Many species of plants and animals have medicinal properties and most of these are used in traditional healing, some are being investigated for commercial production. Approximately 10 per cent of Southern African plants (roughly 3 000 species) are used medicinally, and 10 per cent of these (about 350 species) are commonly and widely used (van Wyk, Van Oudtshoorn & Gericke 1997). They include Warburgia salutaris, a plant of which the root and bark are used to treat coughs, headaches and stomach problems, and which is fast disappearing in Southern Africa (Cunningham 1993). The locally known 'African Potato' (*Hypoxis sp*) is being researched for the extraction of hypoxicide, a sterol (plant acid) used traditionally to treat dizziness and bladder disorders and which has now been shown to inhibit the growth of tumour cells and also to have anti-inflammatory properties (Drewes, Hall, Learmonth & Upfold 1984).

Threats to biodiversity in Southern Africa

As in other sub-regions of Africa, natural habitats in Southern Africa are coming under increasing pressure from expansion of agriculture and plantation forestry, human settlements, mining activities, and other commercial or subsistence activities, both inside and outside of protected areas. Individual species are threatened through habitat loss, selective harvesting, poaching, and through the spread of alien invasive organisms.

Ivory and animal skins impounded in Dar-es Salaam, Tanzania

Sabine Vielmo/Still Pictures

One of the greatest pressures on wild species is the trade in plant and animal products, such as ivory, horn, and skins. Over the past 30 years, trade restrictions, mainly through CITES, have been used at the global level as a tool to control trade and thus help conserve populations in the wild. Implementation of regulations has had varied levels of success in Southern Africa. For example, the listing of the Black Rhino in Appendix 1 (species threatened with extinction) of CITES during the 1970s has not helped revive the rhino population which is still too low for breeding and multiplication in the wild. Trade controls have resulted in higher prices being paid on the black market for rhino horn, which in turn encourages poaching of wild populations. As already mentioned, restrictions on the trade in ivory, and sound conservation practices have seen significant growth in national herds of elephant in Botswana and Zimbabwe, and these countries are now pushing for limited trade in ivory to provide economic incentives for continued conservation.

Sub-regional cooperation plays a significant role in the conservation of biological resources in Southern Africa, and the Southern African Convention for Wildlife Management has been successful in regional monitoring, assessment and management of wildlife resources. However, such conservation measures need continued resourcing and support, so that benefits continue to be derived from conservation of species in the wild.

Alien invasive species of plants and animals are causing massive disturbance in natural ecosystems across Africa. In Southern Africa, the introduction of alien tree species, originally for plantation, is of greatest concern. The Catalogue of Problem Plants in Southern Africa (Wells, Balsinhas, Joffe, Engelbrecht, Harding & Stirton 1986) lists 789 species some of which, like *Acacia saligna* and *Hakea sericea*, have dominated areas to the extent that natural vegetation has been almost completely lost. Others, for example pine and eucalyptus trees, present a threat to water availability because they use greater amounts of water than the natural vegetation, and therefore reduce the amount of run-off reaching streams and rivers. Other species form dense stands that reduce the amount of light reaching the understorey, physically strangle native species and inhibit regeneration of native seeds. These impacts reduce the diversity and cover of indigenous plant species, and thus alter functioning of the ecosystem.

In South Africa, where the problem of alien invasive species has been well quantified and documented, about 180 species of trees and shrubs have invaded, covering 10 million hectares (8 per cent of the land area) (Versveld, Le Maitre & Chapman 1998). The plant diversity of the Cape Floral Region is particularly threatened by invasive species, with an estimated 33 of 70 threatened plant species being potential extinction victims of invasions of alien woody plants (Hall, De Winter & Van Oosterhout 1980). As in other sub-regions, the water hyacinth (Eichornia crassipes) is a problematic invasive plant in Southern Africa, forming dense mats that block water channels, disrupting flow patterns, reducing light and nutrients reaching below the surface of the water, and thus creating an undesirable habitat for native plants and animals. Decaying mats of the weed generate unpleasant odours and lead to eutrophication of the water body. Areas afflicted by the water hyacinth include Lake Kariba and Lake Chivero (Zambia/Zimbabwe).

There is a marked lack of information available on most invertebrates, algae, bacteria and fungi in Southern Africa, including on their genetic diversity. It is therefore thought that many species in the sub-region (as elsewhere) become extinct before they can be named and described. Lack of knowledge of biodiversity issues has also been compounded by the

fact that indigenous knowledge has not been accepted or documented by research institutes or in publications. As a result, protected areas, many of which were established more than three decades ago without consultation of local people, were set aside without accurate assessment of the biological richness within their boundaries. Thus some areas that have little significance in terms of biodiversity are protected while many others with significant biodiversity lack protection. In addition, farmers, who have custody of much of the sub-region's biological diversity, are rarely invited to share their knowledge it, even though that knowledge extends to crop and animal genetic diversity and includes wild plant and animal species that serve humanity as biological resources. The lack of comprehensive knowledge of biodiversity in Southern Africa also contributes to growing discontent about unauthorized access to biodiversity and lack of reciprocity in benefit sharing, mainly on the part of the rich developed countries. For example, while acknowledging that developing drugs is costly, it is also important to attain goals of wealth creation that will provide substantial benefit to those who conserve biodiversity through a culture of bio-partnership, rather than indulging in bio-piracy.

In spite of the numerous pressures on Southern Africa's biological resources, only one species of mammal (the Blue Antelope) has become extinct in recent times, but several sub-species have been lost. The demise of the Blue Antelope has been blamed on competition for grazing from sheep farming, and on subsistence hunting. The African Wild Dog is also an endangered species in Southern Africa, surviving only in large protected areas (Ledger 1990). Similarly the Bearded Vulture has undergone serious population declines in the sub-region and is now restricted to the Drakensberg Mountain range of South Africa and Lesotho. Declines in the Bearded Vulture's population have often been blamed on reduced prey, changing animal husbandry practices and direct persecution—in Lesotho, for example, the bird is killed for its plumage which is used in traditional ceremonies. The number of threatened plant species in Southern Africa continues to grow. Estimates show that 58 species had become extinct by 1995 compared to 39 in 1980, while the number of endangered plant species grew from 105 to 250 during the same period (Hilton-Taylor 1996). The numbers of threatened species in Southern Africa are shown in Table 2b.9. In terms of area, Southern Africa has the highest concentration of threatened plant species in the world (Cowling and Hilton-Taylor 1994). A large percentage of these are in the Cape Floral Region, and are threatened by the rapid urbanization of the Cape Metropolitan Area.

Table 2b.9 threatened species in Southern Africa 2000

Country	Mammals	Birds	Reptiles	Amphibians	Fishes	Inverts	Plants	Total
Angola	18	15	4	0	0	6	19	62
Botswana	5	7	0	0	0	0	0	12
Lesotho	3	7	0	0	1	1	0	12
Malawi	8	11	0	0	0	8	14	41
Mozambique	15	16	5	0	3	7	36	82
Namibia	14	9	3	1	3	1	5	36
South Africa	41	20	19	9	30	111	45	275
Swaziland	4	5	0	0	0	0	3	12
Tanzania	43	33	5	0	15	47	236	379
Zambia	12	11	0	0	0	6	8	37
Zimbabwe	12	10	0	0	0	2	14	38

Source: IUCN 2000a

Towards sustainable management and conservation of biodiversity in Southern Africa

The past 30 years have seen expansions in protected areas in Southern Africa, from just 260 areas (6 per cent of the total area) in 1989 (although this assessment excluded Tanzania, which was still associated with Eastern Africa), to a current total of 578 nationally protected areas with a combined area of over 65 million hectares (including the sizeable reserves of Tanzania) (WRI UNEP & UNDP 1990; World Bank 2001). There are also currently 44 marine protected areas in Southern Africa (see Table 2b.10)

Southern Africa is home to some of the world's largest protected areas including the Okavango Delta in Botswana, the largest inland delta in the world (16 000 sq. km), the Selous Game Reserve in Tanzania (52 200 sq. km), and the Namib-Naukluft National Park in Namibia (49 768 sq. km) (McCullum 2000). However, Swaziland has seen one of its three protected areas opened up for other land uses in the last 20 years and civil wars in Angola and Mozambique have resulted in the loss of some protected areas. The war in Mozambique saw widespread habitat and species loss in the Gorongosa National Park and Marromeu Buffalo Reserve in the Zambezi Delta. The ecosystems have not yet fully recovered (Chenje 2000).

Table 2b.10 Nationally protected areas in Southern Africa

	Terrestrial			Marine
Country	***Number***	***Area (000 ha)***	***% land area***	***Number***
Angola	13	8 181	6.6	4
Botswana	12	10 499	18.0	
Lesotho	1	7	0.2	
Malawi	9	1 059	8.9	
Mozambique	11	4 779	6.0	7
Namibia	20	10 616	12.9	4
South Africa	390	6 619	5.4	20
Tanzania	39	13 817	14.6	9
Zambia	35	6 366	8.5	
Zimbabwe	48	3 071	7.9	
Total	**578**	**65 014**		**44**

Source: World Bank 2001a

Data not available for Swaziland

The Peace Parks initiative is based on a concept similar to that of the Biosphere Reserve and several sites are now being established as transfrontier conservation areas. These include the Kgalagadi Transfrontier Park, established in 1998 between Botswana and South Africa, the Maloti-Drakensberg Park between Lesotho and South Africa, the Gaza-Gonarezhou-Kruger Park between Mozambique, South Africa and Zimbabwe, and the Greater Limpopo Transfrontier Park, between Mozambique, Zimbabwe and South Africa. Internationally protected areas are shown in Table 2b.11.

Efforts have also been made to deal with invasive species. For example, the Working for Water Programme was set up in 1995 to provide sustainable employment through alien-clearing projects. There are currently over 300 projects which have cleared over 235 000 hectares of alien-infested land, rehabilitated a further 50 000 hectares, and employed 21 000 people in the year 2000 (Working for Water 2000). Countries affected by water hyacinth have initiated biological and chemical control programmes in addition to mechanical clearance, with some success to date (Global Water Partnership 2000).

The positive trends in biodiversity conservation in the sub-region are partly attributed to the fact that all countries in Southern Africa have ratified the Convention on Biological Diversity, the Bonn Convention, and the Ramsar Convention. To a large extent the provisions of these conventions have also been included in national policies. Furthermore, many Southern African governments have adopted structured approaches to decentralizing management of natural resources through Community Based Natural Resources Management (CBNRM) programmes. CBNRM programmes have helped to extend resource access and management rights over the last 15 years to farmers operating in some communal lands. This has resulted in rural farming communities deriving direct benefits from wildlife through returns from either safari hunting or direct sales (Cumming 2000).

Prominent CBNRM programmes in the sub-region include Zimbabwe's Communal Areas Management Programme for Indigenous Resources, hailed for raising household incomes by as much as 15–25 per cent in CAMPFIRE-designated areas since 1998 (CAMPFIRE & Africa Resources Trust 1999). Zambia's Administrative Management Design for Game Areas (ADMADE), South

Table 2b.11 Internationally protected areas in Southern Africa

Country	Biosphere Reserves*		World Heritage Sites		Ramsar Sites	
	Number	*Area (000 ha)*	*Number*	*Area (000 ha)*	*Number*	*Area (000 ha)*
Angola	0		0	0	0	0
Botswana	0		1	1	1	6 864
Lesotho	0		0	0	0	0
Malawi	1	N/A	1	9	1	225
Mozambique	0		0	0	0	0
Namibia	0		0	0	4	630
South Africa	4	N/A	1	243	17	500
Swaziland	0		0	0	0	0
Tanzania	3	N/A	4	6 860	2	3 474
Zambia	0		1	4	2	333
Zimbabwe	0		2	733	0	0
Total	**8**		**10**	**7 850**	**27**	**12 026**

Source: Ramsar 2002, UNDP and others 2000, UNESCO 2002.

**Some Biosphere Reserves are also World Heritage Sites or Ramsar sites*

Africa's Peace Parks initiative and Namibia's Living In a Finite Environment (LIFE) are other successful CBNRM programmes in the sub-region. The LIFE programme has seen local communities reap substantial benefits from sales of thatching grass, crafts, tourism, and trophy hunting. In the Kunene region, game guards are employed from the local communities and Himba nomads, creating jobs and stimulating incomes whilst helping to conserve wildlife. Public-private partnerships are being developed to ensure conservation of threatened species in the Kafue wetlands of Zambia, whilst providing a source of materials and income to local communities. Despite these successes, some analysts have questioned whether these CBNRM-created incentive structures can promote a conservation ethic among rural residents. One study concluded that it was increased enforcement activities and not any increased motivation by residents to conserve animals which led to declines in poaching in Zimbabwe and Zambia. It appears that poaching remains a problem in these areas (Gibson 1999). Indications are that CAMPFIRE may, in some cases, have been successful in stimulating communities to secure rights to wildlife resources and may have more influence over utilization of the resource. This may have allowed communities to improve their agricultural infrastructure and equipment and to improve household conditions (Murombedzi 2001). Whether this change in the community relationship to the local authority will result in enhanced conservation of biodiversity remains to be seen.

In the Kunene region, members of the local communities and Himba nomads are employed as game guards, thus creating jobs and stimulating incomes whilst also helping to conserve wildlife.

UNEP

Governments and scientific institutions are slowly realizing the value of indigenous knowledge and attempts are now being made to document and record what still exists and to incorporate traditional conservation methods into modern ones. For example, over 5 000 samples of mainly traditional food crop seed species have been collected by states that are members of the Southern African Development Community (SADC) for preservation at the sub-regional genetic resources centre in Lusaka, Zambia. In addition, a Genome Resource Banking in Southern Africa programme has been initiated and materials from many wildlife species, including buffalo and rhino, have been banked. Plans are underway to include other species. Many computer databases—increasingly being used as tools to develop biodiversity inventories—have now been set up and placed on the Internet, including a meta-database of resources, a fish database, and a database for threatened plants. The Southern African Bird Atlas (Harrison, Allan, Underhill, Herremans, Tree & Brown 1997) maps the distribution of bird records from across Southern Africa, providing a major source of information against which conservation threats can be determined or judged. Other responses to calls for greater documentation and application of indigenous knowledge include policies to assign intellectual property rights to certain countries, communities or individuals, and participation in the World Bank's Programme on Indigenous Knowledge in Africa. Indigenous knowledge is being used via this programme in the treatment of HIV/AIDS in Tanzania, through the use of medicinal plants to treat secondary infections and community support programmes that assist people living with AIDS to live positively and raise modest incomes (World Bank 2001b).

CENTRAL AFRICA

Central Africa has a wide diversity of habitats spanning dense humid forests, savannas, semi-deserts (on the Sahelian borders), freshwater lakes, mangrove forests and coral reefs. Species diversity and endemism are high in the sub-region, mainly due to the abundant tropical forests. The forest of the Congo Basin is the second largest contiguous area of forest in the world, and the largest in Africa. It is also one of the most biologically diverse and most poorly understood of Africa's ecosystems (IUCN, WWF & GTZ 2000). Data compiled in 1992 indicate that, of the 40 850 plant taxa so far enumerated in Central Africa, nearly 16 per cent are endemic to the area, and 175 of them are classified as rare (WRI, UNEP & UNDP 1992). There are 11 000 forest plant species in the Democratic Republic of Congo (DRC) alone and over 3000 of these are endemic. Cameroon has 8 000 forest plant species while the Central African Republic is home to 1000 endemic species of plants (IUCN, WWF & GTZ 2000). Bird diversity is also high in Central Africa, with more than 1 000 species in the DRC (IUCN, WWF & GTZ 2000).

ECOLOGICAL, ECONOMIC AND SOCIAL VALUES OF BIOLOGICAL RESOURCES IN CENTRAL AFRICA

Central Africa's biological resources are the backbone of the sub-region's economy and support millions of livelihoods. Timber extraction is growing rapidly and timber exports exceeded 50 per cent of all exports from Equatorial Guinea in 1993. They totalled more than 1.7 million m^3 in 1998 (IUCN, WWF & GTZ 2000). Up to 63 per cent of the Central African countries' population live in rural areas, and many people are dependent on forest resources such as wood for construction and fuel, plants and animals for food, medicines, clothing, and household items.

The Drill *(Mandrillus leucophaeus)*—one of Africa's least known primates—is facing increasing pressure as a target for bushmeat.

Frank W. Lane

Table 2b.12 Threatened species in Central Africa 2000

Country	Mammals	Birds	Reptiles	Amphibians	Fishes	Inverts	Plants	Total
Central African Republic	12	3	1	0	0	0	10	26
Chad	17	5	1	0	0	1	2	26
Congo	12	3	1	0	1	1	33	51
DRC	40	28	2	0	1	45	55	171
Equatorial Guinea	15	5	2	1	0	2	23	48
Gabon	15	5	1	0	1	1	71	94
Sao Tome & Principe	3	9	1	0	0	2	27	42
Cameroon	37	15	1	1	27	4	155	240

Source: IUCN 2000a a

Threats to biodiversity in Central Africa

Over the years, wildlife habitat in the sub-region has come under increasing pressure from conversion to alternative land uses, particularly cultivation of cash crops, subsistence slash-and-burn cultivation and expansion of human settlements. Weak infrastructure and lax enforcement of protection have contributed to excessive rates of deforestation. Resettlement campaigns by the French administration, together with rural-urban migration, have also left large areas of forest unpopulated, and therefore unpatrolled. In the late 1980s, it was estimated that only 50 per cent of an estimated original 404 390 000 hectares of wildlife habitat remained (McNeely, Miller, Reid, Mittermeier & Werner 1990).

The rate of forest loss is a particular cause for concern in Central Africa, with the DRC losing more than 500 000 hectares of forest per year between 1990–2000 and Cameroon losing over 200 000 hectares (FAO 2001). Even though these are not the highest rates of deforestation in Africa—and allowing for the fact that even these large losses represent small percentages of the total forest area—the impacts on the functioning and biodiversity of the ecosystem, and the impacts on the local communities are highly detrimental. Loss of habitat has resulted in species becoming threatened or extinct—in DRC, for example, 40 species of mammals and 28 bird species are threatened (IUCN 2000a). The communities dependent on these species for food, construction, medicinal products or subsistence incomes are forced to find alternatives or go without. Agricultural, pharmaceutical, and industrial opportunities are also lost, and economies suffer in the long term as a result. More sustainable rates of harvesting of forest products must therefore be adopted in order to ensure medium- to long-term supply.

In addition to the threat of habitat loss, numbers of threatened or endangered species in Central Africa are increasing because of pollution and overharvesting of selected species for food, medicinal, and commercial purposes. For example, gorillas, chimpanzees, mandrills, forest elephants, buffalo, and antelopes are coming under increasing pressure for sale as bushmeat, and illegal logging is destroying large areas of their habitat. The Drill (*Mandrillus leucophaeus*) is one of Africa's least-known primates, and is one of the most endangered. Its range is limited to parts of Nigeria, Cameroon and Bioko Island in Equatorial Guinea. Drills are under severe pressure from hunting (Gadsby & Jenkins 1998). The savannas of northern Cameroon are an important wildlife habitat for the critically endangered, endemic, black rhino subspecies *Diceros bicornis longipes*. Fewer than 20 individuals remain, due to pressure from poaching. War and civil unrest are also contributing factors in the decline of these species because of resettlement of refugees in forest habitats, illegal poaching by soldiers and guerrillas, and clearing of habitat for military training. The DRC and Cameroon—richest in endemic mammals, birds and higher plants—also have the highest numbers of threatened species (see Table 2b.12). Gabon and Cameroon had the highest numbers of plants known to be threatened in the sub-region in 1997 (World Bank 2000).

Table 2b.13 Protected areas in Central Africa

Country	Terrestrial Number	Terrestrial Area (000 ha)	Terrestrial % land area	Marine Number
Cameroon	18	2 098	4.4	
Central African Republic	13	5 110	8.2	
Chad	9	11 494	9.0	
Democratic Rep Congo	15	10 191	4.3	1
Congo	9	1 545	4.5	1
Equatorial Guinea	0	0	0.0	4
Gabon	5	723	2.7	4
Total	**69**	**31 161**	**33.1**	**10**

Source: World Bank 2001a

Data not available for SwazilandData not available for Sao Tome & Principe

Towards sustainable management and conservation of biodiversity in Central Africa

In response to loss of natural habitat in Central Africa, the network of protected areas has been expanded though creation of new areas and extension of existing nationally protected areas, and through the creation of protected areas of international significance, such as Biosphere Reserves and Wetlands of International Importance (Ramsar sites). Protected areas in the tropical forest of the Congo basin amount to 6 per cent of the total forest area, and include the rainforest refuge areas of the Korup National Park, Mount Cameroon and Dja Forest Reserve (Cameroon); the Crystal Mountains (Gabon); Maika National Park and Salonga National Park (DRC); and the Mayombe Forest Reserve (DRC and Congo) (IUCN, WWF & GTZ 2000). The Youndé Declaration—a 12-point resolution on the conservation and sustainable management of the forests of the Congo Basin—was signed, in 1999, by the heads of state of Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, and Gabon. Under its guidance, the Sangha Park has been created, linking the protected areas of Lobeke National Park in Cameroon, the Dzanga-Sangha in the Central African Republic, the Nouabale-Ndoki Park in Congo, and production forests and hunting zones surrounding each of these areas. This is one of the first efforts at a coordinated approach to forest resource conservation, through harmonization of the laws and policies of the six countries, and coordination of patrolling for illegal activities. Nationally and internationally protected areas in Central Africa are shown in Table 2b.13 and Table 2b.14 respectively.

However, protected areas in Central Africa are reportedly still experiencing degradation, mainly as a result of poor enforcement of protection regulations. Logging activities, bushmeat poaching, agriculture, and oil exploration regularly encroach on protected areas. For example forest concessions have been granted in Gabon in the La Lopé Wildlife Reserve, the Wonga Wongé Presidential Reserve, and in the Monkalaba and

Table 2b.14 Internationally protected areas in Central Africa

Country	Biosphere Reserves* Number	Biosphere Reserves* Area (000 ha)	World Heritage Sites Number	World Heritage Sites Area (000 ha)	Ramsar Sites Number	Ramsar Sites Area (000 ha)
Cameroon	3	850	1	526	0	
Central African Republic	2	1 640	1	1 740	0	
Chad	0		0	0	2	1 843
Congo	2	246	0		1	439
Democratic Rep Congo	3	283	5	6 855	2	866
Equatorial Guinea	0		0		0	0
Gabon	1	15	0	0	3	1 080
Total	**11**	**3 034**	**7**	**9 121**	**8**	**4 228**

Source: Ramsar 2002, UNDP and others 2000, UNESCO 2002

*Data not available for Sao Tome & Principe. *Some Biosphere Reserves may also be World Heritage Sites or Ramsar sites*

Offoué Reserves, where logging activities are affecting at least 50 per cent of the protected areas (IUCN, WWF & GTZ 2000).

Patrolling of reserves in the sub-region is also desperately under-resourced, with rates as low as one guard per 35 000 hectares in Congo (IUCN, WWF & GTZ 2000). Other constraints on management of protected areas include war and civil conflict, lack of an integrated management vision, high demand for bushmeat from urban areas and the international market, inadequate staff, equipment, and infrastructure for patrolling and enforcement of regulations, and inadequate involvement or exclusion of local communities in protected area management.

Steps towards rectifying this situation include projects implemented in conjunction with WWF to protect the Black Rhino in the northern savannas of Cameroon, and to create awareness and sustainable rates of bushmeat hunting in Gabon, by establishing quotas and using local people as patrol guards. Central African countries have also ratified the Convention on Biological Diversity, confirming their commitment to protecting biological resources. They have also formulated a sub-regional Plan of Convergence for Forests of Central Africa (Plan de Convergence) which was validated by the first Conference of Ministers in Charge of Forests at its December 2000 session. In the context of this sub-regional plan, each member country was to draw up its own emergency action plan (Plan d'Action d'Urgence) for the forestry sector. Institutional and legal frameworks for conservation have also been established—for example, the National Programme for Environmental Management (Programme National de Gestion de l'Environnement). National Environmental Action Plans (NEAPs), forestry laws, and environmental management laws are other measures that countries have introduced. National Biodiversity Strategies and Action Plans (NBSAPs) have also been developed for many Central African countries, and sub-regional initiatives such as Global Environment Facility (GEF) Biodiversity projects, the Ecosystèmes Forestiers d'Afrique Centrale (ECOFAC) programme, and the Central Africa Regional Program for the Environment (CARPE) have been launched. ECOFAC has been very active in assessment of biological resources, legislation pertaining to use of the resources, traditional methods of resource management, and in making recommendations for protection of various habitats under different types of management (such as recommendations for National Parks, Ramsar sites, and agro-forestry projects). CARPE is a long-term initiative funded by USAID and aimed at identifying the necessary conditions for reducing deforestation in the Congo Basin. This will be achieved through gathering of baseline information on the forest resources and threats to the ecosystem, establishing monitoring programmes, and building capacity amongst decision makers. To date a vast array of reports, maps, and briefing notes have been published.

Mayombe rainforest reserve, Congo

Michel Gunther/Still Pictures

WESTERN AFRICA

Habitat diversity in Western Africa ranges from semi-desert and savanna to tropical forests, mangroves, freshwater lakes and rivers, and inland and coastal wetlands. The Upper Guinea forest, which extends from western Ghana through Côte d'Ivoire, Liberia, and Guinea to Southern Sierra Leone, is a biologically unique system that is considered one of the world's priority conservation areas because of its high endemism (Conservation International, 1999). Nearly 2000 plants and over 41 mammals are endemic to the ecosystem. Species diversity is also high, with more than 20,000 butterfly and moth species, 15 species of even-toed ungulates, and 11 species of primates.

Ecological, economic and social values of biological resources in Western Africa

The richness of Western Africa's biological resources has constituted the basis of survival of the sub-region's indigenous societies. The local human populations have developed knowledge systems and practised traditions which have protected and conserved plants, animals, water resources and other components of their life support systems. In Ghana, sacred groves protect biodiversity in three different ways: by protecting particular ecosystems or habitats, by protecting particular animal or plant species, and by regulating the exploitation of natural resources (Ntiamoa-Baidu 1995). Many plant species are also used in Ghana in traditional herbal medicines (Mshana, Abbiw, Addae-Mensah, Adjanouhoun, Ahyi, Ekpere, Enow-Oroc, Gbile, Noamesi, Odei, Odunlami, Oteng-Yeboah, Sarpong & Tackie 2000), and the Kakum National Park in Ghana, with its canopy walkway, attracts thousands of visitors a year, helping to boost the economy as well as awareness of environmental issues.

Threats to biodiversity in Western Africa

Since the beginning of the last century, biological resources in Western Africa have been rapidly degraded and lost through practices such as large-scale clearing and burning of forest, overharvesting of plants and animals, indiscriminate use of persistent chemical pesticides, draining and filling of wetlands, destructive fishing practices, air pollution, and the conversion of protected lands to agricultural and urban development. These activities are the results of uncontrolled population growth and increasing poverty, as well as of economic policies and priorities. For example, economic pressures led to concessions being granted to foreign logging companies to exploit Western Africa's tropical moist forests and prices of cash crops, especially in the 1980s, resulted in clearing of large areas of natural habitat for agriculture. Benin, Côte d'Ivoire, Liberia, Mauritania, Niger, Nigeria, Sierra Leone, and Togo all have rates of deforestation of more than 2 per cent per year (FAO 2001). Remnants of forest vegetation are presently found in protected areas in coastal countries. The Upper Guinea forest extends over approximately 420 000 square kilometres, but estimates of existing forests suggest a loss of nearly 80 per cent of the original extent (Conservation International 1999). The remaining forest is highly fragmented and spread across national borders. The forest fragments that remain are under severe threat, mainly arising from slash-and-burn agriculture which accounts for much of the sub-region's subsistence food production.

Savannas are the dominant ecosystems in Western Africa after tropical forests. Like the forests, they also support extremely biologically diverse communities of animals and plants but persistent exploitation for food, fuelwood and other resources from the savanna has resulted in their widespread degradation. For example, the rich and extensive savanna vegetation found in the northern portions of the sub-region has been severely degraded with resultant loss of vegetation cover, fertile top soil and wild faunal species.

Political instability in Liberia, Sierra Leone, and Senegal, has created large numbers of refugees that add further pressure to the threatened forests through resettlement and subsistence agriculture. Political instability also creates economic distress indirectly in the sub-region, resulting in unsustainable resource use and lack of patrolling and enforcement of protection regulations.

Another major biodiversity issue in Western Africa is the loss and degradation of wetlands. Coastal and inland wetlands in Western Africa have been regarded as wastelands constituting habitats for pests and thus representing a threat to public health. As a result of this perception, wetlands in Western Africa have been under constant threat from development activities, especially agriculture and construction of harbours. Draining or in-filling of wetlands changes hydrological regimes so that they no longer provide suitable habitats for wildlife. Untreated effluents from domestic, commercial and industrial sources in nearby settlements have polluted coastal wetlands creating a toxicity risk for flora and fauna.

Rapid urbanization in coastal areas has created a number of very large cities in the sub-region, for example Lagos (Nigeria), Accra (Ghana) and Abidjan (Côte d'Ivoire). These cities surround major coastal wetlands some of which have been degraded by pollution and eutrophication to the extent that they have now become unsightly sources of odour and are biologically unproductive (IDRC 1996). Korle Lagoon in

Accra is one such example. Degradation of wetland ecosystem in the sub-region has also been attributed to extraction of woody material for fuel and charcoal production for domestic use and for curing of fish for the market. In Senegal, *Salvinia molesta* molesta (an invasive waterweed) appeared in the Djoudj Park and delta in 1999 and has since spread to a number of man-made lakes. This is a serious threat to the delta, which is a vital habitat for many migratory species.

Habitat loss is not the only threat to wildlife in Western Africa. The demand for bushmeat is driving high rates of poaching and an international trade in endangered species and wildlife products is also flourishing. A series of surveys of endangered primates in the forest reserves of Eastern Cote D'Ivoire and southern Ghana from 1993 to 1999 document the first recorded extinction of a widely recognized primate taxon, Miss Waldron's red colobus (*Procolobus badius waldroni*). Hunting rather than habitat loss is considered to be the primary cause (McGraw, Monah & Abedi-Lartey 1998, Oates, Abedi-Lartey, McGraw, Struhsaker & Whitesides 2000).

Drills (*Mandrillus leucophaeus*) (see Central Africa) are also found in the Cross River area of Nigeria (Gadsby & Jenkins 1998). Like the critically endangered Cross River Gorilla (*Gorilla gorilla diehli*), this species is found in an area which straddles the international border between Nigeria and Cameroon, as well as the sub-regional border between Western and Central Africa (Oates 2001)

Rural people in Western Africa depend heavily on medicinal plants for their health needs. However, as a result of extensive agricultural practices and annual bush fires, many medicinal plants have been lost at a time when conscious efforts are being made in many countries to promote herbal and traditional medicine.

Other species are threatened by a few invasive species of animals and plants. The Nypa palm, for example, is threatening mangrove forests in coastal Western Africa, and the bracken fern is encroaching on savanna ecosystems. Invasive plants such as these use up available water and nutrient resources and thus deprive native species and reduce biodiversity. The threatened species in Western Africa are shown in Table 2b.15.

Table 2b.15 Threatened species in Western Africa, 2000

Country	Mammals	Birds	Reptiles	Amphibians	Fishes	Inverts	Plants	Total
Benin	7	2	1	0	0	0	11	21
Burkina Faso	7	2	1	0	0	0	2	12
Cape Verde	3	2	0	0	1	0	2	8
Côte d'Ivoire	17	12	2	1	0	1	101	134
Gambia	3	2	1	0	1	0	3	10
Ghana	13	8	2	0	0	0	115	138
Guinea	11	10	1	1	0	3	21	47
Guinea Bissau	2	0	1	0	1	1	4	9
Liberia	16	11	2	0	0	2	46	77
Mali	13	4	1	0	1	0	6	25
Mauritania	13	2	2	0	0	0	0	20
Niger	11	3	0	0	0	1	2	17
Nigeria	25	9	2	0	2	1	119	158
Senegal	11	4	6	0	1	0	7	29
Sierra Leone	11	10	3	0	0	4	43	71
Togo	9	0	2	0	0	0	9	20

Source: IUCN 2000a

Towards sustainable management and conservation of biodiversity in Western Africa

The countries of Western Africa have responded to the problems of habitat loss by placing natural areas under protection. However, the number and size of protected areas in Western Africa varies from country to country (see Table 2b.16). In 1999, Burkina Faso and Senegal had over 10 per cent of their land area under national protection, whereas in Guinea and Guinea-Bissau this was less than one per cent, although they do have marine protected areas (World Bank 2001a).

International efforts to conserve natural habitats have been very successful in Western Africa, mainly as a result of ratification of the Ramsar Convention, and the Convention on Biological Diversity. There are 15 Biosphere Reserves in the sub-region, 10 World Heritage Sites, and 37 Ramsar sites (see Table 2b.17).

Nearly all countries within the sub-region are signatories to the Convention on Biological Diversity, and the Ramsar Convention, and many have drawn up programmes and projects under these agreements. Capacity development activities are also underway, under the aegis of new institutions created to coordinate and implement them. Most notable in this area has been GEF support for biodiversity programmes and projects in the sub-region. Western Africa was the principal African recipient of GEF biodiversity funding by mid-1998, with emphasis on coastal, marine and fresh water ecosystems.

In the arid and semi-arid areas of the sub-region, emphasis is on plant genetic resources, protected area management and capacity building. At the country level, relevant legal instruments have been enacted to protect and conserve biological diversity, especially forests, fauna and wetlands. However, these are largely out of date and too under-resourced to be implemented satisfactorily. More recently, National Action Plans and Conservation Strategies for the environment in general, and for forests, wildlife and biodiversity in particular, have been formulated and implemented with external funding. For example, Sierra Leone began implementation of its Biodiversity Strategy and Action Plan in December 2001, and its government has embarked on a joint programme with an NGO, the Conservation Society of Sierra Leone, as a partnership for sustainable Biodiversity Management.

Western African states nevertheless face several obstacles to implementation, including financial and human resource constraints, lack of awareness among the general public and among decision-makers, inadequate legal structures at the national level, and ineffective cooperation between countries in the sub-region. It is critical that these efforts be strengthened and that they become sustainable, financially as well as environmentally. Developing policies with donor funds is a step in the right direction, but funding streams need to be established to ensure implementation of policies and enforcement of regulations.

In Côte d'Ivoire, the Taï National Park, a large tract of undisturbed rainforest, is a World Heritage Site but is nevertheless threatened by slash-and-burn agriculture, poaching, and illegal logging and mining activities. A long-term management plan has recently been developed for the area, by WWF in conjunction with local people, and is currently being implemented. The Gashka Gumpti National Park, in Nigeria, encompasses

Table 2b.16 Nationally protected areas in Western Africa

	Terrestrial			Marine
Country	***Number***	***Area (000 ha)***	***% land area***	***Number***
Benin	2	778	6.9	
Burkina Faso	12	2 855	10.4	1
Côte d'Ivoire	11	1 986	6.2	3
Gambia	6	23	2.0	5
Ghana	10	1 104	4.6	
Guinea	3	164	0.7	1
Guinea Bissau	0	0	0.0	2
Liberia	1	129	1.2	
Mali	13	4 532	3.7	
Mauritania	9	1 746	1.7	5
Niger	6	9 694	7.7	
Nigeria	27	3 021	3.3	
Senegal	12	2 181	11.1	7
Sierra Leone	2	82	1.1	
Togo	9	429	7.6	1
Total	**123**	**28 724**	**68.2**	**25**

Source World Bank 2001a

Data not available for Cape Verde

Table 2b.17 Internationally protected areas in Western Africa

Country	Biosphere Reserves*		World Heritage Sites		Ramsar Sites	
	Number	*Area (000 ha)*	*Number*	*Area (000 ha)*	*Number*	*Area (000 ha)*
Benin	1	623	0	0	2	139
Burkina Faso	1	186	0	0	3	299
Côte d'Ivoire	2	1 480	3	1 504	1	19
Gambia	0		0	0	1	20
Ghana	1	8	0	0	6	178
Guinea	2	133	1	13	6	225
Guinea Bissau	1	110	0	0	1	39
Liberia	0		0	0	0	0
Mali	1	2 349	1	400	3	162
Mauritania	0		1	1 200	2	1 231
Niger	2	25 128	2	7 957	4	715
Nigeria	1	<1	0	0	1	58
Senegal	3	1 094	2	929	4	100
Sierra Leone	0		0	0	1	295
Togo	0		0	0	2	194
Total	**15**	**31 111**	**10**	**12 003**	**37**	**3 674**

Source: Ramsar 2002, UNDP and others 2000, UNESCO 2002

*Data not available for Cape Verde. *Some Biosphere Reserves are also World Heritage Sites or Ramsar sites.*

a range of habitats across a range of altitudes from 450 to 4000 m. Chimpanzees are among the threatened species that survive in the forests. The Nigerian Conservation Foundation and WWF are developing a plan to promote tourism in the park, stimulating the economy through conservation efforts. The Drill Rehabilitation and Breeding Centre (DRBC) in Calabar, Nigeria, was set up in cooperation with the Cross River State Ministry of Agriculture, Forestry Department and Cross River National Park. This is the only purpose-built in-situ captive-breeding programme for an endangered African primate. The programme is achieving a high rate of live births and successful rearing of offspring. In May 2000, the Afi Mountain Wildlife Sanctuary was 'gazetted' (i.e. legally protected) and will protect one of the Nigerian populations of the Cross River Gorilla as well as drills, chimpanzees and other primate species. It also houses a new facility for the DRBC. The DRBC is also conducting community outreach programmes to bolster support for conservation activities within the community (Gadsby & Jenkins 1998, Oates 2001).

Traditional protection and conservation beliefs and practices have always existed in all countries in the sub-region, but some of them have been eclipsed by modern activities. However, African countries are now realizing the importance of documenting knowledge and implementing traditional practices. The United Nations University Institute for Natural Resources in Africa (Accra, Ghana) has, for example, initiated a project to catalogue local indigenous plants that are useful as food and for pharmaceuticals, and to promote homestead gardens (Baidu-Forson 1999). Also in Ghana, the traditional grove system has been re-introduced into conservation models, enhancing biodiversity while sustainably using the resources in surrounding buffer zones of the grove (Oteng-Yeboah 1996).

Actions at the local level include a project in Ghana to support the conservation and sustainable use of

Traditional knowledge and practices must be re-incorporated into regional conservation strategies, and communities and commercial companies must be provided with alternative resources or means of production. Simply excluding activities from one area intensifies the pressure on other areas and resources

medicinal plants. The main aims of the project are to establish and document base-line data, build capacity and raise awareness, and relieve the pressure from harvesting of these plants in the wild. Plans are in place to establish a working example of a medicinal plant garden, and to provide training to promote others across Ghana to help people to become able to manage their own medicinal garden businesses. The World Bank's Indigenous Knowledge for Africa Programme has encouraged research and promotion of the role of traditional hunters in natural resource management in Burkina Faso (World Bank 2001b). In Mauritania, WWF has supported the Banc d'Arguin National Park (a World Heritage Site) by assisting local communities and park officials to improve patrolling and control illegal fishing.

CONCLUSION

The range of climatic conditions and geomorphology found in Africa has created a wide diversity of habitats, which various species of flora and fauna have evolved to exploit. As a result, the region is exceedingly well endowed with diverse biological resources. The forests of Africa are particularly diverse and support many millions of Africans by providing them with food, clothing and construction materials, medicinal products, and cultural and recreational facilities. However, in many cases the value of these resources is undetermined because they are not traded on the open market. Other products, such as timber are commercially traded and make substantial contributions to GDPs. Studies have estimated the value of biological resources to be millions of dollars every year.

Africa's biodiversity has been subjected to increasing pressures of habitat loss (through conversion of natural habitats to urban, industrial or agricultural uses), overharvesting (due to increasing population and rising consumption levels), pollution (from urban and industrial sources), and the introduction of alien species (which dominate and alter habitat conditions). These pressures are set to continue and intensify over the next decade or two because of rapid population growth and extensive use of natural resources in most economic activities. At the root of this, however, is a lack of proper valuation of natural resources. In many cases, resources are not perceived to be limited and are therefore consumed as if they were 'free', rather than being consumed sustainably, i.e. leaving sufficient resources in the system to regenerate or reproduce and thus ensure a continued supply.

Traditionally, African societies recognized the importance of biological resources, and employed traditional conservation measures. Under colonial administrations the perceived solution to habitat loss was to declare nationally protected areas and ban all or most activities. The current rate of species extinctions all across the Africa region testifies that this approach is insufficient. Traditional knowledge and practices must be re-incorporated into regional conservation strategies, and communities and commercial companies must be provided with alternative resources or means of production. Simply excluding activities from one area intensifies the pressure on other areas and resources. Community conservation, or community based natural resource management can take a variety of forms, and presents a range of options. It is likely to be more successful where care has been taken to understand the situation faced by each community, and to apply a strategy that best fits the circumstances (Adams & Hulme 2001). Ratification of international conventions and establishment of regional action plans is a measure of political commitment to resolving these issues, but needs to be supported with human and financial resources not just to comply with obligations, but to implement activities and projects at the national and sub-national level. It is important to take into account the inequalities and local costs that form the basis for losses of biodiversity, and to avoid the temptation of trying to rely entirely on free-market economics (Western 2001) Win-win situations must be developed in order to sustain livelihoods and economies while retaining a biological resource base which is intact and functioning properly.

Many of the most valuable biodiversity resources extend beyond national or sub-regional borders. In order to avoid conflicts, and to manage and use these resources sustainably, African countries and sub-regional groupings must cooperate in devising policies, programmes and projects that harmonize biodiversity management and conservation throughout ecologically determined regions. This calls for a sustained effort on regional integration of environmental management.

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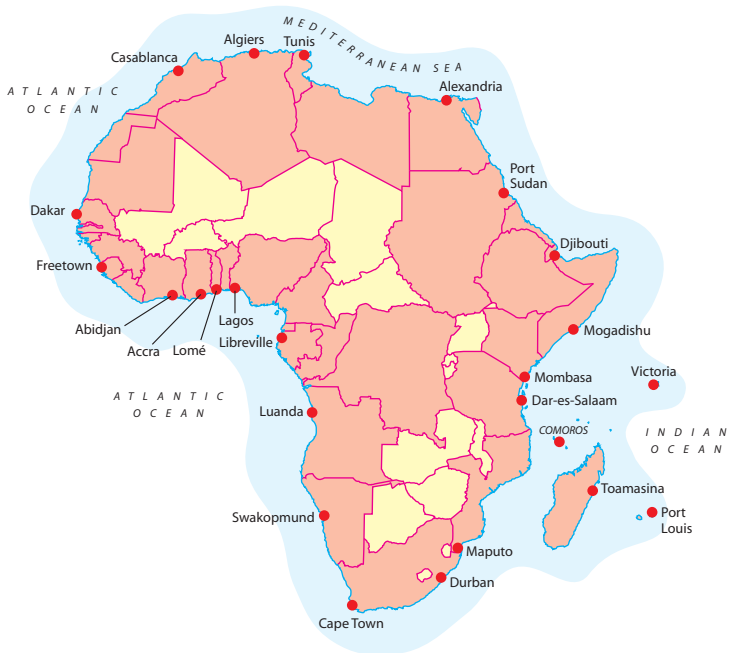
PART C: COASTAL AND MARINE ENVIRONMENTS

REGIONAL OVERVIEW

There are various definitions of the geographical, legal and functional scope of a coastal zone. According to Clark (1996), *'at a minimum, the designated coastal zone includes all the inter-tidal and supra-tidal areas of the water's edge; specifically all the coastal floodplains, mangroves, marshes and tide-flats as well as beaches and dunes and fringing coral reefs.'* Africa's 40 000 km coast consists of a narrow, low-lying coastal belt which, as shown in Figure 2c.1, includes the continental shelf and coasts of 32 mainland countries.

Coastal ecosystems and issues relating to management of the coast often cross political boundaries and frequently extend inland. Similarly, the boundaries of marine ecosystems do not necessarily correspond with those of Exclusive Economic Zones (EEZ)—the 200 nautical-mile zones from the land edge of coastal states where they have sovereign rights over natural resources and over certain economic activities. Discussion of issues affecting the coastal environment may therefore extend beyond country borders or over more than one sub-region. There may therefore be some overlap in the analyses presented here.

Figure 2c.1: Map of Africa showing coastal countries, cities, and EEZ



Economic, social and ecological value of coastal and marine environments

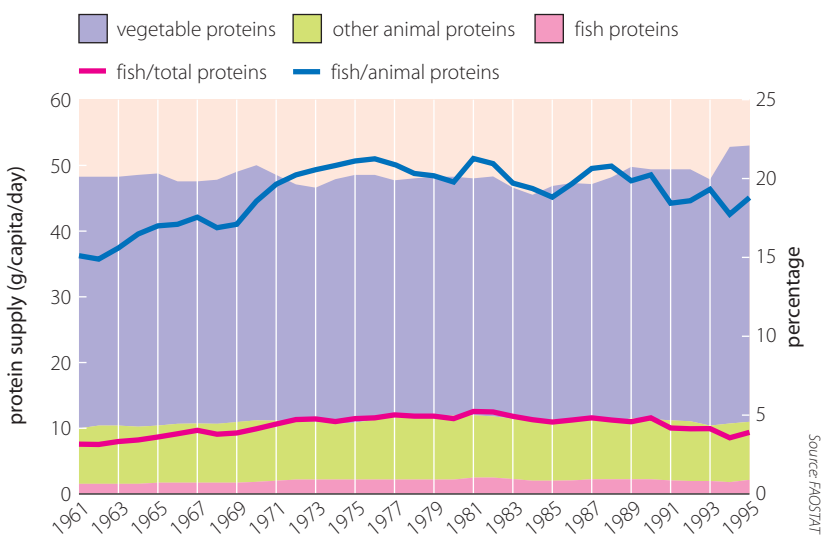
Coastal ecosystems are some of the most biologically productive in the world, occupying only 8 per cent of the earth's surface but accounting for 26 per cent of all biological productivity (Hare 1994). These high productivity rates result from the extreme climatic and physical conditions of coasts, and the dynamic nature of the forces acting on these zones. Opportunistic organisms have adapted to these conditions and their rapid rates of growth and reproduction when conditions are favourable have led to high productivity rates.

The African coastal zone supports a diversity of habitats and resources encompassing mangroves, rocky shores, sandy beaches, deltas, estuaries and coastal wetlands, coral reefs and lagoons. Coral reefs and mangroves are especially important features because they protect the coastline by moderating storm and wave impacts and because mangroves stabilize sand and soils, cycle nutrients, absorb and break down waste products, provide wildlife habitat, and maintain biodiversity. Reefs and mangroves also contribute significantly to the economies of coastal countries by providing opportunities for tourism and for harvesting of resources. For example, mangrove species are used extensively by local communities for construction material, fuel, food and animal fodder, and for medicinal preparations. Mangroves extend from Senegal to Angola on Africa's west coast and from Somalia to South Africa on the east coast. Coral reefs—some of them spectacular—are abundant in the Red Sea and the Western Indian Ocean.

Periodic upwelling in African waters encourages diverse and rich production in fisheries, including crustaceans, fish, and molluscs. In 1997, total marine fish catch exports from Africa contributed US$445 million to countries' economies (FAOSTAT 2001). Fisheries in estuaries and lagoons also contribute to national economies, accounting for over three-quarters of fishery landings in Africa (IPCC 1998). Fisheries also provide significant amounts of employment, particularly in small islands such as Cape Verde and Seychelles where more than one-third of agricultural workers are employed in the fisheries sector (FAO 1996). Artisanal fishing activities are also an important source of income for coastal communities and fish is an important source of protein for many African populations, as shown in Figure 2c.2.

Oil and gas reserves and other mineral deposits, including diamonds off the western and south-western African coast, are additional important economic resources for coastal countries. For example, in Benin, Ghana, Nigeria, Sierra Leone and Togo the majority of industries and oil and mineral mining activities are located in the coastal zone.

Figure 2c.2 Contribution of fish to the African diet



The ports of Mombasa, Maputo and Durban are also major trade centres. Industrial development has expanded in the neighbouring areas to take advantage of opportunities for trade, tourism and other commercial activities opened up by the ports.

The highly attractive and diverse resources of the coastal and marine environments mean that coastal areas in Africa (as elsewhere in the world) are experiencing rapid population growth, industrial expansion and infrastructure development. Most colonial settlements in Africa were established along the coast in order to maximize trade opportunities and this has resulted in all but three of African countries from Mauritania to Namibia having their capital cities on the coast. A large proportion of Western Africa's urban population also now lives in coastal cities. The exceptional demand for resources and infrastructure development in the coastal zone is putting pressure on fragile ecosystems and 38 per cent of Africa's coastal ecosystems are under severe threat from development-related activities (FAO 1998). The major challenges facing coastal African countries at present are coastal erosion, the potential impacts of climate change, overharvesting of resources and pollution. Although the causes of coastal erosion and climate change are entirely different the effects of climate change are so frequently and so firmly interlinked with those of erosion that they are described in the same sections in the following analyses.

Coastal erosion and climate change

Erosion and deposition are natural and dynamic processes occurring in coastal zones throughout the world. However, certain human activities, both inland and in the coastal zone itself can change patterns of erosion and deposition and thus place a burden on the adaptive capacity of coastal ecosystems and pose a challenge to effective coastal management. Human activities including conversion of natural coastal habitats such as wetlands and mangroves to urban or agricultural uses lead to their loss or modification. For example, it is estimated that about 40 per cent of Nigeria's mangroves had been lost by 1980 as a result of clearing for development, coastal erosion, and increased salinity (WRI 1990). When such ecosystems are reduced, the natural buffer they provide against wave action and storm surges is compromised, resulting in increased erosion and worsened impacts of flooding.

Mining of coastal resources such as coral and sand also contributes to erosion by disturbing the surface and exposing the substrate to rain, rivers and wave action. Mining of coral to provide stone for construction means that the protection the coral normally gives to the shoreline is lost, and land recession results.

Damming of rivers further inland forces sediments to settle upstream allowing fewer sediments to reach the river mouth. This increases the river's scouring potential leading to higher rates of erosion in the coastal zone. For example, damming of rivers in Western Africa has accelerated rates of coastal erosion and these have now reached as much as 30 m/yr (Chidi Ibe & Quelennac 1989). Damming of the Nile River at Aswan reduced the nutrient load reaching the Nile Delta and this reduced sardine fishery catches from 22 618 million tonnes in 1968 to only 13 450 million tonnes in 1980, with rates still falling. Although the reservoir behind the dam created new fishing opportunities, there are doubts as to the sustainability of harvesting of these resources and many coastal communities have lost their livelihood. (Acreman 1999). Sedimentation in ports and harbours can also interfere with activities, and dredging is costly.

Sea level rises resulting from global climate change will exert additional pressures on the coastal zone, causing inundation of low-lying areas, erosion of infrastructure, displacement of populations, and contamination of freshwater sources. According to the Intergovernmental Panel on Climate Change (IPCC), the average global sea level has risen by 1–2 mm per year during the last century. The most likely cause of this is expansion of seawater and widespread loss of land ice caused by higher mean global temperatures. The IPCC also predicts that, by 2100, the global sea level could rise by up to one metre (IPCC 2001a). The consequent flooding, and changes in salinity, wave conditions and ocean circulation will put natural habitats and human settlements at risk of flooding and accelerated erosion. The extent and severity of the impacts of storms will also increase as a result of further climatic changes, and because the buffering capacity of coral reefs and mangrove systems will have been lost. Human settlements and economic activities in the Gulf of Guinea, Senegal, Gambia, Egypt, and along the eastern

Damming of the Nile River at Aswan reduced the nutrient load reaching the Nile Delta and this reduced sardine fishery catches from 22 618 million tonnes in 1968 to only 13 450 million tonnes in 1980, with rates still falling

African coast, including the Western Indian Ocean, are likely to be most severely affected (IPCC 2001b). Some of these countries may be unable to cope with the financial and technical burden of implementation of mitigation measures (Leatherman & Nicholls 1995).

In addition to sea level rise, sea-surface temperatures in the open tropical oceans surrounding Africa are predicted to rise by about 0.6–0.8 °C (less than the global average). This may increase the frequency and intensity of tropical cyclones and result in bleaching of coral that will impact on the economies of countries on the eastern African coast, of the Western Indian Ocean Islands, and of the countries of the Red Sea.

Mitigation of coastal erosion

African countries have promulgated laws and regulations requiring environmental impact studies to be carried out before development in coastal zones or hinterlands, thus regulating change of land use and expansion of human activities. Countries that have taken such action include Egypt, Gambia, Ghana, Kenya, Mauritius, Nigeria, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. Short-term measures against coastal erosion include the construction of physical barriers such as sea walls and groynes, although these are expensive and require constant maintenance.

In addition, many African countries are adopting more integrated environmental management strategies, based on ecological management units rather than political boundaries. A holistic management approach improves the integration of different resource-use objectives and reduces competition between user groups. Coastal erosion is therefore being tackled in some countries through improved water catchment management, more conservative agricultural practices, and soil conservation programmes.

Integrated Coastal Zone Management (ICZM), discussed more fully below, is a holistic approach that has been adopted widely within Africa's coastal zone to help to reduce the causes and impacts of coastal erosion. Sub-regional and regional cooperative programmes and action plans (such as UNEP's Regional Seas Programme) provide the framework and necessary capacity building for implementation of ICZM at the national level. If the state of coastal and marine ecosystems and the sustainability of commercial and subsistence activities dependent on them are to be improved, continued support for such programmes is necessary, in the form of trained staff, finance, equipment for policy implementation, research, monitoring, and enforcement of regulations.

Harvesting of coastal and marine resources

Marine and coastal fishery resources are extremely important in Africa, both to national economies and to the livelihoods of local communities. In the late 1990s, fishing contributed over 5 per cent to GDP in Ghana, Madagascar, Mali, Mauritania, Mozambique, Namibia, Senegal, and Seychelles, and the shrimp fishery on the Sofala Bank in Mozambique contributed 40 per cent of Mozambique's foreign exchange (FAO 1997). From 1973 to 1990, fish supplied an average 20 per cent of the animal-protein intake of the population in sub-Saharan Africa (FAO 1996). Improvements in refrigeration and transport technologies have increased the availability of fish and shellfish to inland population centres and to international markets and this has pushed up prices, especially for species such as lobster and prawns. Population increases, both inland and in coastal centres, have also contributed to increasing demand for fish and seafood. In addition, technological developments in commercial boats and nets and in fishing techniques over the past 30–40 years have increased the potential volume of fish catches and contributed to depletion of fish stocks (Chenje & Johnson 1996). According to the most recent data from the FAO, exploitation of fish stocks increased between 1974 and 1999, by which time at least 70 per cent of fish stocks worldwide were considered fully or overexploited (FAO 2000). Figure 2c.3 shows the fish catch from African waters in the 1972–2002 period.

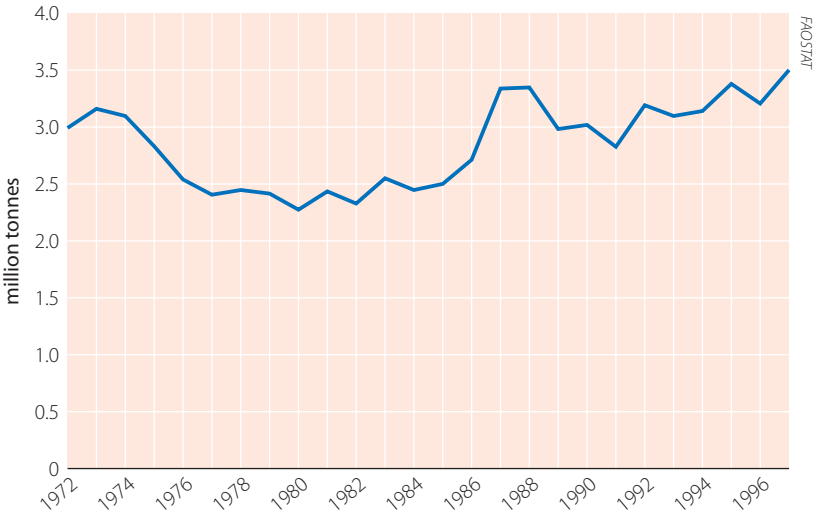
Certain methods of harvesting can also be destructive and a cause of depletion of marine and coastal resources. For example, dynamite fishing is still practised in the coastal zone of Eastern Africa where it damages coral reefs and has resulted in declines in the fisheries in these areas. The practice has, however, been eliminated from some protected marine areas, thanks to good conservation and educational measures (WWF

2001a). Bottom trawling is also a destructive method which disturbs benthic (seabed) communities and drags up accumulated material such as sand, rocks, plants and non-target animal species, all of which are regarded as waste and are dumped elsewhere.

Overfishing by foreign fleets is another significant factor in the decline of African fish stocks, particularly along the west African coast. For example, the European Union (EU) pays around US$234 million in subsidies for EU boats to have access to Mauritanian waters (WWF 2001b). African governments originally saw fishing by foreign fleets as an easy means of earning foreign exchange, but overfishing has made it a serious threat which depletes fish stocks and forces local small-scale fishermen to endanger their lives by fishing further and further out to sea, or to fish in protected areas such as marine national parks. The impacts of overharvesting of fishery resources include the suppression of local livelihoods, reduced capacity to meet food requirements and reduced potential for economic returns on exports. Over the past 30 years, availability of fish per capita in Africa as a whole has declined and, in some countries (e.g. Ghana and Liberia), the average diet contained less fish protein in the 1990s than it did during the 1970s (FAO 2000).

An outlook study over the next ten years predicts that local supplies of fish may continue to decline in Africa (FAO 2000). The reasons for this include lack of resources for enforcing controls on fishing in overexploited multi-species fisheries, particularly those exploited by numerous companies from all over the world. In addition, any aquaculture developments are likely to focus on high-value products and, therefore, concentrate mainly on export markets.

Figure 2c.3 Marine fish catch for African coastal countries, 1972–97

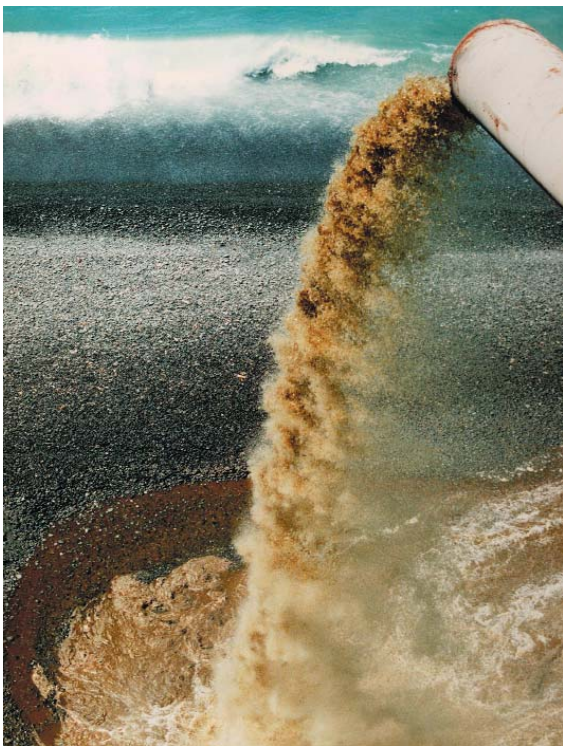


Sustainable harvesting of coastal and marine resources

Declining catches, together with a decrease in the mean sizes of fish caught, have led to calls for the protection of line fish stocks in some African countries. Management measures have been introduced including minimum size limits, bag limits, use of appropriate fishing gear, and closed seasons.

International agreements—between African countries and between African and European or other international fisheries—also have an important role to play in attaining sustainable harvesting of coastal and marine resources. For example, the 1982 United Nations Convention on the Law of the Sea (UNCLOS)—which came into force in 1994—defines world coastal boundaries, development rights, the extent of EEZs, and covers research and policing issues. Thirty-six African countries have signed the Convention, and are thus obliged to protect and preserve the marine environment by cooperating regionally and internationally, and to adopt policies and regulations to deal with land-based sources of marine pollution. Many of the provisions of the Convention are legally binding and an international tribunal has been established to resolve disputes over resources in international waters.

In spite of such agreements, African countries are still experiencing exploitation of their resources by foreign fishing fleets. For example, the large stocks of small pelagic (open sea) species off the north-west and south-west coasts could be harvested at a low cost and could constitute an adequate replacement in local African diets for the exported high-value products. Countries along the Gulf of Guinea should develop joint strategies with countries in north-west and south-west Africa to exploit these stocks as a source of cheap and nutritious fish for local consumers. Existing regional fishery management organizations would provide an institutional mechanism for coordinating national policies in this area.



Uncontrolled discharge into coastal waters

UNEP

Pollution of Africa's coastal and marine environment

Africa's coastal and marine ecosystems are under extreme pressure from pollution from both land-based and marine-based sources. Among these are uncontrolled discharges of industrial waste and sewage from coastal settlements, refuse blown or washed out to sea from formal or informal rubbish dumps, general and toxic wastes deliberately dumped at sea, and oil spills and leaks. Effluents from fish processing plants and industries located in the coastal zone are frequently discharged directly into the sea or into surrounding watercourses and wetlands, from where contaminants are washed out to sea. This practice has been driven by lack of affordable alternative disposal facilities, often because the rate of industrial development in the coastal zone has outstripped rates of infrastructure provision or because industries consider the tariffs for waste disposal to be too high. Residues of fertilizers are also washed down in rivers and contribute to eutrophication of coastal waters and the development of algal blooms and toxic red tides.

In densely populated urban centres, domestic sewage is sometimes discharged directly or indirectly into the sea. This is due to the pressures of tourism and population growth and a demand for infrastructure in the coastal zone which exceeds the capacity of local authorities to supply adequate sanitation and treatment of wastes. Solid domestic waste can also be blown or washed out to sea or onto beaches when waste collection, treatment and disposal services are inadequate.

The impacts of coastal and marine pollution are widespread and affect natural habitats, human communities and economic activities. For example, contamination of shellfish through red tides, heavy metals in industrial effluents or accumulation of toxic organic compounds can result in severe economic losses. Pollution of coastal waters by sewage can expose local communities and tourists to cholera, typhoid, and hepatitis. Solid waste washed up on the shore is unsightly and a health hazard (especially sharp objects and toxic substances), and may have a deterrent effect on tourists. At sea, solid waste, especially plastics, can be mistaken for food items by dolphins, turtles, seals and sea birds. These creatures are also at risk from entanglement and poisoning from solid wastes.

The waters around Africa are major transportation routes for oil and there have been many serious accidents in recent years, including the break up of the Apollo Sea in 1994, and the Treasure in 2000, both off the Cape of Good Hope. Oil spills resulting from such accidents smother plants and animals and break down thermal insulation in sea birds and mammals. Soluble organic compounds from the spilled products get into the food web where they are toxic to wildlife and can cause behavioural changes, physiological damage or reproductive failure. Clean up and subsequent disposal of oily wastes is difficult and extremely expensive. In response to this, national and regional oil spill contingency plans have been established in many parts of Africa. However, it is not just oil spills that are a problem. Oil tankers frequently empty ballast and wash engines on the high seas and residues of degraded oil are consolidated and washed onto the shores by wind,

currents and waves, resulting in tar balls. Added to this are leaks from oil drilling activities, port handling of oil and petroleum products and refineries located in coastal zones, and leaks from barges, tankers, pleasure craft and fishing boats.

Enhancing coastal and marine environmental quality

Responses to marine and coastal pollution include the ratification and national implementation of international agreements such as the Convention for the Prevention of Pollution from Ships (MARPOL), the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention), the Barcelona Convention's Mediterranean Action Plan, the Nairobi Convention, designed to ensure that resource development in Eastern Africa's coastal zone is in harmony with the maintenance of environmental quality, and the Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan Convention). Whilst some conventions have been implemented with significant success to date, others have experienced delays in ratification and have received inadequate human-resource and financial support. The Nairobi Convention, for example, was signed in 1985 but only came into force in 1996. Difficulties in monitoring and enforcement of penalties for non-compliance have also been experienced, mainly because of the extensive territories requiring policing and lack of efficient surveillance systems. The governments of Africa have embarked on an African process for development and management of the coastal areas and are now committed to strengthening and reviewing the Abidjan and Nairobi Conventions. Public health legislation and municipal cleaning of coastal areas are additional responses from some governments of coastal African countries.

Integrated Coastal Zone Management

Integrated Coastal Zone Management (ICZM) is a holistic management approach which considers not just individual resources but the entire coastal and marine environment, and thereby aims to overcome the fragmentation inherent in the sectoral management approach. It has become a popular mechanism for national implementation of regionally accepted

Traditional small-scale fishing in the Comoros

Roland Seitre/Still Pictures

management objectives and is intended to overcome the diverse nature and distribution of resources, the complex activities and sources of environmental degradation, and competition for access and use of resources between user groups. ICZM has been defined as '*a continuous and dynamic process by which decisions are taken for the sustainable use, development, and protection of coastal and marine areas and resources*' (Cicin-Sain & Knecht 1998). By recognizing the relationships between different elements of the environments and the impacts of multiple uses and pressures, sustainable harvesting levels and patterns of non-consumptive use can be achieved and maintained. According to Agenda 21 (Chapter 17), ICZM programmes should be designed to:

- identify existing and projected uses of coastal areas with a focus on their interactions and interdependencies;
- concentrate on well-defined issues;
- apply preventive and precautionary approaches in project planning and implementation, including prior assessment and systematic observation of the impacts of major projects;
- promote the development and application of methods such as natural resource and

environmental accounting that reflect changes in value resulting from uses of coastal and marine areas;

- provide access for concerned individuals, groups and organizations to relevant information and opportunities for consultation and participation in planning and decision-making.

Towards ICZM in Africa

During the last decade, the international community has recognized the intensity and complexity of pressures on coastal and marine environments and has demonstrated a commitment to more integrated management. An important step in this direction was the 1995 Washington Declaration in which 110 government recognized the importance of integrated management of coastal zones and adopted the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA).

UNEP was tasked with coordination of the GPA which is designed as a global framework and source of practical guidance for devising and implementing sustained action to prevent, reduce, control and/or eliminate marine degradation from land-based activities. Specific aims of the GPA are to identify and assess problems relating to the coastal and marine environments, establish priorities for action, set management objectives for tackling these priority issues, develop strategies to achieve these objectives, and evaluate the effectiveness of the strategies. The GPA will be implemented through UNEP's Regional Seas Programme which provides support to regions in implementing its objectives and in building capacity for sustained implementation.

The Regional Seas Programme was initiated by UNEP in 1974 and has been repeatedly endorsed as a regional approach to the control of marine pollution and the management of marine and coastal resources. In Africa, there are Regional Seas Programmes for Eastern Africa (encompassing Comoros, France (La Reunion), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and the United Republic of Tanzania), the Mediterranean (encompassing the African states of Algeria, Egypt, Libya, Morocco, and Tunisia, as well as many European states) the Red Sea and Gulf of Aden (encompassing the African states of Djibouti, Sudan and Somalia), and for Western and Central Africa (encompassing Angola, Benin, Cameroon, Cape Verde, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, Namibia, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, Togo and Congo). Action plans have been developed under each of these programmes, as well as conventions and protocols for implementation of regional objectives at the national level.

Many African governments have realized the benefits of ICZM and have enacted policies and legislation to put its principles into effect. However, sustained resourcing (i.e. financial support, equipment, training of personnel, and monitoring of activities) is required to achieve maximum benefits to the coastal and marine environments and the economies that depend on them.

NORTHERN AFRICA

The main issues of concern in the coastal zones of Northern Africa are the effects of rapidly developing tourism and industrial activities along the coast combined with rapid population growth (UNEP 1997). These pressures are beginning to have impacts on the quality and stability of the physical and biological coastal environment. There are also serious concerns over the potential impacts of climate change, particularly the vulnerability of coastal settlements and natural habitats to sea level rise and saltwater intrusion.

Economic, social and ecological value of coastal and marine environments in Northern Africa

The marine and coastal zones of Northern Africa support tourism, fishing, and petroleum industries. The significant onshore and offshore oil and gas deposits in the sub-region are the mainstays of countries' economies, providing opportunities for export and employment.

Coral reefs are widely spread and well developed in the Red Sea, with 194 species of coral and at least 450 common reef-associated species. These are also some of the most northerly located coral reefs, and have many endemic species

Mangroves are found along the southern Red Sea coast, and are important sources of molluscs, crabs,

shrimp, fish, and raw materials for construction, animal fodder, and fuel. They are also important nesting sites for migratory waterbirds. Sea grasses are also fairly common along the southern Red Sea, and rare or protected species such as turtles and dugongs add to the species richness and diversity that attracts an estimated one million tourists per year to the region (UNEP 1997).

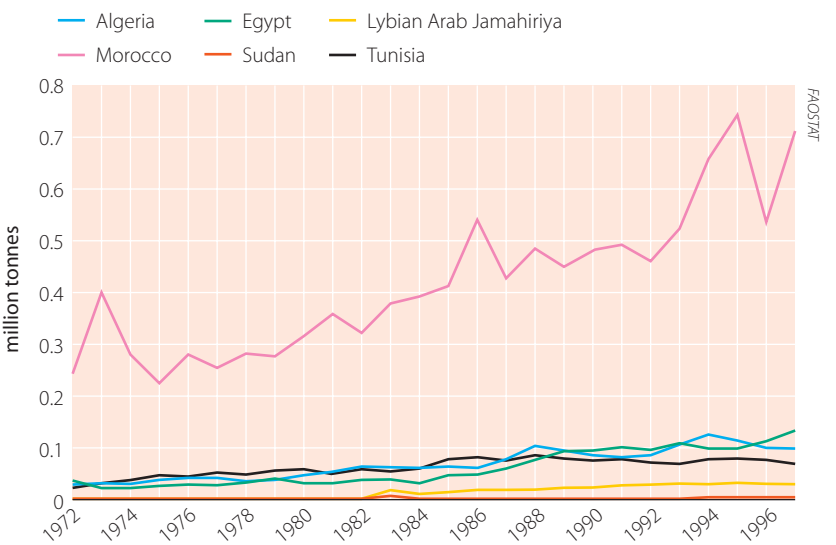
Northern Africa also has economically important marine fisheries from which total catches increased from 845 211 tonnes in 1990 to 1.1 million tonnes in 1997, an increase of about 30 per cent (FAOSTAT 2001). The trend in marine fish catches in the Northern Africa sub-region over the past 30 years is shown in Figure 2c.4.

Although fishing activity has increased in the Mediterranean over the years, its fisheries are not showing signs of overexploitation. In fact, surprisingly—as the demand for fisheries products is growing and as most countries lack formal and coordinated fisheries management—there has been an increase in production for all major species (FAO 1997).

Mediterranean states are party to the FAO's General Fisheries Council for the Mediterranean, but this is largely ineffectual and fishing by commercial fleets is virtually unregulated. At the 22nd session of the Council, member states were urged to negotiate and implement an effective management regime based on the precautionary principle and reflecting the underlying tenets of important international initiatives (WWF 1997). Artisanal fishery resources are also important in the Mediterranean and Red Seas. Shallow water species such as butterfly fish and damselfish are most common, although the area also supports rock lobster, cuttlefish, shrimp, and sea cucumber.

More than 40 per cent of the Mediterranean area's population live in coastal zones (UNEP 1996), with the greatest densities along the Nile Delta and Algerian coast (up to 500–1000 inhabitants/km^2 in some areas) (Blue Plan 1996). Urbanization in coastal north-west Africa has been driven mainly by oil discoveries and increased industrialization in or near the coastal areas and the associated new economic opportunities. This has led to an almost complete transformation of north-west African society and gradually increasing pressures on coastal areas.

Figure 2c.4 Trends in marine fish catch for Northern Africa, 1972–97



Coastal erosion and climate change in Northern Africa

Most lowland coastal areas in Northern Africa, especially deltas and islands, are subjected to slow tectonic subsidence that will accentuate the effects of the rise in sea level predicted as a result of climate change. For example, lowlands in Libya stretch along the Gulf of Sirte where there is an important oil shipment facility and, in Tunisia, lowlands are of great economic value for agriculture, urbanization, harbours, industry, and tourism. These would all experience accelerated coastal erosion and inundation of land. It is, however, the deltaic plain of the Nile River, the most important coastal lowland of the Mediterranean shoreline, that is expected to suffer the greatest losses. A one-metre rise in sea level would inundate 2 000 km^2 of land in the lower Nile Delta area and render 1 000 km^2 of agricultural land unusable. The costs of this are estimated at US$750 million (Khafagy, Hulsbergen & Baarse 1992). If erosion is taken into account, an additional 100 km^2 of land would be lost, at a cost of US$60 million (Khafagy and others 1992).

The Egyptian city of Alexandria would be severely affected, losing most of its infrastructure, the country's most popular beaches and cultural and scenic monuments. There would be associated losses of revenues from tourism and of industrial, residential and agricultural land. Alexandria's population currently

A one-metre rise in sea level would inundate 2 000 km^2 of land in the lower Nile Delta area and render 1 000 km^2 of agricultural land unusable. The Egyptian city of Alexandria would be severely affected, losing most of its infrastructure, the country's most popular beaches and cultural and scenic monuments

stands at three million and is predicted to grow to eight million by 2030, by which time half the residents would be at risk from inundation and displacement. However, public awareness and concern is low, with fewer than 20 per cent of residents prepared to move away, and the majority of the population regarding it as the government's responsibility to provide protection. In addition to inundation of land, sea level rise would also increase coastal erosion, flooding and saltwater intrusion into underground aquifers. The coastal zone is likely to suffer increased impacts from wave action and storm surges due to sea level rise. The average rate of coastal erosion in Alexandria is currently only 20 cm/yr, but three beaches have disappeared since the beginning of this century and eight of the other twelve are showing signs of erosion (El Raey and others 1995, in IPCC 1998).

Mitigating the effects of climate change on Northern Africa's coastal zone

A three-pronged approach is required to mitigation of sea level rise and other effects of climate change on Northern Africa's coast, including research and monitoring of potential impacts, development of appropriate responses to those impacts, and the integration of response strategies into planning and development, policies and programmes. Furthermore, this approach should take account of the ongoing coastal erosion and pollution as well as of the activities responsible for these, both in the coastal zone itself and in the hinterland. An integrated approach is therefore required, with a focus on long-term issues appropriate to managing the impacts of sea-level rise and climate change. It is therefore recommended that Northern African countries continue with and strengthen assessments of vulnerability of coastal areas to the consequences of climate change, as well as formulating and implementing adaptation options within integrated coastal management strategies (Nicholls & de la Vega-Leinert 2000).

The Mediterranean and Red Seas are particularly sensitive to pollution; they are semi-enclosed basins with straits leading to the Atlantic and Indian Oceans, through which replacement of seawater is slow. Exchanges of freshwater and seawater are low in these basins and dilution is limited, meaning that pollution entering the basins is likely to become concentrated over time

Pollution of Northern Africa's coastal and marine environment

The Mediterranean and Red Seas are particularly sensitive to pollution because they are semi-enclosed basins with straits leading to the Atlantic and Indian Oceans respectively, and through which replacement of seawater is slow. They also have high evaporation rates and relatively low run-off from the arid lands surrounding them. Exchanges of freshwater and seawater are therefore low in these basins and dilution is limited, meaning that pollution entering the basins is likely to become concentrated over time.

In the Red Sea, there is a high risk of marine-based pollution including phosphate poisoning, industrial pollutants, sewage, solid waste and other contaminants related to tourism activities, dumping of general and hazardous wastes from ships, and leaks and spills of oil. Over 100 million tonnes of oil are transported through the Red Sea annually and both regulation of maritime traffic and maintenance of navigational aids are inadequate (World Bank 1996a). As a result, there have been over 20 oil spills along the Egyptian Red Sea coast since 1982 (Pilcher & Alsuhaibany 2000). Offshore oil leaks and spills from the oil industry are another threat to human and coastal and marine resources in the Northern Red Sea, and Suez Gulf area.

An emerging issue of concern is the increasing presence of Red Sea fish and algal species in the Mediterranean basin, transported via ballast water of cargo ships passing through the Suez Canal (FAO 1997). Introduction of such alien species could potentially disturb the balance of species in the Mediterranean ecosystem.

Domestic and agricultural wastes contribute to pollution in Northern Africa's coastal zone, with sewage being the major cause for concern, followed by persistent organic pollutants (POPs) from pesticide residues, then heavy metals and oils, predominantly from industrial effluents. Sewage discharge and agricultural run-off into coastal waters are causing eutrophication and algal blooms have been reported on the coral reefs of the Sudanese coast (Pilcher & Alsuhaibany 2000).

Egypt has a flourishing tourism industry with sites such as Hurghada and Sharm el Sheikh well developed and expanding rapidly. However, some reports suggest that these and other resorts, such as the Ras Mohammad National Park, are experiencing pollution and reef degradation caused by levels of tourism and infrastructure that are too intensive for these sensitive habitats (UNEP 1997).

Box 2c.1 Protection of the environment in the Red Sea

Recognizing the need for international cooperation in marine and coastal management in Northern Africa, an interdisciplinary research programme for the Red Sea was initiated, in 1974, under the auspices of the UNEP Regional Seas Programme. Following from this, an Action Plan for the Red Sea and Gulf of Aden was approved (1976). In 1982, the Jeddah Convention for the Conservation of the Red Sea and Gulf of Aden Environment was signed, along with the Protocol for Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency. Djibouti, Egypt, Jordan, Palestine, Saudi Arabia, Somalia, Sudan, and Yemen are parties to the Convention. In 1995, the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) was formally established to implement the objectives of the Convention and its protocol. Achievements to date include environmental assessments of the coast and surveys of natural habitat, collection of oceanographic data, impact assessments of shrimp and pearl industries, training workshops in combating oil pollution, environmental impact assessments, ICZM, and establishment of a marine national park. Publications include state of the environment reports, directories of capacities and legislation and an assessment of the land-based sources and activities affecting the marine and coastal environment.

Source: PERSGA 2000

Enhancing coastal and marine environmental quality in Northern Africa

The most significant response from governments in Northern Africa to combat pollution of all types has been the establishment of the organization for the Protection of the Environment in the Red Sea and Gulf of Aden (PERSGA). The purpose and achievements of PERSGA are detailed in Box 2c.1. Based in Jeddah, Saudi Arabia, its main function is to implement the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention).

The Mediterranean Action Plan (MAP) was adopted in Barcelona, Spain, in 1975, by 16 Mediterranean States and the European Community, under the auspices of UNEP and within the framework of its Regional Seas Programme. The aim of MAP is to protect the environment while encouraging sustainable development in the Mediterranean Basin. It has six associated protocols covering coastal zone management, pollution assessment and control, protection of ecosystems and preservation of biodiversity. MAP was revised in 1995 to become more action-oriented and an instrument for sustainable development. Activities to date include gathering of pollution-trend data and compliance monitoring, the establishment of a list of Specially Protected Areas of Mediterranean Importance and related programmes for protection and conservation of species, and regulation of the introduction of non-indigenous or genetically modified species. The MAP Coastal Areas Management Programme is a mechanism for enhancing cooperation between national and local authorities and institutions—13 projects have been implemented since 1989. A Mediterranean Environment and Development Observatory has also been established to provide information to support decision making (UNEP 2001).

There are two Marine Protected Areas (MPA) along the Gulf of Aqaba, and there is a proposal for additional protected areas. In the northern Red Sea, there are three MPAs which need support through further strengthening of regulations, and proposals for new protected areas. There is only one protected area in the Dahlak Islands (in the south-eastern Red Sea), recognized as forming unique habitats that are under increasing pressure from tourism and oil transportation. There are 14 coastal protected areas and 5 marine

Unique habitats in the south-eastern Red Sea are under increasing pressure from tourism and oil transportation in the region.

Rafel al Ma'ary/Still Pictures

areas along the Mediterranean coast of Northern Africa. There are no MPAs in the Gulf of Suez and the only one proposed covers only a portion at the southern end of the Gulf. There are proposals for a much wider network of protected areas all along the coast. Overall, the standards of protection on both the Mediterranean and Red Sea coasts are below those afforded by protected area mechanisms. In line with the shifting paradigm of environmental management—away from protection and towards responsible and sustainable development—Egypt Morocco and Tunisia have taken steps to develop and implement ICZM plans. However, as these are recent measures, few conclusive studies have been undertaken to measure their progress.

Towards ICZM in Northern Africa

All countries in Northern Africa are party to either the Barcelona Convention or the Jeddah Convention (both in the case of Egypt). The objectives of the Barcelona Convention, which came into force in 1978, are to achieve international cooperation for a coordinated approach to protection and enhancement of the marine environment and coastal zone of the Mediterranean. The Jeddah Convention came into force in 1985 and sets similar objectives for the Red Sea and Gulf of Aden. These conventions and the strategies in their associated Action Plans have set the background for development of ICZM at the national level.

In Egypt, an ICZM strategy has been developed by the Egyptian Environmental Affairs Agency and is being prepared for distribution and implementation. A National Environmental Sustainable Tourism Strategy is also being developed and pilot-scale implementation is under way in the Red Sea. Egypt has also signed all regional and international agreements regarding the protection of seas and coastal zones, and a number of ecotourism projects for the Red Sea and the Mediterranean Sea are attempting to implement the principles of sustainable coastal development (CSD 1999).

In Morocco, protection of the coastal and marine environments is under the joint responsibility of the Ministries of Services (ports) Transport and Shipping, Environment, and the Interior. These ministries are responsible for compliance with regulations on environmental impact assessments and pollution and wastes, especially agricultural effluents, sewage, and flushing of ballast waters. The Ministry of Fisheries has jurisdiction over harvesting of marine and coastal resources and is responsible for ensuring sustainable use of these resources. There are also measures in place to ensure coordination between these organizations, including the National Emergency Plan for dealing with environmental accidents (1996), the National Environment Council, and the Inter-ministerial Committee for Coastal Tourism (CSD 1999).

Tunisia has ratified the MARPOL Convention and has established a national plan for dealing with emergencies and accidents. Projects are also underway to monitor and rehabilitate marine fish stocks, to establish and enforce water quality guidelines, and to protect against pollution by hydrocarbons from oil processing and transport activities, giving force to the policy on sustainable use of marine resources.

EASTERN AFRICA

The issues facing the coastal Eastern African countries are erosion and pollution of coastal and marine environments, as well as harvesting pressures resulting from rapid population growth in the coastal zone and expansion of the tourism industry. Rises in sea level and in temperature resulting from global climate change are also emerging as issues of concern.

Economic, social and ecological value of coastal and marine environments in Eastern Africa

The Eastern African coast supports a diversity of ecosystems including dry coastal forests, coastal dunes, floodplains, freshwater and saltwater marshes, mangrove forests, coral reefs, lagoons, sandy beaches and rocky shores. These support a rich and diverse resource base, including fish and seafood, construction materials, energy sources, wildlife habitat and tourism opportunities, as well as industrial and transportation activities.

The Red Sea coral reefs off the coasts of Djibouti, Eritrea, and Somalia are in good, often pristine, condition with 30-50 per cent live coral cover and the richest diversity of coral and other reef species in the entire Indian Ocean (Pilcher & Alsuhaibany 2000).

Rich mangrove forests not only protect the shoreline from storm surges and buffeting by ocean swell, but are also breeding grounds for many species of waterbirds. Along the coast of Kenya and southern Somalia, mangroves support commercial crab, oyster, and mullet fisheries, as well as artisanal harvesting of these and other species. These are extremely important to local economies and to many communities where fish is almost the sole source of animal protein (FAO 1997).

The natural assets of the Eastern African coast make it an ideal tourist destination. Kenya's tourism industry is the country's second largest earner of foreign exchange, contributing 19 per cent to GDP (World Bank 2000). In addition, the larger scale fisheries and associated industries provide a valuable source of foreign exchange and make a significant contribution to GDP.

Coastal erosion and climate change in Eastern Africa

Erosion is a common phenomenon along the Eastern African coast (UNESCO 1997, Ngoile 1997). Human activities, including beachfront developments, and mining of sand, coral and lime, contribute to accelerated rates of erosion. Activities inland—such as clearing and draining water catchments and river basins for agriculture and aquaculture, and clear-felling of coastal and inland forests—are additional causes of accelerated erosion.

Residential areas have expanded and commercial developments such as hotels and resorts have been constructed rapidly and widely along the coast of Eastern Africa, from southern Sudan to Kenya, often without adequate planning or provision of basic services such as waste disposal and sanitation. Many developments are concentrated on beaches and sea fronts, to benefit from the clean beaches, clean lagoon waters, and healthy coral reefs, and to attract as many visitors as possible. Excavation of sand, limestone, coral stone, and other building materials, as well as clearance of natural habitat to make way for urban and commercial developments contribute to coastal erosion. Coastal development in Somalia has been suspended after the collapse of the government, but as peace and stability return, it is expected that coastal development will be accelerated (Pilcher & Alsuhaibany 2000).

Erosion in one area leads to accretion of material in other areas, resulting in shifting coastal features (e.g. dunes, beaches, cliffs, and shoreline). For example, the Tana Delta and Sabaki Estuary (Kenya) have accreted extensive coastal plains due to coastal drift and the high sediment loads carried by the Tana and Sabaki Rivers. These high sediment loads are a result of poor land use practices in their upper catchments and high rates of soil erosion from their agricultural lands. Such a high rate of sediment discharge is threatening the ecological integrity of marine and coastal habitats such as mangroves, seagrass meadows and coral reefs. In addition, the high concentrations of silt in river water make the rivers unattractive for recreational purposes and limit the extent to which the water can be used for other purposes (UNEP 1998a). Furthermore, dams upstream on the Tana River have reduced water flows reaching the delta and lowered frequency of flooding, causing die-off in coastal forests (International Rivers Network 1995–2000).

Coastal erosion also threatens the breeding and nursery grounds of marine species, some of which are listed as endangered. Five sea turtle species recorded in the Western Indian Ocean and the Red Sea, and the cetacean *Dugong dugon* are threatened with extinction because of loss of breeding and nursery grounds (IUCN 1998). The breeding sites for turtles have been excavated, built on, or simply washed bare.

The impacts of erosion and shoreline retreat in Eastern Africa are likely to be compounded by sea level

rise resulting from global climate change. Sea level rise will increase the intrusion of seawater and flooding as most of the low-lying coastal plains are just a few metres above the highest spring tide water level (Okemwa, Ntiba & Sherman 1995). A rise of one metre would result in damage to or loss of infrastructure and natural habitats, which in turn would reduce economic potential of tourism and other commercial ventures and displace hundreds of thousands of people, especially in coastal cities such as Mombasa (IPCC 1998).

Sea temperatures are also predicted to increase in certain areas under the effects of global climate change and this would stress coral reef ecosystems and the economic activities that they support (IPCC 2001b). For example, the El Niño disturbances of 1998 caused sea temperatures in the Western Indian Ocean to rise by 1–1.5 ºC, and between 50 and 90 per cent of the corals off the Kenyan coast were killed through bleaching. The surviving corals had recovered significantly by 1999 but damaged areas were still not re-colonized (Obura and others 2000). Over 30 per cent of the coral in Djibouti was killed by bleaching as a result of the same El Niño event (Pilcher & Alsuhaibany 2000).

The negative impacts of aggravated coastal erosion include loss of investments, loss of agricultural lands, loss of critical habitats, and loss of employment opportunities. Governments and investors have to spend large sums on mitigating processes and the potential for tourism is reduced because recreation sites are lost. Cleared mangrove swamps and destroyed coral reefs also expose coastal areas to inundation or contamination from seawater.

Mitigation of coastal erosion in Eastern Africa

The Nairobi Convention covers, among other things, regulation and minimization of ecological damage from dredging and land reclamation, and introduces a requirement for prior assessment of environmental impacts to control and coordinate urban and industrial development and the development of tourism. All countries in Eastern Africa are party to the Convention and, now that the difficulties in its implementation (i.e. legal and institutional arrangements), have been overcome, regulation of coastal development and mitigation of erosion will be priority action areas.

At the local level, private developers are putting up defensive structures such as sea walls and groynes. However, in some cases these have actually increased rather than slowed rates of erosion (Anon 1996) and mangrove and reef rehabilitation projects are now recognized as more effective long-term measures.

Harvesting of coastal and marine resources in Eastern Africa

Eastern Africa is unusual in that its coastal fish production is low in relation to the surface area and potential productivity of its fisheries, in spite of large amounts of nutrients made available by coastal upwelling resulting from the Somali Current. The coastal fishery yield for the entire eastern and south-eastern African coast, including the Western Indian Ocean Islands, represents less than 1 per cent of global landings and most of the coastal fish stocks of the sub-region are considered to be fully exploited or overexploited (FAO 1997).

Destructive fishing practices pose a threat to coastal fisheries and coral reefs. Use of dynamite, pull-seine nets, poisons, and heavy pressure on selected species and juveniles are widespread along the Eastern African coast, contributing to decline of the ecosystem. However, national and international pressure to ban these practices has stimulated the empowerment of local communities to monitor and manage their resources (Obura, Suleiman, Motta & Schleyer 2000).

The countries of the Eastern African coast are the main exploiters of their coastal waters, but their EEZ is being increasingly harvested by foreign fleets from Europe and Eastern Asia. Somalia is experiencing an extreme case of this, as outlined in Box 2c.2. Reported catches by foreign nations increased dramatically in the early 1990s, with the Republic of Korea, Japan, France, Taiwan and Spain playing a major role (Okemwa 1998). Shark populations are declining rapidly with consequent drops in shark-fin catches by fishermen from Yemen, Somalia, Djibouti and Sudan. Most shark fishing is illegal and also impacts on turtles, dolphins and finfish which get caught in the nets and lines. Lack of surveillance and enforcement is a contributing factor (Pilcher & Alsuhaibany 2000).

Box 2c.2 Somali fisheries require international control

Somalia has one of the longest coastlines of any African country—around 3 300 km. Highly productive upwelling provides significant potential for the development of offshore tuna fisheries. However, the fall of Somalia's government, in 1991, left the country without a central government or control of its waters. Control has been assumed by self-promoted militia, some of whom have made controversial fishing arrangements with foreign countries, whilst others operate like pirates demanding ransoms from foreign vessels. Although these are highly dangerous waters, access to Somali fisheries is now virtually open, driven principally by foreign interests and demand for high-value tuna, shark and ray fins, lobster, deepwater shrimp and demersal whitefish. Harvesting rates are thus not known and it is not possible to determine whether marine resources are being harvested sustainably or not. Furthermore, the years of civil conflict have damaged the fisheries infrastructure, and have reduced previous oil spill response capability, aids to navigation, and search and rescue capacity.

Somalia is party to the Convention on International Trade in Endangered Species (CITES), UNCLOS, and the Nairobi and Jeddah Regional Seas Conventions. However, few of the provisions of these treaties are being implemented since the breakdown of national governance, and Somalia is looking to the international community to assist with implementation and enforcement of regulations. The current challenge is to develop a regional institutional proposal to address the situation.

Yemeni stern trawler (unflagged) fishing illegally with warps visible, 1.5 miles off Bossasso, 28 February 1998

Source & photo: Coffen-Smout 1998

Sustainable harvesting of coastal and marine resources in Eastern Africa

Eastern African countries are party to the 1982 UNCLOS which establishes fishing rights, and to international agreements on harvesting limits and areas. However, countries in the sub-region, like many African countries, lack both the infrastructure to exploit their own territories and the capacity to police and monitor the activities of international fleets or unsustainable harvesting rates. In addition, fishing agreements with foreign countries have been poorly defined, based on the need by African states for income and foreign exchange.

In Eritrea, marine resource harvesting is being regulated as peace returns to the area, through development of formal management procedures. Similar efforts are anticipated in Somalia. In Kenya, the MPA system is managed by the Kenya Wildlife Service and extends over 5 per cent of the coastline. There are two types of protection: full protection in marine parks, and the traditional resource harvesting allowed in marine reserves. Tourism is the main activity at all sites, and plans are underway to involve local communities and other stakeholders in the management of some areas (Obura and others 2000).

Pollution of Eastern Africa's coastal and marine environment

Environmental quality in the coastal and marine environments of Eastern Africa is under increasing pressure from land- and sea-based sources of pollution. Land-derived agrochemical and municipal wastes and sea-based petroleum wastes are the major causes of pollution in the sub-region (Martens 1992, Okemwa & Wakwabi 1993). Residues of fertilizers and pesticides from agricultural inputs in the hinterland enter main drainage systems and are washed into the sea where they have cumulative effects in the marine and coastal environment (Onyari 1981). At the same time, increased siltation resulting from deforestation in the hinterlands also impacts the coastal habitats by increasing the turbidity of the waters, and smothering habitats, flora, and fauna. Eutrophication is not yet a serious issue in the sub-region, but isolated pockets in sheltered bays (especially along the Kenya coast) are

threatened with blooms of toxic algae (Wawiye, Ogongo & Tunje 2000) and phytoplanktonic bacteria (Mwangi, Kirugara, Osore, Njoya, Yobe, & Dzeha 2000).

The coastal waters of the Red Sea and Western Indian Ocean are the major sea routes for large petroleum and oil tankers supplying the world with products from the Middle East. Major shipping routes run close to the coral reefs near the port of Djibouti and Port Sudan and ships often discharge oily wastes and sewage. Ships also cause physical damage to the reefs when poor navigation brings them into collision with the reefs (Pilcher & Alsuhaibany 2000). Longshore currents and winds in the Western Indian Ocean are instrumental in the horizontal distribution and spread of pollutants, particularly in bringing oil slicks from the open sea (beyond the EEZ limit) into the coastal waters. In addition to the elevated risk of high-impact oil spills, frequent transport operations also contribute to oil pollution—oil tankers often empty ballast and wash engines on the high seas and residues of degraded oil are consolidated and washed ashore by onshore winds, currents and waves. Tar balls litter beaches with deleterious effects on wildlife and on humans that use the beaches (Munga 1981). Soluble PCBs from these products poison marine life and accumulate in the food web, causing physiological disorders in top predators.

Treated and untreated effluents from municipal, industrial and domestic sources further contribute to coastal and marine pollution. Waste treatment facilities are often poorly designed or sited, and are old and poorly maintained or overloaded. Location of dumpsites and municipal sewage outfalls is therefore critical in maintaining environmental quality (especially water quality, both inshore and offshore) when urbanization and other forms of coastal development increase. (Mwaguni & Munga 1997).

Most Eastern African coastal municipalities do not have the capacity to handle the vast quantities of sewage and solid wastes they generate every day; large volumes of solid and liquid waste are disposed of at sea, or in an unsatisfactory manner, and end up by being washed or blown out to sea where they pose a threat to wildlife and human health

Most Eastern African coastal municipalities do not have the capacity to handle the vast quantities of sewage and solid wastes they generate every day. For example, the Mombasa Municipal Council (Kenya), can handle only 30 per cent of the waste generated (Anon 1996). In Djibouti and Somalia, sewage treatment plants are few in number and are, generally, poorly maintained (Pilcher & Alsuhaibany 2000). Large volumes of solid and liquid waste are therefore disposed of at sea or are disposed of in an unsatisfactory manner and end up by being washed or blown out to sea, where they pose a threat to wildlife and human health. It is evident that a restructuring of waste management policies and plans is required to handle the increase in solid wastes and sewage in the coming years.

Enhancing coastal and marine environmental quality in Eastern Africa

Governments in Eastern Africa have enacted public health legislation to regulate responsible environmental use of chemicals. There are also integrated resource management plans aimed at improving land use practices in the hinterland, thereby reducing the incidence and impacts of siltation and eutrophication. Global and regional agreements and treaties are also in place for enhanced cooperation on environmental management in the region. Furthermore, the Nairobi Convention calls for enhanced management of land-based and marine-based sources of pollution, and mitigation of their impacts.

Effective implementation, monitoring, and regulation of activities requires enhanced political commitment and coordination, as well as sustained resourcing. For example, Kenya's National Oil Spill Response Committee should be given legal status and contingency plans should be developed comprehensively. The Kenya Marine Fisheries and Research Institute also requires further financial and human resources to support its research work and monitoring of the coastal and marine environments (FAO/EAF 1999).

Djibouti and Somalia are parties to the Jeddah Convention and members of PERGSA, its implementation agency. Progress in enhancing environmental quality in these countries includes assessment, monitoring and state of the environment reporting, capacity building in oil spill response and integrated coastal management.

Towards ICZM in Eastern Africa

ICZM and appropriate legislation and regulations on environmental management are important steps towards the sustainable use of Eastern Africa's coastal zone and resources in the hinterland. There are already national initiatives that should be encouraged by enhanced regional cooperation (Linden 1993, Ngoile 1997, PERSGA 2000). For example, ICZM plans for Kenya and Eritrea use a site-specific approach for the integration of beachfront/seafront developments and waste management in coastal urban centres. Under these

Box 2c.3 Priorities for enhancing environmental quality in Eastern Africa

- Creation of incentives for waste recycling
- Upgrading of waste treatment plants and landfills
- Establishment of environmental impact assessment policies and practices, to reduce coastal erosion and pollution, and to design criteria for shoreline protection
- Implementation of policies that address poor agricultural practices
- Implementation of water quality guidelines and introduction of monitoring practices, together with enforcement of polluter payments
- Public awareness campaigns on improved waste management
- Support for reef restoration and mangrove planting projects
- Improvements to waste handling and implementation of cleaner technologies
- Strengthening of institutional capacity and fund-raising

Source: FAO/EAF 1999

plans, location of dumpsites and sewage outfalls will be properly planned and their effects closely monitored.

If success of such initiatives is to be sustained, their institutional structures will need to be strengthened, their coordination improved, and their capacity and funding will need to be increased. Priorities include improved waste management and erosion control in the coastal zone and, in the hinterland, improvement of agricultural practices and introduction of measures such as reforestation schemes, and soil conservation programmes to prevent soil erosion (see Box 2c.3).

WESTERN INDIAN OCEAN ISLANDS

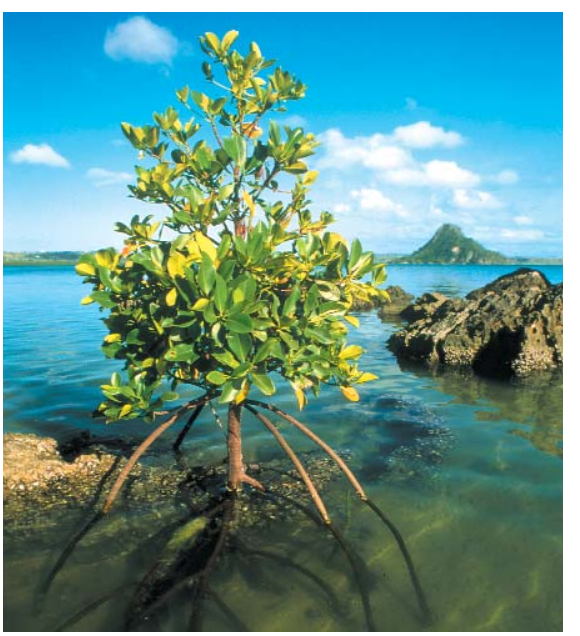
Small oceanic islands, such as those in the Western Indian Ocean, experience problems in controlling and regulating activities in their relatively extensive EEZ, making them vulnerable to overexploitation of their marine resources, particularly deep-water fisheries. In addition, land- and marine-based sources of pollution, associated with rapidly growing coastal populations, development of tourism and oil transportation by sea, are a further cause for concern over the state of the coastal and marine environments.

The Western Indian Ocean Islands are also experiencing accelerated rates of coastal erosion resulting from poor coastal planning and development, exacerbating their vulnerability to climate-change-related sea level rise which threatens to inundate large areas of land and displace large populations. Sea temperature rises in the Western Indian Ocean, also associated with global climate change, may cause bleaching of the exceptionally biologically rich and economically important coral reefs.

ECONOMIC, SOCIAL AND ECOLOGICAL VALUE OF COASTAL AND MARINE ENVIRONMENTS IN THE WESTERN INDIAN OCEAN ISLANDS

The oceanic islands of Comoros, Madagascar, Mauritius, and Seychelles have evolved in isolation from continental Africa, and were colonized by humans only relatively recently. They are therefore unique in their physical characteristics and in terms of the biological communities they support. The fringing coral reefs and the reefs surrounding the islands include the Aldabra Atoll (Seychelles), one of the most spectacular reefs in the world and a World Heritage Site.

All the islands support well-developed tourism industries which are important sources of income and foreign exchange. Coastal tourism is, for example, the mainstay of the economy in Seychelles, contributing



Mangroves provide a spawning ground for fish and shellfish, and provide resources for construction, weaving, and food. They also offer protection against coastal erosion and saltwater intrusion.

Dominique Halleux /Still Pictures

46–55 per cent of GDP, 70 per cent of foreign income, and employing 20 per cent of the population (International Ocean Institute 2001).

There are also extensive seagrass beds, mangroves, diverse fisheries and seafood species, and lagoons. These resources mainly support artisanal fishermen (about 90 per cent of all fish landings are from small-scale operators (International Ocean Institute 2001). The majority of fish landed in the Western Indian Ocean Islands are from coastal waters, and molluscs, prawns, shrimp and lobster are important economically and in local diets. Mauritius and Seychelles are also exploiting open sea tuna fisheries on a more commercial scale, and shrimp fisheries, which have a high potential for foreign exchange earnings from export, are growing in importance in Madagascar.

Coastal erosion and climate change in the Western Indian Ocean Islands

The coastlines of all the Western Indian Ocean Islands are threatened by erosion. Coastal erosion and destruction of natural habitats such as mangroves and coral reefs in many parts of the sub-region are the major threats to sustainable use of resources and development in the coastal zone. Erosion is primarily a result of uncoordinated and inappropriate developments in the coastal zone, due to rapid population growth and development of the tourism industry.

Mining of sand, coral, limestone and shells is depleting the buffer zone provided by the coral reefs and, as a result, the shores are more exposed to wave action, storm surges, and inundation. For example, in Mauritius a million tonnes of coral sand are excavated every year, by hand, and transported with dugout canoes (Bigot, Charpy, Maharavo, Abdou Rabi, Paupiah, Aumeeruddy, Villedieu & Lieutaud 2000). Sand mining also has noticeable impacts in Comoros and is creating major problems in Madagascar.

Fishermen using dynamite, walking on the coral reef and using nets out of season contribute to a level of coral destruction that is out-pacing the coral's natural capacity for regeneration. The situation is fragile and political commitment is needed to ensure that action is taken to arrest the decline in quality of the coral reefs, to restore the damage done, and to establish effective monitoring systems.

One of the most serious impacts of coastal erosion is increased vulnerability to the rise in sea level that will result from global climate change. The IPCC predicts an average sea level rise of up to one metre by the year 2100 (IPCC 2001a). In the Western Indian Ocean Islands, this would flood natural habitats such as mangroves, and contaminate habitats further inland with saltwater, changing the ecological conditions and biological composition. Precious groundwater resources may also be lost through saltwater intrusion.

In Seychelles, a one-metre sea level rise would submerge many of the islands and result in a loss of 70 per cent of the land area (Shah 1995, Shah 1996). Mauritius is estimated to fare better, losing less than one per cent of its land. (IPCC 1995). This would, nevertheless displace around 3 000 people and even small losses of beach area could have detrimental impacts on tourism and fisheries activities.

Global climate change also brings a threat of change in sea temperature and increasing frequency and intensity of cyclones or tropical storms. In 1998, the coral reefs of the Western Indian Ocean were subjected to intensive bleaching from an El Niño-induced sea temperature rise and up to 30 per cent of the coral in Comoros and 80 per cent in Seychelles were killed (PRE/COI 1998). Initial assessments of the economic costs of this coral bleaching were between US$700 million and US$8 000 million (Wilkinson, Linden, Cesar, Hodgson, Rubens & Strong 1999), although recovery has been observed in Mauritius and Rodrigues.

Loss of habitat and food supply has caused depletion of fish populations dependent on coral throughout the sub-region and this may reduce the aesthetic quality of the environment essential for development of sustainable tourism. In addition, the decrease in income from fishing and the loss of fish in local diet may affect human health (UNEP 1999a).

Mitigation of effects of climate change in the Western Indian Ocean Islands

In view of the predicted sea temperature rises which will become more common as global temperatures increase, mitigation efforts to protect coral reefs must include reductions in GHG emissions (Reaser, Pomerance & Thomas 2000). All of the Western Indian Ocean countries have signed the UNFCCC and Seychelles has signed the Kyoto Protocol. However,

these countries contribute negligible amounts to global GHG emissions and it is therefore important that major GHG contributors be held to their commitments if the world's coral reefs are to be protected.

Another key component for protection against future damage to reefs is monitoring and improved understanding of the ecological system and of natural and human influences on it. Sea level changes are being monitored carefully in the sub-region, and Madagascar and Mauritius have set up Cells for Monitoring and Analysis of Sea level (CMAS), as part of the IOC-UNEP-WMO pilot project on sea level changes and associated coastal impacts. These cells will cooperate with others in the Western Indian Ocean (from Bangladesh to Kenya), sharing data and identifying common problems. The ultimate aim is to develop a framework for data collection and analysis which will provide understanding of variability and allow assessment of trends (Sheyte 1994). Information and recommendations should be integrated into regional and sectoral development policies and action plans (CSD 1999).

Harvesting of coastal and marine resources in the Western Indian Ocean Islands

The EEZ associated with the Western Indian Ocean Islands extends over more than 2 106 km^2, an area larger than the state of California. This not only creates difficulties for administration and protection, but also for monitoring and regulation of fishing practices and harvesting rates (Brooks/Cole 1998). International regulations are in place to protect the interests of small island states, but resources are required for their monitoring and enforcement, as evidenced by the dramatic increase in reported catches by distant-water fishing nations during the 1990s (FAO 1997). Catches of non-target, endangered species, especially turtles, dolphins, and dugongs, are also cause for concern in the sub-region, as are the destructive practices of dynamite fishing, purse-seining and drag-netting.

Domestic fish catches in Comoros, Seychelles and Mauritius grew steadily between 1975 and 1995, but have declined recently by up to 24 per cent (see Table 2c.1). This is in contrast with catches from other low-income countries, reported to have increased by 4 per cent during the same period, and with world total catches which are reported to have grown by 8 per cent (UNEP 1999a, Commonwealth Secretariat 2000). The FAO believes that this stagnation of catch is a result of stocks being fully exploited, as there has been no reduction in fishing activities during this period (FAO 1997).

Sustainable harvesting of coastal and marine resources in the Western Indian Ocean Islands

Control of overfishing requires elaborate marine regulatory facilities and surveillance, and lack of these has meant that compliance with regulations in the Western Indian Ocean Islands has been weak to date. However, measures have been introduced recently, including training of fishermen and provision of equipment to fish beyond the reef and in deep waters, to encourage re-growth of populations in coastal waters (UNEP 1999a). Legislation to outlaw turtle fishing and to protect the species has proved difficult to enforce and evaluation of the impact has been hindered by lack of specific data. National coral reef monitoring networks have been established, under the Indian Ocean Commission's Regional Environment Programme, with annual reporting on the state of the coral reef and its resources.

Table 2c.1 Marine fish catch in the Western Indian Ocean Islands (thousands of tonnes) 1975–97

	Comoros	Madagascar	Mauritius	Seychelles	World Total
1975	3 850	19 020	7 038	3 950	NA
1990	12 200	NA	14 700	5 400	86 408
1995	13 200	85 463	16 933	7 000	91 558
1997	12 500	NA	13 700	5 300	93 329

UNEP 1999a; Commonwealth Secretariat 2000

A festival of underwater film has also been held to promote awareness of the underwater world and the need for resource conservation. There are three nationally protected marine reserves in the Western Indian Ocean Islands where fishing activities are restricted, and one World Heritage Site (the Aldabra Atoll in Seychelles).

Pollution of the Western Indian Ocean Islands' coastal and marine environment

Increasing quantities of domestic and industrial waste discharged without treatment into coastal waters have seriously affected coastal and marine areas. This is a priority concern because of the high level of economic dependence on tourism and other uses of coastal and marine resources. Coastal populations are increasing and, in general, most of the countries in the sub-region suffer from a lack of planning for urban development and for development of tourism. Many informal settlements have grown up as a result of this situation (UNEP 1998b). Approximately 41 per cent of the coastline of Mauritius has now been developed for urban use, tourism or industrial purposes. These developments are overloading existing wastewater and sewage treatment services, and the rate of development of new infrastructure has not kept pace with rates of population influx. For example, Seychelles treats only a fraction of its wastewater (19 per cent of domestic wastewater in 1995), and only eight hotels had sewage treatment plants in 1997 (Shah 1995, Shah 1997). In Mauritius, two thirds of coastal residents discharge their waste into the sea and in Comoros there are no wastewater treatment facilities (UNEP 1999a).

The West Indian Ocean Islands are home to a wide range of endemic bird species like this Great Frigatebird (*Fregata Minor*) found in the Aldabra Islands, Seychelles

Gilles Martin/Still Pictures

Agricultural run-off, containing large volumes of silt, fertilizer and chemical residues, further contributes to pollution problems by smothering habitats, poisoning some species, and encouraging the proliferation of algal blooms which in turn cause further loss of flora and fauna (PRE/COI 1998). Smothering of seagrass beds, for example, results in loss of shelter, food, and nursery grounds for important and valuable fish, shellfish, dugong and turtles (UNEP 1999a).

Industrial developments in the coastal zone include large fish processing plants, tanneries, sugar refineries and shrimp farms. Many of these do not have wastewater treatment facilities and discharge their wastes directly into the ocean (UNEP 1999a).

The increasing use of motorized vessels rather than human or sail-power for fishing and pleasure craft is increasing pressure on the environment by causing oil slicks and by direct physical damage from boat propellers.

There is also a high risk of major oil spills, given that 30 per cent of all oil exports from the Near East pass through the sub-region (Salm 1996). This high level of transport traffic also exposes the marine and coastal environments to oil pollution through discharge of ballast water and oil leaks.

Commercial and domestic pollution of lagoons and coastal waters throughout the sub-region has reduced the numbers and variety of fish available for local consumption. This in turn has resulted in overexploitation of the remaining stocks of certain popular species, causing collapse of the coral reef ecosystems and reducing tourism opportunities (UNEP 1999a). Protected and endangered species found in the region, such as marine turtles, dugongs, whales and dolphins, are reportedly declining as a result of increasing levels of waste, notably plastics, and of overfishing and predation by humans and other predators (UNEP 1998b).

Enhancing coastal and marine environmental quality in the Western Indian Ocean Islands

All of the Western Indian Ocean Islands have signed the Nairobi Convention, but effective actions for controlling pollution are yet to be implemented. The Indian Ocean Commission has developed a five-year action plan for a

Regional Environmental Programme that concentrates on monitoring of coral reefs and ecotoxicology, development of an environmental information system, and ICZM pilot projects. The Regional Environmental Programme has established an agreement and a framework for cooperation, as well as a proposed cooperation policy.

At the national level, Mauritius has introduced control of marine pollution into its national law, as part of its obligation's under the UNCLOS. The island has also drafted regulations to control pollution by oil, noxious liquid wastes, harmful packaged substances, sewage and garbage, thus implementing the Convention on the Prevention of Pollution from Ships (MARPOL) (UNEP 1999a). The provisions of the Convention would be strengthened by ratification by other Western Indian Ocean Islands. Comoros, Madagascar, Mauritius and Seychelles have all developed National Environmental Action Plans, and Seychelles and Mauritius have Environmental Protection Acts (UNEP 1999a). Provision of port reception facilities for oily and other wastes (as required under MARPOL) is recommended, to enhance response capacities to oil spills. Additional resources should be sought to improve equipment, training, and financial resources for emergency response activities.

At the local level, schools and NGOs have been involved in coastal protection and beach cleaning campaigns to prevent refuse, especially plastic bottles, being washed out to sea.

Towards ICZM in the Western Indian Ocean Islands

The Indian Ocean Commission's Regional Environmental Programme has been instrumental in helping the sub-region's countries to develop and implement Environmental Management Plans and sustainable development policies. These include measures such as coordination of development in the coastal zones and requirements for assessments of environmental impacts prior to certain developments being undertaken.

Programmes to reduce coastal erosion have been implemented in Seychelles and in Mauritius, with limited success. An approach combining construction of physical defences, relocation of populations and industries, and adoption of new building designs is likely to be most effective (Commonwealth Secretariat 1997).

Comoros, Madagascar, Mauritius, and Seychelles are parties to the UNEP Regional Seas Programme for Eastern Africa, for which the Regional Coordinating Unit is in Seychelles. The mission of the Eastern African Regional Coordinating Unit is '*to provide leadership and encourage partnerships by inspiring, informing and enabling nations and people of the Eastern African Region and their partners to protect, manage and develop their Marine and Coastal Resources in a sustainable manner.*' The components of an Action Plan for Eastern Africa provide a framework for comprehensive action at the sub-regional and national level and activities are designed to help the governments of the sub-region strengthen their environmental management processes (UNEP 2001).

The objectives of the Action Plan for Eastern Africa are to promote sustainable development through development of appropriate legislation, pollution prevention, protection of the sub-region's living resources, strengthening of institutional coordination and activities, capacity building, and raising awareness. Particular attention is paid to assessment of causes and impacts of coastal and marine environmental degradation, and adoption of financial arrangements for successful and sustained implementation (UNEP 2001).

SOUTHERN AFRICA

The major issue for coastal countries of Southern Africa is the depletion of fish stocks by unsustainable levels of harvesting. There are also increasing incidences of pollution from activities on land and from oil spills and potential impacts from sea level rise including inundation of major coastal settlements with associated damage to ecosystems, infrastructure and displacement of populations.

Economic, Social and Ecological Value of Coastal and Marine Environments in Southern Africa

The Southern African coastline extends from Angola on the west (Atlantic) coast to Tanzania on the east (Indian Ocean) coast. The coast is rich in fish, seafood, mangroves and coral reefs as well as oil, diamonds and other mineral deposits. The long sandy beaches and warm waters of the Indian Ocean create good opportunities for tourism, and the many deep-water ports along the Southern African coast present opportunities for industry and export.

These coastal resources are important economically, at the subsistence level and commercially. In South Africa, for example, the annual revenue from coastal resources has been estimated at more than US$17 500 million (approximately 37 per cent of South Africa's GDP). This includes revenues from transport and handling of cargo, tourism and recreation, and commercial fishing industries (DEA&T 1998). Mangrove forests along the east coast, from Tanzania to northern South Africa, support a diversity of tree species that are used for furniture, firewood, building dugout canoes, and of which the leaves are collected for animal fodder. Plants are also used for medicinal purposes—*Xylocarpus granatum*, for example, is said to cure stomach problems and hernia (Sousa 1998). Mangrove forests also provide important nursery grounds and habitats for crustaceans and fish, exploited by artisans and commercial fishermen alike. Estimates of the value of the shrimp fisheries of the Sofala Bank (Mozambique), for example, are as high as US$50–60 million per year (Acreman 1999), or about 40 per cent to the country's net foreign exchange earnings (Sousa 1997). The mangrove forests also protect the coastline from storm surges and other natural hydrological influences such as high-amplitude tidal ranges and disturbances resulting from currents (Tinley 1971).

Coastal erosion and climate change in Southern Africa

Sea level rise as a result of global climate change would cause inundation of the extensive mangroves of Mozambique and Tanzania and these would retreat, thus increasing rates of erosion of the shoreline. The coastal lagoons of Angola would also be inundated. Sea level rise is also a major threat to low-lying coastal urban centres and ports, such as Cape Town, Maputo, and Dar es Salaam. Its impacts could result in a loss of income from coastal industries and port activities throughout the sub-region, as well as loss of opportunities for development of tourism (IPCC 1998). In Tanzania, a sea level rise of 0.5 m would inundate over 2 000 km^2 of land, costing around US$51 million and a rise of 1.0 m would inundate 2 100 km^2 of land and erode a further 9 km^2, resulting in costs of more than US$81 million (IPCC 1998).

The coral reefs off the coasts of Mozambique, South Africa and Tanzania are under threat of bleaching due to sea temperature rise resulting from El Niño events and global climate change. In 1998, the El Niño induced sea temperature rise of around 1 °C caused the death of up to 90 per cent of the corals in the sub-region (Obura and others 2000).

Mitigation of the effects of climate change Southern Africa's coastal zone

All countries of the sub-region, with the exception of Angola, have ratified the UNFCCC but, as most of them (with the exception of South Africa) contribute negligible amounts to global carbon dioxide emissions, more immediate mitigating measures are required. Construction of physical barriers is a short-term measure which has been implemented, but relocation of human settlements and industry could also be considered.

Harvesting of coastal and marine resources in Southern Africa

Most of Southern Africa's coastal and marine resources are under pressure from unsustainable rates and methods of harvesting, resulting from increasing demand on marine resources for food (driven by population increase, rising demand by wealthy consumers, export markets, and tourists). Demand

Shrimp and prawn seafood fisheries are important for the local and national economies.

UNEP

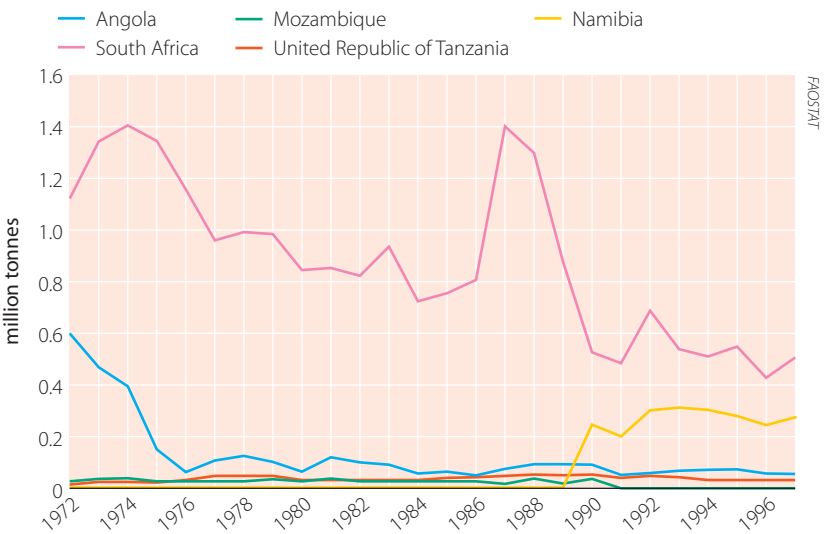
comes not only from the maritime countries but also from inland nations. FAO trends for marine harvest, indicate a decline in marine stocks since 1972 for most countries in the sub-region (FAOSTAT 2001). This is illustrated by Figure 2c.5.

Mangrove forests are also subjected to unsustainable harvesting pressures and are being cleared for agricultural uses, salt production and human settlements. The rate of deforestation in Mozambique has been over 3 per cent per year in the last 18 years (Saket and Matusse 1994). Lack of monitoring and research as well as inadequate policy enforcement also contribute to overharvesting of mangrove resources by both domestic and commercial users. The slow regeneration rates of mangrove trees and mining of coastal sands are exacerbating the rate of loss of mangrove habitats and are accelerating erosion rates in the coastal zone. Loss of mangrove habitat also impacts on productivity of artisanal and commercial shrimp and crab fisheries. Elevated sediment loads in coastal waters (due to erosion in the coastal zone and upstream) can increase turbidity and cause siltation of estuaries. In the open ocean, sediments can be deposited, smothering fragile habitats such as coral reefs, and benthic habitats in sheltered bays. This not only has impacts on the ecosystems but may also affect the potential revenues from tourism.

Sustainable harvesting of coastal and marine resources in Southern Africa

Reduced catches and a decrease in the mean sizes of fish caught have led to calls for the protection of line fish stocks by many governments in the sub-region, although controls have not always been easy to monitor and enforce. Fisheries management measures include minimum size limits, bag limits, closed seasons, and closed areas (marine reserves). For example, under the Marine Living Resources Act of South Africa (1998), all South African fish stocks must be used on a sustainable basis and overexploited populations must be allowed to recover to sustainable levels before harvesting is resumed. In December 2000, drastically reduced stocks of line fish prompted South Africa's Minister of Environmental Affairs & Tourism to declare a State of Emergency, suspending the activities of commercial, artisanal and recreational anglers until stocks regenerate (DEA&T 2000a).

Figure 2c.5 Trends in marine fish catch for Southern Africa, 1972–97



Public awareness, policy directives and technological development are essential for ecosystem management and some countries have made progress in this regard. Other proposals for the management of coastal and marine resources include formulation of marine resource management plans, community-based management of mangroves and fishery resources, and institutional capacity building (Sousa 1998).

MPAs have been established in Southern Africa to limit harvesting of coastal and marine resources. There are 44 MPAs along the sub-region's coast, mostly under the jurisdiction of central or provincial governments (WCMC 1999). Where MPAs have been formally established and regulated, as in some parts of South Africa, inshore fisheries have successfully recovered (Msiska, Jiddaw & Sumaila 2000). In other areas, however, lack of education and of enforcement of regulations has hindered the success of MPAs in regulating extraction rates of some species. For example, more than 17 tonnes of Abalone (a species covered by Appendix III of the CITES) were confiscated from poachers along the coast of Cape Town during December 2001 and January 2002 (Craig Haskins, City of Cape Town, personal communication).

By contrast, informal protection has been successful in other areas. In Namibia, for instance, fishing within 200 m of the coast is illegal although there is no formal protection, and fisheries resources within this zone have been successfully protected (Msiska and others 2000). In some countries,

In South Africa, there are some 63 ocean outfalls along the coast discharging approximately 800 000 m^3 of sewage and industrial effluent into the sea every day

partnerships are being formed to protect marine and coastal resources, as governments recognize the need to balance subsistence and small-scale activities with commercial demand and export revenues. This can be expected to substantially improve not only the management of resources but also relations between fishermen and authorities because subsistence fishermen will come to regard themselves as stakeholders and managers of common resources and not simply as acting under instruction from the government.

Pollution of Southern Africa's coastal and marine environment

Marine and coastal ecosystems are being degraded rapidly in Southern Africa by pollution from land-based activities and dumping at sea. Land-based pollution sources include discharge of sewage, industrial effluents, stormwater run-off, wind-blown litter, suspended sediments, and agro-chemicals. The increase in these types of pollution is largely a result of the rapid growth in population and in tourism in coastal centres, and of unsustainable land management practices inland. For example, in South Africa, the populations of Cape Town and Port Elizabeth, two major coastal cities, grew by 22 per cent and 24 per cent respectively during the 1990s (Macy 1999). Raw sewage is discharged in these cities because the large and rapidly growing population requiring sanitation facilities exceeds the capacity of municipal treatment plants. In South Africa, there are some 63 ocean outfalls along the coast discharging approximately 800 000 m^3 of sewage and industrial effluent into the sea every day. Most of the large pipelines discharge into deeper waters, but 27 older pipelines discharge above the high water mark (DEA&T 1999). This is dangerous to human health because bathing waters are contaminated and popular seafood species such as mussels may become contaminated.

Industrial effluents in the sub-region come mainly from large fish processing plants, abattoirs, and chemical and manufacturing industries. In the case of Mozambique, for example, 126 factories in and around Maputo do not have waste treatment plants and their drains discharge toxic wastes, poisons, non-degradable substances and organic matter into their neighbourhoods (Chenje & Johnson 1996). Most of Tanzania's textile mills release dyes, bleaching agents, alkalis and starch directly into Msimbazi Creek in Dar es Salaam, from where they can easily flow into the Indian Ocean (Chenje & Johnson 1996). Agricultural run-off containing fertilizer residues and soil sediments contributes to silting of estuaries and to smothering of habitats, and has also been suspected of contributing to the occurrence of toxic algal blooms (such as red tides). Pollution of coastal and marine environments poses a threat to human health, through direct contact or through consumption of contaminated fish or seafood. It also degrades marine environments, resulting in declines in economic returns from fisheries and tourism.

Solid waste also enters the marine environment through stormwater run-off or is blown out to sea. Plastics constitute an increasing proportion of marine and coastal litter and present a particular hazard because of their endurance in the environment. Litter, especially plastics, kills many marine animals through ingestion and entanglement. It is also unsightly and a hazardous deterrent to beach users (Ballance, Ryan & Turpie 2000, Ryan 1996). Efforts have been made to reduce the volume of plastics entering the marine environment in South Africa, including regulations on the thickness of plastics used in the packaging industry and incentives for re-use of plastic bags or use of alternative materials (Ministry for Environmental Affairs & Tourism 2000).

South African fur seal, Namibia

Klein/Hubert/Still Pictures

Sources of pollution at sea include accidental and deliberate discharges of oil and dumping of garbage such as plastics. Dredge spoils—often rich in heavy metals such as lead, copper, zinc, mercury, and cadmium—are dumped at designated sites. There have been several recent incidences of oil spills off the South African coast that have had serious adverse effects on the Africa penguin populations in the area and on other marine life, particularly large numbers of sea birds, seals, as illustrated in Box 2c.4.

Box 2c.4 Oil spills and emergency responses in South Africa

In June 1994, the iron ore carrier the *Apollo Sea* broke up and sank in Table Bay. The resulting pollution caused oiling of 10 000 penguins, of which 5 000 died. The clean-up costs of this disaster were estimated at around US$1.5 million, including costs of beach cleaning, penguin rehabilitation, and interruption of port activities. Six years later, another vessel, the *Treasure*, spilled more than 1 500 tonnes of fuel oil and 20 000 penguins were oiled. In the world's largest and most successful seabird rescue operation (involving members of the public from all over South Africa) almost 20 000 birds were translocated to avoid further oiling, and oiled birds were rehabilitated and released.

Source: University of Cape Town 2001, Minister of Transport's declaration to Senate, 30 August, 1994

Enhancing coastal and marine environmental quality in Southern Africa

South Africa's Prevention and Combating of Pollution of the Sea by Oil Act (1981) provides for the prevention and combating of pollution in South Africa's territorial waters. However, in 1986, responsibility for administration of the Act was divided between the Department of Transport and Environmental Affairs and the Department of Tourism and this has created problems in assigning responsibilities during emergencies and reduced the effectiveness of coordination with community groups (Trevenen-Jones 2000).

Pollution problems are further complicated by lack of awareness and weak policies and institutional frameworks, or legal instruments for enforcing national and international regulations. The most effective means of controlling coastal and marine pollution and degradation is therefore to demonstrate to industry and the public the benefits of maintaining a healthy environment—for example, improved aesthetic qualities and leisure facilities, improved harvests, and increased revenues from tourism. South Africa's Coastal Policy White Paper (from which a draft Bill is to be tabled in the country's parliament in 2002) includes measures to minimize, control, and monitor pollution of coastal waters from point and non-point sources (DEA&T 2000b).

Towards ICZM in Southern Africa

Mozambique, South Africa and Tanzania participate in the UNEP Regional Seas Programme for Eastern Africa, and have ratified the Nairobi Convention. Under the convention, several capacity-building exercises have taken place in the sub-region and countries are well on their way to developing and implementing national ICZM policies and programmes. Angola and Namibia come under the UNEP Regional Seas Programme for West and Central Africa and have signed the Action Plan and Abidjan Convention, in 1981. South Africa has also shown interest in participating in implementation of the Abidjan Convention.

Angola Namibia and South Africa, the three countries bordering on the Benguela Current Large Marine Ecosystem, have initiated a cooperative management plan designed to overcome previous fragmentation in coastal zone management and to ensure integrated and sustainable development of coastal and marine resources. Improved understanding through research and monitoring, together with increased capacity and resources, is critical to successful implementation of the plans (O'Toole, Shannon, de Barros Neto & Malan 2001).

Countries on the east coast of Southern Africa have been actively involved in cooperation for improved coastal zone management, including a meeting of Ministers of the Environment from east-coast African states, in Seychelles in 1996. A Secretariat for Eastern Africa Coastal Area Management (SEACAM) was established at the meeting, to assist countries in implementing ICZM. Achievements under this cooperative arrangement include training workshops and publication of training manuals, development of an Eastern Africa Coastal Management database, information dissemination via newsletters, a website, distribution of documents, and participation in international conferences.

At the national level, all countries in the sub-region are in the process of developing ICZM policies. For example, the Marine Research Institute in Angola currently has a number of research programmes aimed at improving understanding of the living marine resources in order to provide management recommendations to the Ministry of Fisheries. However, lack of funding is limiting the activities of research vessels and laboratory operations. Capacity is being enhanced in coastal and marine resource management through university courses and at two Maritime Technical Schools. Mozambique developed a national ICZM policy and programme in 1998 and has since implemented environmental legislation. ICZM projects are also being conducted in Namibia for particularly sensitive regions of the coast such as the Erongo region. South Africa is expected to pass a draft Bill relevant to ICZM through its parliament in 2002 (see above), and Tanzania developed a Green Paper in 1999.

The Central African countries of Cameroon, Congo, and Gabon are among the top net oil-exporting countries in Africa.

Chris Martin/Still Pictures

CENTRAL AFRICA

The total length of coastline of Central African countries is 1 789 km, the area of the continental shelf to a depth of 200m is 66 500 km^2, and the EEZ extends over 537 900 km^2. Central Africa's coastal zone is characterized by lagoons, mangroves, seagrass beds, sandy beaches, and estuarine wetlands constituting vital resources for subsistence activities and for economic development.

With large human settlements and major economic activities along its coast, Central Africa is one of the most vulnerable areas to sea level rise. Current patterns of coastal erosion are exacerbating the problem and many of the unique coastal wetland habitats are under threat. Pollution from land- and sea-based sources is also a priority issue, particularly with the potential expansion of offshore oil and gas production activities.

Economic, social and ecological value of coastal and marine environments in Central Africa

Central Africa's coastal belt is an area of significant commercial activity including mining, agricultural plantations and industrial developments. The belt is experiencing rapid urbanization as a result of these activities. Offshore economic resources, including petroleum and gas, are also significant and the Central African countries of Cameroon, Congo, and Gabon are among the top net oil-exporting countries in Africa. Despite political turmoil in Central Africa, the region has seen offshore and inland crude oil production rise from 650 000 barrels per day (bbl/d) in 1993 to 875 000 bbl/d in 1998. The largest increases in those years were in Equatorial Guinea, Congo, and Gabon. Central Africa's proven gas reserves (about 3 per cent of the continent's total) are concentrated in Cameroon, Congo, Equatorial Guinea and Gabon. Central Africa accounted for less than 1 per cent of Africa's natural gas production in 1997, but plans are under way to increase production and utilization of gas in national electricity generation (EIA 1999). This could have implications for marine environments, particularly in terms of habitat degradation and pollution.

Commercial fisheries are also important resources for the coastal nations of Central Africa, although the FAO considers stocks of demersal fish (i.e. living close to the sea bottom) to be either close to or fully exploited (FAO 1997). It has recommended that efforts to catch

these species be reduced or re-directed, to relieve pressure on the inshore zone and on juveniles. Similarly, catches of small pelagics (i.e. open sea species) in the west and central Gulf of Guinea were considered to be fully exploited, although further south, small pelagic stocks are underexploited (FAO 1997). Pelagic fish abundance around the coast is largely controlled by variability in intensity of coastal upwelling and nutrient levels (FAO 1997). Coastal Central African countries are experiencing similar problems to those in Western Africa with exploitation of their waters by foreign fleets (FAO 1997). There is an urgent need to tighten agreements and to enforce regulations in order to protect national interests, local economies and subsistence livelihoods.

Coastal erosion and climate change in Central Africa

Population densities in coastal urban centres in Central African countries are increasing under the dual pressure of population growth and migration. Major coastal cities include Douala in Cameroon (population 1.6 million in 2000) (UNCHS 2001), and Libreville in Gabon (population approximately 400 000 in 1993, around 50 per cent of the total population of Gabon) (World Bank 1997). Migration to the coast is prompted by opportunities for agriculture (fertile soils and favourable climate) and employment (large number of industries based on the coast). The resulting conversion of natural habitat to urban settlements and agricultural plantations, together with poor resource management practices inland, has accelerated rates of coastal erosion and this is now a significant problem in Central Africa. The rate of coastal erosion in Gabon, for example, is reported as having reached around 10 m per year as a result of clearance of mangrove forests (ESA-ESRIN 1996). Erosion is accelerated by construction of dams upstream of the coastal zone. Dams reduce the sediment load in rivers reaching the coastal areas and control their flow patterns, thereby increasing their erosive potential.

Development of coastal infrastructure and poor design and management of coastal cities lead to clearance of natural, stabilizing vegetation and increased exposure to wind and water erosion, thus contributing to destabilization of the sands and soils in the coastal zone. Mining of dunes also destabilizes the coastal zone and enhances the potential for erosion by changing patterns of erosion and deposition. Eroded material is washed out to sea where it settles out along shipping routes which then have to be dredged to prevent grounding of ships, particularly oil tankers (ESA-ESRIN 1996).

In oil producing states, the development of canals for oil transportation is an additional modification to the coastline that has contributed to altered patterns of erosion and accretion of material.

Coastal erosion also renders Central Africa's coastal settlements and economic activities more vulnerable to sea level rise resulting from global climate change. Impacts include intrusion and contamination of freshwater sources by seawater, flooding, damage to infrastructure and displacement of populations. Cameroon and Gabon have low-lying lagoonal coasts which support large and growing populations, as well as some unique habitats for fisheries and waterfowl habitat. Sea level rise would aggravate existing problems of coastal erosion and increase the risk of saltwater intrusion into surface and groundwater resources (IPCC 1998).

Mitigation of coastal erosion and climate change in Central Africa

Cameroon has signed the Declaration for Environmentally Sustainable Development of the Large Marine Ecosystem of the Gulf of Guinea (Accra Declaration), pledging political commitment to environmentally sustainable development in the Gulf of Guinea. One means of enhancing environmental conditions in the Gulf is to establish ICZM plans and institutions to implement policy at national level. Another is to increase existing efforts to prevent and mitigate the effects of coastal erosion and sea level rise, funded by international donor agencies and to be implemented within the framework of the Gulf of Guinea Large Marine Ecosystem Programme (see 'Enhancing coastal and marine environmental quality in Western Africa' and Box 2c.5). The Accra Declaration calls for improved sharing of information and coordination of activities between member countries (Cameroon, and the Western African States of Benin, Côte d'Ivoire, Ghana, Nigeria and Togo). The Declaration was signed in 1998, but is not legally binding and progress has been

slow. Three MPAs have been established along the Central African coast with the aim of protecting areas of natural habitat from modification, overharvesting, and pollution (WCMC 1999). As elsewhere in Africa, lack of resources and weak institutional structures contribute to frequent infringement of MPAs by commercial and artisanal operations.

Pollution of Central Africa's coastal and marine environment

Marine pollution is a cause for concern in Central Africa, especially in the Gulf of Guinea extending from Guinea-Bissau in Western Africa to Gabon, and in the nearshore waters of oil-producing states. Sources of pollution include offshore oil exploration, coastal industries and oil refinery activities, urban solid wastes and sewage from coastal towns, and illegal activities including dumping of wastes at sea. Marine pollution disturbs habitats, disrupts functioning of ecosystems and causes loss of biodiversity.

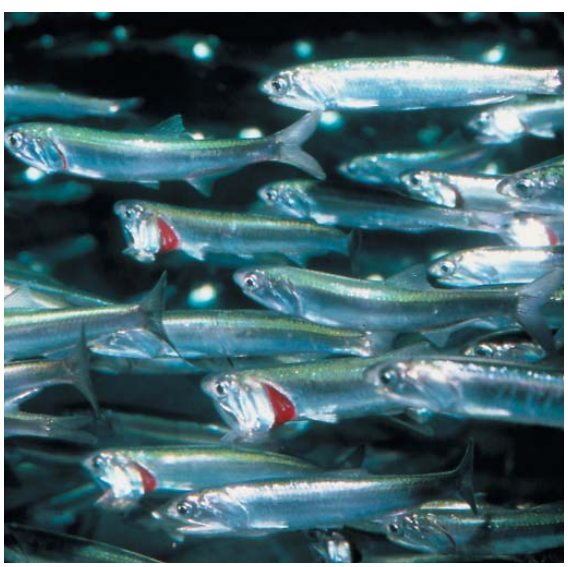
The significant oil reserves off the coast of Gabon have been exploited and have contributed to the country's economic growth. But they have also contributed to the risk of pollution by oil and hydrocarbons from spills, leaking valves, corroded pipelines, ballast water discharges, and production-water effluents (Chidi Ibe 1996). Diesel and other toxic chemicals are present in drilling fluids, adding to the burden of pollution from oil exploration and exploitation. Heavy metals are also associated with oil extraction. These are both toxic to marine life and, because they accumulate in the food chain, ultimately pose a threat to human health through consumption of fish and seafood (Chidi Ibe 1996). Tar balls have appeared on the beaches of Pointe Noir, the economic capital of Congo, and residents of the coastal zone have complained of pollution and an oily aftertaste in locally-caught fish (Pabou-M'Baki 1999).

Domestic sewage and agricultural effluents are additional significant sources of marine pollution. This form of pollution arises because the rates of urban and industrial development in the coastal zone exceed the capacity of municipal wastewater treatment facilities. In some cities along the coast of the Gulf of Guinea, less than 2 per cent of households have water supply and sanitation (UNIDO 2000).

Enhancing coastal and marine environmental quality in Central Africa

The Gulf of Guinea Large Marine Ecosystem Programme has been successful in establishing regional effluent regulations and standards, and an industrial waste management programme has been piloted. Cameroon has been an active participant in the programme, establishing a National Steering Committee and adopting a regional Integrated Coastal Area Management Programme that lays the foundations of environmental policy. A waste management programme will also be implemented in Cameroon in the near future (UNIDO 2000). Additional measures to combat marine pollution in the sub-region include signing and ratification by Central African countries of the 1976 MARPOL Convention on preventing dumping of wastes at sea, and the Montego Bay Convention on the Law of the Sea.

The Abidjan Convention, to which all coastal Central African countries are party, calls for cooperation in combating pollution in cases of emergency through early warning of emergencies, and cooperation in clean up, as well as mitigation activities. As a follow up to signing of the Convention, a Regional Workshop on Oil Spill Preparedness, Response and Cooperation for West and Central Africa was held in Luanda, Angola, in



Small pelagic fish, like these anchovies, are one of the most abundant species along the Central and Western African coastlines.

FLPA

November 2000. The focus of this was to generate and facilitate communication and links within the WACAF region. A series of conclusions and recommendations were drawn up at the workshop focusing on improving national and regional cooperation (IPIECA 2000).

Towards ICZM in Central Africa

Cameroon, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon, and Sao Tome and Principe are all members of the UNEP Regional Seas Programme for West and Central Africa, and are party to the Abidjan Convention. Although this has facilitated the development of ICZM policies and programmes at the national level, many countries have nevertheless experienced slow progress. The institutional structures and capacity for effective coordination and holistic integration of marine and coastal ecosystem issues into development planning and environmental management remain weak. Political commitment and financial resources also need to be augmented. Programmes to raise awareness among the public and among other stakeholders have also been initiated, but funds, staff and equipment are required to implement regulations and environmental protection activities.

The Sustainable Fisheries Livelihoods Programme involves the Central African countries of Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, and Sao Tome and Principe. The aim of this programme is to reduce poverty in coastal and inland fishing communities. It is heavily dependent on the participation of communities and sharing of benefits among the 7 million people whose livelihoods depend directly on the use of marine and freshwater resources. Communities will be involved in environmental and economic assessments, and the programme will include extensive public awareness activities to improve communication and cooperation on sustainable development (FAO 1999).

WESTERN AFRICA

Coastal erosion and the risk of sea level rise are the most serious issues facing coastal countries in Western Africa. However, there are also concerns over unsustainable harvesting patterns and rising levels of pollution.

Mangroves provide a natural habitat for fish, crustaceans, molluscs and water birds.

Adrian Arbib/Still Pictures

Economic, social and ecological value of coastal and marine environments in Western Africa

The coast of Western Africa spans a broad range of habitats and biota, including the pristine islands of the Bijagos Archipelago and the islands of Cape Verde. Ecosystems and resources are diverse, including abundant mangrove forests, sandy beaches, lagoons, coastal wetlands, and plentiful fisheries. Nearly 200 fish species were recorded in the area between 1950 and 1994 and there are a total of 22 local countries and 25 foreign fishing nations (FAO 1997). It is estimated that over half a million people in Mauritania, Guinea-Bissau and Senegal depend directly on fisheries for incomes and food supply (IPS 2001). There are approximately 6.5 million hectares of mangroves (mainly *Rhizophora spp.*) along the coast of Benin, Côte d'Ivoire, Ghana and Nigeria, providing habitat for fish, crustaceans, molluscs and water birds (Akpabli 2000).

Storm surges are common along the coast, and patterns of erosion and accretion are highly dynamic. The protection afforded by the mangroves and other coastal wetlands is therefore vital in stabilizing the coastal zone and enabling infrastructure and development.

There are abundant oil and gas reserves off the Western African coast, especially around the Niger Delta, as well as mineral deposits (including placer minerals in Sierra Leone) and abundant sand, gravel and limestone, as well as opportunities for shipping and tourism activities.

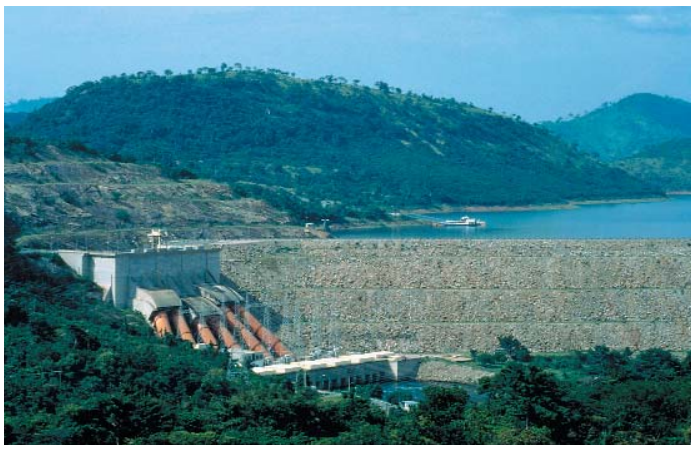
Population pressures are among the factors that have and will continue to contribute to substantial resource degradation in the coastal zones of Western Africa. For example, in Ghana, 35 per cent of the population live on the coast, and 60 per cent of industry is concentrated in the Accra-Tema metropolis (Chidi Ibe 1996). In Nigeria, about 20 million people (22.6 per cent of the country's population) live along the coastal zone, and 13 million people live in the coastal capital of Lagos which is also the centre for 85 per cent of the country's industrial activity (UNCHS 2001, Chidi Ibe 1996). The coastal region of Dakar (Senegal) is home to about 4.5 million people (66.6 per cent of Senegal's population) and 90 per cent of the country's industries (IPCC 1998). The coastal population in Western Africa is likely to rise to about 20 million by 2020, through growth of existing coastal populations and migration from inland areas (Snrech, Cour, De Lattre & Naudet 1994).

Traditionally, opportunities for agriculture and employment in the more humid coastal areas have encouraged steady migrations from the Sudano-Sahelian area towards the coast. Much of the coastal rain forest has been cleared to make way for agricultural plantations and urban development and what remains is decreasing at an annual rate of between 2 and 5 per cent (World Bank 1996b). Fragile coastal ecosystems, such as the stretch of coast between Accra (Ghana) and the Niger Delta (Nigeria), are under further stress because of increasing demand for resources compounded by industrial and urban development and their associated pollution loads.

Construction of the Akosombo Dam in Ghana and the Kainji Dam in Nigeria has lowered the sediment loads in rivers that reach the coast by up to 40 per cent, making less sediment available to replace that eroded or extracted in the coastal zone. As a result, coastal erosion east of Accra has been accelerated, reaching a rate of 6 m/yr

Coastal erosion and climate change in Western Africa

Coastal erosion has been recognized as one of the most crucial issues along the coast of Western African with erosion rates of 23-30 m per year being recorded in some areas (Smith, Huq, Lenhart, Mata, Nemesova & Toure 1996). Mining of sand and gravel from estuaries, beaches, and directly from the continental shelf contributes to coastal erosion and shoreline retreat. In some cases, construction of ports and harbours perpendicular to the littoral zone can cause acute down-drift erosion and this has been experienced in Benin, Côte d'Ivoire, Ghana, Liberia, Nigeria and Togo. The Bight of Benin, off the coast of Guinea, is an area particularly affected by erosion resulting from the construction of jetties and large harbours with breakwaters extending into the sea, dredging activities, and the extraction of sand for construction (Wellens-Mensah 1994). Accentuated erosion has also been documented in the Niger Delta. This is one of the impacts of offshore oil production, causing subsidence of the continental shelf and effectively raising the sea level (Chidi Ibe, Awosika, Ihenyen, Ibe & Tiamiyu 1985).



The Akosombo hydro-electric power project, Ghana

Ron Giling/Still Pictures

Construction of the Akosombo Dam in Ghana and the Kainji Dam in Nigeria has lowered the sediment loads in rivers that reach the coast by up to 40 per cent, making less sediment available to replace that eroded or extracted in the coastal zone. As a result, coastal erosion east of Accra has been accelerated, reaching a rate of 6 m/yr. In Togo and Benin, coastal retreat has exceeded 150 m over the past 20 years and is threatening the potential for future development in the coastal zone (UNEP 1999b).

Climate change scenarios for the sub-region predict increases in frequency and intensity of tidal waves and storm surges which will exacerbate erosion problems by

moving greater amounts of coastal material (Allersman and Tilsmans 1993). Predictions also include a rise in sea level of one metre which would result in land loss of 18 000 km^2 along the Western African coast. Major cities such as Banjul, Abidjan, Tabaou, Grand Bassam, Sassandra, San Pedro Lagos, and Port Harcourt would be inundated, with damage to infrastructure, and displacement of populations (Jallow, Barrow & Leatherman 1996, ICST 1996; Awosika, Chidi Ibe & Schroeder 1993). Inundation of Dakar, in Senegal, for which conditions are described above, would also create a significant problem of relocation and resettlement (Dennis, Niang-Diop & Nicholls 1995).

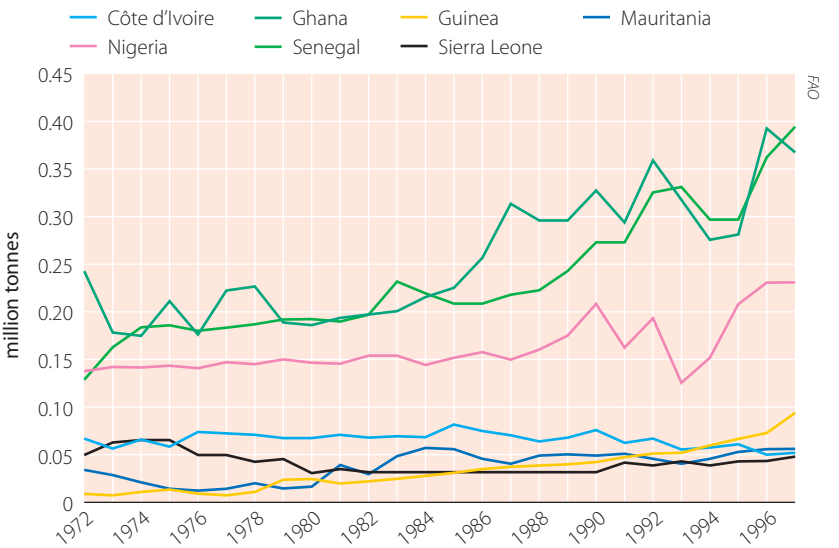
Natural habitats and resources are also at risk from sea level rise. Mangroves, for example, constitute an important resource as they stabilize coastal lands, prevent erosion and provide breeding grounds and sheltered habitats for many species and provide raw materials for medicine, food, and construction to the local communities. Inundation of these habitats would displace many species and disrupt the economic activities they support.

Sea level rise of more than one metre would flood over 15 000 km^2 of the Niger Delta and force up to 80 per cent of the population to higher ground, with consequent damage to property estimated by the IPCC at US$9 000 million (World Bank 1996b, Leatherman & Nicholls 1995). The Niger Delta encompasses wetlands and lagoons that are the spawning grounds for commercial shrimp and oysters, and bait-fish for the large tuna industry. It also contains 1 300 oil wells responsible for 90 per cent of Nigeria's oil exports and foreign exchange earnings (French, Awosika & Ibe 1995). Flooding would disturb these habitats and economic activities and could worsen problems associated with oil pollution.

Mitigation of coastal erosion and climate change in Western Africa

Coastal protection measures to date have included piecemeal construction of groynes, sea walls and other physical barriers, often at high costs and, in many cases, further contributing to the problem rather than curbing it (Wellens-Mensah 1994). An integrated, holistic framework for preventing coastal erosion is required to address the causes of erosion inland as well as those in the coastal zone. As erosion accelerates under sea level rise, considerable financial resources will need to be accessed and allocated, for example to build sea walls along the Barrier Coast (near Lagos). Protection of the oil wells in the Niger Delta will be another significant cost (French and others 1995). New drilling technologies may have to be developed and harbours will require upgrading, to maintain their functionality.

Figure 2c.6 Marine fish catch for Western Africa, 1972–97



Harvesting of coastal and marine resources in Western Africa

Small pelagic fish—herring, sardines and anchovies—are the most abundant species in the fisheries off the Western African coast and these represented almost half of all catches in 1994 (see Figure 2c.6). Catches have increased on average by 20 per cent per year since the 1950s under the impetus of national fisheries development policies. Total catches of demersal stocks on the Mauritania continental shelf fell by almost two-thirds between 1984 and 1992, which could reflect a change in fishing strategy. In Mauritania, Senegal and the Gambia, demersal resources are considered to be fully exploited or overexploited. In Cape Verde waters, the most important resource is tuna, and recent data indicate that fisheries' resources in Cape Verde are not fully exploited. In the west and central Gulf of Guinea, potential shrimp catches have been estimated at 4 700 tonnes, which is above the maximum sustainable yield (FAO 1997).

Since the late 1980s, market forces have driven foreign fleets to fish in these waters, to the detriment of catches by local countries. For example, fishing agreements between African nations and the EU have been poorly negotiated because African governments are in need of the foreign exchange and income capital. Not only have commercial fishery stocks been drastically reduced, but other species such as dolphins, sharks and turtles have also been affected and their numbers are now declining (WWF 2001b).

Sustainable harvesting of coastal and marine resources in Western Africa

Benin, Côte d'Ivoire, Ghana, Nigeria, and Togo are party to the UNCLOS which protects national and international fishing rights and exploitation zones. However, additional resources are required to enforce these regulations and to prosecute law-breakers. Guinea-Bissau, Mauritania, and Senegal have taken additional action to protect their fisheries and Mauritania is banning all fishing except traditional, non-motorized boat fishing by local communities in the Banc d'Arguin National Park. Guinea-Bissau is establishing the Joao Viera/ Poilao National Park in the Bijagos Archipelago, as a refuge for green turtles, dolphins, sharks, rays, and migratory waterbirds. Senegal is also expected to establish marine protected areas in the near future (WWF 2001b). These are in addition to the 25 existing MPAs established to reduce pressures on natural resources from overharvesting, pollution, and modification of the physical characteristics of the coastline. However, enforcement of protection regulations in most MPAs has been limited by lack of resources.

Pollution of Western Africa's coastal and marine environment

As Western African economies have diversified and concentrated on exports, sources of industrial pollution have developed in the coastal zone. The main sources are breweries, textile industries, tanneries, aluminium smelting, petroleum processing, and edible oil manufacturing. At present, effluents are often discharged untreated into rivers, lagoons and the coastal waters of the Gulf of Guinea, and this is likely to increase with rising economic pressures to expand industrial operations (Akpabli 2000). The Korle Lagoon, a large coastal wetland in Accra (Ghana), has been severely degraded by pollution from industrial and domestic sources (WRA 1997). Agricultural pollution is widespread, with chemical residues, fertilizers and soil being washed from the surrounding cultivated areas, and causing eutrophication in coastal wetlands and estuaries.

Pollution of such environments reduces their potential to support wildlife and commercial fisheries. Polluted waters are also a risk to human health, through direct contact or contamination of drinking water sources. Pollution by sewage creates a risk of typhoid, paratyphoid, and hepatitis infections, through direct contact and consumption of contaminated seafood. Microbial and bacteriological contamination are cause for concern in the Bay of Hann, near Dakar (Senegal), in Ebrie Lagoon (Abidjan), and in Lagos Lagoon (Nigeria) (UNEP 1984).

Offshore mining and oil drilling activities are major sources of oil pollution, mainly because of leaking pipes, accidents, ballast water discharges, and production-water discharges. Drilling also involves the use of heavy metals such as vanadium and nickel, and contamination of seawater with these metals is known to affect plants and animals. Oil pollution damages coastal resources and habitats, as well as fisheries, reducing catches and incomes.

Enhancing coastal and marine environmental quality in Western Africa

The Gulf of Guinea Large Marine Ecosystem Programme is a jointly funded, regional cooperative programme for improving environmental quality and productivity in the Gulf of Guinea (see Box 2c.5). Benin, Côte d'Ivoire, Ghana, Nigeria, and Togo from Western Africa and Cameroon in Central Africa, have participated in the programme which has established a framework for sub-regional cooperation and national level, integrated coastal management plans. It also facilitated the adoption of the Accra Declaration (Declaration for Environmentally Sustainable Development of the Large Marine Ecosystem of the Gulf of Guinea), in 1998. The Declaration, aims at institutionalizing a new ecosystem-wide strategy for joint actions in environmental and natural resource assessment and management in the Gulf of Guinea. Ministers of participating countries have also called for the initiation of a second phase of the project with participation expanded to involve 10 other countries from Senegal to Angola. The Programme received

Box 2c.5 Enhancing environmental quality in the Gulf of Guinea

The Gulf of Guinea coastal area (from Guinea-Bissau to Gabon) is one of the world's most productive marine regions, supporting 80 million inhabitants through use of the fisheries, habitat, and energy resources. Rivers and lagoons serve as important waterways for the transportation of goods and people. The Gulf is also rich in petroleum deposits, and is important globally for its marine biological diversity. Unfortunately, pollution from residential and industrial sources has resulted in habitat degradation, loss of biological diversity and productivity, and risks to human health. Coastal erosion, resulting from urbanization and clearing of mangroves constitutes a further threat to the ecosystem. Large oil and gas deposits make a major contribution to the region's economy, but also bring additional habitat modification and pollution risks.

Regional cooperation has been successful in addressing some of these environmental stresses within the framework of the Gulf of Guinea Large Marine Ecosystem Programme, funded by UNDP, GEF, and NOAA. The programme includes the Industrial Water Pollution Control and Biodiversity Conservation in the Gulf of Guinea project, in which all of the programme countries have participated. This aims to improve the health of the coastal waters by strengthening institutional capacities for pollution prevention and remediation, developing an integrated information management system, establishing a region-wide ecosystem monitoring and assessment programme, identifying measures to prevent and control pollution, and developing policies and strategies for sustainable development of the Gulf's resources.

The project has been successful in building capacity within institutions, designing a regulatory policy to conserve fisheries resources, rehabilitating mangroves, establishing regional effluent regulations, and in getting all countries to adopt a regional integrated coastal areas management programme.

Source: UNIDO 2000

recognition by other coastal African nations during the Pan-African Conference on Sustainable Integrated Coastal Management (PACSICOM) (Mozambique, 1998) and by the Advisory Committee on the Protection of the Sea (ACOPS) Conference (South Africa, 1998).

Towards ICZM in Western Africa

Western African States signed the Abidjan Convention in 1981. This obligates them to place controls on land and marine-based sources of pollution, to harmonize and strengthen national policies and to cooperate with other countries in the sub-region to enhance environmental management. Parties to the Convention are also required to take steps to control and mitigate coastal erosion and its causes, and to develop contingency plans to prevent and deal with pollution arising from oil exploration and transport activities. Under the Convention, countries are also obliged to conduct environmental impact assessments prior to new developments in the coastal zone as a means of regulating uncoordinated, unplanned developments which could accelerate pollution and erosion. Unfortunately, the Convention was unsuccessful in establishing an effective Regional Coordinating Unit, and progress has been slow. In response, UNEP has established a joint secretariat for the Abidjan and Nairobi Conventions, operational from September 2000. The new work programme of the Abidjan Convention countries includes assessments of coastal erosion and activities for improving the management of coastal ecosystems, with a special focus on mangroves and oil pollution.

CONCLUSION

The African coastline has abundant and diverse natural resources and highly productive ecosystems that provide protection and stabilization of the physical coastline, regulation of global atmospheric gases, and nutrient cycling. The natural beauty of the coastline and

its abundant resources have attracted high numbers of tourists and migrants in recent years. Local communities are heavily dependent on coastal resources such as mangrove trees for construction and medicinal and food products, and for subsistence or small-scale trade. Inland communities are now also able to access these resources and demand, as well as the price, for some food species is sufficient to support national fishing industries. These fisheries and other industries (notably oil and gas, and tourism) make substantial contributions to the national economies of coastal African countries. The coastal and marine resources therefore have great ecological, social and economic importance, both locally and for the global community.

Abundance of natural resources and economic opportunities have led to very high rates of migration and urbanization, tourism, and development in Africa over the past 30 years. Housing and urban infrastructure, industrial sites, ports, agricultural activities and hotel and leisure facilities have all also developed and have brought with them activities such as mining of sand, limestone and coral to provide building materials. These pressures have combined to destabilize Africa's coastal zone, increase erosion, smother habitats, deplete resources, pollute ecosystems, and reduce biodiversity. The consequence of these impacts has been a drop in economic opportunities and increasing poverty amongst coastal communities dependent on natural resources. Pollution levels are also threatening human health, directly through exposure to contaminants in coastal waters at popular resorts, and indirectly through accumulation of toxins in seafood. This pattern of overextraction and overloading with wastes is likely to continue, if not intensify, in future.

The challenge for Africa is to use its resources wisely, so that economic development can be achieved without destroying the resource base on which it is founded. ICZM is a proposed tool for doing this, and one that has been adopted, in principle, by many coastal African nations. However, implementation in many countries has been hampered by lack of human and financial resources, lack of scientific data and monitoring programmes, and by institutional fragmentation and lack of cooperative mechanisms and integrated development models. Similarly, international treaties, such as the United Nations Law of the Sea, and MARPOL, have been signed but are ineffective without the necessary commitment to ensure implementation and enforcement of penalties for non-compliance.

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