SECTION 2

ENVIRONMENT STATE-AND-TRENDS: 20-YEAR RETROSPECTIVE

CHAPTER 2
ATMOSPHERE

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REGIONAL SYNTHESIS

Africa is endowed with diverse and abundant atmospheric resources. These resources include rainfall, air, solar radiation or insolation, and wind. Unlike land and marine resources, atmospheric resources are found in all African countries, although at varying levels, distribution and frequency.

Atmospheric resources provide life-supporting goods-and-services. The air contains oxygen, carbon dioxide and nitrogen that are essential for life and livelihoods. The clouds, with their accompanying lightning phenomenon and rainfall, play a critical role in supporting life on Earth. Rainfall is a source of water for people, animals and plants, and for rain-fed agriculture. The ozone layer, found in the stratosphere, protects human beings from ultraviolet radiation that is likely to cause cancer. Solar insolation provides light and energy. The sun, wind and rivers are sources of energy for direct use or electricity generation.

The northern and southern countries in Africa receive little rainfall, below 1 000 mm per year. The equatorial countries receive over 1 000 mm of rainfall on average. Higher speed winds are generally found in the southern and northern parts of the continent. Virtually all countries in Africa receive over ten hours of sunshine a day, providing good potential for solar energy generation. The air in Africa, except in major industrial cities, is relatively clean.

Atmospheric resources offer a variety of opportunities for sustainable development. Air pollutants including soot and dust, greenhouse gases (GHG), chlorofluorocarbons (CFCs), and heavy metals affect the quality of air and threaten the goods-and-services provided by the atmosphere. These pollutants contribute to climate change, climate variability, depletion of the ozone layer, and low air quality. Climate variability and climate change manifest themselves in global warming, and extreme weather events including floods, droughts, heat waves and typhoons. These phenomena affect human well-being through increasing the incidence of diseases, affect land and marine productive systems from which livelihoods are derived, and destroy infrastructure.

Thus, threats to atmospheric resources undercut development opportunities. Mitigating the causes and impacts of potential threats is important: Africa needs to develop appropriate policy and action. Investing in programmes and businesses that mitigate the effects of climate variability, climate change and air pollution presents opportunities for sustainable development. There are also benefits that can be derived in reversing degradation of atmospheric resources.

INVENTORY OF RESOURCES

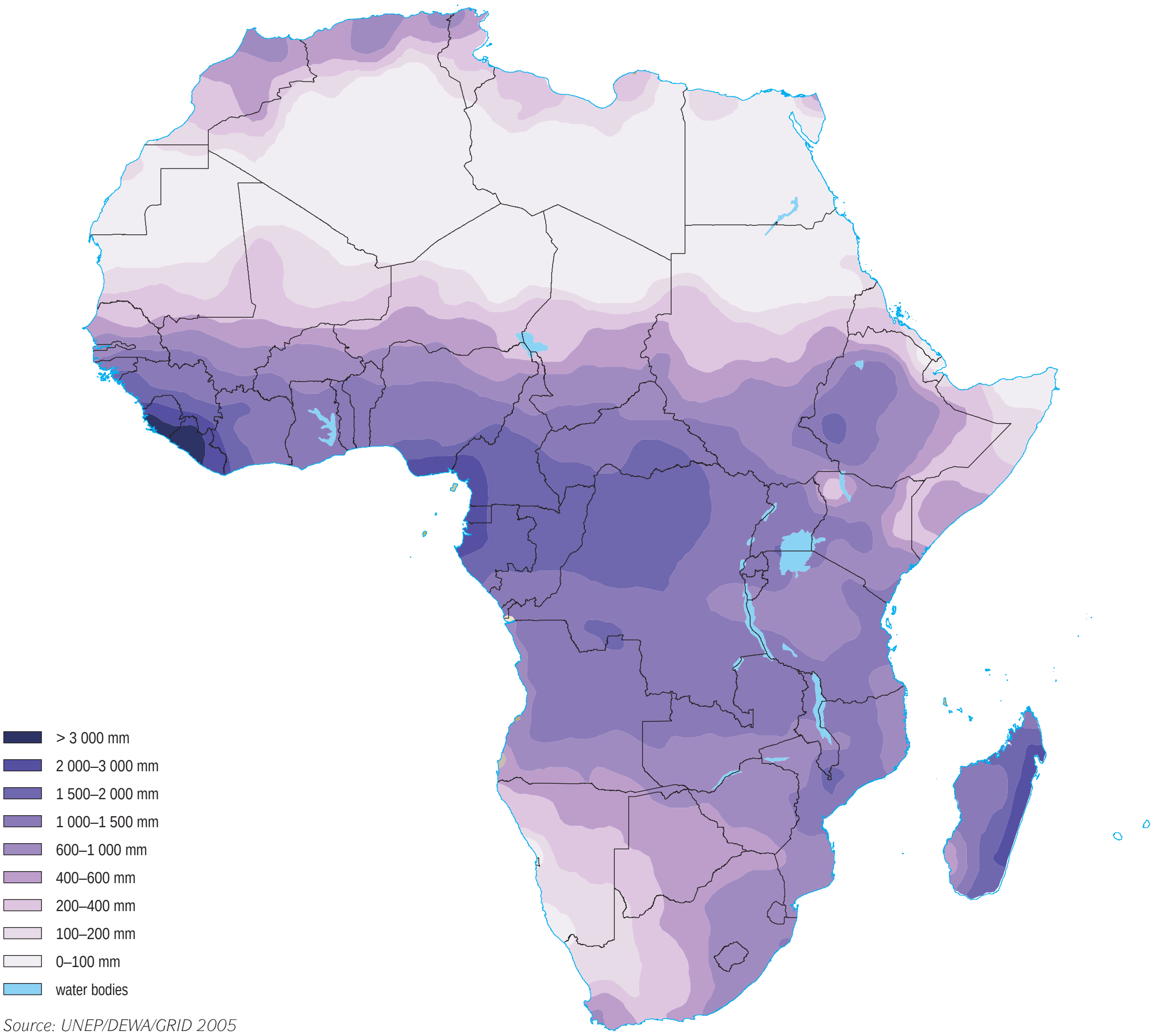
Rainfall and rivers

Africa has virtually the same climatic zones in the northern and southern hemisphere, and these zones are arranged symmetrically on either side of the equator. The zones are determined mainly by latitude, except in the east where highlands greatly modify the climate.

Africa is predominantly a tropical region: only its northern and southern extremes, which are directly influenced by mid-latitude westerly winds, are considered to have temperate climates. Nevertheless, it is, after Australia, the driest region in the world (ECA 2000). The amount, duration and seasonal distribution of rainfall are the most important factors differentiating its climates. Africa has six climatic zones. These are equatorial, savannah, semi-arid, arid, highland and Mediterranean:

- Equatorial climates occur close to the equator in the west and the central parts of Africa, and in eastern Madagascar. Rainfall is high, typically exceeding

Figure 1: Map of rainfall zones



Source: UNEP/DEWA/GRID 2005

1 500 mm per year and as much as 3 200 mm in some places. Rainfall occurs in every month, and many areas experience two rainy seasons per year.

- Tropical savannah climates occur north and south of the tropical wet zone, in much of west and southern Africa, and in most of Madagascar. This climatic zone is marked by a well-defined dry season of three to eight months. Annual rainfall is usually between 500 and 1 500 mm, although limited areas have considerably more: for example, Freetown in Sierra Leone averages 3 800 mm per year. The tropical savannah zone is a transitional zone between tropical wet and semi-arid zones, so there is a progressive decline, moving towards the poles, in total rainfall and the duration of the rainy season. Areas with a longer rainy season tend to have two rainy periods separated by a short dry spell, while areas with a shorter rainy season have a single rainy period.
- Surrounding the tropical savannah climate zone are areas of semi-arid, and then arid climates in the west, north-central, east-central and southern parts of Africa. The semi-arid zone has a short rainy season of up to three months, with about 250-500 mm of rainfall per year. Precipitation is unreliable and scarce.
- Tropical highland climates are common in much of east Africa. In most parts of the world, higher elevations receive higher levels of precipitation, but the highlands of east Africa are an exception, experiencing rather low levels of rainfall. However, the highest mountains and the south-eastern flank of the Ethiopian plateau receive greater precipitation on their windward slopes.
- The coastlands of the Cape in South Africa and the north African coast, from Morocco to Tunisia, have Mediterranean climates. These areas have mild, rainy winters followed by a prolonged summer when conditions are warm and dry. They receive between 250 and 1 000 mm of rainfall per year.

Most of the African continent receives moisture from air originating over the Atlantic Ocean. In the eastern part, however, rainfall south of the equator comes from large tropical cyclones originating over the Indian Ocean during the southern hemisphere summer. Rainfall from these cyclones is particularly high in eastern Madagascar and the coastal mainland between South Africa and southern Tanzania.

Average rainfall has decreased since 1968, and has been fluctuating around a notably lower mean (UNEP 1999). In Africa, some 3 988 km^3 of renewable water is available annually (ECA 2000). In recent years, the pattern of rainfall has tended to extremes, with the severity and frequency of droughts and floods increasing.

Africa has many rivers, but some, particularly in the mountainous areas, are seasonal and the water flow rates are gradually declining over the years.

The major rivers include the Senqu or Orange, Niger, Zambezi, Limpopo, Senegal, Congo and the Nile. The Nile is the longest river in the world, at about 6 679 km (Pickett 2000). The Nile starts from Lake Victoria and passes through Uganda, Sudan and Egypt to the Mediterranean Sea. The main headstreams, the Blue Nile and the White Nile, join at Khartoum in Sudan to form the Nile proper. The Senqu/Orange River is 2 092 km long and passes through Lesotho, South Africa and Namibia, flowing south-west, north-west, and west to the Atlantic Ocean (Pickett 2000). The Niger River is found in Western Africa, rising in Guinea and flowing about 4 183 km in a wide arc through Mali, Niger and Nigeria to the Gulf of Guinea (Pickett 2000). The Zambezi River is about 2 735 km long, rising in northwest Zambia and flowing south and west to the Mozambique Channel (Pickett 2000). The Limpopo River runs through South Africa, flowing about 1 770 km in a north-east-south-east arc to the Indian Ocean in southern Mozambique (Pickett 2000). The Congo River is 4 666 km long and flows through Congo and the Democratic Republic of the Congo to the Atlantic Ocean (Pickett 2000). The Congo, which alone accounts for some 38 per cent of the continent's discharge into the ocean, drains an area of more than 4.1 million km^2, ranking second only to South America's Amazon River in terms of discharge and size of drainage basin (Microsoft Encarta Online Encyclopaedia 2005). The Congo River basin alone holds almost 30 per cent of Africa's total fresh surface water reserves and the world's largest hydropower potential in any one single river basin (ECA 2000). Africa's rivers provide extensive hydropower potential including for large (> 500 MW), medium (> 10 MW, < 500MW) and small (< 10 MW) plants. The opportunities and challenges associated with Africa's rivers and freshwater systems are discussed more fully in Chapter 4: *Freshwater*.

Wind and solar resources

Africa has traditionally relied on woody biomass for energy. Declining forest and woodland resources creates new challenges for meeting energy needs. Africa's rate of deforestation, at 0.8 per cent per year, is the highest in the world: between 1990 and 2000 an average annual loss of 5 262 000 ha per year was incurred (FAO 2005). Chapter 6: *Forests and Woodlands* considers the challenges and opportunities associated with forest resources and energy more fully. There are no reliable statistics on the extent to which other biomass, such as farm and urban waste, is available for energy. In this context, wind and solar energy are particularly important.

Low wind speeds prevail in many African countries, particularly in those that are landlocked. South Africa has some of the highest wind potential in the region. For example, wind speeds of 7.2 to 9.7 metres per second have been recorded around Cape Town and Cape Agulhas (Karekezi 2001). Northern Africa's coast also experiences optimal wind speed, especially Morocco. Other countries in Africa have relatively low speeds, as shown in Table 1 (Karekezi 2001).

Table 1: Wind energy potential for selected countries

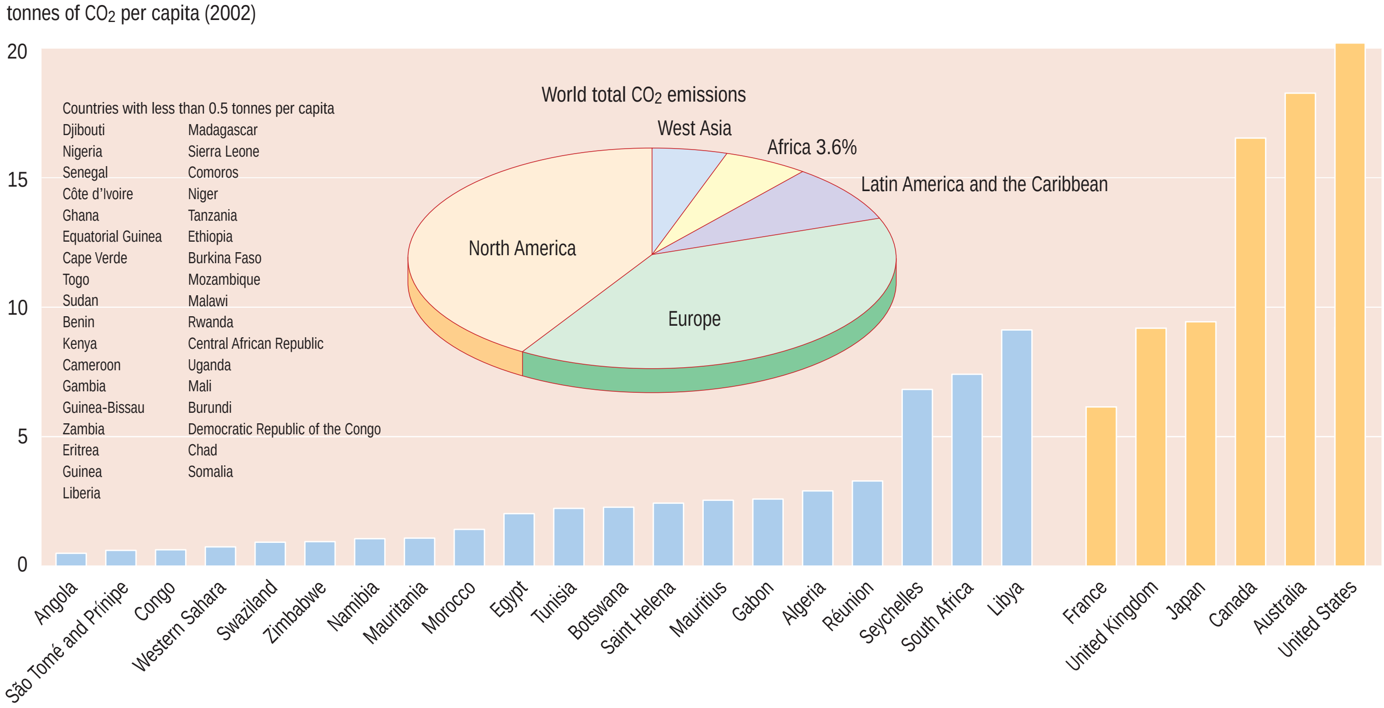
Country	Potential (metre per second)
Botswana	3
Burundi	>6
Djibouti	4
Kenya	3
Morocco	>10
Mozambique	0.7-2.6
Seychelles	3.62-6.34*
South Africa	7.29-9.7**
Sudan	3
Tanzania	3
Uganda	2
Zambia	3.5
Zimbabwe	2.9

** average wind speed for two seasons,*

*** highest wind speed recorded*

Source: adapted from Karekezi 2001

Figure 2: World CO_2 emissions per capita



Source: UNSTATS/CDIAC 2006

Africa is endowed with enormous potential for solar energy generation; the actual potential depends on how its primary solar energy is converted into a useable resource such as through photovoltaic cells or power-concentrating technologies. Concentrating solar power technologies use reflective materials, such as mirrors, to concentrate the sun's energy and direct it into a thermal receiver, and can be used to provide heating and lighting. Photovoltaic technologies use light to produce electricity. Estimates of the globally available solar energy is more than adequate to meet current and projected energy needs up to 2020 (Rogner 2000). For sub-Saharan Africa (SSA), the minimum estimated solar energy is 371.9 exajoules and the maximum is 9 528 exajoules (Rogner 2000).

Air

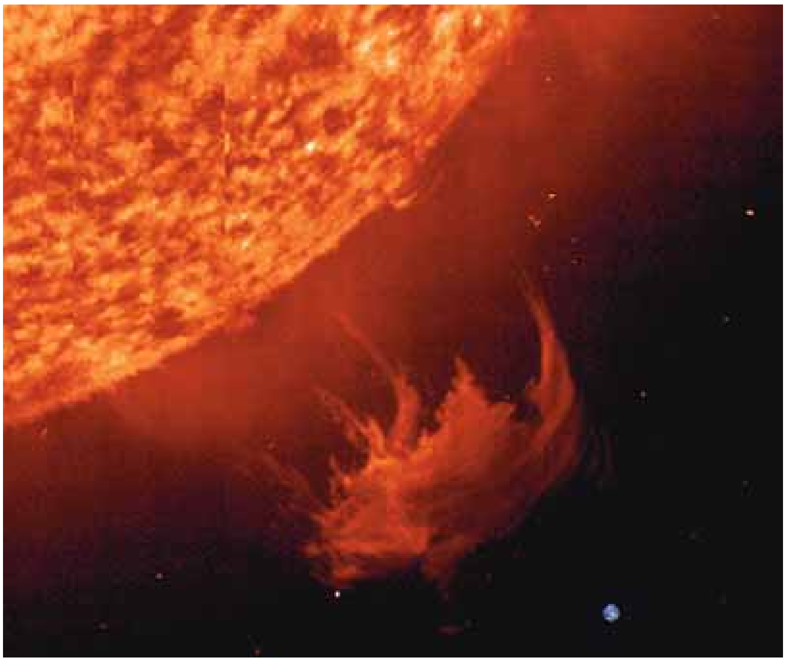
Africa's air is relatively clean. However, pollution is an emerging issue in urban centres and is already a problem in major industrial cities, like Cairo. The air is polluted by emissions from industry, motor vehicles and households, including oxides of sulphur, carbon, nitrogen, particulates, lead and organic compounds. Because of the reliance of many households on woody biomass for energy, indoor pollution is a concern. This has a disproportionately high impact on women and children (Gordon and others 2004).

Industrialization is taking root in many countries, and this, along with the increasing number of households, is putting pressure on the quality of air. In the transport sector, the excessive use of second-hand vehicles and poor maintenance of vehicles are major contributors to air pollution. The use of leaded fuel is also a contributor. However, Africa contributes only 3.6 per cent of global emissions of carbon dioxide, the principal gas linked with global warming.

Endowment opportunities

Atmospheric resources offer important opportunities for sustainable development and improving human well-being. Their sustainable management can contribute towards the realization of the Millennium Development Goals (MDGs) and meeting the MDG targets, as well as regional and national targets:

- Rainwater harvesting can increase access to safe and clean water;
- Effective rain-fed agriculture can improve food security and thus reduce extreme hunger;
- Harnessing renewable energy resources can power small-scale rural industries and improve income;
- Developing national renewable energy resources can enhance reliability and lower costs of electricity to the productive sectors;
- Harnessing solar energy can improve access to household lighting and power, and increase livelihood and educational opportunities;
- Increasing participation in global businesses and the market sector can lead to improved income and enhance opportunity; and



Solar flares from the sun
This image shows how tiny the Earth (blue dot on the right) is compared to the size of the flare.

Source: SOHO (ESA & NASA)

- Reducing air pollution can result in improved health and reduce child and maternal mortality levels.

Improving scientific and technological capacity, including through partnerships with the global community, is an important strategy for harnessing the full potential of atmospheric resources. Information and knowledge are increasingly driving societies and economies. The success of future societies, businesses and economies will be determined by their abilities to generate, process and make use of knowledge. Thus, harnessing atmospheric resources for sustainable development demands that Africa invest in broadening and strengthening science and technology capacity. Adding value to natural resources requires the development of new materials, processes and products. Advances in materials and biotechnology are crucial for most renewable energy technologies (IEA 2004). In the short term, Africa will have to rely heavily on technology transfer, although in the medium to long term, developing indigenous technology will be essential.

Africa can promote innovations through the establishment of science parks. These will serve as seed-beds for new technology-based firms (NTBFs), which could contribute to poverty reduction in the medium to long term. In the short term, African governments could enter into partnerships with scientists in the African diaspora to support research and development in Africa. This strategy will repatriate knowledge and skills to Africa and assist in mitigating the "brain drain".

Investment in basic research is important for maximizing opportunities. International cooperation, including through establishing partnerships between developing countries, could offer crucial support and access to resources. Cooperation between South Africa, India and Brazil in nanotechnology development is one example for an effective research partnership. Investing in basic research is important, as noted by the IEA:

> "Developing advanced technologies requires not only applied research and technology refinement, but also the innovation that stems from advances in basic science. Knowledge flowing from basic research is what will feed the development of new materials, bioprocesses, nanotechnologies, and other approaches that could reduce clean technology costs. It could also lead to new unforeseen technologies and novel approaches to providing energy services. Effective linkage between basic science and applied technology development will be important to ensure that these opportunities are opened up" (IEA 2003a).

The availability of fossil energy reserves underpins the wealth of African countries and their ability to invest in the development of renewable energy resources, such as hydropower and solar energy. Oil reserves are found mainly in Algeria, Angola, Chad, Gabon, Mauritania, Equatorial Guinea, Egypt, Nigeria, Libya and Sudan and have been an important factor in improved economic growth (ECA 2005b). Africa has just 5 per cent of the world's coal resources, and over 97 per cent of this is found in South Africa, Mozambique, Zimbabwe and Botswana (EIA 2003). Most of the natural gas reserves are found in Western Africa (Nigeria 30.8 per cent) and Northern Africa (Egypt 10.7 per cent, Algeria 39.6 per cent, and Libya 11.5 per cent) (WEC 2001). Countries not endowed with fossil fuel reserves require substantial financial support to develop their atmospheric resources.

Wind

Where good sites are available, wind energy is an option that should be given a chance. Although generation costs vary from site to site, these have come down considerably over the last 15 years and it is estimated that generation costs are equivalent to more traditional energy generation, making wind energy a competitive option (Morthorst and Jacobsen 2003, ISES 2006). The world potential for wind development is enormous. It is projected that 130 GW will have been installed globally by the year 2010 (IEA 2004).

Wind speed and frequency determine how much energy can be produced by wind turbines (Rogner 2000). Low wind speeds prevail in most of Africa, with average wind speeds of between 3 to 6 metre per second (Karekezi 2001). Despite the average low wind speeds, there are some localized sites with good wind speeds that could be tapped for water pumping and electricity generation. There is potential to generate wind power from 24 per cent of Africa's land – with an estimated gross electrical potential of 106 000 TWh (Rogner 2000) Africa can utilize this potential through the development of community-level systems. Hybrid energy systems, coupling wind turbines with conventional generators, may be used to mitigate the intermittent nature of wind and energy constant energy supply.

African governments should invest in local capacity to plan, design and construct wind plants. Wind towers are site-specific and are best suited for local design and construction. Electrical and electronic components may

Box 1: Wind power generation in South Africa

The South African government has strongly embraced wind power generation and has committed itself to producing 4 per cent of its requirements as renewable energy by 2012.

The South African electricity supply authority, ESKOM's wind power generation project, the South African Bulk Renewable Energy – Generation (SABRE-Gen) (of ESKOM) is investigating the potential of using wind energy for bulk electricity generation in Southern Africa (using turbines of 600 KW or higher capacity). This project focuses on:

- Understanding the implications of using wind energy on a large scale in a Southern African environment;
- Determining the most suitable applications for wind energy;
- Determining the most appropriate scale of implementations.
- Information sourcing and documentation for the effective implementation of wind energy;
- Preparing the market and industry for implementation; and
- Investigating the sustainability of wind energy in a Southern African environment.

This study has five components, namely: scanning/pre-feasibility; wind resource assessment; feasibility; research and demonstration facility; and business case development. The research and demonstration facility has been established and the last component, business case development, is ongoing (2003-2005) (SABRE-Gen 2004).

Wind turbine, Germany.

Source: M. Schroeder/Still Pictures

South Africa's first commercially available, wind-generated electricity could be lighting homes in the Western Cape soon. The US$11 million project has come closer to reality with the approval by the Department of Environment Affairs and Tourism of a plan to erect four wind turbines on a farm near Darling, 70 km outside Cape Town. The wind farm project, supported by the Danish International Development Agency (DANIDA), the United Nations Development Programme (UNDP), and the Global Environment Facility (GEF) will produce 5.2 MW, enough to light a town like Darling. The Danish government is backing the project with US$3 million. The South African Wind Energy Programme, through GEF, will mobilize about US$65 million to be spent on wind energy to the tune of 50 MW capacity. The British government has promised US$3 million for a training centre on the farm once the Western Cape Department of Nature Conservation gives the go-ahead (SABCnews 2005).

During the predicted lifetime (20 years) of the Darling National Demonstration Project, the main environmental benefits will be the reduction of pollutants from conventional electricity generation, including of carbon dioxide, sulphur dioxide, nitric oxide, particulates, and slag and fly ash (DME 2005). The Project will also result in the saving of 100 000 t of coal and 60 million l of water.

Source: SABRE-Gen 2004, SABCnews 2005 and DME-Danida 2005 be sourced from global markets. However, there is a need to standardize these components. Wind power plants are capable of powering small industries in off-grid locations. Governments should harmonize their policies on energy and industry. Partnerships with the private sector as well as with the global community, as envisaged under the World Summit on Sustainable Development (WSSD) Johannesburg Plan of Implementation, are important.

Powering small-scale industries in rural and off-grid areas

Where suitable sites exist, wind presents opportunities for powering small-scale industries, including water pumping. However, investment in local capacity to plan, design and construct wind, biomass and hydro turbine-generator sets is essential to take advantage of this opportunity. Wind towers and hydropower plant civil works are site-specific. Planning, engineering and design costs would be drastically reduced if local personnel undertook these tasks. This is the strategy used by China and India (Lew and Logan 2005), who are among the world leaders in wind and small hydropower plants.

Development of rural power plants should be encouraged to supply power to communities and homes and thus improve livelihood opportunities and human well-being. Investments could target the following:

- Invest in planning and design of plants;
- Standardize key components of plants and produce most of these components in Africa;
- Invest in a large number of small plants to achieve economies of scale;
- Develop computer-based tools and instruments and standardize design of plants; and
- Invest in technology for modern computer-based survey and mapping techniques as a means of lowering design and engineering costs.

Access to electricity in rural areas, transmitted or generated, will contribute to the improvement of the lives of the rural women and children who are forced to spend lots of time in search of firewood and often trek long distances for water and firewood.

Solar radiation

The availability of solar resources is not a factor undermining its potential use; instead, there are three factors determining uptake: the availability of efficient and low-cost technologies to convert solar energy into electricity and hydrogen, effective energy storage technologies, and high efficiency end-use technologies (Rogner 2000).

Concentrating solar power

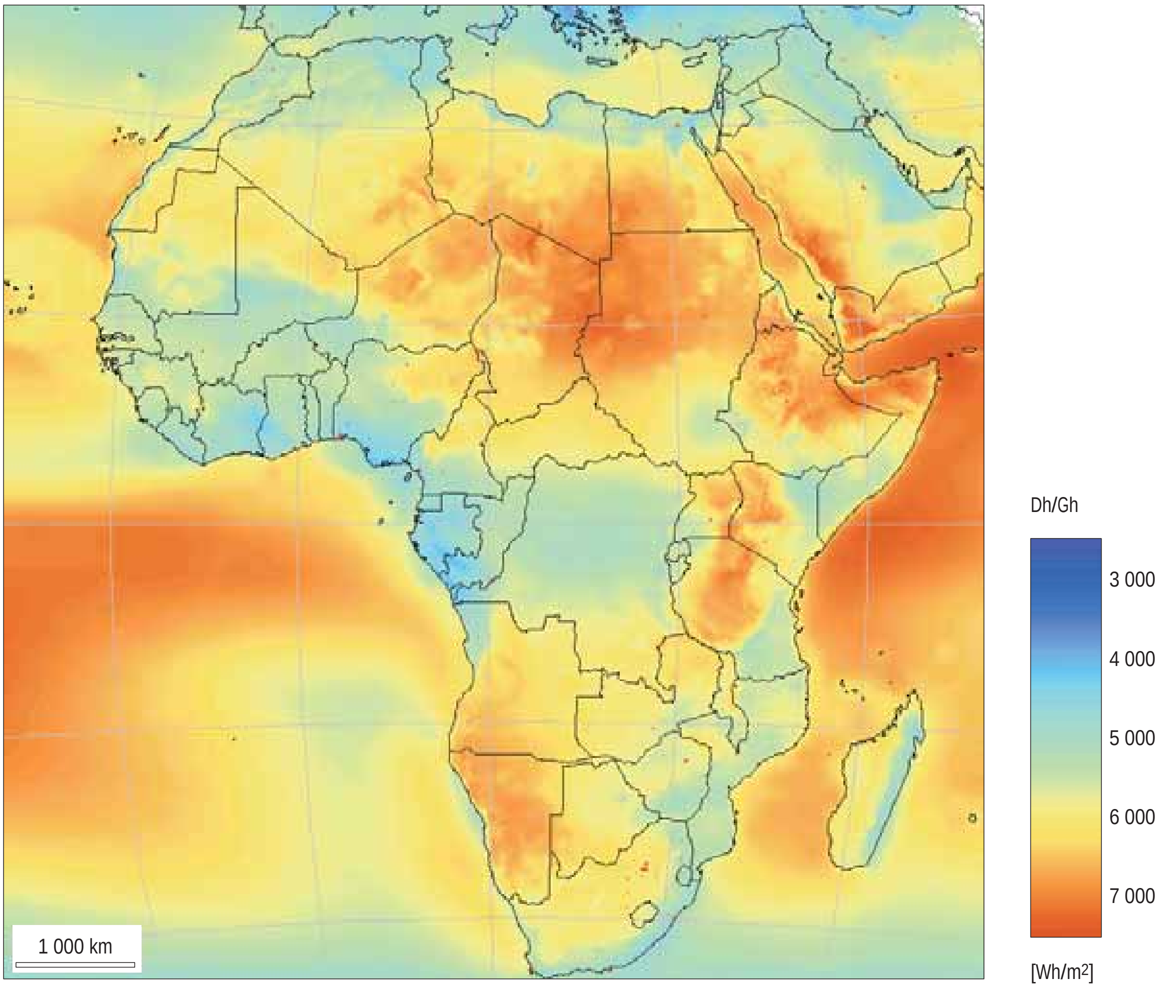
Concentrating solar power systems – or solar thermal energy – provide both heat, such as warming water, and electricity through the use of reflective techniques. These systems are particularly suitable where there is plenty of direct solar irradiation. Concentrating solar power systems have high potential in the arid and semi-arid lands (ASAL) of the northern and southern parts of Africa. Concentrating solar power systems are suitable for provision of industrial and commercial power. These systems may replace conventional fossil fuel plants and contribute significantly to environmental conservation. Although they have not been extensively used, these systems are not new to Africa. Egypt has an early and continued interest in this sector. Egypt is one of the few countries in the world that has a government department dedicated to the development of renewable energy sources. Under the direction of the New and Renewable Energy Authority (part of the Ministry of Energy), one of the first solar thermal power plants built since the 1980s will come on line in 2007 at El Koraimat near Cairo (Greenpeace International 2005).

The costs of investing in concentrating solar power systems are relatively high. Investment costs range from US$3 600 to $15 400 per KW in places with insolation levels of 1 700 KWh per m^2 (IEA 2003b). Generation costs are in the order of US$0.1 to US$0.15 per KWh (IEA 2003b). Where insolation levels are over 1 700 KWh per m^2 , as is common in Africa, optimal cost-competitiveness is achievable.

A concentrating solar power plant located at Kramer Junction in the Mojave Desert, California, USA.

Source: M. Bond/Still Pictures

Figure 3: Solar radiation



Source: EC 2005

Compared to other renewable energy systems, concentrating solar power systems currently have a low market potential. Global capacity was estimated at 825 MW in 2005, and was predicted to increase to 2 225 MW by 2010 and to 20 150 MW by 2020 (IEA 2003b). The global energy contribution from these systems stands at over 1 TWh, and growth rates of about 20 per cent are foreseen (IEA 2003b). Africa stands to benefit by investing in concentrating solar power systems. Morocco and Egypt have ongoing projects in this area. Morocco is setting up a 30-50 MW plant (IEA 2003b), while Egypt is working on a 35 MW plant (El-Sayed 2005).

Africa needs to build its research and development (R&D) capacity to participate effectively in the fast-growing concentrating solar power market. The projects in Egypt and Morocco will help accumulate knowledge and experience, and in turn lower engineering and development costs. The Egyptian government has increased interest and incentives for development of electricity supply utilizing renewable energy such as solar power. Two 130 MW solar-supported steam generation power plants are being constructed at Kuraymat in Egypt (El-Sayed 2005). One option is to develop capacity and capability to manufacture plant and machinery necessary for power generation. In the short term, one strategy may be to acquire disembodied technologies from developed countries.

Solar photovoltaic power

Solar photovoltaic (PV) power has the potential to meet the small energy services needs of isolated off-grid communities as it is ideal for lighting, powering electronic equipment and charging of telecommunication equipment. Lighting and small power needs of schools and community health centres may also be met from solar PV. Photovoltaic systems tend to penetrate the market faster when marketed as complete energy service packages like solar lanterns.

The high prices of solar PV equipment have contributed significantly to the low sales and poor adoption. The cost of a PV panel at US$4.7 per Watt (based on retail prices in Nairobi for 40 Watt panels) is prohibitive in comparison to competing fuels like wood, kerosene and gas. These prices will have to come down for this technology to be widely adopted and the benefits of solar energy to be utilized.

Apart from deriving energy services from PV solar generators, there are also business opportunities associated with this sector. This market is growing at 30 per cent per year (500 MW per year) and is set to continue growing at this high rate beyond 2010 (IEA 2004). The capital cost of the PV system has been halving every decade. This trend is expected to continue. This should serve as an incentive for Africa to invest in PV systems.

Solar home systems (SHS) and solar lanterns are ideal for lighting and powering most domestic electrical and electronic equipment. Concerted efforts to achieve widespread adoption of these technologies continue to be hampered by high initial investment costs. For example in 2005, an SHS of 40W, capable of powering an average rural home, costs US$500 in Kenya. The cheapest solar lantern of 11W retails for US$100 in Kenya. These prices are well beyond the reach of the average income in Africa. The cost challenge presents an opportunity for Africa to invest in projects that will reduce the current prices by at least half in the short term. Opportunities for investment in solar PV production, construction and use include:

- Cell assembly into panel modules; cell manufacture requires huge expertise and costly infrastructure and is not a priority for Africa at the moment;
- Research and development to improve on and manufacture batteries in Africa. Some countries like Egypt have already achieved this and others may learn from them;
- Invest in manufacture of inverters and controllers;
- Grid-connected SHS should be encouraged. These systems use the grid for energy storage and eliminate the battery and are ideal for urban homes.

Solar dryers and heaters

Natural solar drying of raw foodstuffs and linen is common in Africa. Direct drying of grains and tubers preserves and prepares food for milling. Solar heat is also used for heating water and space. However, practices and methodologies currently in use do not make maximum use of the available solar heat. Developing indigenous drying and heating solar systems through increasing investment in technology development will create new business opportunities in the manufacturing and marketing sectors.

The potential for solar drying and heating is enormous, particularly in ASAL. Drying food is an important part of the food security strategies of poor communities. There is potential to develop and widely use solar drying systems for the preservation of food. This could contribute to meeting the MDG target of reducing the number of people experiencing chronic hunger by 2015. The commercialization of the drying of fish and agricultural products may also increase and diversify income-generating opportunities (UNEP and

Fish drying in KwaZulu-Natal, South Africa.

Source: A. Mohamed

AREED undated). This technology may also be used to dry timber and tobacco.

Botswana has implemented several solar heating projects and accumulated experience which other countries can benefit from. The government of Botswana, in partnership with the housing corporation and the mining companies, has installed over 10 000 solar water-heating units. The full potential was not realized because the first generation units did not supply adequate hot water and thus were abandoned by users (Bakaya-Kyahurwa and Oladiran 2000) illustrating the need for a better match between technology and demand. Box 2 illustrates the success of solar power in rural electrification.

Enhanced use of natural lighting

Sunlight is a natural resource that offers opportunities for sustainable development. Daylight can reduce reliance on artificial lighting during the day and improve indoor ambience where innovative architectural designs are adopted. Investment in architectural technologies and training is critical to harvest these benefits. This would include education and information on available technologies; improving capacity to use computer-aided design in architectural and engineering consultancy; developing and enforcing standards for incorporating environmental concerns in building design; and constructing government demonstration projects.

There are an increasing number of examples globally of how buildings can be designed to benefit from natural light and air flows and reduce energy consumption. In the US, the Leadership Energy and Environment Design (LEED) has developed green building standards and these have become widely accepted, with developers of 1 700 buildings seeking certification. All new federal buildings are required to meet minimum LEED standards (Gunther 2005).

Box 2: Solar rural electrification

The government of Botswana recognizes the need for electricity in rural areas and has initiated a rural electrification programme in Manyana based on home lighting systems.

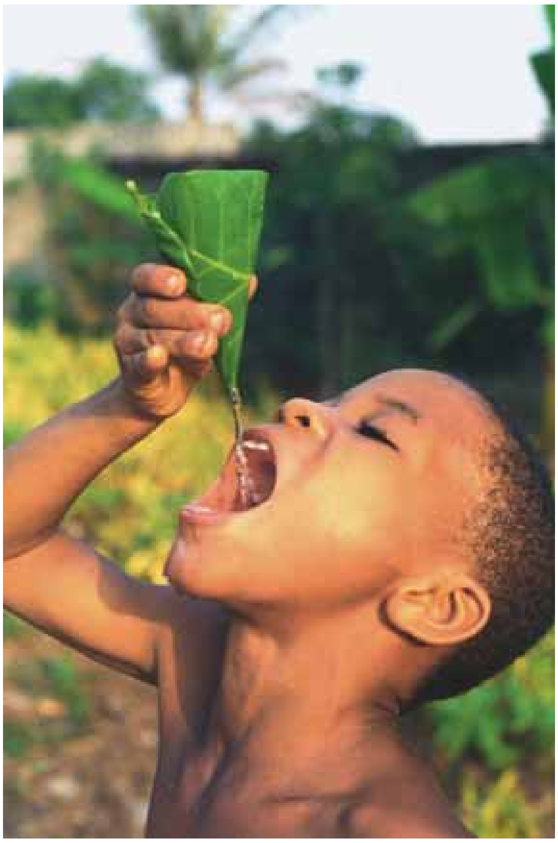
In 1992, as the first phase of this programme, the government implemented a solar pilot project in the village of Manyana. The pilot project consists of 42 PV lighting systems, 6 PV powered streetlights, PV lighting and refrigeration systems for the village clinic, and 6 solar water-heating systems. The 42 participating households in Manyana are using the systems on a long-term (15 year) lease-purchase arrangement where monthly payments are roughly equivalent to their former expenditures on kerosene and candles.

The Renewable Energy for African Development (REFAD) Programme evaluated the project and provided additional input for establishing a widespread, commercially-driven rural electrification programme. The REFAD team's research indicated that the project had overwhelmingly positive effects on the lifestyles and economy of the rural community. Nearly all the households in the area, without electricity service, expressed interest in purchasing the PV systems.

Source: Solar Industry Journal 1994

Rainwater

Relatively few African countries have an average annual rainfall exceeding 1 000 mm. More countries receive an average annual rainfall below 500 mm, and are thus considered to be dry lands. However, despite a history of drought and floods, rainwater has the potential to supply safe water and enhance food security through effective rain-fed agriculture.



Boy drinking water from a banana leaf, Nigeria.

Source: I. Uwanaka/UNEP/Still Pictures

Rainwater harvesting for enhanced access to safe and clean water

Collecting rainwater for drinking, livestock and domestic use is an established practice in Africa. However, traditional collection techniques have become inadequate due to population growth and reduced rainfall. New methods of rainwater harvesting are taking root in Africa; for example, roof catchment and collection in tanks are particularly popular. Plastic or concrete tanks are preferred over metal tanks, as the latter corrode. Box 3 demonstrates the success of rainwater harvesting in Kenya.

Improving the effectiveness of rain-fed agriculture

With the use of appropriate technologies, rainwater could play a bigger role in irrigation and combating the effects of drought. However, appropriate technologies will need to be developed and or acquired, and widely disseminated.

There is growing acknowledgement of the value of rainwater harvesting in rural areas. In Kenya, for example, road run-off catchment, water and farm ponds, sand and sub-surface dams, and conservation tillage have been adopted to increase agricultural production (rainwaterharvesting.org 2003). A non-governmental organization, Practical Action's (ITDG) work in Darfur, western Sudan, is a further example of effective use of rain-fed agriculture. In Darfur, ITDG is supporting the construction of dams across gullies, crescent terraces, shallow wells and channels as appropriate technologies for rainwater harvesting.

Investment in research and development to produce new irrigation systems that use water effectively, particularly in ASAL, should be encouraged. Widespread adoption of low-cost tube irrigation can contribute to poverty alleviation and improve food security and protect against famine. It has, for example, been successfully used in eastern India (Barker and others 2000).

Box 3: Rainwater harvesting in Kenya

The National Museum of Kenya has introduced the concept of large-scale rainwater harvesting in Nairobi city by executing rainwater harvesting in the museum campus. With the support of the Regional Land and Water Management Unit (RELMA), a rainwater harvesting plan for the botanical garden was designed and initial funding for the construction of three underground tanks, all of 105 000 litre capacity, was provided. The tanks receive water from the roof catchment. Following this initial success, RELMA, upon the request of the museum, further facilitated the design and installation of a plastic-lined tank of 30 000 litre capacity for re-use of water from the snake park which houses tropical snakes and crocodiles.

The Elementaita Rotary Community Corps implemented a rainwater harvesting project for Elementaita village in the Nakuru district of Kenya. The women of this village initially fetched water from a seasonal river 10 km away from the village. The project entailed construction of rainwater storage tanks of 10 000 litres with the help of community participation. The total cost of the storage tank was US$600. The community and Rotary International shared the costs. By 2005, 116 such tanks had been constructed. Rotary International has a target of constructing 100 storage tanks every year in the region.

Source: rainwaterharvesting.org 2003

THREATS TO ATMOSPHERIC RESOURCES

Climate variability and change

Climate change is a major threat to atmospheric resources and is resulting in climatic variations that have effects at multiple scales – temporal and spatial. It is closely linked to global patterns of energy consumption and production. Its impacts are increased by poor natural resource management.

Climate change has multiple impacts, at diverse scales and in particular affects ecosystems, which in turn affect livelihoods and human well-being. Even a temperature rise of as little as 1 °C will affect land, coastal and marine, freshwater, and forests and woodland resources. Biodiversity will also be affected, as will human settlements. New health challenges are expected as vector-borne diseases, such as malaria, are predicted to increase. Environmental change affects food production systems, contributing to malnutrition, famine and starvation, and insect ranges and numbers, increasing the incidence of diseases such as malaria. Climate change contributes to population displacement, undermining social cohesion and cultures. The impacts of climate change are also considered in Chapter 3: *Land* and Chapter 5: *Coastal and Marine Environments*.

Several factors, including an over-dependence on rain-fed agriculture and the high incidence of poverty, make Africa's people particularly vulnerable to climate variability. Poor people have little protection against extreme climatic events: they have few resource reserves, poor building structures, and depend directly on natural resources for their livelihoods. Extreme weather events have serious economic and business implications. Floods and droughts cause damage to property and loss of life that affect the opportunities available and that increase the cost of business through higher insurance premiums and claims.

Climatic variations manifest themselves as extreme weather variations, such as floods and droughts. These events are increasing in magnitude and frequency over the years. The mean annual

El Niño floods in Rhoka Village, Tana River Valley, Kenya.

Source: G. Griffiths/CHRISTIAN AID/Still Pictures

rainfall has been decreasing over the decades. Many countries, including Botswana, Burkina Faso, Chad, Ethiopia, Kenya, Mauritania and Mozambique, experience drought at regular intervals. The 1997-98 El Niño floods caused heavy damage to roads, buildings, bridges, railway lines and other property including schools. Incidences of epidemic diseases such as malaria increased during this period. This is related to improved conditions for mosquito breeding; mosquitoes transmit many viruses, over 100 of which are known to infect humans, including malaria, dengue, yellow fever and severe and sometimes fatal encephalitis and dengue haemorrhagic fever (Akhtar and others 2001). Cholera, which is transmitted by water or food, could aggravate health problems in many parts of the world including Africa. During the 1997-98 El Niño event, excessive flooding is reported to have caused epidemics in Djibouti, Somalia, Kenya, Tanzania and Mozambique (Hassan and others 2005).

Mean global temperatures are rising, slowly but surely (Christy and others 2001). This rise in global temperature is attributed to anthropogenic emission of GHG, particularly carbon dioxide. Greenhouse gas emissions result from the burning of fossil fuels in industry, transport vehicles, waste disposal and in households. Africa contributed 341 836 m^3 of CO_2 in 1970, or 2.2 per cent of global emissions (WRI 2005); by 2000 this had risen to nearly 3.6 per cent of global emissions (UNSTATS/CDIAC 2006). Although African emission levels are low, their steady increase demands increased investment in clean production processes and the fulfilment of the commitment made by industrialized countries at WSSD to support Africa in this through partnership and investment.

Climate change is causing the rapid melting of snow caps and a concomitant rise in sea level. For example, the glaciers on Kilimanjaro have shrunk by 73 per cent over the century (Mastny 2000). This process may result in the displacement of people, loss of lowland areas, reduced agricultural production, health problems and enhanced climate variability. The challenges associated with climate change are discussed in relation to land resources in Chapter 3: *Land*.

Atmospheric pollution

In comparison to developed countries, Africa's air pollution levels are still relatively low. However, air pollution is increasing fairly fast as a result of increasing population, urbanization and industrial production. Major pollutants include sulphur dioxide, carbon monoxide, soot, dust and lead. For large industrial cities, like Cairo, air pollution is of immediate concern. Indoor pollution emanating from the burning of fuelwood is another area of concern.

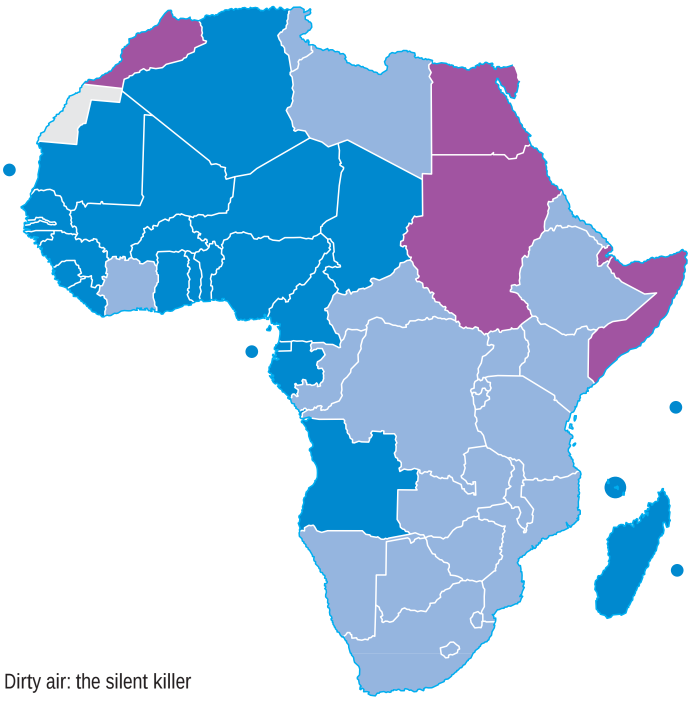
Many factors contribute to increasing air degradation. Inefficient industrial technologies and vehicle emissions are important contributors in urban areas. High dependency on old vehicles is a result of the high taxes many governments place on new vehicles and the lack of financial resources available to consumers. The lack of emission controls on vehicles, and poor monitoring and enforcement systems, exacerbate pollution problems. The transportation system, with its use of trucks for long-distance transportation of goods and poor railway systems, contributes to pollution problems. Open burning of waste also contributes to air degradation. In rural areas, burning of biomass for energy services in small-scale industries like brick firing contributes to air pollution. The use of biomass fuel for cooking and heating in households also lowers the quality of air. Indoor pollution disproportionately affects women and children (Gordon and others 2004) as women bear the burden of cooking and are thus more vulnerable. Improving air quality is essential for improving health, and in particular for reducing the maternal and child mortality rates as envisaged in MDGs.

Ozone layer depletion

The ozone layer shields people and plants from harm from ultraviolet radiation, which causes skin cancer and cataracts in people, stunts growth in plants, including food crops, and kills the tiny organisms which form the base of the marine food chain.

The ozone layer is threatened by the production of industrial chemical emissions, particularly the CFCs.

Figure 4: Air pollution in cities and indoor air pollution



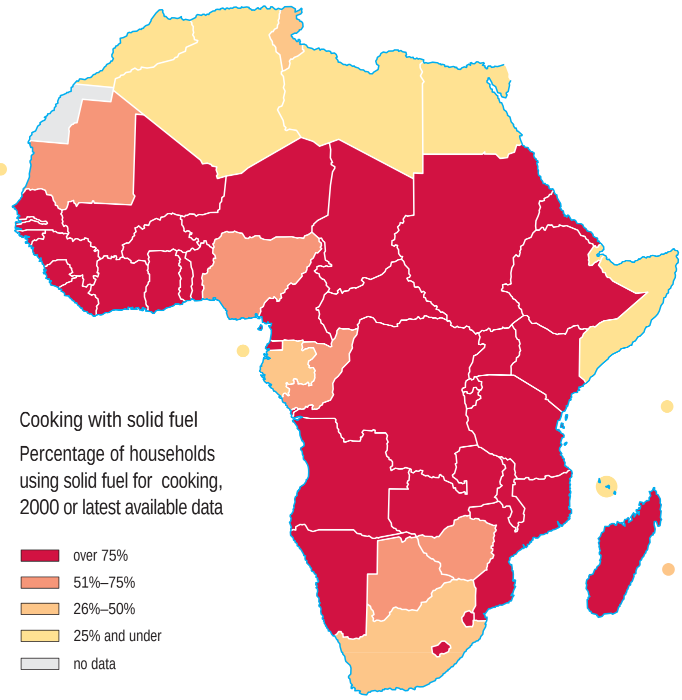
Dirty air: the silent killer

Average concentration of small particles (PM_{10}) in outdoor urban air by WHO sub-region, 2000

micrograms per cubic metre

- over 25
- 21–25
- 16–20
- no data

PM_{10} refers to particles less than 10 micrometres in diameter, which can penetrate deep into the lungs and cause adverse health effects.



Cooking with solid fuel

Percentage of households using solid fuel for cooking, 2000 or latest available data

- over 75%
- 51%–75%
- 26%–50%
- 25% and under
- no data

Source: Adapted from Gordon and others 2004

These chemicals are stable and stay long enough in the atmosphere to reach the ozone layer where they decompose due to strong radiation and eventually react with and destroy the ozone layer, causing "holes" that let the ultra violet (UV) radiation through. The rapidly rising level of UV-radiation in some parts of the world is alarming: in the Arctic, their intensities are 130 per cent higher than 1970s levels.

Measures to reduce the release of CFCs into the atmosphere have now been stipulated in the Montreal Protocol. Parties to the Montreal Protocol agreed to phase out CFCs, halons and carbon tetrachloride by 2000, and methyl chloroforms by 2005. A global fund to help developing countries adopt environmentally friendly technology was established. Most African countries have taken the opportunity to eliminate ozone depleting substances (ODS) through national action plans. Chapter 11: *Chemicals* considers the opportunities and challenges faced by the use of chemicals and Africa's policy response.

Energy production from coal is one of the largest contributors to CO_2 emissions. Power generation, South Africa.

Source: A. Mohamed

Challenges faced in realizing opportunities for development

Mitigating causes and impacts of climate variability and air pollution

Policy interventions are necessary:

- In the short term, to reduce the effect and impact of extreme climate changes on lives, livelihoods and infrastructure.
- In the medium term, to reduce emissions and pollutant concentration in the atmosphere, whilst at the same time limiting the release of more emissions and pollutants into the air.
- In the long term, to adapt to climate variability and change.

Globally, mitigation measures have primarily targeted reducing pollutants and ozone depleting substances as well as stabilizing GHG concentrations in the atmosphere through increased sinks and reduced emissions. Programme Area 5 of the New Partnership for Africa's Development Environment Action Plan (NEPAD-EAP) specifically focuses on combating climate change in Africa. These global and regional responses may help reduce the frequency and severity of floods, drought and heat waves; the loss of snowcaps; and sea-level rise. This will have positive implications for livelihoods and human well-being. Additionally, mitigating climate change and air pollution interventions offer business opportunities that contribute to job creation, poverty reduction and other NEPAD objectives.

Early warning systems

Given the failure to reduce emissions significantly, extreme weather events are predicted to occur with increasing frequency and severity. Investing in capacity for early warning systems will reduce both direct and secondary impacts of such events. Forewarned is forearmed: people will be able to accumulate food reserves, reinforce shelter or move to safer ground. Information and capacity-building lie at the heart of developing effective response systems. The ability to respond effectively is also affected by available resources, such as transport, to leave a threatened area. Poverty may prevent many communities from taking proactive measures, even if they are forewarned. Public support and international partnerships are critical for effective response systems.

Africa should invest in research to be able to develop, construct, deploy and use early warning systems. Community-based traditional warning systems should be researched and, where viable, developed and deployed. Early warning requires regionally and internationally linked systems, where spatial and temporal data from numerous observation points are brought together for analysis. International cooperation is therefore essential in developing effective early warning systems. Investing in the production of early warning systems will contribute to wealth creation and achievement of NEPAD objectives.

Investing in drug availability

In the short term, diseases and epidemics linked to climate change and climate variability will continue to occur. African governments should encourage the private sector to invest in the pharmaceutical sector and manufacture drugs to combat malaria, typhoid, diarrhoea and other diseases. Manufacture of other disease-preventing products, like mosquito nets and repellents, will help reduce the incidence of diseases. These measures are essential to meeting regional and global development targets.

Building buffers

Floods, when left uncontrolled, cause severe damage to livelihoods and result in the loss of life. Building buffers along coastlines and rivers prone to flooding will help reduce damage. Investing in capacity to design and construct such buffers creates jobs which contribute to reducing poverty. This is particularly effective when the affected communities are actively involved in the process. Building buffers will also boost the construction sector. Preventing damage to infrastructure will directly contribute to a NEPAD objective of ensuring good infrastructure in Africa.

Investing in food production and storage systems

Given agricultural production systems and the high levels of subsistence production, rural people are particularly vulnerable to extreme weather events.

In the face of climate change and possibly increasing aridity, developing crops that will grow with minimal rain is a good investment. Agricultural research institutes in a number of African countries, including Kenya Agricultural Research Institute (KARI) in Kenya, are already working on developing drought-resilient food and cash crops (Odame and others 2003). The success of this research could contribute to poverty alleviation in some of the most disadvantaged and marginalized communities. Women in ASAL areas will particularly benefit from drought-resilient crops. Men will be most likely to continue with livestock husbandry. Chapter 10: *Genetically Modified Crops* considers the opportunities and challenges associated with the adoption of genetically modified (GM) crops.

Investing in food reserves and storage improves food security. Besides storage, there are benefits in investing in post-harvest food processing and distribution networks. A large network of retailers can serve as a food reserve. South Africa has an elaborate post-harvest food processing and packaging industry that should serve as an example to other countries.

Establishing an extreme weather fund

Extreme weather events create a series of problems that can lead to severe loss of production and the collapse of an entire economy. For example, Kenya experienced a severe drought in 1999-2001, which

Rain clouds gather over The Amphitheatre in the Drakensberg Mountains, South Africa.

Source: A. Mohamed

caused a shortage of water in a dam, leading to closure of power plants and subsequent blackouts and power rationing. This has forced many industries to reduce production or even to shut down. The Kenya economy lost so much that the government was forced to invest in emergency generators at a cost of US$120 million. Raising such large amounts of money at short notice can prove to be a major challenge to most African governments, and such unplanned investments divert funds from other sectors and interrupt planned programmes. Establishing a financial mechanism to ensure an extreme weather reserve fund will reduce the impact on the economy and reduce loss of lives and property.

Conservation of wetlands and woodlands

Draining wetlands and destroying woodlands is a major cause of environmental degradation. Investing in the conservation of these zones will reduce the impacts of climate variability. In addition, woodlands and wetlands provide opportunities for ecotourism thereby contributing directly to job creation, poverty reduction and other NEPAD objectives.

Investing in energy efficiency

The efficient use of energy is an opportunity for reducing GHG emissions which also contributes directly to achieving social and economic development. Efficient burning of fuels in industry, transport and household sectors is a win-win process. Saving energy saves fuel and money. Investing in energy-efficient technologies will contribute to an improvement of a firm's bottom line. For example, Kenya is currently implementing a GEF- and UNDP-funded, energy-efficient project for small and medium enterprises (SMEs); this US$5 million project has contributed to awareness creation and capacity-building for energy-efficient adoption in SMEs.

Investing in cleaner production saves materials and energy and also reduces GHG emissions. Africa should continue with the ongoing establishment of national cleaner production centres. These centres will assist industries switch to "cleaner" production and products. The Clean Development Mechanism (CDM) adopted under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) is a project-based tool designed to make it easier for industrialized countries to reduce GHG emissions. It relies predominantly on market-based tools. Through carbon trading, developing countries can use this mechanism to support sustainable development initiatives. Africa's participation in carbon trading is still relatively small.

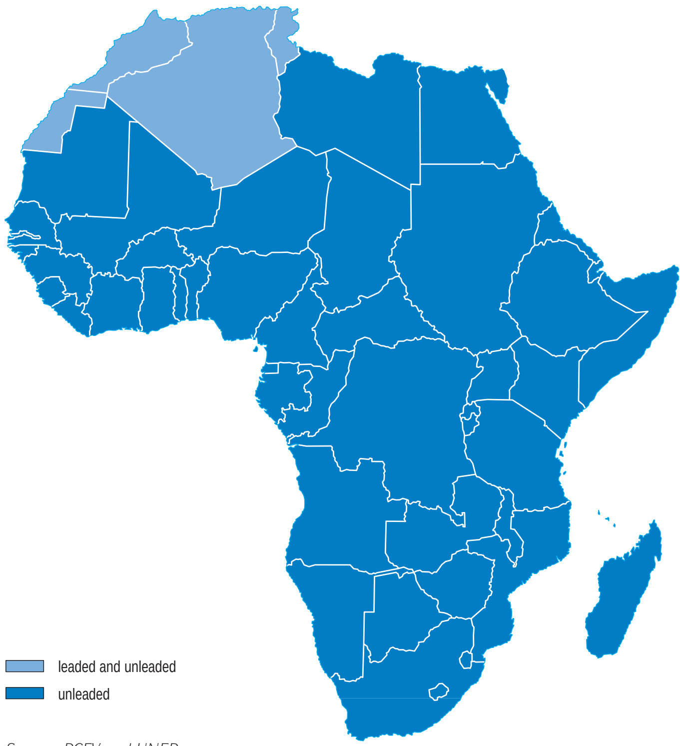
Fuel switch

Switching from fossil fuels to renewable energy resources contributes to GHG emission reduction. Moving away from traditional to modern energy forms entails changing fuels from solid to liquid, liquid to gas, and gas to electricity as end-use energy forms. African rural and urban poor will particularly benefit from fuel switch.

Phasing out leaded fuels will reduce pollution and lead-induced sicknesses. In the Dakar Declaration of 2001, SSA agreed to phase out leaded petrol. The Partnership for Clean Fuels and Vehicles (PCFV), formed at WSSD in 2002, was developed to support this phasing out. At that time, only one country in SSA, Sudan, was completely lead free. However, as of January 2006, with South Africa going unleaded, all of SSA has now switched (UNEP 2005c).

There are several projects across Africa implementing fuel switch programmes. The Servant Flood of Light Development Foundation and Community Uplift Ministries of the USA is promoting a fuel switch project in Kenya. The project involves replacing firewood with gas for cooking, and kerosene with battery-powered electric lamps for lighting. The project relies on a gas-powered electricity generator for charging batteries at community levels. Two projects, recently launched in Kitale and Vihiga districts, are so far giving the expected results. However, it is still too early to make concrete conclusions on the future of these projects.

Figure 5: Status of leaded gasoline phase out



Source: PCFV and UNEP

Local vehicle manufacture and traffic management

The manufacture of motor vehicles in Africa is an opportunity for job creation and poverty reduction, which could contribute to GHG emission reduction by making new vehicles more easily available to consumers. Many countries in SSA rely on imported used vehicles. Not only is this practice paramount to exporting jobs, but it contributes to pollution problems. By building capacity for new vehicle production, Africa will create jobs, reduce poverty and help conserve the environment. Investing in efficient combustion and engine tuning will provide new business opportunities whilst reducing GHG emissions.

The development of efficient public transport systems in developing countries can provide badly needed mobility, reduce the rate of growth of private vehicle use, and offer an opportunity to reduce pollution (IEA 2003c).

SUB-REGIONAL OVERVIEWS

EASTERN AFRICA

Eastern Africa has a large variety of complex topographical features that play an important role in modulating the global climate; these include variations in its surface terrain and a large inland moisture source in the Congo basin and inland lakes (Atheru and Mutai 2002). The processes that influence climate over Eastern Africa include the ITCZ, Intra-Seasonal Oscillations (MJO), Quasi-Biennial Oscillations (QBO), tropical cyclones, jet streams, subtropical anticyclones, and other anomalies over the Atlantic and Indian Oceans. Others factors include disturbances from the mid-latitudes, El Niño/Southern Oscillation (ENSO), easterly waves, equatorial westerlies, mesoscale circulations and monsoon circulation (Atheru and Mutai 2002).

Drought and floods are frequent in Eastern Africa, particularly affecting areas of southern Ethiopia, southern Somalia and eastern Kenya. Rainfall is the most important climatic factor for many African countries and its inter-annual variability has a major impact on national economies. Climatic variability over the past millennium has resulted in extended periods of drought followed by periods of heavy rainfall (Atheru and Mutai 2002). This has resulted in major disasters: alternating flooding and droughts are an important reason for food insecurity. In 2003, Ethiopia's food aid requirements of 1.34 million tonnes amounted to over half of that for Eastern Africa's requirements.

Sources of GHG emissions include fuel combustion in transport, household biomass use, animal waste and rice cultivation There are other minor sources such as industrial fuel combustion. The National Communications to the UNFCCC are the most authoritative statements by Eastern African governments on climate change and related impacts on their economies. The contribution by the sub-region to the global GHG concentrations still remains unquantified. The National Communications to UNFCCC, however, serve to provide a baseline for future studies.

Increasingly, there are reports pointing to the emerging importance of dust as a key factor in the sub-region's climate variability and change. Dust storms over the eastern plains of Somalia, northeast Kenya, northern Sudan and Ethiopia are common phenomena through most of the year. Dust is one of the least understood components of the Earth's atmosphere and it may have a greater importance for climate change than has been realized up until now (RGS 2004). As dust deposits increase, levels of carbon dioxide in the atmosphere could change, which in turn would affect temperatures and rainfall.

Progress has been made in assessing the vulnerability of local communities and ecosystems to climate change. For instance, the Assessment of Impacts and Adaptations to Climate Change (AIACC) study shows that climate change has altered the microclimates in the highlands. Analysis of time-series data from 1978 to 1999 reveals that the maximum and minimum temperatures have changed, with significant increases generally recorded at all sites.

Vehicles – both land and water – are an essential part of modern life but they are also major polluters.

Source: M. Chenje

Analysis of data over the period 1961-2001 also reveals decreasing rainfall. The temperature changes have been more pronounced at the higher altitudes than in the lowlands with, for example, temperatures in the Kabale district of Uganda increasing dramatically by 2°C in the last three decades (Wandiga and others, forthcoming).

The temperature increases in the eastern highlands have resulted in an increased range for malaria-carrying mosquitoes. There have been increasing malaria epidemics in the highland communities. Communities living at altitudes above 1 100 m are more vulnerable to malaria epidemics due to lack of immunity (ECA 2005a).

The Intergovernmental Panel on Climate Change (IPCC) warns of potentially disastrous global warming effects on agriculture and water supplies in tropical and sub-tropical Africa. Even a small increase in temperature will mean a decrease in agricultural production (Wandiga and others forthcoming, CGIAR 2000). There is gradual yet dramatic disappearance of glaciers on the Ruwenzoris in Uganda and Mt Kenya. The ice cap on Mt Kenya has shrunk by 40 per cent since 1963, and a number of seasonal rivers that used to flow from atop the mountain to the surrounding areas have since dried up (ECA 2005b). The snow and glaciers act as water towers and thus towns and farming communities around the mountains will be affected.

Eastern Africa has a very high rate of urbanization. In 1980, the urban population was just over 10 million people and by 2005 it had reached 37.14 million (WRI 2005). Increased activities in key economic sectors are contributing significantly to air pollution. Although the manufacturing sector is responsible for part of the pollution, the transportation sector is increasingly being recognized as the highest polluter, emitting atmospheric reactive gases and other toxic chemicals. These gases, including sulphur, are products of combustion of diesel and gasoline.

There are also concerns on the contribution of household emissions to the GHG load. In Kenya, for example, charcoal production and consumption are believed to be emitting more GHGs (mainly CO_2, CH_4 and NO_x) than the industry and transport sectors combined (Republic of Kenya 2002). The use of traditional kilns in the charcoal production process, characterized by low efficiencies in the range 8-15 per cent, has been found to be responsible for about 4 per cent of the global biomass burning-derived CH_4 emissions and 0.12 per cent of all known sources (Kituyi 2000). Besides emission of GHGs, biofuel production and consumption has other important impacts. They contribute to acute respiratory infections (ARI) in children under 5 through emissions of particulate matter (PM), polycyclic aromatc hydrocarbons (PAHs) and CO_2.

Though not to the same level, governments have demonstrated commitment to conserving the atmosphere through regional and international initiatives. They have all ratified the UNFCCC and the UN Convention to Combat Desertification (UNCCD) – this being a key indicator of commitment in its own right. Some have also ratified the Kyoto Protocol, which came into force in February 2005.

There are a number of initiatives focused on sustaining atmospheric resources, including the NEPAD-EAP Programme 5: combating climate change; the CDM defined under Article 12 of the Kyoto Protocol which provides opportunities for mitigating climate change through energy conservation and emission reduction initiatives; the NAPA driven by the UNFCCC process which provides opportunities for LDCs to develop their agenda for adaptation to climate change (see Box 4); and the World Bank's Clean Air Initiative in SSA which was launched in 1998 as a response to

Box 4: National Adaptation Programme of Action (NAPA)

The National Adaptation Programme of Action (NAPA) has been established to address the urgent and immediate national needs of Least Developed Countries (LDCs) for adapting to the adverse impacts of climate change and for preparation of national communications to the UNFCCC. It is funded through the GEF from a special LDC fund established at the Seventh Conference of the Parties (COP-7). An LDC expert group was established at COP-7 to advise on the preparation of NAPAs.

National Adaptation Programmes of Action will serve as simplified and direct channels of communication for information relating to the urgent and immediate adaptation needs of the LDCs as they prepare for the predicted impacts of climate change.

While the NAPA identifies urgent and immediate action, it still needs to fit within development goals, plans and frameworks, especially in relation to rural citizens and economic development plans for the country. NAPAs will not attempt to implement broad national development goals but will build upon national goals and integrate into national plans. They should also promote synergies with other plans of action, and action in the context of other Multilateral Environmental Agreements (MEAs). Most, if not all, countries have elaborated their development goals, and have systems in place to implement the associated plans through economic planning, among other things. It is important that the NAPA team be aware of these, because NAPAs may be expected to safeguard important systems, including infrastructure, that would be critical in achieving economic goals for the country. For example, a NAPA may wish to flood-proof a single bridge that connects a major cash crop producing area of a region.

Source: UNFCCC 2002

deteriorating air quality attributed mainly to increased traffic and the changing landscape of African cities as a result of rapid urbanization.

With respect to capacity-building for monitoring, prediction and early warning, a WMO-supported Drought Monitoring Centre (WMO-DMC) has been established in Nairobi, Kenya, but unfortunately this is under-utilized. Climatic monitoring and skilful seasonal climate prediction is crucial for proper planning and management of all climate-sensitive activities including agriculture, water resources and hydroelectric power generation among others. A few universities also offer meteorology studies leading to both graduate and post-graduate degrees. These need to be revised to take into consideration the identified concerns. The Inter-University Council for East Africa (IUCEA) could play a key role in ensuring cross-border learning and information exchange at the universities.

The greatest threat to the success of interventions to protect the atmosphere is low funding for government programmes and projects. This is mainly due to low budgetary allocations by governments in the sub-regions and low interest by donors on the subject, who instead are interested in HIV/AIDS etc. Most national policies remain weak mainly on elements of regional cooperation, technology transfer, and cross-border training to optimize sub-regional opportunities. Most countries lack appropriate mechanisms for domesticating key multilateral environmental agreements such as the Kyoto Protocol, among others. This is also attributed to weak national and regional institutions – weak in terms of programmatic focus, funding levels and overall organizational structures. Lastly, atmosphere-related issues rarely rank high on any country's political agenda compared to health or food security issues. The natural links between drought and poverty or food insecurity, and air pollution and human health, for instance, have not been made clear to politicians and other critical decision-makers. They therefore remain of low priority on the political agenda.

NORTHERN AFRICA

Industrial development and high levels of urbanization contribute towards the present situation in large urban centres in Northern Africa. There are two main sources of air pollution:

- Natural, such as dust and sandstorms; and
- Anthropogenic activities including stationary sources, such as thermal power generating plants and industrial parks, and mobile sources including vehicles.

Libya has the highest per capita share of CO_2 emissions compared to its neighbours. All countries have experienced significant growth in CO_2 emissions, which is often related to economic growth.

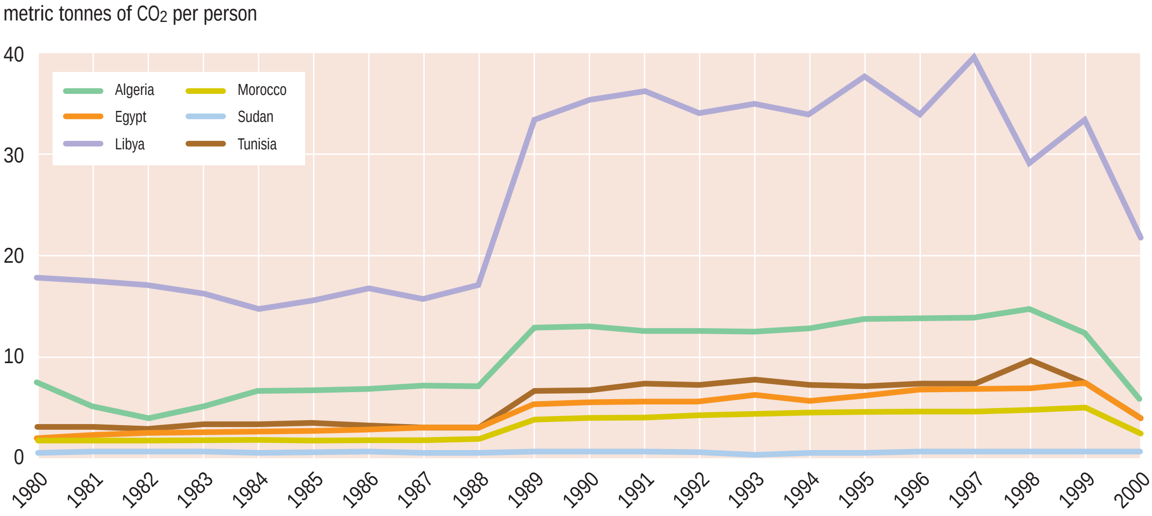
Cairo, the capital of Egypt, has poor air quality. The average inhabitant ingests more than 20 times the level of accepted air pollution. When this is manifested as smog – known to Egyptians as the Black Cloud – health problems ensue (Evans 2004).

In Tunisia, energy generation and the transport sector are among the major contributors to air

Pollution hangs over Cairo.

Source: M.Chenje

Figure 6: Per capita carbon dioxide emissions in Northern Africa



Source: UNEP 2005a

pollution, at 31 per cent and 30 per cent respectively. The transport sector is the top contributor of CO_2 and lead emissions (Tunisia 2002). CO_2 emissions account for 92 per cent of the total GHG emissions, while methane emissions account for 7 per cent, and nitrogen oxide for 1 per cent. GHG emissions of CO_2 from the transport sector rose from 3.4 million tonnes to 5.8 million tonnes between 1994 and 2002, with an annual increase rate of 9 per cent. They also accounted for about 29 per cent of the total emissions generated by the energy sector in the year 2002, rising from 23 per cent in 1994 (Tunisia 2002).

The national plan to survey air quality in Tunisia is based on the installation of a network of fixed stations and the acquisition of mobile laboratories to monitor air quality and control the sources of pollution. By 2002, five stations had been set up. The stations revealed that, except at peak hours during which time higher elevations in the concentrations of CO_2 and SO_2 were recorded, the air quality in Tunisia conforms to standard. A national commission for the protection of the ozone layer was established in which all relevant ministries are represented (Soussi 2004).

In Libya, the main sources of air pollution are related to the use of petroleum derivatives as fuel in many industrial, artisan and transport fields. Oil refineries are the main sources of atmospheric pollution due to the harmful gas emissions, mainly hydrocarbons, carbons, nitrogen oxides and sulphur from burning fuel in oilfields and refineries. Most of the plants were not subjected to environmental evaluation prior to their establishment, and they have adverse effects on the surrounding residential and maritime areas. The plants do not have the necessary pollution control, monitoring and measurement systems, nor the necessary equipment and devices for limiting or decreasing the volume and concentration of the pollutants.

In Morocco, the emissions of GHG and the use of ODS contributes little to the pressures on the environment. Air pollution is mainly due to road traffic and industry, particularly along the Mohammedia-Safi road axis. The effect of the deterioration of air quality on the economy, in terms of the decrease of productivity due, in part, to respiratory diseases, is estimated at 1.9 per cent of the Gross Domestic Product (GDP) (Firadi 2004).

All countries experienced significant growth in CO_2 emissions, which is often correlated with economic growth. For example, there was a 14.28 per cent increase in per capita CO_2 emissions between 1990 and 2001 in Libya (WRI 2005).

There has recently been increasing awareness of the diverse and complex results of air pollution. Public and private sector establishments are becoming more interested in undertaking preventive measures to control air pollution, and there is a detectable shift from end-of-pipe treatments to a more proactive approach. including cleaner production and waste minimization at source. National Cleaner Production Centres have been established in some countries, such as Morocco and Tunisia, and will soon be set up in Egypt, to raise awareness, build the capacities of development partners, and support stakeholders.

There are many instances of how industries are integrating environmental considerations into industrial development and implementation. For example, some

SMEs have been keen to incorporate the components of environmental management systems (EMS) into their day-to-day operations. For example, the Coptic Evangelical Organization for Social Services (CEOSS), an Egyptian non-governmental organization (NGO), has mobilized approximately US$1 million to institutionalize EMS in SMEs of western Minya in Upper Egypt.

In both Egypt and Morocco there has been some investment in the development of renewable energy. The Egyptian government has been working with USAID to plan a combined natural gas/solar power plant in Egypt. Feasibility studies have been completed on the 127-MW plant, which will use solar energy during the day and natural gas at night. The plant, which has received funding from USAID and the Global Environmental Facility, is expected to cost $120 million and come online in 2006 (EIA 2005).

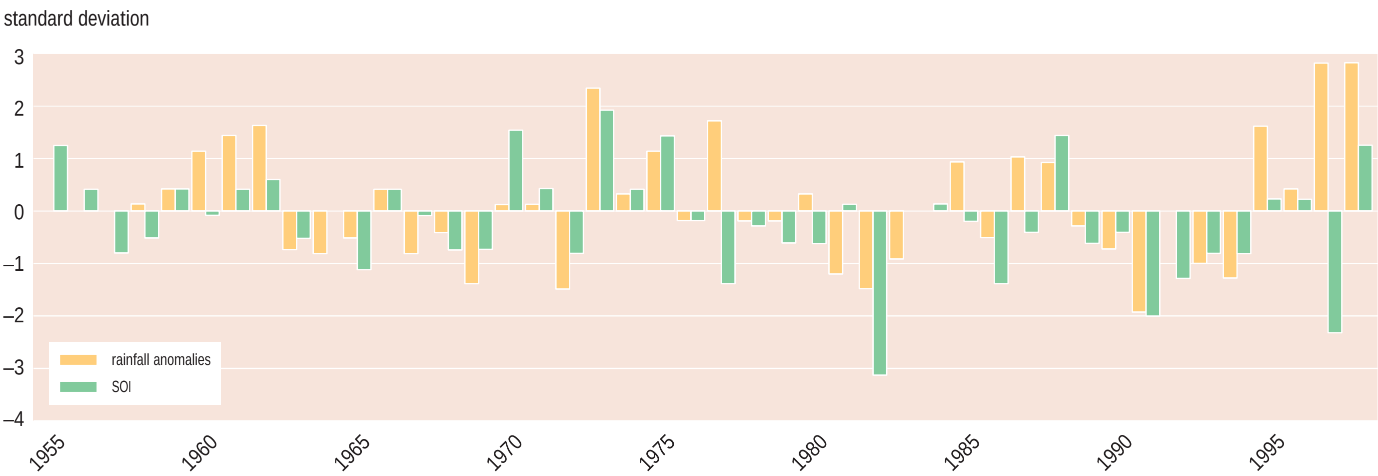
SOUTHERN AFRICA

The atmosphere provides the supporting medium for human well-being and environmental goods-and-services. Its dynamism is characterized by seasonal and daily changes in temperature, rainfall and wind systems which shape human cultures, food production and the location of settlements, as well as the general state of the environment. Climate is the most important aspect of atmospheric phenomena. However, changes and variability in climate patterns in Southern Africa in the form of changes in rainfall patterns, rising temperatures and the increased frequency of extreme weather events such as droughts, floods and tropical cyclones, have far-reaching impacts on socioeconomic development and human well-being.

The monthly variation in temperature is gradual, with the peak of the rainy season occurring between December and March. During this period, surface temperatures are warmest over the desert areas of Botswana and Namibia and exceed 26°C; relatively cooler conditions prevail over the central parts and also to the southeast where temperatures may be less than 20°C as a result of the cloudiness associated with summer rains (DMC undated). In the dry winter, the temperatures are cooler; the coldest areas, stretching from Lesotho through South Africa and to the southern tip of Namibia, experience temperatures averaging less than 14°C (Chenje and Johnson 1996).

Rainfall is the most critical factor for livestock and crop production in the ASAL. Generally, rainfall increases towards the equator, resulting in more rain in Tanzania, northern Mozambique and Angola, and less in South Africa, Botswana and Namibia. Rainfall is generally seasonal. Some important determinants of rainfall patterns include the Inter-Tropical Convergence Zone (ITCZ), the Botswana Upper High and the El Niño phenomenon. The ITCZ migrates seasonally over Africa, in response to the position of the sun, and its arrival leads to substantial rainfall amounts; it is responsible for most of the rainfall in the sub-region. A middle-level atmospheric condition, known as the Botswana Upper High, occurs from time to time and is inimical to rainfall activity in its vicinity. The persistent occurrence of the Botswana Upper High results in drought. The El Niño phenomenon is thought to decrease Southern Africa's rainfall. During most El Niño episodes, the bulk of Southern Africa is likely to experience drought conditions while during a La Niña, there are chances of higher than normal rainfall. However, as shown in Figure 7, the relationship between the El Niño and rainfall anomalies sometimes breaks down, as happened in the 1986/87 and 1997/98 seasons.

Figure 7: Standardized mean rainfall anomalies and El Niño Southern Oscillation Index (SOI)



Source: Hirji and others 2002

Table 2: Rainfall trends in Southern Africa 1986-2003

1986-87	Drought conditions returned to the region.
1988-90	Near normal seasons.
1991-92	Severe drought in southern Africa, excluding Namibia.
1993-94	Conditions improved.
1994-95	Many SADC countries were hit by the worst drought in memory, surpassing effects of the 1991-92 drought in some parts of the region.
1996-97	Normal rainfall for most of the region.
1997-98	Normal rainfall throughout the region, including the northeast, although impacts of El Niño were significant.
1999-2000	Cyclone Eline hit the region and widespread floods devastated large parts of the Limpopo basin (southern and central Mozambique, southeastern Zimbabwe, parts of South Africa and Botswana).
2001-03	Another severe drought in the SADC region, particularly from Zimbabwe northwards.

Source: adapted from Chenje 2000

The most common indicator of climate variability is the amount of rainfall received over the years, and year-to-year rainfall variability is high. The most critical variations are manifested as droughts, floods and tropical cyclones. Droughts have occurred periodically in Southern Africa throughout recorded history. As shown in Table 2, serious droughts have afflicted the sub-region in 1986-87, 1991-92, 1994-95 and 2001-2003 (Chenje 2000). The droughts of the 1980s and 1990s have had a marked negative impact. For instance, the water level of the Kariba Dam on the Zambezi River dropped by 11.6 metres between 1981 and 1992, resulting in a reduction of the dam's capacity to generate hydropower.

In addition to droughts, Southern Africa experiences exceptionally wet seasons resulting in extensive flooding. Most flooding is associated with active cyclones that develop in the Indian Ocean. The 1999-2001 rainfall seasons were dominated by active tropical cyclonic activity, which caused considerable human suffering. Tropical cyclone Eline had the most devastating effects during this period. As a result of cyclone Eline, heavy rains were experienced over southern Mozambique, parts of South Africa's Limpopo Province and southeastern Zimbabwe, with over 200 mm of rain recorded over periods of less than 48 hours at many weather stations.

Apart from these vagaries of nature, climate change poses a serious threat: records have revealed temperatures to rise by over 0.5°C over the past 100 years (Zöckler and Lysenko 2000) and the 1990s were the warmest ever (WWF-Nepal 2005). There are also concerns about the possible negative impacts of sea-level rise. Climate models project an increase in global mean surface temperature of about 1-3.5°C by 2100 and an associated increase in sea level of about 15-95 cm (UN 2003). Crop yields are expected to be affected, dropping by as much as 10-20 per cent in some parts of the sub-region (Hoffman 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 (Watson and others 1998).

Addressing the threats associated with climate change demands new levels of research. Technological investment is an important aspect of responses, and partnerships with the international community can support this. The opportunity offered by carbon trading, by forestation and reforestation should be captured.

The Southern African Development Community Drought Monitoring Centre (SADC-DMC) was established in 1991 with the main objective of minimizing the negative impacts of climatic extremes on socioeconomic development in the sub-region. This is achieved through the monitoring of near real-time climatic trends and generating long-range climate outlook products on monthly and seasonal (up to six months) time scales. These outlook projections are disseminated to the sub-regional community to afford greater opportunity to decision-makers for the development of strategic plans.

The SADC Regional Early Warning System, in conjunction with the Famine Early Warning System and SADC-DMC, is providing advisory services regarding the status of the food security situation. Such systems have been useful in informing national and regional policies, forming the basis for food aid requests, as well as laying the foundation for land and agrarian reforms. Recently, there have been further efforts in Southern Africa to develop long-lead climate forecasting based on tropical sea surface temperature conditions. In order to maximize the benefits of advances in climate prediction, Southern Africa has demonstrated a need for a sub-regional climate network, which would meet regularly, interpret global and regional climate signals, and provide seasonal rainfall forecasts. This is currently done through the Southern Africa Regional Climate Outlook Forum (SARCOF) process, which advises on the likely status of the rainfall season before its onset.

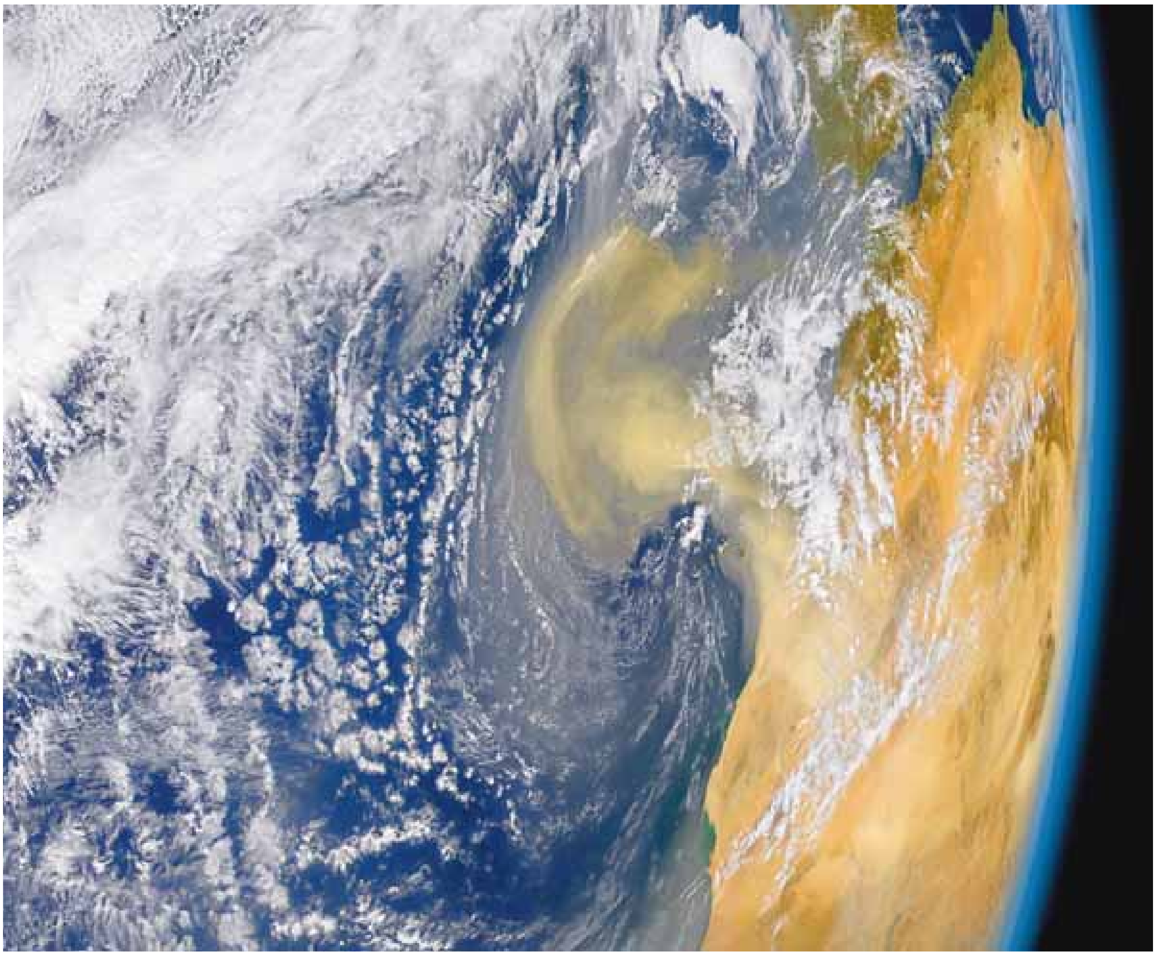
Climate change and variability are global issues, requiring concerted international efforts. The global nature of these atmospheric phenomena presents a great challenge as it is difficult to reach international consensus on appropriate solutions and levels of responsibility. Some countries may find no direct value in addressing climate change and variability issues since their contribution to the phenomena is minimal. There is, therefore, a need to increase awareness on the affects of climate change.

The reliability of sub-regional predictions is still low, and the degree to which climate variability may change is uncertain. Given this, policymakers need to consider the value of taking precautionary measures by, for example, reducing GHG emissions and enhancing the resilience of vulnerable systems.

WESTERN AFRICA

There are four climatic zones in Western Africa: Sahelian (rainy season does not exceed three months; irregular rainfall not exceeding 500 mm); Sudanian (precipitations between less than 88 mm in the north of Nigeria and 1 000 mm in the north of Mali); tropical humid (annual mean rainfall approximately 1 500 mm); and equatorial (essentially localized along the Gulf of Guinea, with annual rainfall above 2 000 mm).

The temperature in Western Africa is influenced by two air masses: the Harmattan, a dry and hot northeast wind blowing through the Sahara, and the monsoon, a



Dust is a poorly understood factor in climate change

A massive sandstorm blowing off the northwest African coast, blanketing hundreds of thousands of square kilometres of the eastern Atlantic Ocean with a dense cloud of Sahara Desert sand.

Source: SeaWiFS Project, NASA/GSFC and ORBIMAGE humid southwest wind blowing through the Atlantic Ocean. These two air masses are controlled by the seasonal movement of the inter-tropical convergence zone and move from the north to the south. Rainfall patterns are unequally distributed through the sub-region and influenced by this airflow.

GHG emissions affect climate variability by generating, for example, a deficit in rainfall. Greenhouse gas emissions in the region are low. However climate patterns are affected by global emissions, these variations have an effect on ecosystems and the economy. The immediate effect of climate variability is food insecurity: for example, groundnut production has virtually disappeared in Niger and a similar trend is evident in Senegal. The Sahel region – including Senegal, Mauritania, Mali, Burkina Faso, Niger, Nigeria and Chad – has experienced three decades of drought and patchy rain (IRIN 2005). The quality of rain is as important as the amount of rain, with heavy downpours and wind causing flooding, erosion and deterioration of the soil (IRIN 2005).

In addition to food insecurity. there is deterioration in air quality, especially in urban areas. The resulting pollution affects the quality of life of people in these areas. It also generates environmental costs and impacts on public health. Drought has resulted in increased dust generation in Western Africa and this affects not only the countries of the region but is believed to impact on climatic systems in the Carribean and may affect coral reef health.

These challenges compel the sub-region to implement strategies to reduce the risks and place value on the available potentialities.

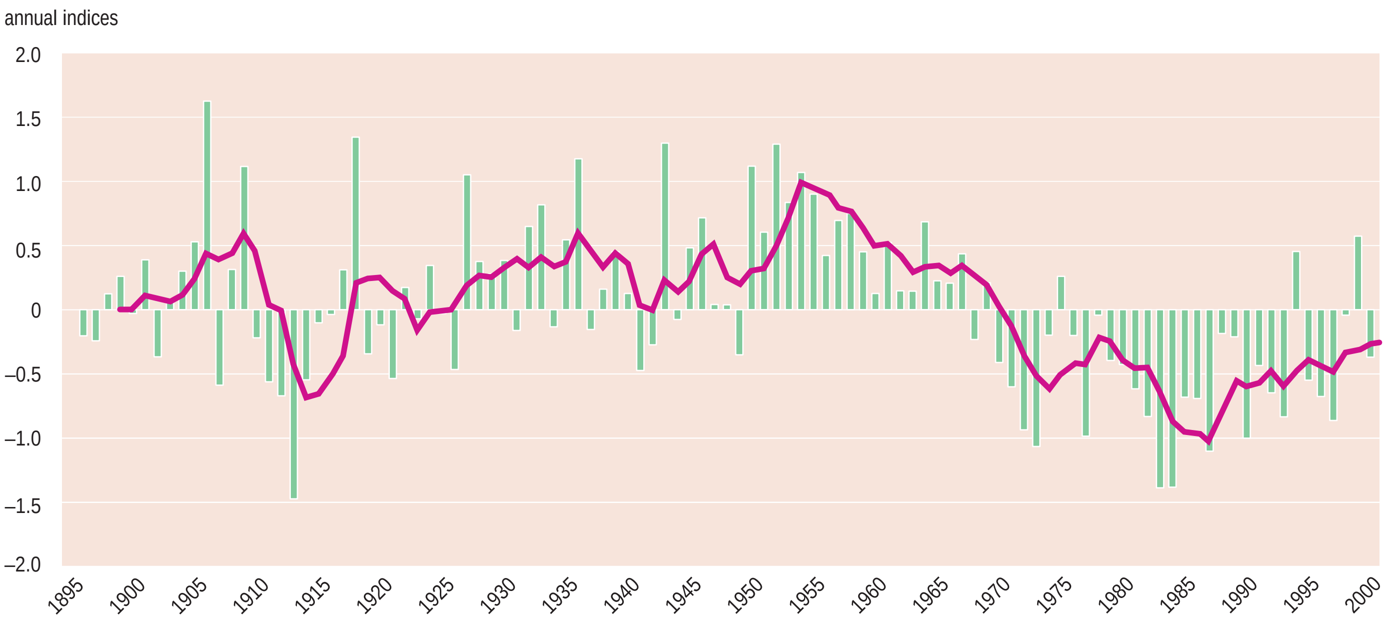
The utilization of renewable energy is still weak, but with effective policy interventions can increase in the short term. Wind and solar energy is still underexploited.

Greenhouse gas emissions affect climate variability and contribute to climate change in the long term. Climate variability is a major threat to the utilization of biomass energy. Climate is an important element of the capacity of land to produce in quantity and quality, and extreme climatic events (drought, floods, sand wind, etc) have important environmental and socioeconomic costs. Furthermore, global warming associated with GHG emissions has adverse effects on the climate. This can result in, for example, a reduction in the duration of the rainfall season.

Some adaptive measures to mitigate vulnerability to climate variability have been developed and are being implemented. These include measures to improve agricultural productivity through, for example, the setting up of integrated water resources management programmes and the selection of species that are not prone to drought.

Facing climate modification requires the strengthening of climatic forecast and early warning systems, especially given the probability of further deterioration of rainfall patterns. To avoid water unavailability that may result from this, water collection and management systems are set up for irrigation and for domestic use.

Figure 8: Annual index of rainfall in the Sahel region



Source: L'Hôte and others 2002

Addressing the challenges of climate change requires better implementation of the NEPAD climate change strategy, and specifically of projects dealing with:

- The elaboration of decision-making tools for assessing the vulnerability to climate;
- The promotion of initiatives and strategies to capitalize renewable energies; and
- The assessment of the synergetic effects of adaptation and mitigation activities through agroforestry pilot projects.

WESTERN INDIAN OCEAN ISLANDS

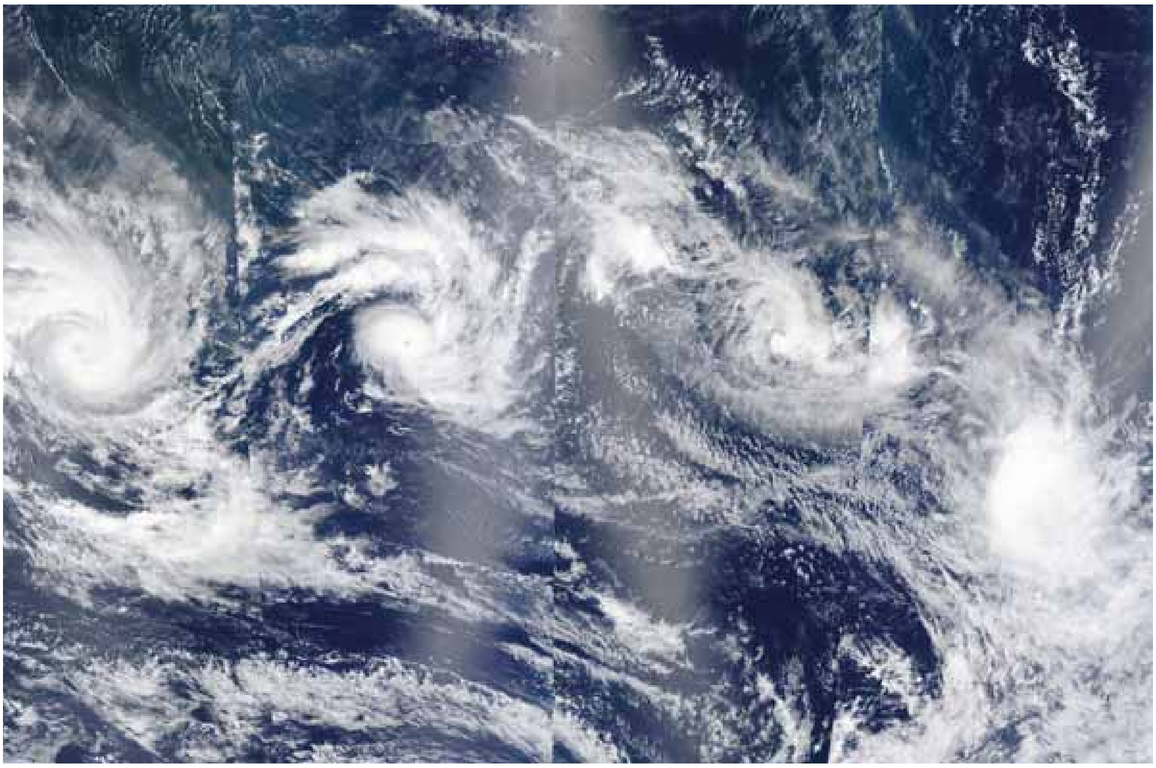
One of the most important assets for the Western Indian Ocean (WIO) states is its climate, which supports the evolution of a wide diversity of ecosystems and helps to promote socioeconomic activities such as agriculture, fisheries and tourism. This favourable climate is at risk, however, from external and internal stresses. The sub-region is already experiencing the negative impacts of global warming. Although the emission of GHG is small, industrialization and urbanization are contributing to deterioration of the state of the atmosphere. Many of these effects are long-term, and possibly irreversible, with adverse social and economic consequences. Climate variation affects the potential to attract tourists, the capacity for agriculture and the propensity for disease.

Madagascar experiences serious periods of both drought and torrential rain. The high humidity, coupled with large areas of stagnant floodwater in the summer months, can promote malaria. Malaria, once endemic in Mauritius, has now been eradicated by a sustained, integrated programme of prevention, early detection and effective treatment.

All WIO countries suffer from water scarcity and this is exacerbated by the increasing demand from agriculture and tourism, particularly in Mauritius and the Seychelles.

The high percentage of warm and wet days in Mauritius has proved well-suited to the production of sugar cane. September, October and November have the lowest rainfall, fewest wet days and a temperature range more comfortable for the European tourists.

Two important climate systems affecting the WIO islands are the ITCZ and the Indian Ocean Dipole. The ITCZ, which is the breeding ground for tropical cyclones,



Cyclones are an important feature of weather patterns for the WIO islands

Multiple cyclones in the Indian Ocean, 12 February 2003. The cyclones pictured are (west to east) Gerry, Hape, 18S (later named Isha) and Fiona.

Source: Earth Observatory/NASA

Table 3: Passenger motor vehicles per thousand population, Western Indian Ocean countries, Africa and North America 1990 and 2001

	Passenger motor vehicles per thousand population	
Countries/regions	**1990**	**2001***
Madagascar	4	4
Mauritius	43	77
Seychelles	95	104
Africa	15	17
North America	692	749

** or latest year*

Source: UNEP 2005b

also gives rise to heavy rainfall over the Seychelles during the summer months (November to April) when it oscillates around the latitude of 8°S. In March 2005, the Mascarene Islands experienced record rainfall as the ITCZ oscillated much further south for days, causing widespread flooding and accumulation of water with increased mosquito breeding and sanitation problems. When the Indian Ocean Dipole occurs at the same time as the ENSO event, changes are produced in the patterns of circulation of the air and sea across the Indian Ocean, affecting temperature and rainfall across the sub-region. However, further studies are necessary to confirm the nature and extent of the impact of these phenomena on cyclone formation and climate generally. The ENSO is predicted to become more frequent with global climate change, and expected to cause important disruption in coastal processes. Coral bleaching events may become more frequent and severe, as the climate continues to warm, exposing coral reefs to an increasingly hostile environment. In the 1997-98 El Niño event, coral reefs in the Indian Ocean suffered extensive and severe bleaching.

There are widespread socioeconomic impacts of abnormal weather. Records show that in the period 1951-2004, windstorms accounted for 80 per cent of the deaths from natural disasters. Although the Seychelles lie outside the cyclone belt, these islands are experiencing an increasing frequency and intensity of storms. In August 1997, extreme rainfall conditions led to floods and landslides causing damage to more than 500 houses and almost 40 per cent of public roads. A similar event in September 2002 hit the island of Praslin, the second largest island in the Seychelles, destroying over 25 000 trees, and causing damage to housing and infrastructure with a total estimated loss of US$87 million.

The future likely impacts of climate change and sea-level rise in the WIO countries include coastal erosion, droughts, coral bleaching, more mosquito-borne disease, saline intrusion into water sources, flooding, storm surges, and greater water scarcity in the face of increasing demand. October 2004 was the warmest month of the year recorded in the WIO countries since the industrial revolution. This followed October 2003 which was the warmest October ever recorded in Mauritius. Building resilience against climate change requires establishing special funds and making new investments.

The prevalence of passenger motor vehicles and CO_2 emissions are rising steadily in the more developed of the WIO countries, and at much higher rates than for Africa as a whole. Whilst these levels remain substantially below those reported for North America, the trend presents a growing threat to both livelihoods and to health, in terms of road congestion, increasing travel times, higher transport costs and air pollution.

The WIO countries have established environmental programmes and developed policies to integrate climate-related concerns in their political agendas. All WIO countries have submitted their first National Communication within the framework of the UNFCCC, and some are in the process of preparing their second National Communication.

Initiatives to reduce air pollution and promote greater efficiency in energy generation and use require a variety of educational and other measures in the public and the private sector. These include the

Table 4: CO_2 total emissions WIO countries, Africa and North America per head per year (metric tonnes) 1982[1] and 2001[2]

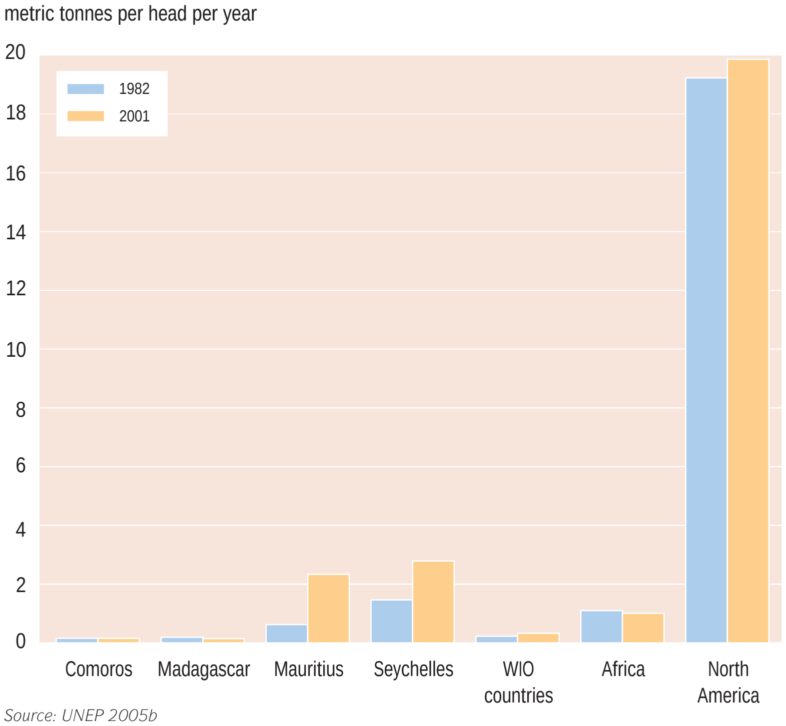
Countries/regions	**1982**	**2001**
Comoros	0.1	0.12
Madagascar	0.18	0.14
Seychelles	0.61	2.44
WIO countries	0.22	0.31
Africa	1.11	1.04
North America	19.32	19.94

[1] or earliest reported later year

[2] or latest year

Source: UNEP 2005b

Figure 9: Comparison of emission levels



Source: UNEP 2005b

promotion of low energy lighting, photovoltaic systems, solar water heating and solar wood drying kilns for timber treatment for construction, liquid propane gas (LPG) cookers for domestic cooking, solar street lighting, methane gas for energy production, ethanol as a partial fuel substitute, sugar cane bagasse for energy production, and wind-generated energy in, for example, Mauritius' outer island of Rodrigues. But these initiatives, with the exception of the use of bagasse, have yet to be developed as major programmes which benefit from standardization and economies of scale, in any of the countries. Both wind and solar equipment have to be made more robust against cyclone damage. Moreover, the public sector has yet to show a coherent, environmentally friendly approach to energy efficiency in the provision of its own services and in public contracts in building designs and materials for schools, hospitals and public sector housing.

CONCLUSION

Atmospheric resources are essential for the maintenance of life and human well-being, and they provide multiple opportunities for development. Atmospheric resources are transboundary resources and are affected by global, regional and national practices. The unsustainable management of these resources – at the global, regional, sub-regional and national levels – have implications for development and livelihoods in Africa. This is most acutely felt in activities directly dependent on natural resources and processes such as agriculture. Thus partnerships at multiple scales are critical to addressing the challenges and maximizing opportunities.

Policy interventions are necessary to remove barriers to investments in renewable energy resources and mitigation of impacts of climate change, extreme weather events and air pollution. Policy objectives should promote investments in businesses and projects which contribute to sustainable development whilst conserving the value and quality of atmospheric resources. African governments are called upon to bridge the gap between the existing information and policy actions. Policies should be translated into laws and regulations as a strategy to ensure implementation and smooth governance of the use of atmospheric assets.

Poor access to modern environmentally sound technologies, lack of capacity to develop or acquire technology, and restrictions imposed by developed countries, contribute significantly to denying African people the opportunity to use atmospheric resources. Barriers that contribute to low use of modern technologies in exploiting renewable energy resources include lack of information, high capital cost of renewable energy supply systems, the intermittent nature of renewable energy resources, site-specific constraints, and poor access to modern technologies.

Harmonizing policy interventions across sectors is critical given the close relationship between energy, consumption and production patterns, environmental management and climate change. This involves building cooperation between different stakeholders. The value of such an approach is discussed in Chapter 8: *Interlinkages: The Environment and Policy Web*. Planning and setting clear targets is important, especially regarding a shift to renewable energy. Formulating and enforcing standards in relation to equipment as well as pollution is crucial. The implementation of MEAs through policies and programmes designed to meet their objectives and targets can be an important complement to national activities. These MEAs include UNFCCC and its Kyoto Protocol, as well as the Montreal Convention.

Developing capacity for early warning systems is crucial given the wide-ranging impacts of climate variability. This must be coupled with effective response systems.

The key to successful policy interventions is political will, as expressed in the following quote:

> "The reductions in poverty in both countries [India and China] are primarily the result not of the policies of the global great and good, or of the charity of rich countries, but of better domestic government – including the provision of basic education and health care and, crucially, the freeing up of markets. In both countries, even better government would reduce poverty further. For instance, corruption remains rife in both countries, and has a particularly severe impact on the poor by depriving them of needed services and raising their cost of access to markets and to finance" (Economist 2004).

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