IMPACTS OF CLIMATE CHANGE IN THE TROPICS:
The African Experience

A Keynote Presentation

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ABSTRACT

Global warming is already happening, with its impact being felt most by the world’s poorest people, particularly those in Africa. Climate data for Africa for the last 30–40 years shows global warming has taken a firm hold. If current trends continue, climate models predict that by 2050 Sub-Saharan Africa will be warmer by 0.5°C to 2°C and drier, with 10 per cent less rainfall in the interior and with water loss exacerbated by higher evaporation rates. There will be more extreme events such as drought and floods, and the seasonal patterns will shift. Food production, water supplies, public health, and people’s livelihoods are all being damaged and undermined.

While Africa is highly vulnerable to climate change, the continent’s vulnerability is not caused only by climate change but by a combination of several other stresses that characterise the continent, which all contribute to the weak adaptive capacity of the continent. Although climate change seems marginal compared to the pressing issues of poverty alleviation, hunger, health, economic development and energy needs, it is becoming increasingly clear that realisation of the Millennium Development Goals can be seriously hampered by climate change.

Responding to climate change encompasses two strategies: (i) mitigation: controlling greenhouse gases to stabilize climate change at an acceptable limit, and (2) adaptation: adjustments to the impact of climate change given existing levels of greenhouse gases in the atmosphere. To achieve any stabilization, cuts in emissions of greenhouse gases by industrialised countries in the order of 60–80 per cent (relative to 1990 levels) by the middle of this century are essential. Even if this tall order was achievable, sea level rise and global warming would continue to increase over centuries because of the inertia of the earth systems, adaptation was viewed as a necessary strategy that would complement mitigation efforts. Adaptation is therefore the most feasible option for Africa to deal with the adverse impacts of climate change.

To achieve this, the adaptive capacity of Africa needs to be strengthened through capacity building and sustained funding of adaptation strategies.
1. INTRODUCTION

Article 2 of the UNFCC defines the ultimate objective of UNFCCC as: “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (avoiding dangerous climate change). Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.” Issues that are still to be defined and agreed upon, based on the contents of Article 2 are:

- What stabilized concentration level should/may be adopted?
- What is dangerous anthropogenic interference?
- What time frame is necessary to achieve the objective?

However, some of the goals proposed by the European Union and other Parties to the United Nations Framework Convention on Climate Change (UNFCCC) for the protection of the climate system in the course of the ongoing global climate negotiations. Some of these proposals include:

- a stabilization of the atmospheric CO$_2$ concentration at 550 ppm or lower,
- a limit on global temperature increase of 2°C compared to pre-industrial temperature,
- a limit of 20 cm to sea level rise compared to the level of 1990.

Just eight countries - the world's seven leading economies (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) plus Russia, also known as the G8 – contributed nearly half (48.7%) of world CO$_2$ emissions in 1999. To achieve any stabilization, cuts in emissions of greenhouse gases by industrialised countries in the order of 60–80 per cent (relative to 1990 levels) by the middle of this century are essential. In a study by Onigkeit and Alcamo (2000), it was concluded that to keep global emission reduction rates low over the long term (lower than 0.5% per year until 2100), emissions may not increase by more than 1% per year over the medium term (until 2030) for the 550 ppm concentration pathway. For the 450 ppm stabilization scenario the increase of emissions must stay below 1% per year until 2030 to achieve long term reductions between 1 and 1.5% per year. This on its own is a very ambitious target.

Even if this stabilization was achieved, sea level rise and global warming would continue to increase over centuries because of the inertia of the earth systems, adaptation was viewed as a necessary strategy that would complement mitigation efforts. The implication is that climate change with all its attendant problems will continue to be a burden to us all, particularly to Africa, where virtually all global assessments have confirmed its high vulnerability as summed up by the Third Assessment Report of the IPCC.

*Africa is the most vulnerable region to climate change, due to the extreme poverty of many Africans, frequent natural disasters such as droughts and floods, and agricultural systems heavily dependent on rainfall, (IPCC, 2001).*

To be able to appreciate Africa’s vulnerability to climate change, we begin by putting Africa in context. While Africa is highly vulnerable to climate change, the continent’s vulnerability is not caused only by climate change but by a combination of several other stresses that characterise the continent, which all contribute to the weak adaptive capacity of the continent. Understanding Africa’s vulnerability requires that we see climate change as one more stress, albeit a very important stress, that has set in to increase the vulnerability of an already stressed continent. To us in Africa, change may be seen as “the last straw that broke the camel’s back”.

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2. AFRICA IN CONTEXT

Africa is a continent comprising countries that are highly fragmented in terms of variety of natural resources, sustainable development goals, and levels of poverty. Much of Africa has a very harsh terrain of either very arid regions or very wet coastal areas (Figure 1). The continent is also home to several natural disasters such as droughts, famine, floods and other attendant disaster-related epidemics (Figure 2).

Droughts have mainly affected the Sahel, the Horn of Africa and Southern Africa particularly since the end of the 1960s. One third of the people in Africa live in drought prone areas. At the opposite side of the spectrum, floods are recurrent in some countries and even countries located in dry areas (Tunisia, Egypt, and Somalia) have not been flood-safe. It is not uncommon that some countries experience both floods and droughts in the same year. Droughts and floods will be the two most important avenues through which the impacts of global warming will be felt in Africa.

Besides the physical environment, much of the continent is grappling with other crises arising from overdependence on natural resources, structural adjustment policies, trade liberalization, globalization, conflicts, governance, malnutrition, poverty and a high disease burden, particularly from malaria and HIV/AIDS. The HIV/AIDS pandemic is also a major cause for concern in many African countries. Besides placing great strain on the health infrastructure, results from several studies across Africa are showing the strong links between HIV/AIDS and heightened vulnerabilities to various sectors e.g. agriculture. Maize production, for example, on communal farms in Zimbabwe fell by 54% between 1992 and 1997 largely because of AIDS-related illness and death (Gommes et al, 2004). The impacts of HIV on agricultural outputs and sales have also been tracked in Uganda and Malawi (Hammarskjold, 2003). Switches from high labour-intensive crops such as maize to lower labour-intensive crops such as cassava are occurring, many argue in response to HIV. Likewise in several areas there are signs of people switching from larger livestock that again requires more labour inputs to smaller livestock such as goats and poultry.
Despite the HIV/AIDS mortality, Africa still has one of the highest population growth rates in the world (Figure 3), with a current rate of about 2.4 per year. Three demographic factors that compound Africa’s developmental dilemma are: high fertility rate, rapid and unplanned urbanization and migration. Fertility rates, although declining, are also estimated as being some of the highest in the world. It is generally believed that an unmanaged population growth resulting in a sustained pressure on natural resources will act as a catalyst for the propagation of the adverse impacts of climate change in Africa.

Recent estimates of poverty and human development show that almost all the African countries are classified as being in the low human development category (UNDP, 2004). Of the 49 countries that make up the LDCs, 33 (70%) are in Africa (Figure 4), while the rest are in Asia. Compared with least developed countries in Asia, poverty in African LDCs is widening and deepening. The number of Africans living in extreme poverty in these countries rose dramatically from 89.6 million to 233.5 million between 1960 and 1990 (UNCTAD, 2002).

Exposures to multiple risks and stresses, such as those outlined above, in parts of the continent, increase the vulnerability of Africa and hamper its socio-economic development, even without the addition of climate change. Margaret Beckett (2004).

Figure 4: Least Developed Countries.

3.0 AFRICA’S CHANGING CLIMATE

Observational Records

Observational records show that the continent of Africa has been warming through the 20th century at the rate of about 0.05°C per decade with slightly larger warming in the June-November seasons than in December-May (Hulme et al., 2001) (Figure 5). By the year 2000, the 5 warmest years in Africa had all occurred since 1988, with 1988 and 1995 being the two...
warmest years. The warming trend observed is consistent with changes in the global climate and is likely to be a signal of the anthropogenic greenhouse effect.

![Mean temperature anomaly in °C](image)

**Figure 5: Observed Temperature Changes in Africa** (Source: IPCC (2001) Climate Change 2001, Impacts, Adaptation and Vulnerability)

Since the mid-1970s, precipitation has declined by about 2.4±1.3% per decade in tropical rainforest Africa, this rate being stronger in West Africa (-4.2±1.2% per decade) and in north Congo (-3.2±2.2% per decade). Overall, in the West Africa/north Congo tropical rainforest belt rainfall levels were 10% lower in the period 1968-1997 than in the period 1931-1960 (Nicholson *et al.*, 2000). There has also been a moderate significant increase in dry-season intensity in Africa.

**GCM Results**

Results from GCMs, based on SRES scenarios project an increase in temperature, while projections in precipitation are less consistent. By the 2070-2099 period, maximum warming is expected to occur in Northern and Southern Africa (up to 9°C and 7°C respectively) while it is minimum in the oceanic regions (up to 4.8°C in the tropical NE Atlantic and 3.6°C in the Indian Ocean). Regarding precipitations, the following results have emerged:

- In northern Africa, a decrease (10-25%) in precipitations in JJA and 10-60% in MAM is predicted for the 2010-2039 period.
- In Western Africa, there is an agreement between models to predict a progressive increase in precipitation (between 10 and 35%) for the DJF period (which is normally dry). A similar trend is predicted for the SON period (between 7 and 28%) but some models predict a small decrease (<10%) for the 2070-2099 period.
- In Eastern Africa, a net increase in precipitations is projected for the DJF and SON periods (between 10 and 30%).
- In Southern Africa, a net trend towards decreased precipitations (15-62%) is predicted for the JJA (15 to 62%) and SON (8 to 36%) periods.
Modelled results using HadCM2 based on the IS92a scenario showing the effects of CO2 stabilization at 550ppm (by 2150) and 750ppm (by 2250) indicate that for the Sahel region (10-20°N, 20°W-40°E), the predicted reductions in warming are respectively 2.9°C and 2.1°C. Changes in precipitation are not statistically significant in winter (DJF) while in summer (JJA) a shift from negative to positive changes is predicted even though rather weak (from –0.09 mm per day to +0.12 mm at 550 ppm) and +0.18 mm per day (at 750ppm). According to Arnell et al. (2002) stabilization at 750 ppm could delay warming by around 40 years across Africa. As comforting as this result should be for us in Africa, everyone knows that even with stabilization of CO2 at whatever level we think (750ppm, 550ppm, or even 450ppm), sea level will continue to rise for centuries, even if it is at a reduced rate and bring with it all its attendant problems. This is due to the long time (thousands of years) the deep ocean needs to adjust to climate change.

4.0 VULNERABILITY TO CLIMATE VARIABILITY AND CHANGE

Climate data for Africa for the last 30–40 years shows global warming has taken a firm hold. If current trends continue, climate models predict that by 2050 Sub-Saharan Africa will be warmer by 0.5°C to 2°C and drier, with 10 per cent less rainfall in the interior and with water loss exacerbated by higher evaporation rates.

In Africa, climate change is not only about global warming; it is also associated with changes in climate variability and changes in the frequency and magnitude of extreme events, such as more droughts and floods. Several models forecast not just higher average temperatures and lower rainfall in semi-arid regions, covering about 30% of Africa, but an increasing probability of El Nino – Southern Oscillation events, which have become more frequent, persistent and intense since the mid-1970s (IPCC, 2001, Devereux and Edwards, 2004). ENSO events have been closely correlated with all weather-related famines in the Horn of Africa for at least the past 200 years (Davis, 2001). Besides the impacts from these abrupt climatic events, there is the possibility of imperceptible changes accumulating until thresholds are crossed that could cause entire thresholds to collapse. This risk is greatest in Africa where much of the livelihood and socioeconomic systems depend on the agro-ecology.

In the following sections, we review the vulnerability to and impact of climate variability and change on Africa in major sectors: water resources, agriculture, coastal zones, health and ecosystems and livelihoods.

4.1 Water Resources

Of the 19 countries around the world currently classified as water-stressed, more occur in Africa than any other continent (Watson et al. 1997). In 1994, available freshwater resources in Africa were about 4,050 km³ per year, representing about 9% of the world’s total and about 5.7 thousand m³ per capita per year, against a global mean of 7.6 thousand m³ per capita per year (Shiklomanov, 1996). These resources are not uniformly distributed, Eastern and Southern Africa having 3.87 and 4.8 m³ per capita per year respectively, the Sahel region having only of 2.2 of m³ per capita per year. Rainfall is highly variable and a number of countries have experienced droughts since the 1970s which have led to a general decrease in river discharges, and a consequent reduction in lake areas. For example the Chad lake is now 5% of its former size 35 years ago (Figure 6). Between 1970 and 1995, Africa has experienced a 2.8 times
decrease in water availability (Shiklomanov, 1996). The reduction in precipitation projected by some GCMs for the Sahelian and southern African countries, which will certainly be accompanied by higher inter-annual variability, could be highly detrimental to the hydrological balance of the continent and water-dependent activities (Hailemariam, 1999).

![Figure 6: Reduction in the Size of Lake Chad](image)

A drop in the water level in reservoirs and rivers could adversely affect the quality of water by concentrating sewage and industrial effluents, thereby exacerbating water-borne diseases and reducing the quality and quantity of fresh water available for domestic use (Dixon et al, 2003). This is additional stress in a continent where a sizeable portion of the population is without adequate water and sanitation coverage, particularly in the rural areas.

In Southern Africa, by 2050 the area having water shortages will have increased by 29%, the countries most affected being Mozambique, Tanzania and South Africa. In the Nile region, most scenarios of water availability estimate a decrease in river flow up to more than 75% by the year 2100. These potential impacts of climate change will have important effects on agriculture as reductions in annual Nile flows in excess of 20% will induce an interruption of normal irrigation practices (Dixon et al, 2003). The likelihood of this situation is greater than 50% by the year 2020. Such a situation will be critical since the current allocation of water that was negotiated during periods of high flow would become untenable and need further negotiations with neighbouring countries and creates a scenario for potential conflict.

### 4.2 Agriculture

Agriculture is the most important economic sector in Africa and accounts for more than 40% of total export earnings. One third of the national income in Africa is generated by agriculture. The agricultural sector is in fact the largest domestic producer across the continent and employs between 70% and 90% of the total labor force in most sub-Saharan African countries.
Agriculture supplies up to 50% of household food requirements and up to 50% of household incomes. It is the largest foreign-exchange earner in sub-Saharan Africa, where its share in total export revenues averages about 70 percent. It can therefore be concluded that the overall economic growth and development in Africa depend primarily on the performance of agriculture in driving incomes and employment. Agriculture and agro-ecological systems are most vulnerable to climate change, especially in Africa where the climate is already too hot.

Food production in most of SSA has been on the decline, and has not kept pace with the population increase (Figure 7). Over the past 30 years, the area of agricultural land has increased (from 166 million ha in 1970 to 202 million ha in 1999) at great cost to the environment. But these efforts have been absorbed by rapid population growth. During the same period, the number of undernourished people has doubled (202 million people in 1999-2001, FAO, 2004). This situation is exacerbated by recurrence of droughts and also by civil wars (Figure 8).

**Crop Production**

The main effect of climate change on semi-arid or tropical agro-ecological systems is a significant reduction in crop yield, which may well force large regions of marginal agriculture out of production in Africa. Global warming could reduce rainfall and shorten growing seasons in the tropics to less than the minimum 120 days required for most cereal crops (Devereux and Edwards, 2004). Results from recent country assessments show that most of the crops modeled tend to have decreased yields. C3 crops (rice, wheat, potatoes and vegetables, which are largely grown in the temperate zones) may be less vulnerable to climate change than C4 group (grasses, sugar cane, maize, millet and sorghum) which are largely grown in the tropics (US Country Studies Program, 1999; Desanker et al., 2001). Projected losses in cereal production potentials in sub-Saharan Africa range from 33 percent by 2060. By the 2080s, the net balance of changes
in cereal-production potential for sub-Saharan Africa will very likely be negative, with net losses of up to 12% of the region’s current production (Gitay et al., 2001; Parry et al. 1999). It is also estimated that up to 40% of sub-Saharan countries will lose a rather substantial share of their agricultural resources (implying a loss at 1990 prices of US$10-60 billion). The distribution of these losses is not uniform as certain countries will be affected more than others. It is even projected that by 2100, Chad, Niger and Zambia will lose practically their entire farming sector (Mendelsohn et al. 2000). Africa will not benefit from CO₂ stabilization since cereal crop yields will still decrease by 2.5 to 5% by the years 2080s (Arnell et al., 2002).

**Livestock**

Livestock and livestock products contribute about 19% to the total production value from agriculture, forestry and fisheries in sub-Saharan Africa but pasturelands make up 83% of the agro-ecosystem area. Livestock is also closely linked to rainfall and changes in annual precipitation. Changes in rain-fed livestock numbers in Africa will be directly proportional to changes in annual precipitation. Given that several GCMs predict a decrease in precipitation on the order of 10-20% in the main semi-arid zones of Africa, where most livestock is held, there is a real possibility that climate change will have a negative impact on pastoral livelihoods through a reduction in water availability and biomass (IPCC, 2001). Although it is generally believed that this reduction will be potentially balanced by positive effects of CO₂ enrichment (Desanker et al., 2001), diminished grassland area by trees (with enrichment of CO₂) may place additional stress on livelihoods derived from rangelands.

**Fisheries**

Global climate change is projected to alter freshwater temperatures, water chemistry and circulation. Fish in small rivers and lakes – or where temperature or precipitation changes are greatest – are most at risk. With climate change, fisheries will be affected by sea level rise through either coastal erosion or inundation, which could destroy fisheries infrastructures and fishing villages and could also affect important ecosystems involved in reproduction and larval growth of fishes.

Significant portions of people in African countries depend on fish for protein, thus near-term impacts on the fishery sector may also affect human nutrition and health. Assessments of impacts of climate change on fisheries conducted by some Africa countries show that in coastal states having important lagoon or lake systems, changes in freshwater flows with more intrusion of salt waters in the lagoons will have consequences on fish species. In Congo for example, it is predicted that more than 50% of the fish coming from the Conkouati lagoon could disappear due to an increased penetration of sea water in the lagoon (République du Congo, 2001). Also in Congo, fisheries depending on coastal upwellings will suffer from a potential diminution in their intensity. This will induce a significant reduction in catches of planktonic resources which are a very important source of proteins for the populations.

Shrimp production in Cameroon (mainly in the Cameroon estuary) could increase if rainfall increases. However, due to potential inundation of low lying areas in the estuary (for a 1 m sea level rise), about 38 fishing villages (53% of all the fishing villages) will have to be displaced inducing the migration of 6,000 fishermen (Republic of Cameroon/UNEP, 1998). In Comoros, Djibouti and Kenya, fisheries mainly depend on coral reefs so that the impacts of climate change on this ecosystem (for example coral bleaching) will have consequences on them. In Kenya, a decrease in fish catch (between 10 and 43%) was observed following the 1998 coral mortality induced by a strong ENSO event (McClanahan et al., 2002).
**Food Security**

Climate change impacts on agriculture will increase the number of people at risk of hunger, most of who are in Africa (Figure 9). A mean global temperature increase of 2.5°C could lead to an increase in food prices. Despite the fact that stabilization of CO₂ will globally reduce the number of people at risk of hunger, still the vast majority (around 65%) of the people at additional risk of hunger in the future will still be in Africa. The food security threat posed by climate change is greatest for Africa, where agricultural yields and per capita food production have been steadily declining, and where population growth will double the demand for food, water and forage in the next 30 years (Davidson et al. 2003). Parry et al. (1999) estimated that climate change will place an additional 80-125 million people (±10 million) at risk of hunger by the 2080s, 70-80 percent of whom will be in Africa.

![Figure 9: Countries Facing Food Emergency (Source: FAO, 2004)](image)

Climate change is not the only cause of food insecurity as other economic factors will interact with it to produce insecurity. Some of these factors include:

- Its strong dependence on agriculture (in 2050, agriculture is predicted to represent 38.1% of the GDP);
- Its low flexibility to allow for substitutions between export crops, cereals and other agriculture. This flexibility depends on factors like human capital, technological capacities, credit market access and infrastructure;
- Its low integration in the world market. The possibility for the economy to substitute domestic cereals by imports is also low in Africa. This depends on domestic preferences, regional market integration and trade infrastructure.
- Africa also cannot afford the technologies necessaries to increase its agricultural production and also can’t import food to meet all its needs and it is the main reasons why it is considered as highly vulnerable in terms of food production (Ramankutty et al., 2002).
- Even without climate change and if technological tools are not acquired, it is predicted that Africa will not be able to keep pace with population growth so that it will have to import most of its food (Ramankutty et al., 2002). This situation will be exacerbated by the processes of urbanization and land degradation (Ramankutty et
al., 2002). Other stress could arise from HIV/AIDS epidemics that will reduce the labour force in agriculture and thus food production (Rosegrant and Cline, 2003).

4.3 Health
Africa suffers from a number of diseases that are sensitive to temperature and precipitation. Vector-borne diseases such as malaria and Rift Valley Fever increase dramatically during periods of above normal temperature and rainfall. Cholera, a water and food-borne disease, has been known to cause large scale severe epidemics during periods of strong El Nino. Meningitis, a disease associated with low humidity, causes epidemics before the rains in West Africa, the Sahel and recently in Eastern Africa (Desanker et al., 2001). In recent years, it has become clear that climate change and variability will have direct and indirect impacts on diseases that are endemic in Africa. Following the 1997/98 El Niño event, malaria, Rift Valley Fever and cholera outbreaks were recorded in many countries in East Africa (WHO, 1998). The meningitis belt found in the drier parts of west and central Africa is expanding to the eastern region of the continent. The major climatic factors influencing disease transmission in the continent are flooding, warming and drought.

Malaria and other vector borne diseases will increase in frequency with higher (nocturnal) temperatures. Malaria climbs up high altitude areas where it has not previously been a serious threat. In recent years it has become clear that climate change will have direct and indirect impacts on diseases that are endemic in Africa. Following the 1997-1998 El Niño event, malaria, Rift Valley fever, and cholera outbreaks were recorded in many countries in East Africa. Africa accounts for about 85% of all deaths and diseases associated with malaria (Van Lieshout et al., 2004). It is the main cause of morbidity and mortality (1 million deaths and 300-350 millions of clinic cases per year) in Africa. It can be expected that small changes in temperature and precipitation will support malaria epidemics at current altitudinal and latitudinal limits of transmission (Lindsay and Martens, 1998). Furthermore, flooding could facilitate breeding of malaria vectors and consequently malaria transmission in arid areas (Warsame et al., 1995). Maps of climatic suitability for stable malaria transmission have been developed for Africa, mainly from temperature and precipitation data (Figure 10). Studies have shown that areas that were previously unsuitable areas will become suitable for transmission with small temperature and precipitations variations. In South Africa, it is estimated that the area suitable for malaria will double and that 7.8 million people will be at risk (5.2 million being people that never experienced malaria) (Republic of South Africa, 2000).

Figure 10: Malaria-Prone Zones

Under climate change, the meningitis belt in the drier parts of West and Central Africa will expand to the eastern region of the continent. In a highland area of Rwanda, for example,
malaria incidence increased by 337% in 1987, and 80% of this variation could be explained by rainfall and temperature (Loevinsohn, 1994). A similar association has been reported in Zimbabwe (Freeman and Bradley, 1996). Other epidemics in East Africa have been associated largely with El Niño.

The potential impacts of climate change on the distribution of malaria and other mosquito-borne diseases like dengue raised considerable interest mainly because of their possible expansion to developed countries (Rogers and Randolph, 2000; Hopp and Foley, 2001). On the basis of MIASMA model combined with HadCM3 outputs for different SRES scenarios, Van Lieshout et al. (2004) demonstrated that climate change could be responsible in Africa for an additional population at risk comprised between 21 million (B1) and 67 million (B2) by the years 2080s. The greatest population at risk is located in Eastern and Southern Africa, particularly in the highlands.

The experience of Europe and North America where malaria and other mosquito-borne diseases have been eradicated by public education, mosquito control programmes, piped water, etc. demonstrates the role of socio-economic conditions in malaria control (Hopp and Foley, 2001). Vulnerability of many African countries to this disease is not only due to climate parameters but also to anthropogenic actions (deforestation, irrigation, dam construction, migrations), and to low capacities to tackle the issue: disruption or low capacities of health services, insufficient awareness campaigns, low access to water and sanitation.

**4.4 Coastal zones**

In Africa, coastal zones are characterized by the presence of high productive ecosystems (mangroves, estuaries, deltas, coral reefs) which constitute the basis for important economic activities like tourism and fisheries. The concentration of populations and industries with important urban centers (Lagos in Nigeria had 31 million people in 2001) is another characteristic of these coastal zones. For example, 40% of the population of West Africa lives in coastal cities and it is expected that the coast between Accra (Ghana) and the Niger delta (about 500 km) become a continuous urban megalopolis with more than 50 million people by 2020 (Hewawasam, 2002). The shoreline of East Africa (11,000 km long) is occupied by 30 to 35 million people. By 2015, three megacities with at least 8 million people will be present in coastal Africa (Lagos, Kinshasa and Cairo) (Klein *et al.*, 2002). These characteristics explain the main problems encountered in the coastal zone, mainly pollution, resource and land use conflicts, overexploitation of ecosystems and species.

Studies that have assessed the impacts of sea level rise without considering other climate parameters (temperature, precipitations) have recorded land losses either due to coastal erosion (mainly for beaches) or coastal inundation (for muddy, estuarine and deltaic coasts). They represent between less than 0.1 to 3% of the total area of each country. Another important physical impact is the salinization of soils, surface and ground waters. In Cameroon for example, it is estimated that by the year 2100, the length of the salt wedge would have decreased by 2.6% (39 km against 40 km actually) in case of a 15% increase in rainfall while it would have advanced by 26% (67.5 km) in case of a 11% decrease (Republic of Cameroon/UNEP, 1998). The saline front in the Gambia River could migrate by about 200 km upstream (US Country Studies Program, 1999).
In some islands of the Indian Ocean, potential changes in the location, frequency and intensity of cyclones - which are still highly uncertain - could have serious impacts while east African coasts will also be affected by projected changes in frequency and intensity of ENSO events (Klein et al., 2002). In the southern part of Nigeria bordering the Atlantic Ocean, studies have shown that the sea surface temperature is about one degree short of the requirements for the development of a cyclone.

Population at risk represents between 0.5 and 17% of the total population of the different countries. However most of the studies didn’t consider the population growth rate so that these numbers must be considered as minimal values. Moreover, contrary to other megacities in the developed world that would be more resilient to climate change, the African megacities, due to the concentration of poor populations in potentially hazardous areas, will be less resilient to climate change (Klein et al., 2002). Economic values at risk represent a high percentage of the GDP (between 5.8 and 542%).

In countries where important agricultural products come from the coastal zones, potential losses in crop revenues are another concern since they could be at risk of inundation and salinization of soils. For example, in Benin and Côte d’Ivoire important plantations of palm oil and coconuts are located close to the coast (77.4 km² in Benin representing 33.6% of the inundated areas). In Kenya losses for three crops, mangoes, cashew nuts and coconuts, could reach 472.8 million US $ for a 1 m sea level rise (Republic of Kenya, 2002). In Guinea, rice culture is the main agricultural activity along the coast and it was estimated that by 2050, depending on the inundation level considered (4.6 to 5.7 m), between 132.6 and 234 km² of rice fields will be lost due to permanent flooding, representing respectively 17 and 30% of the existing rice fields (République de Guinee, 2002). In Nigeria, a total of 5,955 km² of agricultural lands, representing 75% of the total agricultural area, will be at threat with a 1 m sea level rise (Awosika et al., 1993). In Nigeria, and in particular, in the Niger delta, another concern are the oil fields. It was estimated that about 259 producing oil fields are located in the threatened areas, representing a value at risk of 10,790 million US $ for a 1 m sea level rise (French et al., 1995).

4.5 Ecosystem

Ecosystems are not only the foundation of the economy of most African Countries, but also contain a number of plants and animals which constitute about 20 percent of all known species (Biggs et al., 2004). With climate change, most of these species are threatened (Figure 11). In Africa, terrestrial animal biodiversity is concentrated in the savannas and tropical forests while unique native environments host very high biodiversity. The small islands as well as Madagascar host very rich ecosystems and species.

**Biodiversity**

Africa occupies about one-fifth of the global land surface and contains about one-fifth of all known species of plants, mammals, and birds in the world, as well as one-sixth of amphibians and reptiles (Siegfried, 1989). About one-fifth of southern African bird species migrate on a seasonal basis within Africa and a further one-tenth migrate annually between Africa and the rest of the world (Hockey, 2000). One of the main intra-Africa migratory patterns involves waterfowl, which spend the austral summer in southern Africa and winter in central Africa. Palearctic migrants spend the austral summer in locations such as the Langebaan Lagoon, near Cape Town, and the boreal summer in the wetlands of Siberia. If climatic conditions or very
specific habitat conditions at either terminus of these migratory routes change beyond the
tolerance of the species involved, significant losses of biodiversity could result.

In South Africa, isolated plant communities, particularly at high altitudes (Cape Floral Kingdom
and the Afromontane phytochorion) will be affected by temperature rise. Changes in the seasonal
distribution of rainfall could affect fire regimes and plant phonological cues, especially in the
southern Cape (Tyson et al., 2002). Models indicate that in South Africa, the savanna and the
Nama-Karoo biomes will advance at the expense of the grasslands. But the results will also
depend on the possibility for plants and animals to migrate (Tyson et al., 2002). Since protected
bird areas in South Africa are already surrounded by places with high densities population it is
predicted that conflicts between human requirements and avian conservation needs will increase
with climate change (Van Rensburg et al., 2004).

In Malawi, climate change could induce a decline of nyala (Tragelaphus) and zebra (Equiferus)
in the Lengwe and Nyika national parks because these species couldn’t adapt to climate
induced habitat changes (Dixon et al., 2003).

Mangroves
Mangroves supply essential ecosystem services for tropical economies by contributing
substantially to timber and charcoal supplies, food supply (rice, oysters), productivity of near-
shore fisheries, tourism and physical protection of coastlines (Panapitukkul et al., 1998; Saenger, 1998). In 2000, the total area of mangroves in Africa was estimated to be around
37,400 km², mainly along the Atlantic coasts (28,000 km²) (UNDP/UNEP/WB/WRI, 2000).
The response of mangroves to climate change is a worldwide concern from both scientific and
policy perspectives but to date most of the studies have only assessed the impacts of sea level
rise (Ellison and Farnsworth, 1997; Blasco et al., 2001; McLean et al., 2001). The main
potential responses to sea level rise are vertical accretion –which will depend on sediment
supply – and inland migration. However, there is concern about the potential obstacle that hard
protection structures (like dikes) could constitute to the horizontal migration of mangroves
(Bird, 1995; Viles and Spencer, 1995; Kennedy et al., 2002; Nicholls, 2004).

In Africa, the few studies on the impacts of climate change on mangroves have been based
mainly on expert judgment. In Senegal, potential changes in the substrate (from mud to sand
brought by increased coastal erosion) and increases in salinity are considered as the main
factors of mangrove degradation. However, the balance between sedimentation and erosion as well as the rate of sea level rise would also be crucial for the response of mangroves to climate change.

**Coral reefs**

Coral reefs play a crucial role in fisheries production and in protecting the coastline from wave action and erosion (Middleton, 1999). In Africa, they are mainly present along the Indian coasts (East Africa and Indian Ocean islands) but also in the Cape Verde and Sao Tome and Principe islands. On the 18 richest endemic coral reef centers, 6 are located in Africa and will need specific protection and conservation measures (Roberts *et al.*, 2002) (Figure 12).

Major coral bleaching events have occurred in recent times. The last major event at the eastern coast of Africa was in 1998. As a result, many reefs dominated by branching species were severely damaged or killed. The 1998 coral bleaching resulted in an average of 30% mortality of corals in the western Indian Ocean region and for Mombasa and Zanzibar decreases in tourism value of coral reefs were estimated to be about US$ 12-18 million. (Payet and Obura, 2004). Estimated economic losses due to the coral bleaching in the Indian Ocean stood at between 706 and 8,190 million US$ (Wilkinson *et al.* (1999).

Other potential consequences of coral bleaching could be an increase in the number of people affected by intoxications due to the consumption of contaminated marine animals. Low lying corals in Seychelles could disappear in case of sea level rise (Payet and Obura, 2004). It is predicted that these impacts will have long term negative effects on fisheries and also on tourism.

Figure 12: Threats to Coral Reef
5.0 ADAPTING TO CLIMATE CHANGE

Responding to climate change, as contained in Article 2 of the UNFCCC encompasses two strategies: (i) mitigation: controlling greenhouse gases to stabilize climate change at an acceptable limit, and (2) adaptation: adjustments to the impact of climate change given existing levels of greenhouse gases in the atmosphere. While the continent has signed up to international agreements to reduce the emission of greenhouse gas, the most viable option for dealing with the impacts of climate change is adaptation.

Most reports have identified factors that explain Africa’s low adaptive capacity and second, why these various intervention efforts have not yielded commensurate results. The fact that about 70% of the least developed countries (LDCs) are African is major constraint since it shapes national priorities and determines financial capacities. Restrictions due to low technical skills, low research capacities, insufficient or lack of institutions able to deal with adaptation, inadequate policies and ineffective governance, also constitute important limits to Africa’s adaptive capacity.

Governments at the country and regional levels have embarked on programmes of actions aimed at reducing the impacts of climate change in Africa. Some of these programmes have been externally funded or aided by organizations such as DFID, CIDA, GTZ, USAID, JICA, etc. Others have been funded through national government budgets. However, for most African countries, the national priorities are often poverty reduction and economic development; and climate change is not often seen as an immediate priority. Regional and Africa-wide collaborations have also been established to deal with the issues of climate change. Despite all these interventions and efforts, virtually all assessments conclude that Africa has the lowest adaptive capacity, hence its high vulnerability to climate change impacts. What is it then that we are not doing right?

The process of adaptation comprises a number of different activities, carried out by different public and private actors. Most simply put, one can distinguish between facilitating adaptation and implementing adaptation. Facilitating adaptation includes developing information and raising awareness, removing barriers to adaptation, making available financial and other resources for adaptation and otherwise enhancing adaptive capacity. Implementing adaptation includes making the actual changes in operational practices and behaviour, and installing and operating new technologies. Recognizing the domain of two adaptation activities is a first step towards a successful and sustainable adaptation.

6. THE WAY FORWARD

Capacity Building

Just as capacity is not static but requires continuous renewal, so is capacity building a continual process of improvement within an individual, organisation or institution, not a one-time event. It is essentially an internal process, which only may be enhanced or accelerated by outside assistance, for instance by donors. Capacity building emphasizes the need to build on what exists, to utilize and strengthen existing capacities, rather than arbitrarily thinking of starting from scratch.

Capacity building to adapt to climate change in Africa is about complex processes of changing people’s mindsets and behaviour and introducing more efficient technologies and systems. This
has two important implications emphasised widely in the literature. First, capacity building takes a long time and requires a long-term commitment from all involved. Second, success of capacity building efforts should not be measured in terms of disbursements or outputs with little attention to sustainability.

The need for capacity building in Africa on the issue of adaptation to climate change can be summarized as:

- **Scientific and research capacity**: In order to build adaptive capacity to deal with climate change there are three main domains of scientific and technical knowledge and capacity that need to be built-up in vulnerable countries. They are (i) the ability to construct credible scenarios of future changes, such as climate change, that would result in exposures of people and the environment to stresses, (ii) the ability to assess vulnerabilities that would arise from the exposures and adaptations to limit or recover from harm, (iii) the ability to effectively communicate information about exposures, vulnerabilities and adaptations to technically trained managers, and their ability to understand and use the information.

- **Strengthening the most vulnerable communities**: Most countries have done a preliminary vulnerability to climate change assessment for their countries which have indicated which sectors and regions within the countries are most vulnerable. However, these need to be made more specific with respect to identifying the most vulnerable communities and based on their own socio-economic needs help them to be better able to cope with future impacts due to climate change.

- **Sector specific capacity building**: Each of the sectors vulnerable to climate change (e.g. water resource management, coastal zone management, agriculture, etc) need to have sector-specific capacity building of the people involved in those sectors about possible adaptations.

- **National policy level capacities**: There are many current policies that instead of reducing vulnerability to climate change in fact may enhance vulnerability (e.g. building houses on floodplains). There needs to be capacity building of policymakers to be able to make judgments regarding policies (including maladaptive policies).

- **Public awareness**: the wider public needs to become more aware about and knowledgeable about the potential impacts of climate change and possible adaptations.

**Use of Appropriate Technology**

As far as possible low cost and appropriate technology options must be favoured. In Nigeria, for example, an experience of deepening existing wells in a river floodplain, and adopting simple rainwater harvesting technologies showed good results indicating that good scientific information and low cost technology can provide appropriate adaptation that can also increase the level of resources management. Better than invest in completely new technologies, there are opportunities to enhance existing traditional technologies.

The development and testing of these varieties should not be restricted to controlled experimental farms, but should be tested in real world situations with local farmers. It is also recognized that investments in education, road infrastructures, agricultural research which need a constant involvement of the public sector (through policy actions and investments) could increase agricultural productivity while reducing poverty in rural areas. In fact, new techniques can be adopted if they can be shown to increase not just economic, but social benefits to the farmers.
Integration of Indigenous Knowledge

The high climate variability that characterizes the African continent presupposes that people have developed successful indigenous adaptation strategies. There are documented successful traditional farming techniques to conserve biodiversity while managing soils so that the soil-plant relationship is maintained. It has been pointed out the fact that traditional adaptation strategies are hindered by widespread poverty, the recurrence of droughts and inequitable land distribution.

It is advocated that indigenous knowledge should be integrated into formal climate change mitigation and adaptation strategies. The first step is to acknowledge that indigenous knowledge has provided communities with the capability of dealing with past and present vulnerabilities to climatic extremes and other stresses. Second, one must adopt the bottom-up participatory approach that encourages the highest level of local participation. The benefits of this are that (i) it provides valuable insight into how communities and households interact and share ideas, and (ii) it allows the intended beneficiaries to develop the skills and practices necessary to forge their own path and sustain the projects. Third, the local communities should be seen as equal partners in the development process. It is basically an internal process, which only may be enhanced by outside assistance. Local actors should progressively take the lead while external partners back their efforts to assume greater responsibility for their development. Capacity building should emphasize the need to build on what exists, to utilize and strengthen existing capacities. Indigenous knowledge plays a significant role in the sum total of what exists in a local community. Fourth, inasmuch as we acknowledge the importance of indigenous practices in climate change mitigation and adaptation, they should not be developed as substitutes of modern techniques. It is important that the two are complements and learn from each other in order to produce “best practices” for mitigation and adaptation.

A Best Practice is the result of articulating indigenous knowledge with modern techniques - a mix that proves more valuable than either one on its own. The interaction between the two different systems of knowledge can also create a mechanism of dialogue between local populations and climate change professionals, which can be meaningful for the design of projects that reflect people’s real aspirations and actively involve communities.

However, it is important to note that not all indigenous practices are beneficial to the sustainable development of a local community; and not all indigenous knowledge can \textit{a priori} provide the right solution for a given problem. Therefore, before adopting indigenous knowledge, integrating it into development programs, or even disseminating it, practices need to be scrutinized for their appropriateness just as any other technology. In addition to scientific proof, local evidence and the sociocultural background in which the practices are embedded also need consideration in the process of validation and evaluation.

Funding Adaptation

While several adaptation funds have been set up to assist developing countries to adapt to climate change, the mechanism for drawing these funds are still vague and Africa, for instance is yet to benefit from such funds. It is therefore important that such funds be made operational and easily accessible to Africa.
7. CONCLUSION

Africa is highly vulnerable to climate change and its vulnerability results largely from the continent’s dependence on agriculture. Africa’s high vulnerability is not only due to climate change but a combination of other stresses the continent has to grapple with. Such stresses include poverty, wars and conflicts, limited technological development, a high disease burden and a rapid population growth rate. The impacts of climate change in Africa, interacting with these other stresses, are capable of hampering the possibility of achieving the Millennium Development Goals.

There must be substantial and genuine reductions in greenhouse gas emissions by the principal emitters. While this is on, mitigation should be supported by effective and sustainable adaptation. This implies that Africa’s capacity to adapt to climate change must be strengthened through capacity building and the facilitation of adaptation through a fusion of top down and bottom-up approaches. Local communities in Africa have lived with large scale variations in climate change and have developed indigenous knowledge systems that have enabled them cope with such variabilities. One major factor that has served as an impediment to successful indigenous adaptation is poverty. Implementing successful and sustainable adaptation would require among other things, the integration of indigenous knowledge systems into western adaptation science.

The bottleneck that surrounds the operation of the various adaptation funds need to be removed so that poor countries, including those in Africa, can begin to draw upon such funds to finance adaptation. Experience has shown that the cost of adaptation is usually much lower than the losses from a climate-induced disaster. Planning for adaptation is a proactive way of dealing with disasters, as it shifts emphasis from disaster management, which is very expensive to disaster reduction.

To shift from disaster management to disaster risk reduction is to exploit hindsight and develop foresight through insight (ISDR, 2004).
REFERENCES


