Background paper
on
Impacts, vulnerability and adaptation to climate change in Africa

for the African Workshop on Adaptation
Implementation of Decision 1/CP.10
of the UNFCCC Convention

Accra, Ghana, 21 - 23 September, 2006

This paper was commissioned by the secretariat of the United Nations Framework Convention on Climate Change and prepared by Dr. Balgis Osman Elasha (Team Leader), Dr. Mahmoud Medany, Dr. Isabelle Niang-Diop, Dr. Tony Nyong, Dr. Ramadjita Tabo and Dr. Coleen Vogel. The information contained in the paper was prepared by the author, although in some instances the secretariat has introduced some modifications

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1 Introduction

1. The Conference of the Parties (COP), by its decision 1/CP.10, requested the secretariat to organize regional workshops, reflecting regional priorities, before the thirteenth session of the Conference of the Parties (November 2007), in order to facilitate information exchange and integrated assessments to assist in identifying specific adaptation needs and concerns.

2. This paper presents background information as input to the African Regional Workshop on Adaptation (Accra, Ghana, 21- 23 September, 2006). The authors aim at facilitating an in-depth discussion on these issues.

3. The paper is wide in scope as it broadly covers the main issues relating to impacts, vulnerability and adaptation to climate change in relation to Africa.

4. It starts with a general outline of African circumstances and an overview of existing capacities as well as gaps related to the availability and use of climate information, including status of existing observational networks and contribution of Africa to the Global Climate Observing System (GCOS), access to information, availability of communication infrastructure and other important issues relating to the dissemination and effective utilization of climatic information in adaptation to climate change.

5. The paper then describes the availability and use of analytical tools, such as climate and impact models and the existing capacity for vulnerability and adaptation studies, including training opportunities.

6. The paper focuses further on current and projected climate change and variability and their impact on key sectors: water, food security, health, energy and biodiversity and ecosystems. It also describes different factors contributing to vulnerability and their interaction with different climatic and non-climatic elements. The paper further explores opportunities for combating future climate change impacts and provides information on previous and current adaptation initiatives and programmes, including National Adaptation Programmes of Action (NAPAs), projects and networks and their role in reducing the overall vulnerability of Africa.

7. Finally, the paper summarises the issues described, underlining major conclusions and bringing to light those important adaptation needs and concerns as well as Africa's potentials and opportunities for future adaptation.

8. The paper draws upon recent studies on vulnerability and adaptation, national communications and other reports, and extracts lessons from the studies which employed both a top-down scenario-driven approach, as well as those that adopted bottom-up approaches.

9. The key sources of information includes the following sources:

- IPCC Third Assessment Report and other relevant IPCC documents;
- National communications and related UNFCCC documents;
- Officially submitted NAPA reports;
- UNEP/GEF AIACC, publications and synthesis reports;
- IRI/GCOS/DfID/ ECA Gap Analysis for the Implementation of GCOS in Africa

- Relevant publications from recent national or international scientific journals;
- Other relevant documents, including NGO documents, reports on bilateral assistance, declarations and analysis papers, as well as graphical *information from* UNEP/GRID-Arendal Maps and Graphics Library.
- UNFCCC Compendium on methods and tools to evaluate impacts, vulnerability and adaptation to climate change.
- UNFCCC Database on Local Coping Strategies.

2 General overview of African circumstances

10. The African continent is the largest of all tropical landmasses and is the second largest of the world's seven continents with a land area of 30 million km^2 - about 20 percent of the world's total land area. Straddling the equator with roughly equal landmasses within both hemispheres. It stretches 8,050 km from the northernmost point in Tunisia to its southernmost tip in South Africa. It is 7,560 km wide, measured from the western tip in Senegal to the eastern tip in Somalia. Mount Kilimanjaro in Tanzania, measuring 5,895 m above sea level, is the highest point while the lowest is Lake Assal (153m below sea level) in Djibouti.

11. Many African regions are coming to be recognized as having climates that are among the most variable in the world on intra-seasonal to decadal timescales. The size of the African continent and its amplitude of climate variability make the region an important component of not only the climate system of surrounding regions but also of the global climate system itself (CLIVAR, 2004). Changes in vegetation, hydrology and dust export from land surface to atmosphere all modify large scale atmospheric properties in the region and have the potential to impact climate variability.

12. Africa is characterized by a high population growth rate (1.9% in 1992-2002). It has a total population of 812 million and a low population density of 249 people per 1000 hectares compared to a world average of 442. Figure 1 shows Africa's population and population growth in comparison to the rest of the world[1].

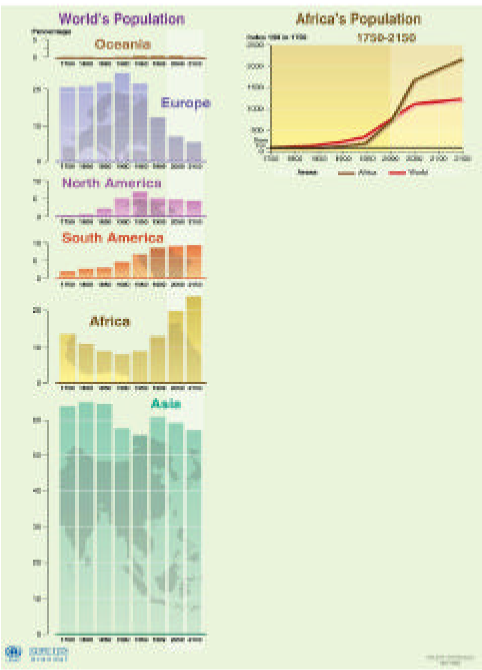

Figure 1: African population in comparison to the rest of the world

13. African water resources are not evenly distributed throughout the continent and are often not located where there is the greatest demand. Africa has 17 rivers with catchment areas greater than 100 000 km^2. It has more than 160 lakes larger than 27 km^2, most of which are located around the equatorial region and sub-humid East African highlands within the Rift Valley (The Africa Water Vision in the 21st Century, 2000). Groundwater represents 15 percent of Africa's water resource with the major aquifers located in arid zones of the northern Sahara, Nubia, Sahel, Chad Basins, and Kalahari. (Lake and Soure, 1997). Groundwater is a very important source of drinking water supply; it used by more than 75 percent of the population. About 52 percent of Africa's total population has access to safe water and the average water use per capita is about 226 m^3 per annum (World Bank, 1995).

14. About half of Africa's cultivable land is arid and semiarid, mostly including desert soils (aridisols and entisols) which have low organic matter content. 65 percent of the cropland and 30 percent of the

[1] Population and development in Africa. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006

pastureland in Africa are affected by degradation with consequent decline in crop yields and chronic food insecurity. It is also estimated that 14 percent of degraded soil result from vegetation removal, 13 percent from over-exploitation, 49 percent from overgrazing and 24 percent from agricultural activities (ECA, 2006).

15. It is estimated that Africa accounts for 27.4 percent of land degradation of the world and that 500 million hectares of land in Africa are moderately to severely degraded (UNEP, 2000d). Land degradation in Africa manifests itself mainly in the form of soil degradation, rangeland degradation, declining soil productivity and desertification. Figure 2 shows levels of soil degradation worldwide[2].

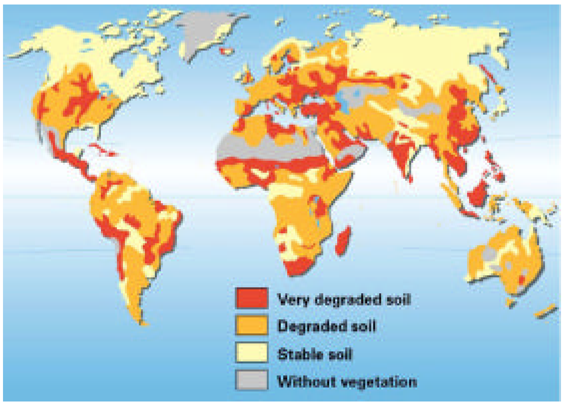

Figure 2: Levels of soil degradation worldwide

16. Agriculture is the economic mainstay accounting for about 20–30 percent of GDP in sub-Saharan Africa and representing up to 55 percent of the total value of African export (Sokona, 2001). 70 percent of all Africans—and nearly 90 percent of their poor—work primarily in agriculture (World Bank, 2000).

17. In Africa, urban areas account for 37.9 percent of the total population and are credited with 60 percent of the region's Gross Domestic Product (GDP). African cities are undergoing rapid population growth (more than 3.5 percent per year) accompanied by rapid development pressures with high demands for housing and infrastructure.

[2] Global soil degradation. (1997). *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006

3 Status and availability of climate data and observations

3.1 Observations and data needs

18. Africa is characterized by a wide variety of climate systems (Hume et al, 2000) ranging from humid equatorial systems, through seasonally-arid tropical, to sub-tropical Mediterranean-type climates. These systems are also *varying* because all these climates exhibit differing degrees of temporal variability, particularly with regard to rainfall. The scientific understanding of these systems, compared to many parts of the world, is considered rather low (Brew & Washington, 2004). The level of understanding varies between regions; in some regions it could be considered reasonable, while in other parts, such as the Congo basin (which is key for the global climate system) very little is known.

19. More recently, deficiency of data on Africa has also been stressed in the G8 Gleneagles Plan of Action, 2005, which noted that *"Africa's data deficiencies are greatest and warrant immediate attention"*. These deficiencies exist despite the phenomenal increase in availability of climate and environmental data from satellite remote sensing. They also exist despite improvements in the overall understanding of, and ability to monitor and model, the global climate system. This progress means that a useful degree of predictability at a seasonal lead-time in some regions of Africa can be provided. The weaknesses of ground-based (and upper air) observing systems contribute to these deficiencies (Washington, et al., 2004).

20. The lack of observational climate data, particularly in Africa, is recognized as a constraint to understanding current and future climate variability (DFID, 2004). Significant gaps are apparent in the surface network in Angola, the Congo basin, Sudan and parts of the Sahel (CLIVAR, 2004). Regional diagnostic studies (which can identify the structure of dry and wet years, their precursors and impacts utilizing empirical and statistical techniques) need further support in Africa. To address this evident gap, coordinated effort of capacity building, training, research and development should be emphasized to provide for continent-wide monitoring. This will make available reliable climate observations which can then be transformed into useful products for a wide spectrum stakeholders.

3.2 Global Climate Observing System (GCOS) and contribution of Africa

21. The Global Climate Observing System (GCOS) was established in 1992 to ensure the availability and improvement of climate observations and information necessary to address climate-related issues for all potential users. It is an internationally sponsored and coordinated global framework for obtaining the climate data needed for climate monitoring (detection and assessment of impacts of climate change), research, policy formulation, and national economic development.

22. In the UNFCCC process, the Conference of Parties (COP) became seriously interested in the global observing system in 1998. It was stimulated by a perception that the availability and quality of data were declining, and that actions are needed to reverse the trend, particularly in developing countries. The COP and its subsidiary bodies, through varies decisions, have endorsed several major activities to address this problem, namely:

- Organising a regional workshop programme which would help to develop specific proposals for the purpose of addressing deficiencies in the climate observing networks and to identify the capacity-building needs and funding required in developing countries to enable them to collect, exchange and utilize data on a continuing basis in pursuance of the Convention;

- Inviting parties to develop and submit separate reports on GCOS as part of their national communications;
- Preparation and monitoring of the Implementation Plan. This plan is to be coordinated by GCOS in collaboration with the ad hoc Group on Earth Observations (GEO).

23. Within this set of actions two workshops were held to develop Regional Action Plans to address issues of observation: one for the countries of Eastern and Southern Africa and one for those of Western and Central Africa. The workshops lead to the development of subsequent two Regional Action Plans for improving the GCOS for eastern and southern Africa[3].

24. The two regional action plans contain project proposals addressing the identified requirements in: climate-related observations, information availability, and building climate application partnerships for decision-making. Common themes in the two Action Plans include the need for improving and sustaining operational observing networks, such as the GCOS Surface and Upper Air Networks; recovering historical data; improving national and regional coordination; education, training, and capacity building; and improved national planning and reporting.

25. The improvement of the quantity and quality of climate data is emphasized as a necessary step for further improving climate services as well for climate risk management. Another important issue identified in the two workshop reports is the urgent need for upgrading the observational network in Africa, indicating a requirement for about 200 automatic weather stations to support provision of services specifically related to floods, droughts and other Africa-relevant climatic phenomena. Moreover, it stressed the need for data rescue underlining the benefits to be gained by preserving and digitizing sensitive historical observational records (WMO, 2003).

26. The regional action plans for Africa revealed the importance of monitoring climate parameters and understanding climate variability and change (GCOS, 2002; GCOS, 2003). The critical role of the GCOS Surface Network (GSN) and GCOS Upper Air Network (GUAN) in increasing this understanding climate change was highlighted. However, the operation of GSN and GUAN is unsatisfactory in Africa.

27. WMO (WMO, 2003) reported that about 26 percent out of 84 GSN and 20 percent out of 10 GUAN stations within eastern and southern Africa are silent, and most of the remaining stations are functioning in a less than desirable manner. This situation creates key gaps in the understanding of and ability to predict the global climate system, rendering the climate observing system in Africa in a far worse and deteriorating state than that of any other continent.

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3 See: http://www.wmo.ch/web/gcos/gcoshome.html

28. The deficiency in providing reliable data for climate monitoring and spatial coverage of some of the highly elevated areas of Africa is identified as a major gap affecting the detection capacity of impacts resulting from long-term climatic changes, e.g. Kenya and Kilimanjaro Mountain with respect to the ice cap, glaciers and runoff (GCOS, 2002). Some studies report the rapid reduction of the ice cap during the last 50 years, and the possibility of its complete disappearance by 2100 (UNEP, 2002).

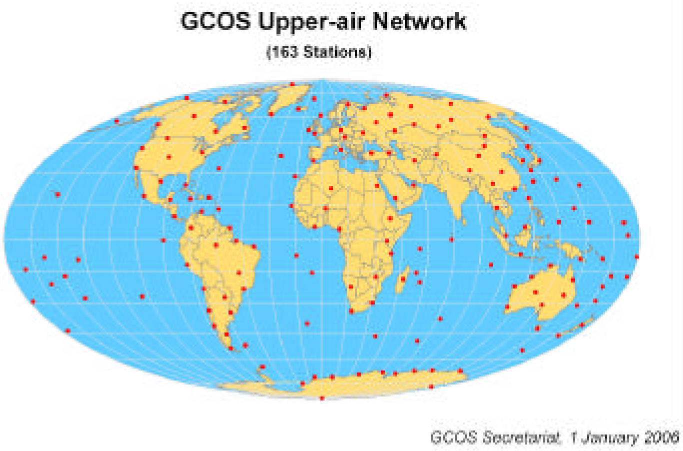

Figure 3: Global distribution of the GCOS Upper Air Network

29. Another gap that has been identified relates to the role played by the network of WMO World Weather Watch (WWW) stations in providing real-time weather data. These provide vital input to weather and climate forecasts worldwide, and form the basis for international climate archives. There are 1152 WWW stations in Africa giving a station density of one per 26,000 km^2, eight times lower than the WMO minimum recommended level. Figure 3 shows the global distribution of the GCOS Upper Air Network[4]. Problems caused by this shortage of data are exacerbated by an uneven distribution of stations, leaving vast areas of central Africa unmonitored and giving Africa the lowest reporting rate of any region in the world, (Washington, 2004).

4 Availability of analytical tools and capacities for studies on vulnerability and adaptation to climate change

4.1 Availability and use of the General Circulation Models (GCMs), downscaling tools and regional models

30. Many of the studies on assessment impacts and adaptation conducted for Africa, e.g. for the purpose of national communications to the UNFCCC, represent so-called "first generation" studies, and provide results that show how different sectors, systems and communities might be impacted by climate change. In these studies, African countries depended on generated climate scenarios based on inputs from general circulation models (GCMs), which are generally designed in developed countries, e.g. through downscaling using MAGIC-SCENGEN.

31. The most commonly used global models are GISS, HadCM2, UKTR, GFDL, CCCM and ECHAM3 (see Table 1 on methods used in national communications). These V&A studies have employed the IPCC IS92 model output used in the IPCC Second Assessment Report (SAR) and to some extent in the Third Assessment Report (IPCC 1996; IPCC 2001). The results of these studies confirmed that these scenarios could provide important information which give a good

[4] GCOS Upper Air Network, 2006, Global Climate Observing System. Retrieved September 12, 2006 from www.wmo.ch/web/gcos/GUAN_Station_Map.pdf

indicator of future climate change and that, the use of Global Climate Change models could provide for long-term climate risk assessments at a general level (DFID, 2004).

32. GCM-based climate change scenarios are generally consistent in predicting temperature rise across Africa, but show considerable uncertainty about both the magnitude and direction of changes in precipitation (IRI, 2006). Appropriate use of a range of such scenarios combined with analysis of trends in historic data can contribute to the understanding of future trends and uncertainties that are crucial for long-term planning horizons.

33. Global General Circulation models provide coarse climate prediction with low resolution and a very broad scale (300km^2). The task of developing reliable predictions of future climate change in Africa is difficult because of the complexity of the African climate coupled with the lack of accurate baseline data on current climate (needed to feed into models of future climate) (DFID, 2004[5]). While global climate models (GCMs) simulate changes to African climate resulting from increased greenhouse gas concentrations, two potentially important drivers of African climate variability, namely the El Niño/Southern Oscillation and land cover change are not well represented in the models (Hume et al, 2000). Moreover, Washington (2004) outlined a number characteristics of GCM models that are critical for model prediction performance including:

- Ability to capture reasonably well the simulation of mean, large-scale patterns of contemporary climate (e.g. temperatures, wind, precipitation), as well as the broad response to Pacific Ocean forcing (ENSO) and to ocean temperature patterns in surrounding basins (Indian, Atlantic and Mediterranean);
- Capturing, to a lesser extent, the precise positioning, timing and intensity of specific features such as the onset of the Sahel precipitation, the precipitation gradient across southern Africa, and the orientation of tropical convection over East Africa;
- The interaction of Saharan dust with climate is not included in most models and inadequate information on the coupled land-surface atmosphere feedbacks.

[5] Key sheet 10

Country							
	Climate hazard	**Climate scenario**	**Agriculture**	**Water**	**Coastal**	**Health**	**Forestry/Rangeland &biodiversity**
Egypt	Drought/aridity		DSSAT3[2] and COTTAM model Cotton/sorghum	No models	Satellite images and Geographical Information Systems (GIS)	Not assessed	Not assessed
Eritrea	Drought/aridity	UKMO89[3], GFD3[4], CCCM[5], and GISS	(DSSAT 3) and the CERES-Barley and CERES-Sorghum models Sorghum	water balance model	-Qualitative analysis	No models	Holdridge life zone classification Model and the forest Gap model,
Ghana	Drought/aridity	3 GCMs MAGICC[6] SCENGEN	DSSSAT V.3.1 (CERES MAIZE and CERES MILLET Model	CROPWAT model. & WEAP[7]	- Qualitative analysis and expert judgment	Not assesses	Not assessed
Nigeria	Drought/aridity	IPCC projection	Qualitative analysis for the millet, sorghum, sugar cane, maize, cowpea , rice, cassava .	Qualitative analysis	Qualitative analysis	Qualitative analysis	QA
Sudan	Drought/aridity	HADCM2, BMRC, and GFDL) and (MAGICC/SCENGEN v. 2.	FAO Impact model Sorghum & Millet	FAOMET model for calc. of PET[8] and FAOINDEX model for calc. of the soil water balance[9].		MIASMA model[10]	GIS and remotely sensed data

Table 1: Methodologies and tools used for climate change assessments in national communications
[2] Decision Support System for Agro-technology Transfer Version, [3] United Kingdom Meteorological Office, [4] Geographical Fluid Dynamics Laboratory, [5] Canadian Climate Change Model, [6] Model for the Assessment of Greenhouse Gas Induced Climate Change, [7] Water Evaluation and Application Model, [8] Potential EvapoTranspiration (PET, a combination of evaporation and transpiration), [9] FAOINDEX is similar to the CLIRUN model (Kaczmarek, 1991) and considered an appropriate tool for this preliminary analysis, [10] Modeling framework for the health Impact Assessment of Man Induced Atmospheric Changes

34. Regional climate models are needed to provide fine-scale climate information for impact studies, particularly in areas characterized by a diverse and heterogeneous land surface. Compared to many parts of the world, scientific understanding of the African climate system as a whole is low, and variations in capacity exist among different African regions (Washington, 2004). A specific example is the Congo basin, for which very little information is known, but which is one of the most important ecosystems affecting the global climate.

35. Some efforts are being undertaken, and Regional Circulation Models (RCMs) with a higher resolution (typically 50 km^2) are currently being developed for smaller areas and for shorter timescales (approximately 20 years). These regional models are capable of providing

more useful information needed by planners and policy makers. The UK Department for Environment, Food and Rural Affairs (DEFRA) funds the development of the Hadley Centre's Regional Climate Model and the UK Department for International Development (DFID) has supported the development of the PC version of the Hadley Centre's model 'PRECIS' designed for use by local meteorological offices or research institutes. To-date, it has been run for the Indian subcontinent and southern Africa. (DFID, 2004).

4.2 Methods and tools for the assessments of impacts and vulnerability

36. In the area of studies of the impacts on specific sectors, in most cases countries applied impact models (such as models such as DSSAT,[6] SPUR2,[7] CLIRUN,[8] and the Holdridge Life Zones Classification,[9] and WATBAL[10]) in most vulnerable sectors such as water resources, agriculture, health, coastal zones and forestry (see table 1 for the overview of methods used in national communications). To a lesser extent, socio-economic analyses were also applied. Still, more capacity and work is needed in region to assess vulnerability and, more importantly, on integrated assessments to include economic and cross-sectional analysis of adaptation options at the national scale.

37. More recent impact and vulnerability studies (e.g. five African studies under AIACC project) employed both more sophisticated impacts models and vulnerability-based assessments, which seek to identify the sources of vulnerability, for example by investigating the ranges of climate variability and the frequencies and magnitudes of extremes with which communities have coped in the past and might be able to cope with in the future, then evaluate the risks from climate change, examine the resources (economic, social, and political) presently or potentially available to a community, and assess its capacity to adapt to change. They evaluate opportunities for, impediments to, and effectiveness and costs of adaptation responses. And they involve stakeholders in the assessment process.

38. Local or rural communities are most vulnerable to climate change, and approaches that emphasize a bottom-up approach, recognizing local coping strategies and indigenous knowledge and technologies, hold the most promise, as these will more easily add to local adaptive capacities.

4.3 Training and capacity-building

39. Africa has a low level of expertise in climate science, particularly in prediction at longer time scales, as most predictions are supplied from international centers external to Africa (see for

[6] Decision Support System for Agrotechnology Transfer (DSSAT) is a software system that integrates crop growth models with crop, weather and soil data and estimates potential changes in crop yields and water use. It is provided to countries within the United States Country Study Program and the Global Environment Facility support programme.

[7] The SPUR2 suite of models simulates the effects of climate change on grassland ecosystems and cattle production. The package includes submodels for plant growth, hydrology/soils, animal production and grasshopper infestation.

[8] CLIRUN is a Microsoft Excel spreadsheet-based integrated water balance model developed for climate change impact assessment of river basin runoff.

[9] This model relates the distribution of major ecosystems ("life zones") to the climate variables of biotemperature, mean precipitation, and the ratio of potential evapotranspiration to precipitation (PET ratio).

[10] Water balance model.

example Brew & Washington, 2004). Also, the continent lags behind other regions in terms of availability of detailed scientific knowledge of its climate. Little resources are allocated to climate at national levels, since climate is seen as a lesser priority compared to other urgent needs.

40. Needs for capacity building and training have been expressed by a number of African countries in their national communications to the UNFCCC and summarised in the compilation and synthesis reports by the Secretariat. The sixth UNFCCC compilation and synthesis report[11] highlighted the critical gaps and institutional and human capacity building needs as identified by African countries. The most commonly mentioned gaps and needs include:

- Lack of knowledge of climate change issues and the need for more longer term training in vulnerability and adaptation assessment, including for developing national communications, and retention of expertise;
- Need for establishing national climate change committees;
- Need for strengthening national institutions to take on work on developing GCMs at appropriate scales;
- Need for improvement of the institutional framework for implementation of adaptation.

41. Moreover, many country reports highlighted specific constraints and data needs to build capacity related to vulnerability and adaptation components of national communications, such as the lack of country-specific socio-economic scenarios, the deficiencies in data collection, quality control, archiving, retrieval, preparation and analysis of data, and the lack of comprehensive studies on possible adaptation measures and cost-benefit analysis of adaptation options.

42. At the institutional level, many countries stressed the critical role that local government units play in the development and implementation of policies and measures to address climate change; so some Parties have established training programmes for local government officials. For example, Ghana assisted its district and metropolitan assemblies to draw up local environmental action plans that contain climate change programmes and projects.

43. Some Parties indicated that they had initiated specific institutional frameworks dedicated to climate change activities. Others have set research activities as part of regional networks, e.g. the Botswana Global Change Research Committee affiliated with the International Geosphere–Biosphere Programme (IGBP). The Central African Republic, Comoros, Gabon, Guinea and Madagascar noted their need to set up an institutional framework for undertaking studies on climate change (FCCC/SBI/2005/18 Add.4).

44. Many of the Parties reported research efforts on variability and impacts, and monitoring and adaptation. Thirteen African Parties indicated that their universities offer post-graduate courses on climate change. In South Africa, for example, five universities undertake climate change research and offer specialized training, such as on implementation of clean development

[11] FCCC/SBI/2005/18 Add.5

mechanism (CDM) projects. South Africa is also funding research on climate change through its National Research Foundation (FCCC/SBI/2005/18 Add.6).

45. The need for training and capacity building in Africa has also been reflected in most of the project concepts of the GCOS-RAP for Western-Central and Eastern-Southern Africa (GCOS, 2002; GCOS, 2003) where the need for training and capacity building are put as priority considerations. Specifically the following areas are mentioned as urgent:

- Application of the PRECIS (Providing Regional Climates for Impacts Studies) model. This is important to all countries in the region in planning for adaptation to climate variability and climate change;
- Ocean modelling and its applications has been identified as a critical requirement in Africa with provision of university fellowships cited as an effective means of addressing this need;
- Database management and the use of national climate data for climate change analyses;
- The provision of advanced training to local staff;
- Satellite applications for monitoring and change detection;
- Estimation techniques to convert the remotely sensed proxy data into measures of weather variables;
- Validation and application of the impact models for use in different countries;
- Methodologies and tools for climate change monitoring, detection and attribution and suitable methods for developing climate change scenarios;
- Methods and tools necessary for vulnerability and adaptation assessment.

46. Due to the limited technical understanding of climate in Africa, and the restricted resource and expertise in handling climate issues, it becomes increasingly essential to raise Africa's capacity to handle climate variability, increase the resilience and reduce the vulnerability of the continent to climate variability and change (DFID 2004).

47. A number of options and initiatives have been identified to address African resource and capacity gaps in the areas of observations, research and model development, prediction activities, and of the delivery of climate services. Examples include: the AIACC programme, an important element of which was to contribute to capacity-building among African scientists in relation to model development and construction of regional scenarios appropriate to the assessment of impacts and vulnerability in Africa (African Climate Report December 2004); the IRI programme which set up contracts for the supply of model software and training (e.g. in Kenya); and WMO and START which have supported training workshops in climate modelling. Another example of supplying data and building capacity through North-South cooperation is the close collaboration of Meteo France with a number of countries in West and North Africa.

5 Key impacts of climate change in Africa

48. The Third Assessment Report (TAR) of the IPCC (IPCC, 2001) highlights major issues related to potential impacts that could occur as a result of climate change in Africa. It also underlined the fact that Africa is characterized by a low adaptive capacity. Major areas of concern addressed in the TAR regarding the possible impacts of climate change relate to water resources and food security/agriculture, including changes in: precipitation and insulation, length of growing seasons, water availability, carbon uptake, incidences of extreme weather events, changes in flood risks, desertification, distribution and prevalence of human diseases and plant pests (IPCC 2001a). The report also revealed that the impact of increased temperature and reduced precipitation in some regions resulting from climate change could lead to overall reduction in agricultural productivity and yields, including rangeland and livestock production, threatening food security and heightening the risk of famine. Based on crop modeling, estimated yield reductions in drylands across Africa may lead to tens of millions of people more at risk of food insecurity by the 2080s (Parry *et al*, 1999).

5.1 Historical and current climatic conditions, changes and extreme events in Africa

5.1.1 Observed changes

49. Based on historical records, a warming of approximately 0.7°C over most of the continent during the 20th century is reported in the IPCC TAR (2001). Observational records show that this warming occurred at the rate of about 0.05°C per decade with a slightly larger warming in the June-November seasons than in December-May (Hume *et al*, 2001). Very high temperature records have also been indexed e.g. the five warmest years in Africa have all occurred since 1988, with 1995 and 1998 being the two warmest years.

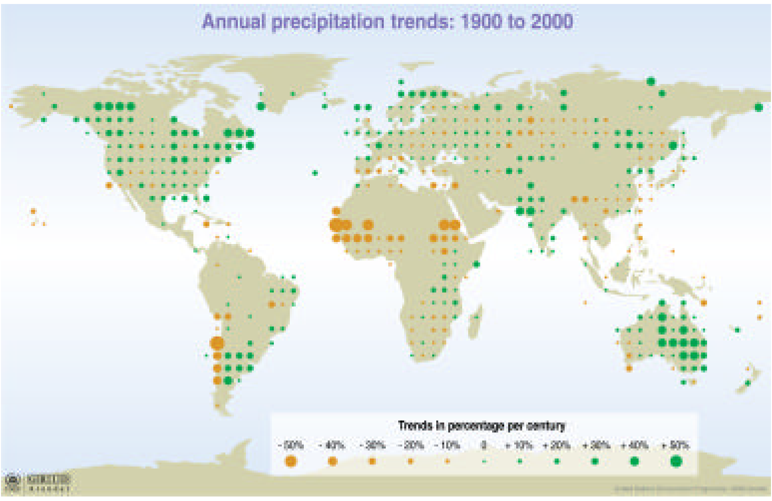

Figure 4: Precipitation changes over land: trends from 1900 to 1994

50. With regard to changes in precipitation, an average of a 25 percent decrease in rainfall has occurred over the African Sahel during the past 30 years. This change has been characterised by a decrease in the number of rainfall events. A decrease in precipitation has occurred over the twentieth century, particularly after the 1960s, in the subtropics and the tropics from Africa to Indonesia (IPCC, 2001). See Figure 4 showing precipitation change over land from 1900-

2000[12]. Hume *et al*, (2001), found a decrease in precipitation by about 2.4±1.3 percent per decade in tropical rainforest regions of Africa since the mid-1970s. This rate was faster in West Africa (-4.2 ± 1.2 percent per decade) and in north Congo (-3.2 ± 2.2 percent per decade).

5.1.2 Floods

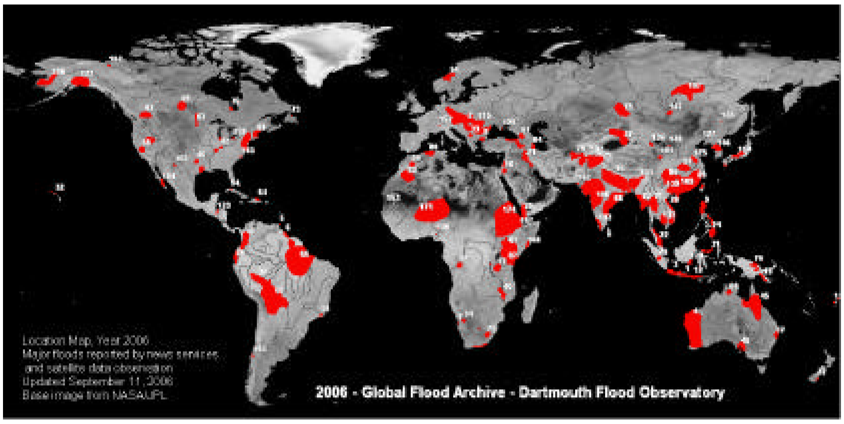

Figure 5: Major flood events worldwide, first 8 months of 2006

51. Floods are recurrent in some countries of Africa; even communities located in dry areas have been affected by floods. The years 2000 and 2001 witnessed a huge flooding event in Mozambique, particularly along the Limpopo, Save and Zambezi valleys. In 2000, floods resulted in half a million people made homeless and 700 losing their lives. The floods had a devastating effects on livelihoods, destroying agricultural crops, disrupting electricity supplies and demolishing basic infrastructure such as roads, homes and bridges (UNEP-Atlas, 2005). It is also not uncommon for some countries to experience both droughts and floods in the same year; the flooding experienced in East Africa followed periods of extended drought. Ethiopia experienced drought early this year (2006), but recently (early August, 2006) it suffered from severe floods leading to the death of more than 200 people with another 250 still missing in the eastern part of the country[13]. Figure 5 presents the major flood events around the world in 2006[14].

5.1.3 Drought

52. Drought is defined in general terms as a 50 percent shortfall in rainfall over three months (UNDP, 2004). The duration of a drought plays the most important role in characterising its hazard level, since it develops slowly and may last over a period of many years. African countries were identified as having the highest vulnerability to drought. The Africa Sahel, situated at the southern fringe of the Sahara desert and stretching from the West African coast to the East African highlands, is particularly prone to drought. Droughts have particularly affected the Sahel, the Horn of Africa and Southern Africa since the end of the 1960s.

53. Estimates suggest that one third of African people live in drought-prone areas and that around 220 million people are annually exposed to drought. Figure 6 shows people affected by natural disasters during the period 1971 to 2001[15].

[12] Precipitation changes: trends over land from 1900 to 2000. (2005). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006
[13] http://allafrica.com/stories/200608110123.html
[14] Retrieved from Dartmouth Flood Observatory website, 13 September 2006
[15] People Affected by Natural Disasters During the Period 1971 to 2001. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006

54. Droughts are often synonymous with famines. The 1980s witnessed very severe famines associated with the famous drought of 1984-85 that hit sub-Saharan Africa, causing many casualties, and loss of life and assets. The region attracted the attention of the international community during the catastrophic drought of the early 1970s when hundreds of thousands of people and millions of animals died due to its impact (de Waal, 1997; Mortimore, 1998).

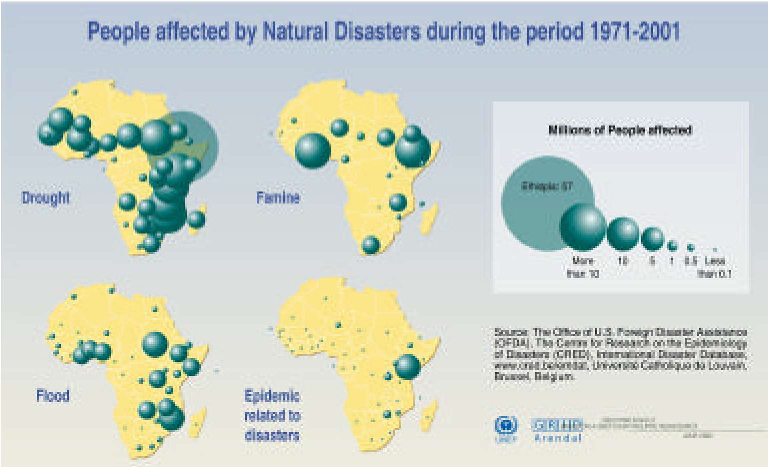

Figure 6: People affected by natural disasters in Africa, from 1971 to 2001

55. These repeated drought cycles, along with many other - mainly socio-economic - factors, have largely contributed to the high vulnerability of the people of the African Sahel. Adger (2002) made the link between recent environmental change (in this case, the increasing frequency of drought over the Sahel) and global economic activity. Also, consecutive dry years with widespread disruption are reducing the ability of the society to cope with droughts by providing less recovery and preparation time between events (Adger, 2002). In South Africa, natural disasters, including droughts, are predicted to occur more frequently under changed climatic conditions (NC, 2000).

5.1.4 Dust and sand storms

56. Atmospheric dust is a major element of the Saharan and Sahelian environments. The Sahara is the world's largest source of airborne mineral dust, and according to some estimates, up to one billion tonnes of dust is exported from the Sahel-Sahara region annually (varying year to year), (Andreae, 1995; Duce, 1995; D'Almeida, 1986). It can be transported large distances, traversing northern Africa and adjacent regions and depositing dust in Europe, Western Asia and the Americas (Moulin *et al.*, 1997).

57. In Sudan, the strong wind is locally called Haboob. The wet-warm strong winds in the Northern Sudan, at the southern fringe of the Sahara Desert, move like a thick wall several hundreds metres high carrying sand and dust (Yuzhao, 2005).

58. The frequency of occurrence of dust storms has increased in some parts of the Sahel from the wet 1950s/1960s to the dry periods of 1970s and 1980s (N'Tchayi *et al*, 1994, 1997). Human impacts like overgrazing, deforestation are contributing factors to the increase in dust storms through the creation of new source of dust; the Sahel is now a more significant source of dust than the Sahara (N'Tchayi *et al*, 1997).

59. Dust storms can have negative impacts on:

- Agriculture: eroding fertile soil, and uprooting of young plants
- Water: burying water canals and increasing evaporation

- Infrastructure: burying houses and other properties
- Health: causing respiratory problems. Meningitis transmission, associated with dust in semi-arid conditions and overcrowded living conditions, may increase with climate change as arid and dusty conditions spread across the Sahelian belt of Africa. (DFID, 2004).

5.1.5 Desertification

60. Desertification has its greatest impact in Africa. Two thirds of the continent is desert or drylands. However, the link between desertification and climate change needs to be better explored. Some recent calculations published in Science Magazine demonstrate a significant contribution of land degradation to atmospheric carbon dioxide levels. Carbon emissions from soil between 1850 and 1998 are estimated at 136 giga tonnes (Gt), equivalent to half the emissions associated with fossil fuel combustion (270 Gt). One-third of the soil related emissions are attributed to land degradation and soil erosion.

61. Africa's desertification is strongly linked to poverty, since poor people have little choice but to overexploit the land. Extensive agriculture in the drylands of Africa and the heavy dependence of rural people on natural resources for subsistence has largely contributed to land degradation and desertification. See Figure 2 for soil degradation in Africa and worldwide.

62. This situation could be further aggravated by the impacts of expected climatic changes e.g. a decrease in precipitation and increasing temperature. Climatic variation is the main cause of droughts in Kenya[16]. Projected climate change by the year 2025, associated with a rise in mean temperature, will exacerbate the losses already experienced due to drought (IPCC, 2001).

5.2 Likely future climatic changes in Africa

63. Africa is a continent characterized by a highly variable climate. Some key limitations to knowledge regarding future African climate have been identified by Hume *et al*, (2000), as the mostly poor representation of the climate variability of El Niño in the global climate models, and the absence in these models of any representation of regional changes in land cover and dust and biomass aerosol loadings.

64. However, climate change models suggest that, in general terms, the climate in Africa will become more variable. Since 1900 mean surface temperature in Africa has increased by only 0.5º, yet by 2100 it could increase by 2–6ºC (Hulme *et al,* 2001).

65. As for changes in precipitation, different views and arguments, which could to a large extent be considered as conflicting, have been cited, e.g. models of future climate change suggest a future warming that may ultimately lead to a more humid regime in the Sahel and parts of the Sahara (Brooks, 2005). This suggestion is based on observations since the late 1990s of an amelioration of the regional climate, and abundant rainfall throughout much of the Sahel and in parts of the Sahara in 2003.

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[16] National Action Plan for combating Desertification in Kenya, 2002

66. Similar results are obtained by Claussen *et al*, (2003), who reported a potential increase of vegetation cover of up to 10 percent of the Saharan land area per decade as a result of increased CO_2 concentrations. Increased CO_2 concentrations trigger increased rainfall which is then sustained through vegetation-atmosphere feedbacks. Maynard *et al.* (2002) also suggested a future wetter regime in the Sahel. Liu *et al*, (2002) examined the impact of a one percent increase in atmospheric CO_2 of per year for 80 years, using models that produce realistic climatological representations of the present-day Sahara, and found that the Sahara shifts northwards in a number of models.

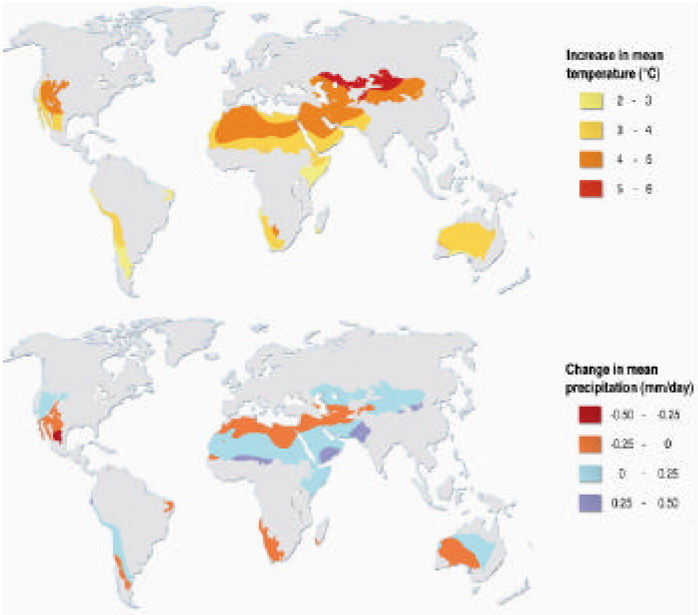

Figure 7: Climate change scenarios for desert areas

67. Some studies have illustrated the large regional differences that exist in rainfall variability, e.g. East Africa has displayed a stable rainfall regime, while a considerable multi-decadal variability and recent drying has been experienced over the Sahel with up to a 20 percent expected decrease of rainfall (Hulme *et al.* 2001).

68. SRES scenarios performed by AOGCMs Scenarios A2 and B2 for desert areas show great variation across Africa for the period 2071 - 2100 relative to the period 1961 – 1990 (IPCC 3rd Synthesis Report. See Figure 7 on climate change scenarios for desert areas (IPCC, 2001). Other regional predictions for changes in temperature and rainfall suggest the following likely effects over the next 50 years (2010-2039) (Hulme *et al*, 2001):

- A decrease in rainfall of 10-25 percent over the northern parts of Africa in the months of JJA and 10-60 percent in MAM. Similarly the model predicted a decrease of 15-62 percent in southern latitudes for the JJA and 8 to 36 percent for SON.

- An increase in rainfall of 10 and 35 percent in the western part of the continent for the DJF period (which is normally dry). A similar trend is predicted for the SON period (between 7 and 28 percent)

69. However some studies have indicated that, these general trends may include hidden variations within the regions and countries, e.g. southern Africa may be drier in general terms, but some countries of the region may become wetter than the average (Hulme *et al*, 2001).

5.2.1 Extreme events

70. Global Circulation models suggest that in a general terms the climate in Africa will become more variable with climate change. The exact nature of the changes in temperature or

precipitation, and extreme events are not known and still debatable, but there is general consensus that extreme events will increase and may get worse.

71. The IPCC (2001a) reports changes in some extreme climate phenomena indicating that extreme events, including floods and droughts, are becoming increasingly frequent and severe. Certain regions of Africa are more prone to extreme events than others. Flooding and droughts are now common across Africa. It is probable that the increased frequency of recorded disasters results from a combination of climatic change and socio-economic and demographic changes.

72. The impacts of possible climate change on the frequency of extreme events in the Sahel is not clear in part because projected future changes in mean seasonal rainfall in tropical Africa remain poorly resolved (Tarhule, 2005). This uncertainty underscores the need to assess the background hazard risk and experience in the region as a basis for evaluating the impacts of future changes.

5.3 Key impacts and vulnerabilities to future climate change

73. UNFCCC, Article 2, sets an ultimate objective of stabilizing greenhouse gas emissions "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system." It states that "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."

74. Significant difficulties exist in defining what impacts are dangerous, in addition to the underlying difficulties with predicting impacts over time as a result of warming. Conclusions from the IPCC TAR suggest that natural, technical, and social sciences can provide essential information and evidence needed for decisions on what constitutes "dangerous anthropogenic interference" with the climate system. At the same time, such decisions are value judgments determined through socio-political processes, taking into account considerations such as development, equity, and sustainability, as well as uncertainties and risk.

75. Information provided by Parties on current and future key vulnerable sectors indicated that an important criterion was the relative importance of the sectors to their economy. The key vulnerable sectors/areas identified by the majority of the African parties included agriculture and food

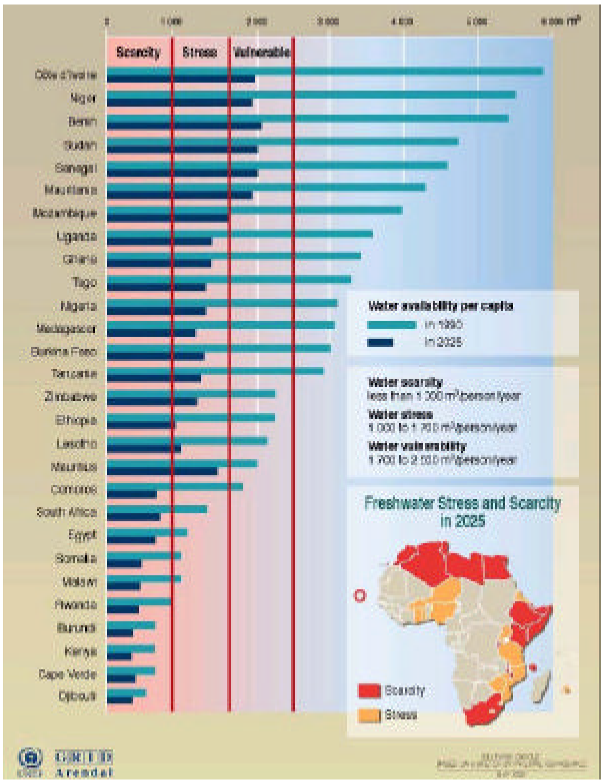

Figure 8: Freshwater stress and scarcity

security, and water resources. (FCCC/SBI/2005/18 Add.5).

76. Africa's vulnerability to climate change is acknowledged in the IPCC TAR, areas of particular concern to Africa being: water resources, agriculture and food security, human health, ecosystems and biodiversity, forestry, coastal zones and attaining the Millennium Development Goals (MDGs). Elaborated assessment of these impacts is given below.

5.3.1 Water resources

77. The impacts of climate change - including changes in temperature, precipitation and sea levels - are expected to have varying consequences for the availability of freshwater around the world. This is of particular concern to Africa, where around 300 million people have no access to potable water or adequate sanitation (UNEP, 1999). Also, much of the population relies on surface water for supplies (De Wit, 2006). Figure 8 shows the situation of fresh water in the different African countries in 2025[17]

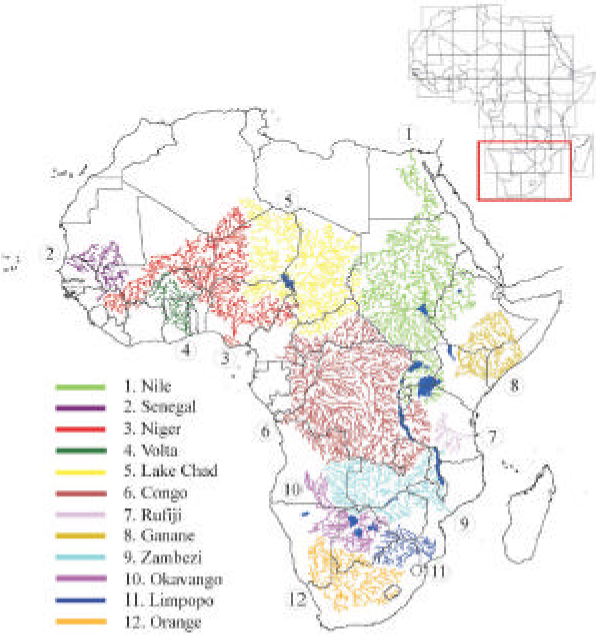

Figure 9: Major basins in Africa

78. Due to the interannual variability of rainfall, many are becoming reliant on groundwater as their primary source of freshwater; groundwater currently represents 15 percent of Africa's water resources and is used by 75 percent of the population, mainly in North Africa (The Africa Water Vision in the 21st Century, 2000). Presently, water availability is decreasing in Africa with disparities between the location of and need for water resources (John Hopkins, 1998). For example, one third of the people in Africa live in drought prone areas mainly in the Sahel, the Horn of Africa and Southern Africa (Brooks, 2004). Reduction in water quantity will lead to a reduction in water quality and associated impacts on health, biodiversity etc.

79. Water demand is also increasing, leading to worries regarding future access to water. By 2025, it is projected that around 480 million of people in Africa will face either water scarcity or stress with a subsequent potential increase of water conflicts (almost all of the 50 river basins in Africa are transboundary) (Ashton, 2002). Figure 9 shows the major basins in Africa (De Wit, 2006).

80. The TAR suggests that climate change is likely to be associated with increased water stress in much of Africa. Moreover, it reports that scenarios for the Sahel region, based on Hulme *et al*. (2001) are ambiguous (IPCC, 2001), reflecting the lack of information on the

[17] Water availability in Africa. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006.

current state of water resources. An assessment by UNEP (2002), suggested that by 2050 rainfall in Africa could decline by 5 percent and become more variable year by year.

81. Within the Nile basin, there is a high confidence that temperature will rise (Conway, 2005) but there are disparities between models on rainfall predictions over both the Blue Nile and White Nile (Hume *et al*, 2001 and 2003). However, temperature rise will lead to greater loss through evaporation placing additional stress on water resources regardless of changes in rainfall (Hume *et al*, 2000). Nine recent climate scenarios showed decreases in Nile flows from zero to approximately 40 percent by 2025 (Strzepek *et al*, 2001).

82. The icecap on Mount Kilimanjaro has been disappearing due to climate change with serious implications for the rivers that depend on ice melt for their flow. Figure 10 indicates a reduction in the ice cap of around 82 percent since it was first surveyed in 1912[18]. Several rivers are already drying out in the summer region due to a depletion in melt water, and recent projections suggest that if the recession continues at its present rate the ice cap may have disappeared completely within 15 years. Other glacial water reservoirs such as Ruwenzori in Uganda and Mount Kenya are facing similar threats (Desanker, 2002).

5.3.2 Health

83. The health effects of a rapidly changing climate are likely to be overwhelmingly negative (IPCC). Desanker *et al.*, (2001) stressed that the vulnerability of Africa to health impacts is a function of climatic as well many other non-climatic factors such as: poverty, conflicts and population displacement, access and availability and management of health services, in addition to other factors related to drug sensitivity of the pathogens, awareness and attitude towards preventive measures.

84. Urban growth unaccompanied by strong public health infrastructure makes African countries even more vulnerable (WHO, 2005). Figure 11 shows the percent of population with access to healthcare in Sub-Saharan Africa.

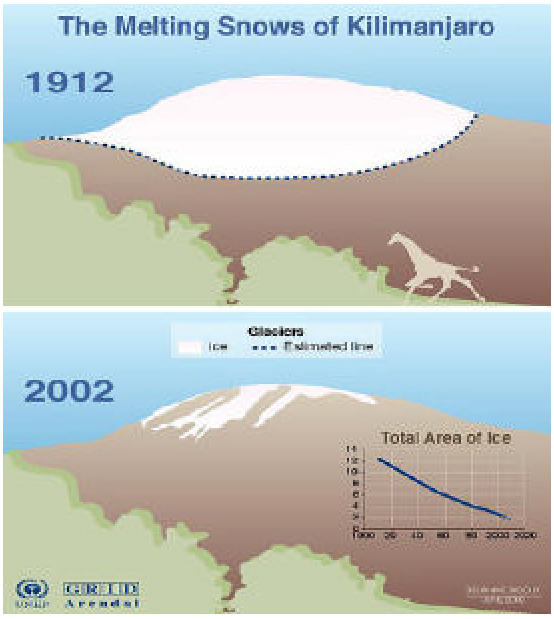

Figure 10: Melting snows of Kilimanjaro

85. Africa is already vulnerable to a number of climate-sensitive diseases (Guernier *et al.*, 2004), some of the most important of which are highlighted below:

- Rift valley fever, which afflicts people and livestock, is closely related to heavy rainfall events, which are predicted to increase with climate change. An outbreak in 1997 associated with an El Niño event killed up to 80 percent of livestock in Somalia and northern Kenya.

[18] Melting snow on Kilimanjaro. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved 15:54, September 12, 2006

- Cholera, associated with both floods and droughts, may increase with climate change. Increased temperatures could increase the levels of cholera bacteria in tropical seas and lakes. Changes in rainfall will affect the transmission potential, and the presence and absence of vector- and water-borne pathogens (IPCC 2001).

- Increased flooding could facilitate the breeding of malaria carriers in formerly arid areas (Warsame et al. 1995). Small geographical changes in the distribution of malaria may expose large numbers of people to infection e.g. densely populated east African highlands (Cox et al., 2002; Lindsay and Martens, 1998).

- The population of disease-carrying mosquitoes is expected to increase as a result of changes in temperature and precipitation, leading to increased malaria epidemics (Lindsay and Martens, 1998). Figure 12 shows malaria epidemics from 1870-2000.

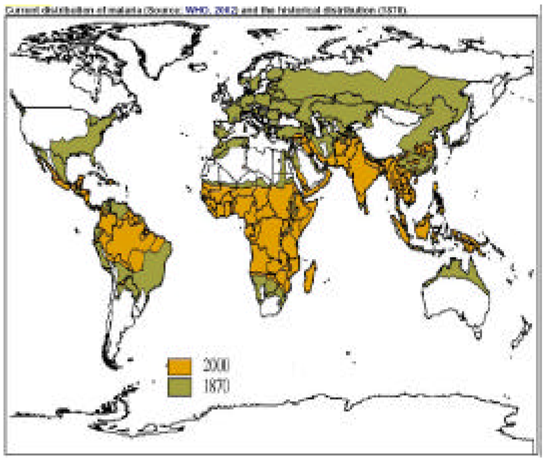

Figure 12: Current and historical distribution of malaria

Heat stress and drought are likely to have a negative impact on animal health, production of dairy products, meat and reproduction (St-Pierre *et al.*, 2003). This in turn could impact food security leading to protein deficiency and malnutrition.

Table 2: Vector-borne diseases that are considered to be sensitive to climate change [19]

Diseases	**Vector**
Malaria, filariasis, dengue fever, yellow fever, West Nile Fever	Mosquitoes
Leishmaniasis	Sand flies
Chagas' disease	Triatomines
Lyme disease, tick-borne encephalitis	Ixodes Ticks
African trypanosomiasis	Tsetse flies
Onchocerciasis	Black flies

[19] WHO, 2003, "Methods of assessing human health vulnerability and public health adaptation to climate change", Geneva: WHO

Box 1: Focus on Malaria in Africa

Malaria and climate change in Africa

Malaria is one of the world's most serious and complex public health problems and it has now been identified as the disease most likely to be affected by climate change (WHO/WMO/UNEP, 1996). Statistics reveal that about 90 percent of the annual global rate of deaths from malaria occurs in Africa south of the Sahara. Moreover, malaria causes at least 300 million cases of acute illness each year costing Africa more than US$12 million annually and slows economic growth in African countries by 1.3 percent a year. Environmental conditions are already so favourable for malaria transmission in tropical African countries that climate change is unlikely to affect overall mortality and morbidity rates in hyperendemic lowland regions. The vulnerable areas are those where transmission is currently limited mainly by temperature in highland areas, such as in East Africa (Lindsay and Martens, 1996).

However, according to (WHO, 2000) epidemics are rarely triggered by a single factor such as temperature change and other factors that affect the distribution and seasonal transmission of malaria must be always considered. Results from the MIASMA Model (Modelling framework for the health Impact Assessment of Man Induced Atmospheric Changes), combined with HadCM3 outputs for different SRES scenarios, demonstrated that by the 2080s climate change put an additional population of between 21 million (on the basis of (B1) scenario) and 67 million (based on (B2) scenario) at risk. Van Lieshout *et al.* (2004) reported that malaria has already increased in the highlands of Rwanda and Tanzania associated with recent changes in temperature. Longer term modelling suggests malaria transmission risk will double by 2080 (Martens, 1999).

However, Christopher (2004), argued that increases in transmission will vary by region, e.g., modest changes to stable malaria by the 2050s are shown in previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi, with conditions becoming highly suitable for transmission by the 2080s. Similarly, areas currently with low values for stable transmission in central Somalia and the Angolan highlands will became highly suitable by the same period. On the other hand, the highland areas in Tanzania were projected to show very little change in transmission, even by 2080. Climate change will cause both increases and decreases in the areas suitable for transmission (Van, 2004).

5.3.3 Agriculture and food security

86. Land resources contribute up to 50 percent of household food requirements and up to 40 percent of household incomes (AMCEN/UNEP, 2002), with 70 percent of the continent's population depending on agriculture for their livelihood. Moreover, agriculture is the most important sector in the economy of most African countries, representing approximately 30 percent of Africa's GDP and contributing about 50 percent of the total export value. Agriculture is mostly subsistence in nature with a high dependence on rainfall (over 95 percent) for irrigation. As a result, agriculture in Africa is highly vulnerable to changes in climate variability, seasonal shifts, and precipitation patterns (WRI 1996).

87. Model results (Hadley Centre, CSIRO, Canadian Climate Centre, and NCAR) indicate that only 80,000 km^2 of agricultural land in Sub-Saharan Africa with currently severe environmental constraints (out of more than 15.1 million km^2) are expected to improve with climate change, whereas more than 600,000 km^2 currently classified as moderately constrained would migrate to the class of severe environmental limitations (Fischer *et al*, 2002).

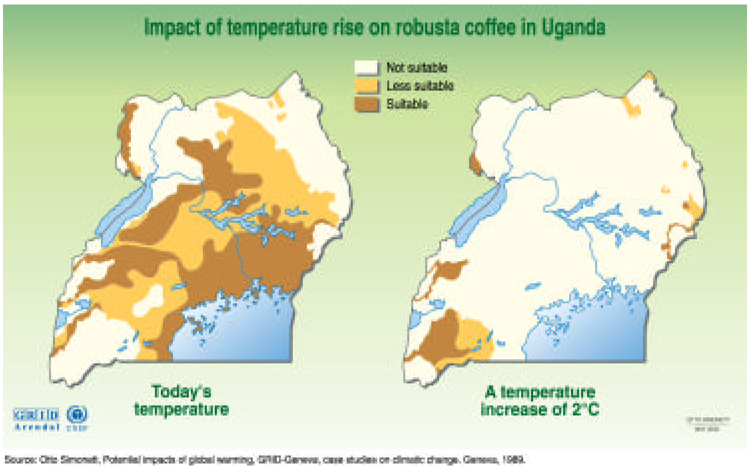

Figure 13: Impact of temperature rise on Robusta coffee in Uganda

88. African countries whose economies rely heavily on one or two agricultural cash crops are vulnerable to climate change. A study in Uganda concluded that an increase in temperature of an average of 2ºC would drastically reduce the area suitable for growing Robusta coffee in Uganda, where it is a major export crop and limit growth to the highlands only (DFID, 2004). Figure 13 shows the impact of temperature rise on Robusta Coffee [20].

89. Arnell et al, (2002), pointed out that, even with a stabilisation of CO2, cereal crop yields in Africa will still decrease by 2.5 to 5 percent by the 2080s. This was illustrated at the national level using models such as DSSAT[21] to assess the impacts of climate change on crop yields. Most of these assessments used the IPCC IS92 emissions scenarios and predicted decreased yields. The results indicated a general decline in most of the subsistent crops, e.g., sorghum in Sudan, Ethiopia Eritrea and Zambia; maize in Ghana; Millet in Sudan; and groundnuts in Gambia (see Table 1 on summaries from selected national communications) and Figure 14, showing the grain production in Africa compared to the other continents for the period 1950-1995[22]

90. With regard to fisheries, carbon isotope records in sediment cores suggests a decrease of up to 20 percent in the primary productivity of Lake Tanganyika in East Africa, implying a roughly 30 percent decrease in fish yields (O'Reilly *et al*, 2003). Predicted future climate change may further reduce the Lake's productivity. Climate change may also adversely affect the rangelands which represent up to 83 percent of the agro-ecosystem area in sub-Saharan Africa.

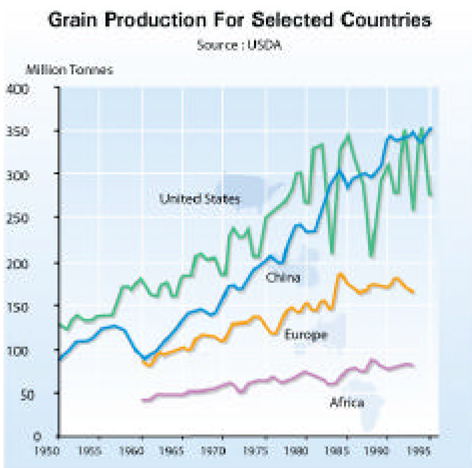

Figure 14: Grain production for selected countries and regions.

91. General impacts of climate change on agriculture include (FAO, 1999):

- Reduction in soil fertility
- Decreased livestock productivity directly (through higher temperatures) and indirectly (through

[20] Impact of Temperature Rise on Robusta Coffee in Uganda. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006
[21] US Country Studies Program, 1999; Dixon *et al.*, 2003
[22] Evolution of the world grain production, comparison World, Europe, China, Africa. (1996). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006

changes in the availability of feed and fodder)

- Increased incidence of pest attacks, resulting from increase in temperature
- The manifestation of vector and vector born diseases
- Negative impacts on human health affecting human resource availability

Figure 15: Food production index for Africa versus the rest of the world

92. Regional differences may occur regarding the distribution of this climate change impacts across the continent. According to FAO (1999) climate change in the already arid northern sub-region of the continent is expected to enhance desertification and bring a gradual decrease in forest cover.

93. The impact of these changes on agriculture is exacerbated by the lack of adaptation strategies, which are increasingly limited due to the lack of institutional, economic and financial capacity to support such actions (FAO, 1999).

94. Increasingly variable growing season conditions (shifts in start of rainy seasons, length and quality of rains, etc) are disrupting subsistence agricultural production leading to famine and severe loss of livelihoods in many semi-arid regions of Africa. Improved seasonal forecasts and application of these results at the community level is a high priority in ensure communities transition smoothly to the changing climate.

5.3.3.1 Food security

95. The food security threat posed by climate change is great 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). According to a 1996 FAO study, Africa's food supply would need to quadruple by 2050 to meet people's basic caloric needs, even under the lowest and most optimistic population projections. Figure 15 shows the food production index in Africa compared to the world's for the period 1961-2001[23].

96. One study revealed that of the total additional people at risk of hunger due to climate change, Africa will account for the majority by the 2080s (Parry et al., 1999, Fischer *et al*, 2002).

[23] Food Production Index. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved 16:46, September 12, 2006

5.3.4 *Biodiversity*

5.3.4.1 *Ecosystems*

97. Africa is endowed with a highly diverse fauna and flora. Africa contains about a fifth of all known species of plants, mammals and birds in the world, and a sixth of the amphibians and reptiles. Africa is home to five internationally recognized areas of particularly high species richness and endemism, referred to as “biological hot spots”. These include the Western Indian Ocean islands, the Cape floristic region, the Succulent Karoo - the most species-rich desert in the world, the upper Guinea forest and the Eastern Arc Mountain forests of East Africa (GEO3, 2005). The continent has a large and diverse heritage of flora and fauna. Savannahs, which are the richest grasslands in the world, are the most extensive ecosystem in Africa.

98. The rich African mammal biodiversity is located in the savannas and tropical forests. Biodiversity in Africa is already under threat from a number of natural as well as human induced pressures; climate change will be an additional stressor (Desanker, 2002). For example, the Great Ape habitat in Central Africa (UNEP, 2003). Figure 16 shows the loss of the Great Ape habitat 2002-2032 in Africa[24].

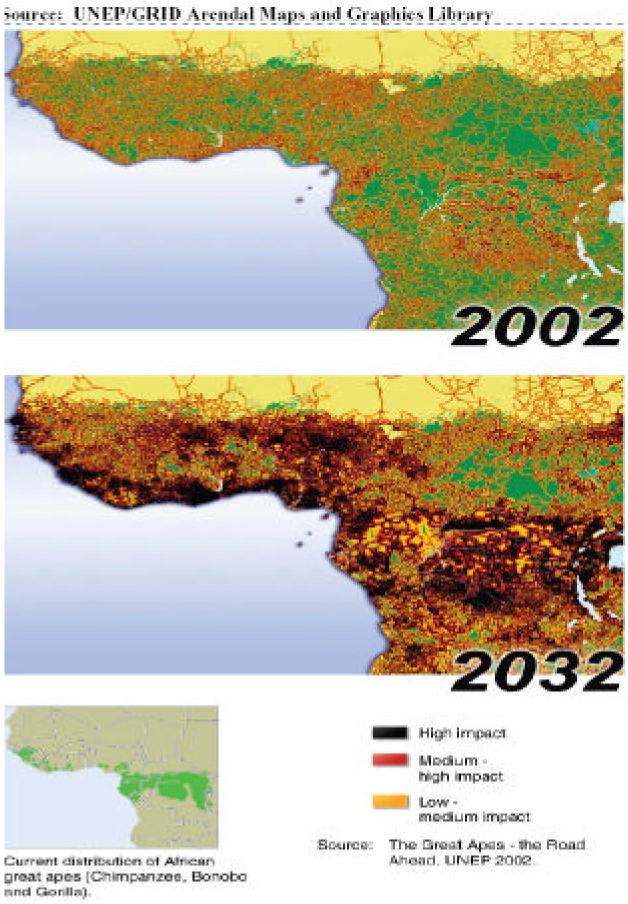

Figure 16: Loss of the Great Ape habitat in Africa due to human activity

99. Other threats include: land-use conversion due to agricultural expansion and subsequent destruction of habitat; pollution; poaching; civil war; high rates of land use change; population growth and the introduction of exotic species. Increasing frequency of droughts and floods associated with climate variability and change could have a negative impact on the ecosystems of some areas in Africa e.g. lakes and reservoirs in the African Sahel could loose part of their storage capacity leading to a complete drying (UNEP, 2004). Changing rainfall patterns could lead to soil erosion, the siltation of rivers and the deterioration of watersheds. Wetlands of international importance and wildlife are also under threat from drought in Southern Africa.

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[24] Loss of Great Ape habitat 2002-2032 (Africa). (2003). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006.

100. Central Africa had lost about half of its wildlife habitats by 1986; during 1980-1995, the number of extinct plants in Southern Africa increased from 39 to 58 and more than 700 vertebrate species and around 1000 species of trees are threatened with extinction (GEO, 2005). Figure 17 shows forest species loss in the African Sahel during the period 1960 – 2000.

101. Climate change will trigger species migration and lead to habitat reduction. One study examining over 5,000 African plant species predicts that 81–97 percent of the plant species' suitable habitats will decrease in size or shift due to climate change. Moreover, the study noted that by 2085 between 25 percent and 42 percent of the species' habitats are expected to be lost altogether (McClean, 2005).

102. Major implications on biodiversity as summarized by the (IPCC, 2002) are:

- Shift in rainfall patterns could affect the *fynbos* and *karoo* -which occur in the winter rainfall regions at the southern end of Africa,- through altering the current fire regime critical for their regeneration

- Increase in temperature could impact the montane biodiversity of east Africa those with limited ability to move up in elevations

- Wetlands ecosystem, could be impacted by a decrease in runoff e.g. *Okavanga Delta* and *Sudd* area.

- Some wildlife species could be affected by the expansion of the range of some vectors and infectious diseases

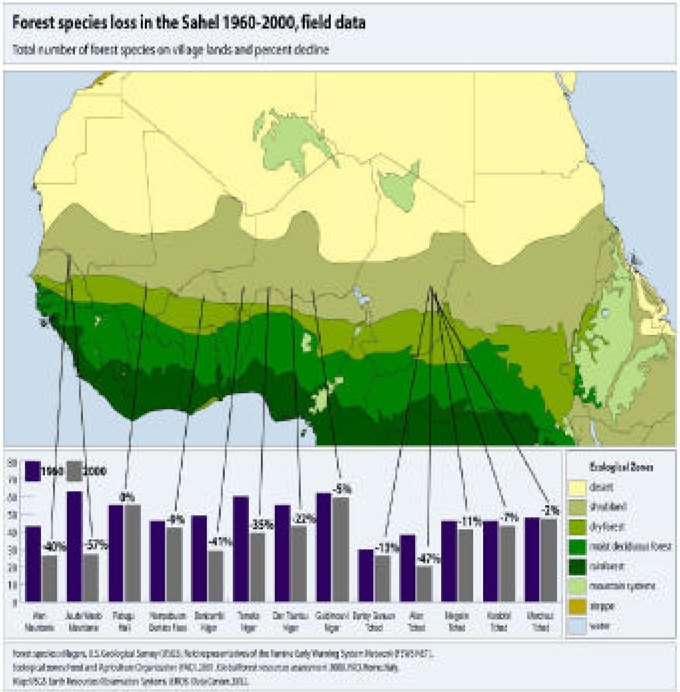

Figure 17: Forest species loss in the Sahel, 1960-2000

- Extinction of some important animal or plant species could impact the local people in Africa, those who depend on them in their livelihoods e.g. food medicinal uses etc.).

5.3.4.2 Forests and woodlands

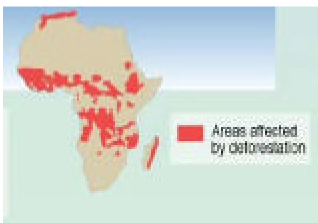

Figure 18: Areas affected by deforestation in Africa

103. Forest and woodlands occupy an estimated 650 million hectare or 21.8 percent of the land area in Africa and the region accounts for 16.8 percent of the global forest cover (FAO 2002). Of the total area of forests and woodlands, only 5 percent is protected area.

104. Forests are currently under pressure from demand for firewood and charcoal as energy sources, and from the export of forest products such as timber, nuts, fruit, gum. This has led to

deforestation and degradation of African forests. See Figure 18 showing the degraded areas that have been affected by deforestation.

105. Deforestation has been documented by field inventories of forest species which show a 25–30 km shift of the Sahel, Sudan, and Guinean vegetation zones in the past half century (Gonzalez 2001). Forest exports are expected to be impacted by climate change which is important as forest products generate 6 percent of the economic product of African countries (FAO, 1999).

106. Ecosystems services that rely on sub-Saharan African plant diversity, including indigenous foods, as well as both locally-used and potential exotic plant-based medicines, are likely to be adversely impacted (WRI, 2005).

5.3.5 Coastal zone and marine areas

107. Coastal ecosystems are among the most productive yet highly threatened systems in the world; they produce disproportionately more services related to human well being than most other systems (Agardy and Alder, 2005). Many factors can interact to increase the vulnerability of coastal zones. Some examples include: unsustainable rates of resource extraction; high population concentrations on the coast; inland activities such as the damming of rivers; increased use of fertilizers and clearing of natural vegetation leading to the degradation of coastal and marine habitats; and accidental oil spills (e.g. in the Western Indian Ocean sea routes).

108. Sea levels around Africa are projected to rise by 15-95 cm by the year 2100 (IPCC, 2001). Impacts of sea level rise include: reduced productivity of coastal fisheries; coral bleaching; mass migration of population from the coast and associated health issues; salt water intrusion; loss of recreational beach facilities and negative impacts on tourism; loss of coastal infrastructure such as ports. More than 25 percent of Africa's population lives within 100km of the coast, and projections suggest that the number of people at risk from coastal flooding will increase from increase from 1 million in 1990 to 70 million in 2080 (DFID,

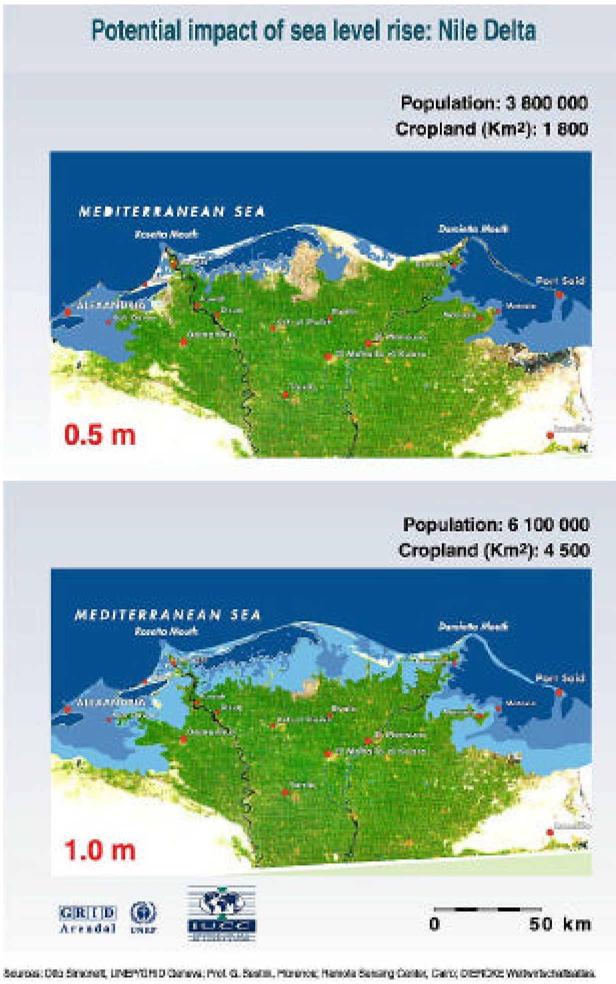

Figure 19: Potential impact of sea level rise on the Nile Delta

2003).

109. National communications indicate that the coastal infrastructure in 30 percent of Africa's coastal countries is at risk of partial or complete inundation due to accelerated sea level rise (Niang-Diop, 2005). For example, coastal settlements in the Gulf of Guinea, Senegal, Gambia, Egypt, and along the East-Southern African coast. In Tanzania, a sea level rise of 50 cm would inundate over 2,000 km^2 of land, costing around USD 51 million (UNEP, 2002). Sea level rise resulting from global climate change threatens different coastal and marine ecosystems e.g. lagoons and mangrove forests of both eastern and western Africa, and will impact urban centres and ports, such as Cape Town, Maputo, and Dar Es-Salaam.

110. In North Africa, a study was conducted to estimate the potential impacts of sea level rise on the Nile Delta. It was found that a one meter rise in sea level would destroy weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed and other valuable agricultural lands. In addition, intrusion of saltwater will affect freshwater quality and so the health of freshwater fish. See Figure 19 which shows the impacts of Sea level rise on the Nile Delta[25].

111. Coral reefs in the Indian Ocean experienced massive bleaching in 1998, with over 50 percent mortality in some regions (Spalding, 2001). Damage to coral reef systems has far-reaching implications for fisheries, food security and tourism. See Figure 20 which shows the bleaching of coral reefs on the Eastern Coast and Islands of Africa[26]. Coral bleaching leads to increased erosion as the ability of the reef to dissipate wave energy is reduced (Sheppard *et al.*, 2005).

Source: WRI, ICLARM and UNEP, 1998

Figure 20: Bleaching of coral reefs off the Eastern coast of Africa

5.3.6 Millennium Development Goals

112. Climate change has the potential to undermine economic development, increasing poverty and delaying or preventing the realization of the Millennium Development Goals (MDGs) (Pachauri, 2004). Particularly, the lack of effective adaptation to the adverse effects of climate change can jeopardize the achievement of MDG goal 1 (eradicating extreme poverty and hunger), goal 6 (combating HIV/AIDS, malaria and other diseases) and goal 7 (ensuring environmental sustainability). This indicates that a direct link can be seen between climate change and development, where the impacts of climate change could largely impede

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[25] Potential impact of sea level rise: Nile Delta. (2000). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 12, 2006

[26] Threats to coral reefs in Eastern Africa. (2002). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved September 13, 2006

development efforts in key sectors while at the same time development strategies and plans could have an impact on coping capacity to climate change.

113. Considering that the adverse effects of climate change pose an additional burden to development goals, the mainstreaming of adaptation into sustainable development adaptation and taking into account additional climate change risks have started to be considered for support through additional funding. For example, OECD Member Countries declared (the Declaration on Integrating Climate Change Adaptation into Development Cooperation) that they will work to better integrate climate change adaptation in development planning and assistance, both within their own governments and in activities undertaken with partner countries. In 2003, the European Commission produced a communication entitled "Climate Change in the context of development co-operation", in which it proposed an EU action plan aimed at integrating climate change concerns into EU development co-operation activities. Similarly, the World Bank's progress report on its investment framework for clean energy and development asserts that "it is essential that the Bank Group, along with other International Financial Institutions, play a leading role in ensuring that maximum impact is obtained from these funds (UNFCCC funds) by mainstreaming appropriate investment and appropriate risk in the global development portfolio".

114. Also, competition for scarce resources, such as freshwater, land or fish resources brought about by changes in climate can lead to conflict which will impact on the successful achievement of the MDGs. TAR (2001) highlights conflicts over water resources, especially in international shared basins, as an important aspect of Africa's vulnerability to climate change. Increased pressure on resources deepened tensions between nomads and agriculturalists in Niger during the 2005 crisis (OXFAM, 2006), and it was argued that increased competition over land was one of the triggers of the conflict in Darfur.

115. Nomadic societies, who have historically been supported by the Kalahari, and the Karoo in Southern Africa, can no longer follow their traditional migration paths due to variations in annual and seasonal rainfall. Areas where wetter weather and permanent water is found are already densely populated leading to loss of human life and livestock (GEO3, 2005). Competition over water resources and the displacement of populations as a result of dam building have led to conflict within nations (Shiva, 2002), usually where other political, religious or ethnic tensions already exist.

6 Adaptation to Climate Change

116. Vulnerability is defined by the IPCC as "the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. In this respect vulnerability is seen as the function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity" (IPCC, 2001).

117. The African continent contains the poorest and least developed nations of the world with low per capita GDP and life expectancy and high infant mortality. Literacy is in the bottom quartile globally; there is a high dependence on the natural resource base; weak governance structures; and a low capacity within African governments to respond proactively to changes. Armed conflict and terms of trade and aid dependence further complicate matters. Africa has a predominantly tropical, hot and dry climate and most of the population resides in the sub-humid and semi-arid zones (ILRI, 2006).

118. However, as a consequence of the resulting high climatic variability, Africa's inhabitants have developed highly effective strategies to cope with drought since the region became semi-arid some four or five thousands of years ago (Andah, 1993; Casey, 1998). Much has been invested in Africa in terms of capacity building, but more is needed to enhance the adaptive capacity of institutions, organizations and individuals (Denton *et al.*, 2001).

119. The high vulnerability of Africa is attributed to a large extent to its low adaptive capacity, not just the prevailing climate. A number of factors can explain this very low adaptive capacity: a deteriorating ecological base, widespread poverty, inequitable land distribution, a high dependence on the natural resource base and the ravages of HIV/AIDS (Hulme, 1996; IPCC, 1998; Magadza, 2003; Ikeme, 2003). Improving adaptive capacity is important in order to reduce vulnerability to climate change.

6.1 Current experiences and lessons on adaptation

120. In spite of the low adaptive capacity of Africa, people have developed traditional adaptation strategies to face the great climate interannual variability and extreme events. Those communities who have faced harsh environmental conditions over prolonged periods, have consequently been trying, testing and adopting different types of coping strategies.

121. An unusually persistent drought may increase people's vulnerability in the short term, but it may encourage adaptation in the medium to long term (Mortimore, 2001). This reinforces the observation that local people have perceived, interacted with, and made use of their environment with its meagre natural resources and changing climatic conditions in what could be seen as practical coping mechanisms. This is particularly true for the drought prone area in the Africa Sahel region, which is susceptible to frequent climatic hazards.

122. It is more important that local communities have early warning systems than relief or development agencies because at the onset of adverse environmental changes the critical decisions are made at the household level (Rahmato, 1988). Stocking (2003), emphasized the role of skills and social networks of small-holder farmers in the tropics who have compensated

for their low human and financ ial capital, and helped them to maintain their sustainable and productive practices. Strategies against drought were adopted by nomadic pastoralists living in the desert margins of Kenya (Langill and Ndathi, 1998). Specific actions include the utilization of wild fruits and vegetables in animal feed and long distance movements to areas less affected by drought (Pandey *et al.*, 2003).

123. Rural farmers have been practicing coping strategies and tactics, especially in places where droughts recur, and have developed their own ways of assessing the prospects for favourable household or village seasonal food production (Downing et al., 1989). In Senegal and Burkina Faso, locals have improved their adaptive capacity by using traditional pruning and fertilizing techniq ues to double tree densities in semi-arid areas. These help in holding soils together and reversing desertification. Similar community-initiated projects in Madagascar and Zimbabwe have been acclaimed successes (ECA, 2001).

124. Other strategies include:

- Diversification of herds and incomes (Bollig, 2003), e.g. the introduction of sheep in place of goats in the Bara province in Western Sudan (Osman B *et al*, 2005)
- Reliance on forest products as a buffer to climate-induced crop failure in climatically marginal agricultural areas (Dube et al. 2005);
- Decentralization of local governance of resources i.e. the Community Based Natural Resource Management (CBNRM) approach to promote use of ecosystems goods and services as apposed to reliance on agriculture (in climatically marginal areas for agriculture); and
- Manipulation of land use leading to land use conversion (e.g. shift form livestock farming to game farming in Southern Africa).

125. However, the fact that the reported number of people killed and affected by climate-related disasters in Africa between 1993-2002 is 136,590,000 and 250,000 people alone during the Soudano-Sahelian drought of 1968-73 (together with 12 million cattle that died from starvation) means that somehow traditional adaptation measures were not sufficient to face climate change (Tarhule and Lamb, 2003; BAfD *et al.*, 2005; Willems, 2005).

126. The UNFCCC secretariat has developed an online database of local coping strategies (<http://maindb.unfccc.int/public/adaptation>), promoting a South-South transfer of knowledge and sharing of experience on adaptation action directly undertaken by those who are vulnerable, without reliance on external intervention.

6.2 Planned future adaptation

127. According to the IPCC Third Assessment Report, climate change is already happening, and will strengthen even if global greenhouse gas emissions are curtailed significantly in the short to medium term (Adger, 2004). This fact, combined with Africa's vulnerability to climate change means that planned adaptation is becoming a must. Most adaptation measures such as better management of agriculture and water resources through the development of a more reliable system of seasonal predictions, or diversifying livelihood sources through engaging in different economic activities (e.g. utilizing forest products as a buffer to climate induced crop

failure from farming in climatically marginal areas (Dube et al. 2005)) are also necessity for the present circumstances. The majority of national communication reports (e.g. Sudan, South Africa, Ghana) mentioned the development of more and better heat- and drought-resistant crops as future adaptation options for agriculture and food security, this is in addition to improving the production efficiencies in arid lands and marginal areas.

128. In terms of adaptation of forestry, examples include the decentralisation of local governance of resources i.e. the Community Based Natural Resource Management (CBNRM) approach to promote the use of ecosystems goods and services as apposed to a reliance on agriculture (in climatically marginal areas for agriculture) (Dube *et al*, 2005) and the manipulation of land use in Botswana. Moreover, some National Communication Reports e.g. Ethiopia, mentioned the establishment of seed banks that maintain a variety of seed types to preserve biological diversity and provide farmers with an opportunity to diversify their products and tree cover. Soil conservation and well-managed tree plantations, are also emphasized (Mortimore, 2001).

129. Home gardens and sheep fattening have contributed greatly to improving the adaptive capacity of small rural farmers in Kordofan and Drafur states of Western Sudan (Osman *et al*, 2006). In many locations food crops have replaced cash crops, and more resilient crop varieties have been introduced (DFID, 2000). Tribal and individual movements and migration are identified as adaptation options, e.g. in Western Africa since they provide for employment and income diversification away from their farms and reduce their vulnerability to drought (Rain, 1999; DFID, 2000).

130. Regarding Coastal zones, proposed adaptation measures include fisheries management e.g. in Seychelles the closed seasons control agreements with foreign fleets and establishment of marine reserves. In West Africa, measures include the development of a Sustainable Fisheries Livelihoods Programme. Dykes and protective measurements are proposed for the Nile Delta in Egypt, as they would probably prevent the worst flooding up to a 50 cm sea level rise. However, it is expected that they may cause serious groundwater salination and aggravate the impact of increasing wave action (UNEP, 2004)

131. The establishment of national and regional oil spill contingency plans have also cited as options in several African regions (ILRI, 2006).

Box 2 Adaptation measures identified under AIACC project

- **Adaptation measures to water stresses** during droughts and high rainfall variability include: irrigation water transfer, water harvesting and storage: (in Gambia and South Africa (Nkomo *et al*, 2005) and in Sudan (Osman *et al* (2005); **Measures specifically for agriculture** include: planting of drought resistant varieties of crops, labour migration, changes in farm location, reduction in herd and farm sizes, improved water exploitation methods (e.g. shallow wells), and food storage. Others include crop and animal diversification, income diversification, selling of assets, early maturing crops, high yield varieties, herd supplementation and sedentarization, and culling animals (practiced in Nigeria and Mali (Dabi *et al*,2005) and in Sudan (Osman *et al*, 2005)).

- **Adaptation measures for heat waves** include: heat resistant cultivars; crop management (shorter season or early maturing crops, shifting time or location, change type of crop, shading both crops and animals, increase irrigation); and early warning and forecast systems (Adejuwon *et al*, 2005).

- **Sea level rise**: Integrated Coastal Zone Management (ICZM) ensures a holistic approach in coastal zone management and has been implemented in Seychelles. Measures include: sea walls and armors; pillar housing and raised foundation level (De Comarmond *et al*, 2005).

6.3 Adaptation requirements

132. Since climate is changing and climate variability is expected to increase in frequency and intensity (IPCC, 2001), it will be expected that current coping strategies may not be considered as sufficient adaptation strategies in the future. Far more work is needed if adaptation itself has to be seen as an essentially dynamic, continuous and non-linear process, (ILRI, 2006).

133. Better forecasting and early warning systems have been identified as a prerequisite for adaptation, particularly to predict and prevent the effects of floods, droughts and tropical cyclones as well as for indicating the planting dates to coincide with the beginning of the rainy season (Tarhule and Woo, 2002) and predicting whether there will be disease outbreaks in areas that are prone to epidemics (Kovats et al., 2000). Githeko and Ndegwa (2001), showed that malaria epidemics in the western Kenya Highlands could be forecasted two to three months before they occur, using the information of Climate Outlook Forums (COF) to identify climate risks associated with malaria (anomalously positive temperature and rainfall) and employ them as alerts for malaria outbreaks. ENSO onsets can also be predicated and used in modelling the outbreak of diseases associated with the phenomenon (Hales et al., 2003).

134. Education and awareness creation on climate change among governments, institutions and individuals should be viewed as a necessary step in promoting adaptation to climate change in SSA, one of the poorest regions that is also likely to experience some of the most serious impacts of climate change (ILRI, 2006).

135. Huq and Reid, (2005) highlighted the importance of linking research to policy-making, with an emphasis on getting research messages to appropriate target groups; linking research to existing local knowledge of climate related hazards and involving local communities in adaptation decision making. Washington et al. (2004) discuss the need for effective communication between the supply-side and demand-side communities of climate information in Africa, and the need to work on means by which climate information can be incorporated into the livelihood strategies of potential users. Sewell and Smith (2004) emphasized the need for building credibility of rainfall forecasts and improving their dissemination and use, especially by people in the drought prone areas of Africa Sahel.

6.4 Adaptation and sustainable development

136. IPCC (2001) proposed “activities required for enhancement of adaptive capacity”, revealing these activities as essentially equivalent to those promoting sustainable development. The activities include *inter alia:* improved access to resources; reduction of poverty; lowering of inequities in resources and wealth among groups; improved education and information; improved infrastructure; and improved institutional capacity and efficiency (ILRI, 2006). About 65 percent of the least developed countries (LDCs) are in Africa. LDCs are characterized by very weak institutional capacity and are particular vulnerable to natural disasters, under-nourishment, and lack of sanitation and safe water supply (Esty *et al*, 2005).

137. Most the African countries are considered under the low human development category, characterized by being highly vulnerable and lacking basic elements for development. In addition to this, Africa suffers a lot of poverty-related problems that could directly impact the human capital (the major pillar in development), including through malnutrition and the increased incidence of epidemic and other diseases. Sub-Saharan Africa is home to 26 million people living with HIV, more than 60 percent of all the people in the world with the virus. In 2005, HIV/AIDS killed about 2.4 million people in Africa, mainly prime-age adults, crippling the workforce, destroying communities and families, and leaving around 12 million orphans. This is in addition to other debilitating diseases, such as TB, and diarrhoea (OXFAM, 2005).

138. Climate models suggest that Africa will be particularly adversely affected by climate change and is expected to lose substantial areas of agricultural land (Devereux and Edwards, 2004), this would be an added burden to Africa which is already struggling with lots of vital issues of development, that require urgent attention. A recent publication by (WWI, 2006) indicated that a 1-meter rise in sea level in the Atlantic Ocean will have damaging impacts on societies of Africa with large cities such as Banjul (the Gambian capital). Part of the Nigerian economic capital of Lagos could disappear and Alexandria, Egypt's second city, could also be lost, costing the country over US$ 32 billion in lost land, infrastructure, and tourist revenue. There is support for the integration of adaptation into national development policies and plans (Apuuli *et al.*, 2000; Denton *et al.*, 2001; Ringrose *et al.*, 2002; BAfD *et al.*, 2005). However, care should be taken to ensure that this approach would not reduce potential funding from the different climate funding mechanisms.

139. There have been calls for the development of strong synergy between the Rio Conventions (e.g. see Denton *et al.*, 2001). One of the problems facing countries in the implementation of these conventions is their integration into national development programmes and establishing synergies and linkages among them. Although many African countries have ratified the international environmental conventions, namely biodiversity, climate change and desertification, yet support is still needed from their development partners to ensure effective implementation of their emerging strategies and plans, as well as to fully exploit the opportunities that could be achieved. There is also a need for employing an integrated and synergetic approach among national level development partners for addressing the requirement of sustainable development. Currently, various national institutions have enacted environmental action plans to address environmental degradation. Several strategies and plans have been formulated in countries including national environmental action plans, forestry management plans, biodiversity plans, coastal management plans and wetland conservation strategies.

7 Opportunities for Africa

7.1 Multilateral funding for adaptation

140. Available funding for adaptation activities include:

(a) **The Global Environment Facility (GEF) Trust Fund**
The GEF, as an entity entrusted to operate the financial mechanism of the UNFCCC, established the Strategic Priority on Adaptation (SPA) under its Trust Fund. The objective of the SPA is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in the focal areas in which the GEF works. The SPA supports pilot and demonstration projects that address local adaptation and at the same time generate global environmental benefits.

(b) **The Special Climate Change Fund (SCCF)**
The SCCF aims at supporting activities in the following areas: (i) adaptation, (ii) technology transfer, (iii) energy, transport, industry, agriculture, forestry and waste management, and (iv) economic diversification. Adaptation activities to address the adverse effects of climate change have top priority for funding under the SCCF.

(c) **The Least Developed Countries Fund (LDCF)**
The LDCF was established to support a work programme to assist Least Developed Country Parties (LDCs) carry out, inter alia, the preparation and implementation of national adaptation programmes of action (NAPAs). NAPAs represent an effort launched after the seventh conference of parties (COP7) held in Marrakech in 2001 for the LDCs. In order to address the urgent adaptation needs of LDCs, NAPAs focus on enhancing adaptive capacity to climate variability, which itself would help address the adverse effects of climate change. NAPAs are prepared through a participatory process, involving, in particular, local communities. After consultations, a national NAPA team develops prioritized proposals for urgent adaptation activities, which is subsequently funded from the LDC Fund. As of mid-2006, six countries have submitted their NAPA, among them Malawi, Mauritania and Niger[27].

(d) **The Adaptation Fund under the Kyoto Protocol**
The Kyoto Protocol Adaptation Fund will be financed from the share of proceeds of the clean development mechanism (CDM) and other sources.

(e) **Funds under other Multilateral Environmental Agreements (MEAs)**
Some funding is also available under other MEAs whose areas of work could be synergetic with adaptation, including the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD) and the Ramsar convention on the conservation of wetland resources.

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[27] http://unfccc.int/national_reports/napa/items/2719.php

7.2 Initiatives and activities in Africa

141. Currently, several adaptation-relevant initiatives and programs are ongoing or proposed for the near future. They have contributed or are expected to contribute to building adaptation capacity in Africa. The list below is not exhaustive but it is meant to shed the light on some of the important adaptation relevant initiatives in Africa

7.2.1 Programmes

142. Concrete planned or ongoing adaptation projects funded under the GEF SPA and the SCCF include:

(a) **Incorporating Climate Change in integrated Water Resources Management in Pangani River Basin, Tanzania**
This Special Climate Change Fund supported projected will initiate Integrated Water Resource Management (IWRM) frameworks in the Pangani River Basin of Northern Tanzania. These frameworks will address climate change and pilot adaptation measures. It is a field-based climate change preparation project with strong links to basin and national planning and policy which will help build national and regional capacity in water resources management.

(b) **Coping with Drought and Climate Change, Regional**
This Strategic Priority on Adaptation funded project, aims to develop and pilot a range of coping mechanisms for reducing vulnerability of farmers and pastoralists to future climate shocks. Components include piloting coping strategies, improving early warning systems, assisting governments in developing drought plans and integrating climate change/drought across sector policies and finally replicating and disseminating the results[28]. The project is ongoing in Kenya, Mozambique, Zimbabwe and Ethiopia.

(c) **Adaptation to Climate and Coastal Change in West Africa (ACCC), Regional**
This is another Strategic Priority on Adaptation funded project which aims to perform adaptation actions in pilot sites particularly vulnerable to natural climate changes and to anthropogenic degradation in the short, medium and long term[29]. It also hopes to formulate national and regional adaptation strategies to help manage the impact of changes to the shoreline within the framework of Integrated Coastal Zone Management. The project will run four years from 2007-2010 and is taking place in Senegal, Cape Verde, Guinea Bissau, Gambia and Mauritania.

[28] Martin Krause, Coping with Drought and Climate Change, Project Inception Meeting, 2005, DDC Nairobi
[29] http://english.accc-afr.org/

(d) **Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Eastern and Southern Africa, Regional**

This project aims to contribute to the mainstreaming of adaptation to climate change into development planning and implementation in southern and eastern African countries. The mainstreaming of adaptation will occur at the project or field level as well as through integration of broader policies related to development priorities. Projects will be carried out in Kenya, Mozambique and Rwanda, with Tanzania and Madagascar as observer countries and is funded through the SPA.

(e) **Community-based Adaptation (CBA) Programme, Global, including Morocco, Namibia, Niger**

This project is aimed at: (i) developing a framework, including new knowledge and capacity, that spans the local to the intergovernmental levels to respond to unique community-based adaptation needs; (ii) identifying and financing diverse community-based adaptation projects in a number of selected countries; and (iii) capturing and disseminating lessons learned at the community level to all stakeholders, including governments. This project is to be funded through GEF's SPA and to be implemented by UNDP.

143. Besides projects funded as part of the UNFCCC process, there are others including: **Sustainable Land Use and Forestry/USAID** programs which help mitigate climate change by absorbing and storing carbon dioxide from the atmosphere**,** promoting biodiversity conservation and improving forest management, and sustainable agriculture. They also help reduce the vulnerability of ecosystems. The Central African Regional Program for the Environment (CARPE) focuses its efforts across the Congo Basin, which contains massive expanses of closed-canopy tropical forest. The region is threatened by unsustainable timber exploitation, shifting cultivation, urban expansion, and decades of human conflict. In addition to providing other valuable ecosystem services, the large forested area of the Congo Basin serves as a globally important carbon stock. CARPE's principal goal is to reduce the rate of forest degradation and biodiversity loss.

144. **MANDISA: South Africa** is the programme for Monitoring, Mapping and Analysis of Disaster Incidents in South Africa (MANDISA) and is a core activity for the Disaster Mitigation for Sustainable Livelihoods Programme of the University of Cape Town (DiMP). MANDISA was initiated as a pilot study in the CMA (Cape Town Metropolitan Area) in the Western Province of South Africa from 1990-1999. The methodology was inspired by DesInventar, but has been adapted for the South African context. MANDISA focuses on South African-relevant losses including large urban 'non-drainage' floods; wildfires and extreme wind events, as well as highly frequent 'small' and 'medium' fires. Socio-economic and environmental risk factors that affect disaster impact are included where possible, allowing the potential for tracking the developmental conditions that prefigure disaster. MANDISA is viewed as an approach rather than a disaster-tracking IT tool. This requires multi-agency cooperation, consultation and

feedback, active sourcing of emergency and disaster information, strategic consolidation of information across agencies and robust geo-referencing. MANDISA is an internet-accessible database. This is intended to encourage local ownership as well as provide on-line information for schools, researchers, planners and disaster management personnel.

145. **The World Hydrological Cycle Observing System (WHYCOS) project** aims to provide information to improve efficient management of the world's water resources. It is based on a series of regional projects providing technology and training to monitor hydrological parameters (rainfall, riverflow and evaporation) in the world's river basins. In Africa, there are two projects; in West/Central Africa (AOC-HYCOS funded by the French Ministry for Foreign Affairs), and Southern Africa (SADC-HYCOS funded by the EU).

7.2.2 Regional organizations, groups and networks

146. **Regional Climate Outlook Fora:** Since 1994 the US National Oceanic and Atmospheric Administration (NOAA), working with a number of partners, has set up a series of Regional Outlook Fora across Africa, with three fora covering West Africa, the Greater Horn of Africa and Southern Africa (SADC region) respectively. The Regional Outlook Fora bring together a range of national and international meteorologists to produce probabilistic, consensus-based seasonal forecasts in addition to information users. The fora used to be supported by a regular programme of training[30] and research activities. Scenarios for the implications for different sectors e.g. agriculture, pastures, water, health etc. are highlighted (DFID, 2004[31]).

147. **Regional water initiatives**: There are a number of regional initiatives for better water resource management that will facilitate the adoption of appropriate adaptation measures, for example the Regional strategic action plan for integrated water resources development and management in the SADC countries (Hirji *et al.*, 2002), and the Africa Water Vision for 2025 (World Water Forum, 2000; Global Water Partnership, 2003). A regional approach is particularly important since 80 river/lake basins are transboundary (United Nations Economic Commission for Africa, 2000).

148. **Consultative Group on Agriculture Research (CGIAR):** The CGIAR has many research centres located around the developing world. The CGIAR has also been running a 'Climate Change Challenge Programme' that has developed useful research findings particularly on crop and livestock management in semi-arid and dry lands.

149. **African Monsoon Multidisciplinary Analysis, (AMMA) Project:** AMMA is a multi-year project involving research and systematic observation to improve understanding of climate change and its impacts on health, food security, and water resources. Its three principal goals are to:

(1) Develop observational strategies for improved description of climate change in West Africa;

[30] The training program is managed jointly by US National Centres for Environmental Prediction, the International Activities of the National Weather Service, and the World Meteorological Organization
[31] Information sheet 7

(2) Enhance understanding of the West African Monsoon and its influence on the physical, chemical, and biological environment at regional and global scales; and

(3) Improve knowledge and understanding of the relationships between climate variability and climate change and problems related to health, water resources, and food security in the nations of West Africa.

150. The AMMA project has the potential to significantly improve the ability to predict the onset and ending of the African Monsoon and to better describe climate change and its impacts through reinforcement of the existing network by adding systematic observations in key sensitive areas. (GCOS, 2003)

151. **Southern African Regional Science Initiative (SAFARI 2000)**: A major regional research campaign with a goal to better understand the mechanisms responsible for transporting emissions over the subcontinent and the impact of those emissions on the environment. Although now finished it is still producing data and products.

152. **Assessments of Impacts and Adaptations to Climate Change (AIACC):** AIACC was developed in collaboration with the UNEP/WMO and IPCC and funded by the GEF to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. By funding collaborative research, training and technical support, AIACC aimed to enhance the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations, and generate and communicate information useful for adaptation planning and action.

153. **Climate Change Adaptation Support Programme for Action-Research and Capacity Development in Africa (CCAA) programme:** Currently, the International Development Research Council (IDRC), Canada, is partnering with the Department for International Development (DFID) in the UK to fund a five-year, $65 million CAD Climate Change Adaptation Support Programme for Action-Research and Capacity Development in Africa (CCAA). Its aim is to support African countries in their efforts to address vulnerability, particularly of the poor, to climate change. Building on current activities and experience, the CCAA programme will strengthen efforts to establish and maintain a skilled body of expertise in Africa to support efforts to cope with climate variability and change with a focus on the poor. The programme objectives are:

- To fund and support research to reduce the uncertainty associated with climate change and variability;
- To strengthen the capacity of African scientists, Africa's research organizations, governments, civil society organizations, and international bodies to work collaboratively in assessing vulnerabilities to climate and other stresses, and supporting adaptation by African people, particularly the poor;
- To support adaptation by rural and urban people by supporting research that contributes to a more inclusive policy-making process; and
- To add value to existing adaptation initiatives.

154. **Linking Climate Adaptation network (LCA)** is an effort to help communities, policy-makers, practitioners and academicians share knowledge on climate change adaptation and is funded by DFID. The first phase of the project (May 2004 – June 2005) identified the role of funding and policy mechanisms in supporting successful community-led adaptation. It also identified longer-term research priorities needed to support community led adaptation in the future. As part of the activities of the second phase of the project (November 2005 – March 2006), first, the LCA Network website is being redeveloped as a valuable resource, with ideas for research (<www.linkingclimateadaptation.org>) Second, structured discussions are being held between LCA Network members exploring the value of NAPAs; the next steps for climate policy and the links between the climate change and disaster communities. Third, efforts will be made to expand and diversify the membership of the LCA Network to create more dynamic exchanges.

155. **Regional and International Networking Group (RING)/CLACC** is a well-established network of research and policy related institutes (all in the non-government sector), which have worked together for many years on issues related to all aspects of sustainable development. The Capacity Strengthening of Least Developed Countries (LDCs) for Adaptation to Climate Change (CLACC) project initiated by IIED and the RING Partner institutions aims at improving the capacity of civil society-based organizations working with the poor and vulnerable countries in 12 selected LDCs (nine in Africa and three in South Asia). The CLACC Project started with strengthening capacity of four Regional CLACC Partners in South Asia (BCAS) East Africa (ACTS), West Africa (ENDA) and Southern Africa (ZERO) in its first phase during 2004/2005 (CLACC, 2005).

156. **Pan-African Start Secretariat**, located in Nairobi, Kenya, coordinates START activities in Africa, and is composed of several regional science networks. It offers several fellowships for research and doctoral research, including Global Change Doctoral Fellowships, Small Research Grants for African Global Change Scientist, Lake Victoria Training Program and the GIS and Remote Sensing Training Program.

157. **The New Partnership for Africa's Development (NEPAD)** is an African-led strategy for sustainable development and poverty reduction in Africa. African leaders are looking for support from the international community to achieve these goals. NEPAD is a long-term agenda for Africa adopted as a programme of the Africa Union. The NEPAD Secretariat is developing an implementation plan and building linkages with existing regional organisations such as the Economic Community of West African States (ECOWAS) and Southern African Development Community (SADC). The Secretariat has engaged with other African organisations, such as the UN Economic Commission for Africa (ECA) and the Africa Development Bank (AfDB), to elaborate proposals in support of NEPAD priorities.

158. **Famine Early Warning System Network (FEWS NET)**: USAID supports activities to help developing countries lessen their vulnerability and adapt to climate variability and change. These activities are intended to build more resilience into economic sectors that may be affected by climatic stresses, including agriculture, water, and key livelihood sectors in coastal areas. The Famine Early Warning System Network (FEWS NET) operates in numerous countries in Africa. The program provides decision-makers with information to respond effectively to drought and famine threats by analyzing remote-sensing data and ground-based meteorological, crop and

rangeland observations to identify early indications of potential famine. In addition to using data produced by host governments for its analyses, FEWS NET uses data from satellite imagery.

159. **The Congo Basin Forest Partnership (CBFP)** is a collaboration of 29 governmental and international organizations, announced by former US Secretary of State Colin Powell at the World Summit on Sustainable Development in Johannesburg, South Africa in 2002. USAID contributed USD 15 million to the partnership through the Agency's Central African Regional Program for the Environment (CARPE). Programme activities aim to improve the management of the region's forests and protected areas, and develop sustainable livelihoods for the 60 million people who live in the Basin[32].

7.2.3 Institutions and centers

160. **The Regional Centre for Space Science and Technology Education in Africa (CRASTE-LF)** established in 1998 in Rabat, Morocco, is one of the constituents of the training network set up by the U.N. It is a training and scientific animation institution affiliated with the U.N., with the objective of promoting the use of space science and technology by strengthening local competence. Its mission is to organize courses, training, seminars, workshops, and expert technical meetings to improve the competence of specialists and decision-makers and to keep them informed about progress in space science and technology applications. Other objectives are to assist in the development of a local indigenous capability in space science and technology, to supply consultative services for State members and regional institutions, to collect and diffuse information concerning space, and to support any activity that seeks to increase scientific development in the region

161. **Sahara and Sahel Observatory (OSS) and CILSS:** During the past ten years or so OSS has initiated a work programme in arid, semi arid and sub-humid areas in North, West and East Africa including long-term observations and networks focusing on land degradation issues. A series of biophysical indicators have been identified and collected. Each of the three sub-regions (North Africa, Sahelian Africa and Eastern Africa) needs to come up with a minimum set of indicators including biophysical, socio-economic issues that will help to assess their vulnerabilities to climate change and thus identify potential action for adaptation. In North Africa, the Union of Maghreb Arab organisation has a mandate to develop policies related to all environmental issues within member countries. In West Africa, the Comite Inter-etat de Lutte contre la Secheresse au Sahel, (CILSS) and in Eastern Africa, the Inter Governmental Authority for Development, are playing similar role. These regional organisations have limited capacity to integrate climate change issues into their activities as little analytical work has been carried out in the region to date. These three organisations are all members of OSS and the outputs of any research activities conducted through OSS would therefore be integrated into their strategic work programmes.

162. **Centre Régional Africain des Sciences et Technologies de l'Espace en Langue Française (CRASTE-LF)** is a training and research institute established under United Nations sponsorship to promote the utilization of space science and technology and develop related national and regional capacity. Twelve African countries are current members of CRASTE-LF,

[32] USAID's Biodiversity Conservation Programs, Fiscal Year 2003 August 2004

and several others have indicated their intention to join. The Centre has broadly based expertise in satellite remote sensing, telecommunications, space, and atmospheric science. It offers graduate and postgraduate training in these fields, carries out research and sponsors seminars, workshops and conferences. CRASTE-LF also has partnerships with international organizations and with institutions in advanced countries that are involved in space applications.

163. **Climate Prediction and Application Center (ICPAC)** was established in October 2003 as a follow-up of a number of projects through USAID/REDSO. Main objectives include improving the technical capacity of producers and users of climatic information, in order to enhance the input to and use of climate monitoring and forecasting products; developing an improved, proactive, timely, broad-based system of information and product dissemination and feedback, at both sub-regional and national scales through national partners; and expanding the knowledge base within the sub-region in order to facilitate informed decision making, through a clearer understanding of climatic and climate-related processes, enhanced research and development, and a well managed reference archive of data and information products.

164. Other institutions and organizations that undertake activities that are relevant to assessment of impacts and vulnerability or preparing for adaptation include the following:

- Institute for Meteorological Training and Research (IMTR);
- Drought Monitoring Centre (Nairobi);
- ICRAF (International Centre for Research in Agro-forestry);
- International Fertilizer Development Centre;
- FAO and the World Bank could enhance the adaptive capacity of Africa;
- Sub-regional cooperation for coral reef management;
- Inter-Governmental Authority on Development (IGAD).

8 Summary

- The lack of observational climate data in Africa is recognized as a constraint to understanding current and future climate variability. Significant gaps are apparent in the surface network, including in Angola, the Congo basin, and Sudan, and parts of the Sahel.

- Regional requirements for increasing Africa's contribution to the global climate observing system have been identified by regional workshops and the regional action plans that followed. Requirements include improving and sustaining operational observing networks, such as the GCOS Surface and Upper Air Networks (GSN and GUAN); recovering historical data; improving national and regional coordination; education, training and capacity building; and improved national planning and reporting. More stations are needed and of those that are in place many are not reporting or are reporting at a substandard level. Africa also has a low density of WMO World Weather Watch real time weather stations, in fact, the lowest of any region in the world.

- Top-down scenario-based assessment is a common approach for assessment of impacts, vulnerability and adaptation to climate change in Africa, although recently the bottom-up approach has been employed, particularly through the NAPA process. General circulation models are the most common tools used for top-down vulnerability and adaptation assessments in Africa, although they show uncertainty regarding both the magnitude and direct of changes in precipitation. The inter-annual, inter-decadal and multi-decadal variations in Africa's climate make future changes hard to understand and predict. Other climate factors important to Africa such as in-land cover change, the interaction of Saharan dust and the ENSO are not represented well in these models. Better regional climate models are required but some such as the Hadley Centre's PRECIS model have already been applied in some areas.

- Approaches that address multiple environmental stresses and factors hold the greatest promise for Africa, particularly given the limitations in capacity (both in terms of human capacity and financial resources). Efforts to design implementation strategies that address land degradation (which leads to desertification), loss of biological diversity and ecosystem services, as well as adaptation to climate change, such as through enhancing adaptive capacity, will more likely succeed than uncoordinated efforts.

- The most major needs in order to increase the capacity of African countries in climate science and adaptation relate to a general lack of knowledge, expertise and data on climate change issues; a lack of specific climate change institutions to take on climate change work and the need for a better institutional framework in which to implement adaptation. Actions to address these gaps include: training programmes for local government officials, dedicated research activities and post-graduate courses; and the initiation of specific institutional frameworks for climate change.

- Africa is already under pressure from climate stresses which increase vulnerability to further climate change and reduce adaptive capacity. Floods and droughts can occur in the same area, within months of each other. Droughts in Africa can often lead to famine and widespread disruption of socio-economic wellbeing. Atmospheric dust, in the form of dust and sand storms, can have negative impacts on agriculture, infrastructure and health in Saharan and Sahelian environments. Desertification is currently a big problem in Africa, partly due to overexploitation of land resources.

- With further climate change, climate in Africa is predicted to become more variable and extreme weather events more frequent and severe. There are likely to be large regional differences in changes in rainfall, e.g. increase in the western part of the continent and decrease for the northern part.

- Key vulnerable sectors and areas for Africa include water, agriculture, human health, biodiversity and ecosystems, and sea level rise.

- Millions in Africa already have no access to potable water. Water scarcity is expected to increase due to increased water demand accompanied by an increase in population in drought-prone areas and possible future decreases in precipitation. Africa is already vulnerable to several climate sensitive diseases such as Rift Valley fever, cholera and malaria. It is expected that the range, timing and severity of outbreaks of these diseases will change with a changing climate. With regard to agriculture, 70 percent of the population relies on agriculture for their livelihood, mostly in a subsistence manner with rainfall as the only source of irrigation. Therefore, there are no mechanisms to buffer outputs from climate effects. A decline in most subsistence crops has been predicted. Africa's biodiversity is currently under threat from natural and human pressures; climate change will be an additional stressor and may lead to changes in habitats, causing species migration or extinction for both flora and fauna. Sea-level rise will threaten coastal areas which are already vulnerable because of overexploitation of coastal resources, over population and pollution. Sea level rise could have devastating effects for areas such as the Nile Delta. The detrimental effect that climate change is expected to have on natural resources will lead to increased competition of those resources still available, with conflict as a possible outcome.

- Climate change has the potential to undermine economic development, increasing poverty and delaying or preventing the realization of the Millennium Development Goals. Particularly, the lack of effective adaptation to the adverse effects of climate change can jeopardize the achievement of MDG goal 1 (eradicating extreme poverty and hunger), goal 6 (combating HIV/AIDS, malaria and other diseases) and goal 7 (ensuring environmental sustainability).

- Some African communities have developed traditional adaptation strategies to cope with climate variability and extreme events. Experience with these strategies needs to be shared among communities. Techniques include: diversification of herds and incomes, use of forest products as a buffer against climate induced crop failure, decentralization of governance of resources and the manipulation of land use leading to land use conversion, to name a few. However, some of these techniques may need to be adjusted to face additional climate risks associated with climate change.

- There are many possible future adaptation options to adapt to future climate change. However, Africa has not developed comprehensive long or short term plans in order to structure their implementation. Requirements for adaptation include: better links between climate research and policy-making, mainstreaming climate change consideration into development plans and programmes, education and awareness-creation in governments, institutions and individuals; better forecasting and early warning systems.

- Mainstreaming climate change considerations into development strategies and country policies and programmes will be key to ensuring that development efforts are not undone by climate change. In addition, African governments need help in developing synergies between all of the Rio Conventions.

- There are a number of adaptation-relevant activities being carried out in Africa. As part of the UNFCCC process, national and regional projects are initiated which receive funding from the GEF's Trust Fund and the special funds including the SCCF and the LDCF. Other initiatives, networks and research centres in the areas of agriculture, forestry, water, and drought also facilitate adaptation planning and implementation.

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