Economic Impact of Climate Change

in the East African Community (EAC)

Final Report

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“Africa will be under severe pressure from climate change. Many vulnerable regions, embracing millions of people, are likely to be adversely affected by climate change, including the mixed arid-semiarid systems in the Sahel, arid-semiarid rangeland systems in parts of eastern Africa, the systems in the Great Lakes region of eastern Africa, the coastal regions of eastern Africa, and many of the drier zones of southern Africa. ”

The Stern Review

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Abbreviations

AOGCM	Atmospheric and Oceanic General Circulation Model
AR4	Fourth Assessment Report
COP	Conference of Parties (of United Nations Conventions, e.g. the United Nations Framework Convention on Climate Change)
DDT	Dichloro-Diphenyl-Trichloroethane
EAC	East African Community
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HIV	Human immunodeficiency virus
IEA	International Energy Association
IFPRI	International Food Policy Research Institute
IK	Indigenous knowledge
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature and Natural Resources
IWRM	Integrated water resources management
LEG	Least developed countries Expert Group
MMD	Multi-Model-Dataset
NAPA	National Action Programme for Adaptation
NGO	Non-Governmental Organization
NT	NAPA Team
PA	Protected Area
PRA	Participatory Rural Appraisal
PSC	Project Steering Committee
SRES	Special Report on Emissions Scenarios
TAR	Third Assessment Report
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VPO	Vice President's Office
WWF	World Wide Fund for Nature

Summary

Climate Change Projections for East Africa

In 2007, the International Panel on Climate Change (IPCC) published its Fourth Assessment Report (AR4) assembling the most recent scientific research results and information regarding climate change. According to AR4, it is very likely that all of Africa will warm up during this century and that, throughout Africa and in all seasons, the warming will be larger than the global annual mean warming.

Temperature projections for East Africa indicate that the median near-surface temperature in the 2080 to 2099 period will increase by 3°C to 4°C compared to the 1980 to 1999 period. It has to be underlined that this increase is about 1.5 times the projected global mean response.

Some scientific study results indicate substantial dryness across most of eastern Africa during the Belg rains. Averages of precipitation projections for East Africa, however, quite clearly indicate an increase in rainfall for East Africa for the 2080 to 2090 period.

The changes in precipitation are likely not to be uniform throughout the year, but will occur in sporadic and unpredictable events. It is estimated that the number of extreme wet seasons in East Africa in the 2080 to 2099 period will increase from about 5% to about 20%.

Climate Change impacts in East Africa

The water sector is considered to be very sensitive to climate changes. In East African lakes (Edward, Albert, Kivu, Victoria, Tanganyika and Malawi), deepwater temperatures, which reflect long-term trends, have risen by 0.2 to 0.7°C since the early 1900s. Inter-annual lake-level fluctuations and lake-level volatility have been observed in East African lakes. This is probably due to the periods of intense drought followed by increases in rainfall and extreme rainfall events in late 1997. The heavy rains and floods have been possibly attributed to large-scale atmosphere-ocean interactions in the Indian Ocean.

Global warming is obviously also modifying natural mountain ecosystems and, in particular, causing glaciers and ice fields to retreat. Since 1912, the area covered by Mt. Kilimanjaro's ice fields has decreased by about 80%. It has been estimated that, if current climate conditions persist, the remaining ice fields are likely to disappear between 2015 and 2020. In Uganda, the Rwenzori Mountains ice cover has retreated to about 40% of the value recorded in 1955. Similar observations have been made at Mount Kenya where the Lewis Glacier is receding leading to water shortages, reduction in water quality and competition for water. Water scarcity has already led to conflicts between large and small scale farmers and between humans and wildlife.

Climate change and variability can impose additional pressures on water availability, water accessibility and water demand in Africa. An analysis shows a probable increase in the number of people who could experience water stress by 2055 in northern and southern Africa. In eastern and western Africa, however, more people will be likely to experience a reduction rather than an increase in water stress.

Climate change is expected to significantly alter African biodiversity. Species which are capable of adapting to climate shifts may survive while others that cannot respond will

probably suffer. An assessment of the species sensitivity of African mammals, carried out in 141 national parks in sub-Saharan Africa, states that 10-15% of the species are projected to fall within the IUCN Critically Endangered or Extinct categories by 2050, increasing to 25-40% of species by 2080.

Recent research assessing biome sensitivity in Africa shows forests to be highly sensitive to climate change. Nevertheless, East-Africa's forests are under serious threat due to the population's high dependency on firewood and charcoal.

Sea level is expected to continue to rise. The projected global average sea level rise at the end of the 21st century is 0.21 – 0.48 m compared to the 1980 to 1999 period.

In East Africa, sea-level rise and resulting coastal erosion is of particular concern for coastal Kenya and Tanzania. Due to the fact that highly productive ecosystems such as mangrove swamps, estuaries, deltas and coral reefs are located in the coastal zones, climate change also impacts the corresponding economic activities like tourism, mining and fisheries. In both Kenya and Tanzania, coral reef loss is a significant cause of coastal erosion and a major coastal management issue. Other research results demonstrate that Indian Ocean islands may be threatened by potential changes in the location, frequency and intensity of cyclones. East African coasts may be affected by potential changes in the frequency and intensity of ENSO events and coral bleaching.

The resurgence of malaria and its links to climate change, in particular in the highlands of East Africa, is being debated intensely. Some studies indicate, for instance, that in areas with two rainy seasons – March to June (MAMJ) and September to November (SON) – more rain is falling in SON than previously experienced in the northern sector of East Africa. The SON season is relatively warm, and higher rainfall is likely to increase malaria transmission because of a reduction in larval development duration.
However, the recent resurgence of malaria in the highlands of East Africa may involve multiple other causal factors, such as poor drug-treatment implementation, drug resistance, land-use change, and various socio-demographic factors including poverty. Future trend analyses estimate that, by 2100, malaria distribution may increase by 5-7%, mainly by extending to higher altitudes. Previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi may experience modest incursions of malaria by the 2050s, with conditions becoming highly suitable for transmission by the 2080s

Vulnerability

Economic development and, in particular, poverty alleviation is a major issue for many African countries. But in recent years it has become evident that climate change impacts in developing countries might hinder the achievement of development goals.

In East Africa, the link between climate and livelihood is very strong. As East Africa depends heavily on rain-fed agriculture, rural livelihoods are highly vulnerable to climate variability such as shifts in growing season conditions. Furthermore, agriculture contributes 40% of the region's GDP and provides a living for 80% of East Africans. In 2003-2004, all East-African countries suffered from weather-related food emergencies and can therefore be considered as vulnerable to the impact of climate change on their agriculture.

Some specific studies and analysis on potential impacts of climate change on crops in East Africa, for instance in Tanzania, indicate that, in a given farming system, the impact may be positive and negative depending on the crops. In the tea-producing regions of Kenya, a small

temperature increase of 1.2 °C and the resulting changes in precipitation, soil moisture and water irrigation could cause large areas of land that now support tea cultivation to be largely unusable. As Kenya is the world's second largest exporter of tea and, since tea exports account for roughly 25% of Kenya's export earnings and employ about three million Kenyans (10% of the population), the economic impact could be tremendous.

Detailed research on livestock vulnerability in East Africa is lacking and impact assessments should be carried out. Recent research on the impact of climate change on livestock farming in Africa showed that income from livestock farms may increase or decrease depending on the intensity of the temperature rise and on the farm size.

Fisheries are a significant source of revenue, employment and proteins for all East African countries. Climate change may have an impact on fisheries. It has been concluded, for instance, that primary productivity in Lake Tanganyika may have decreased by up to 20% over the past 200 years. Although the impact of climate change on fisheries is likely to be significant, it clearly needs to be assessed together with other human activities, including impacts that may arise from governance of fresh and marine waters or pollution and overfishing.

Tourism is a major resource of revenue for East African countries, particularly in terms of game watching, coastal tourism and eco tourism. Climate-change-related impact on natural resources therefore has direct effects on the East African tourism industry. Climate change could place tourism at risk, particularly in coastal zones and mountain regions.

Because of extreme poverty and the lack of access to other fuels, 80% of the overall African population relies primarily on the biomass to meet its residential needs. In Kenya, Tanzania, Mozambique and Zambia, nearly all rural households use wood for cooking and over 90% of urban households use charcoal. Dependence on the biomass as the primary energy resource clearly enhances the removal of vegetation.

There is also a strong link between climate change and hydropower generation, which might be impacted by reduced rainfall and river flow rates. Decreasing East African sea levels are likely to have a direct negative influence on hydropower generation.

Economic impact of climate change in East Africa

Climate change is an important global problem that has been extensively discussed in recent years. Focus on identification and prediction of the economic impacts of climate change on different economic sectors has increased. In this review and analysis we use time series of national rainfall and macro economic indicators to discern the impacts of climate variability and extremes (basically drought), on the economies of East African Community (EAC). We focus on major drought events and also some recent floods.

Major droughts result in sharp reductions in agricultural output, related to productive activity, and employment. This in turn can lead to lower agricultural export earnings and other losses associated with decline in rural income, reduced consumption and investment and destocking and may have additional multiplier effects on the monetized economy.

Major droughts have been recorded in East Africa in 1970, 1975, 1979-80, 1989-90, 1999/2000 and 2005. When weighted by impact on GDP it appears that drought poses a substantially higher impact risk than floods.

Fluctuations in rainfall lead to output and price volatility and periodic risk of famine. A 10 percent reduction in rainfall in a particular year reduces growth 4-5 years later by one percentage point. During the consecutive years 1984 and 1985, in Kenya there was a decline in crop production leading to a 12 percent drop in agricultural GDP leading to a decline in overall growth rate of GDP.

In East Africa climate variability may have devastating impacts on the economies. Major droughts typically result in sharp declines in agricultural output, related productive activity, and employment. In turn, this will lead to lower agricultural export earnings and other losses associated with a decline in rural income, reduced consumption and investment, and destocking. Significant droughts also have additional multiplier effects on the monetary economy, the rate of inflation, interest rates, credit availability, levels of savings, the government budget deficits, and external debt stocks.

A World Bank study found that of the top ten disasters in East Africa between 1970 and 2003, most were caused by droughts. The greatest numbers of people affected by drought were in 1999-2000 which affected 4.4 million people in Kenya alone and about 14.2 million in other EAC countries.

Observations on major rainfall deficient years and the major macro variables show a significant relationship between rainfall amount and GDP. Focusing on major drought years, a negative rainfall anomaly, mainly if it is more than 10% brings a loss in agricultural GDP. When the 1999-2000 drought affected an estimated 13.2 million people, destroyed crops, caused deaths of animals, and affected millions of people the rainfall anomaly was about 29% based on the annual average figures though the rainfall distribution was not uniform. The crop production loss was (-16.8%). In the two consecutive years of 1999 and 2000 agricultural GDP in EAC declined by 11% and 14% leading to a GDP growth rate of -5% and -5.8%.

The regression results for GDP change by country show that increased rainfall has a positive impact on GDP for Kenya and Tanzania. For Uganda and Rwanda the effect is negligible, perhaps because these countries have historically had high rainfall. Increased variation in rainfall significantly reduced value of output for Kenya. In the event of increased variability in rainfall Kenya is likely to be most affected.

An increase in temperature significantly lowers value of output for Kenya, Uganda and Rwanda. However, increased variation in temperature results in significantly higher value of output for the Kenya, Uganda and Rwanda. The results also show that the time trend coefficients are significant and positive for all EAC; this indicates that production technology may have improved over the period of observation.

According to our elasticity estimates, a 10 percent increase in annual rainfall results in a 1.7 and 1.9 percent increase in GDP in Kenya and Tanzania respectively. However, a 10 percent increase in temperature results in a decrease in GDP of 8.7%, 18% and 14% in Kenya, Uganda and Rwanda respectively. According to these estimates, the impact of change in mean annual temperature is more pronounced and adverse to the economy than a similar change in annual precipitation.

There foregoing results should be treated with caution since variables such as labour, capital, and other inputs that influence crop yield are not included. In addition, aggregation of the data by country averages for these variables may have masked important variation on lower levels.

Adaptation

Amongst the EAC partner states, four countries are considered as least developed countries (Burundi, Rwanda, Tanzania, Uganda) and have therefore received GEF funds to develop a National Action Programme for Adaptation (NAPA) in accordance with the LEG guidelines. The national NAPA-teams identified vulnerabilities and priority sectors for each country and developed potential adaptation options.

Kenya has started several projects regarding adaptation to climate change, also aiming to integrate adaptation into national sustainable development plans.

Policy options and recommendations

Climate change is a global problem and its impacts do not stop at national borders. Although many consequences of climate change, such as floods and droughts, will have transboundary implications, the corresponding prevention and adaptation measures mostly remain at national level. Developing national adaptation programmes is essential to address specific national vulnerabilities but transboundary impacts may be better addressed by a regional approach. Furthermore, the exchange of experience among countries, for instance on adaptation strategies and national policies, may create synergies amongst member states.

The following policy options and recommendations resulted from the literature review, field visits in Kenya, Tanzania, Uganda, Rwanda and Burundi and the stakeholder workshop held in Arusha/Tanzania on 29th of August 2009.

I. Development of a regional climate change strategy:

- Strengthen the Regional Climate Change Working Group
- Complement the Regional Climate Change Working Group with sectoral working groups
- Enhance the process of developing the EAC Climate Change Master Plan
- Involvement of civil society and NGO's
- Complementation of the strategy by Sectoral Climate Change Strategies
- Integration of climate change into regional sector strategies
- Integration of mitigation into the Climate Change strategy

II. Regional cooperation in vulnerability assessment and adaptation at regional level:

- Regional in-depth vulnerability assessments
- Organization of regional workshops on vulnerability and adaptation options by sectors
- Setting up of regional sector working groups
- Enhancement of regional cooperation in disaster management
- Capacity development

III. Climate Change research:

- Setting up a Regional Centre of Excellence

- Regional Early Warning System
- Enhancing regional cooperation in disaster management
- Development of a high resolution climate model for East-Africa
- Develop climate change projections for the 2020 to 2030 period
- Study of rainfall patterns in East Africa
- Enhance research on climate change detection
- Rescue existing climate data
- Monitoring stations

IV. Conflict prevention:

- Enhance regional cooperation in conflict prevention
- Organisation of conflict prevention workshop

V. Communication:

- Development of a communication strategy for climate change
- Awareness raising amongst decision makers and governments
- Exchange of experience
- Awareness raising amongst populations
- Creation of a website

VI. Institutional aspects:

- Set up a Climate Change Commission at the EAC
- Set up a Climate Change Unit/Desk at the EAC-Secretariat
- Set up sectoral Climate Change/Adaptation Working Groups at the EAC
- Establish cooperation with existing regional and international institutions in order to create synergies and avoid overlapping of institutional competencies
- Establish mechanisms of inter-regional cooperation on climate change
- Study about existing capacities on climate change in the region (institutional, technical)

1 Introduction

The East African Community (EAC) is the regional intergovernmental organization of the Republics of Burundi, Kenya, Rwanda, Uganda and the United Republic of Tanzania with its Headquarters in Arusha, Tanzania. The Treaty for Establishment of the East African Community was signed on 30th November 1999 and entered into force on 7th July 2000 following its ratification by the Original 3 Partner States – Kenya, Uganda and Tanzania. The Republic of Rwanda and the Republic of Burundi acceded to the EAC Treaty on 18th June 2007 and became full Members of the Community with effect from 1st July 2007.

The EAC aims at widening and deepening co-operation between the Partner States in, among others, political, economic and social fields for their mutual benefit. To this end, the EAC countries established a Customs Union in 2005 and are working towards the establishment of a Common Market by 2010, a Monetary Union by 2012 and, ultimately, a Political Federation of the East African States.

The EAC-GTZ Programme “Support to the Integration Process in the EAC Region” is implemented under the cooperation between the EAC and Germany. GTZ is Germany’s implementing agency for technical cooperation and is owned by the Federal Government of Germany.

While the Programme is oriented to focus on support to the process of economic integration, both parties agreed that the Programme should also provide specific support to the negotiation process for the future East African Common Market.

As the climate change issue is gaining in importance in East Africa, the EAC has decided to raise it to the top of its political agenda and build up the platform to address the climate change issue at regional level.

Recent scientific and economic studies, such as the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) and the Stern Review, have clearly demonstrated that climate change is already happening and that it has considerable impact on economic growth, income, employment and poverty. As climate change continues to alter the living conditions of mankind, its impact is expected to become more and more important. The Stern Review largely shows that damage caused by climate change will be much more costly than investing in preventive measures. The Stern Review, in particular, makes a strong case for early action. This knowledge forms the background to the present study.

Although Africa’s contribution to global greenhouse gas emissions is minimal, it is predicted to suffer the most from the corresponding impacts. This is in particular due to its low adaptive capacity to climate change.

In East Africa, the impact of climate change is already visible. The East African countries have started developing adaptation strategies. However they are not yet being implemented. Although climate change will have transboundary impacts and therefore partly needs transboundary responses, all adaptation plans remain at a national level.
The East African Community can play an important role in developing a regional approach regarding climate change.

Objective of the study

The basic objectives of this study are:

- To analyse the situation of climate change for East Africa and its impact on the major sectors concerned in economic terms
- To develop scenarios and recommendations for policy making within the EAC, and
- To indicate how the EAC could continue to work on the issues of environment and climate in relationship with the process of economic integration in a more extended and deepened manner.

The study was conceived as a first "door opener" to the questions of economic impact of climate change. It is of limited depth and scope and could be followed by in-depth studies on various aspects later on.

Methodology

In order to fulfil the tasks in accordance with the terms of reference, the consultants applied various methodological elements:

1. A **literature review** allowing a synthesis to be made of the most up-to-date information regarding climate change issues in the region. The documents studied include the IPCC 2007 report and the Stern Review.
   During the execution of the study the experts referred as much as possible to the existing studies and information in the EAC region. However, when information pertaining specifically to EAC was limited, they resorted to drawing information from studies covering also neighbouring or other African countries.
2. During a **field visit** to all five member states, the consultants met various stakeholders in order to discuss their specific needs and points of view and to collect additional information.
   Josef Seitz carried out the field visits in Uganda, Rwanda and Burundi, while Wilfred Nyangena covered Tanzania and Kenya.
3. By using a **Just-Pope model** linking climatic variables and resultant variability in economic indicators we show the implications of climate change on economic performance for the EAC.
4. A **team working session** gave the opportunity to fine-tune the information gathered and results obtained.
5. A **stakeholder workshop** was held in Arusha on 29th of July 2009 in order to gather relevant information to add value to the current final draft of the study and to produce a mutually agreed upon final document among stakeholders.

2 Climate change projections for East Africa

In 2007, the International Panel on Climate Change (IPCC) published its Fourth Assessment Report (AR4) assembling the most recent scientific research results and information regarding climate change. According to the AR4, it is very likely that all of Africa will warm during this century and that, throughout Africa and in all seasons, the warming will be larger than the global annual mean warming.

Annual rainfall is likely to decrease in much of Mediterranean Africa and the northern Sahara. In southern Africa, rainfall is also likely to decrease in much of the winter rainfall region and on the western margins. In East Africa, however, annual mean rainfall is likely to increase.

Figure 2.1 shows the predicted changes in temperature and precipitation for the 2080 to 2099 period compared to the 1980 to 1999 period for Africa[1].

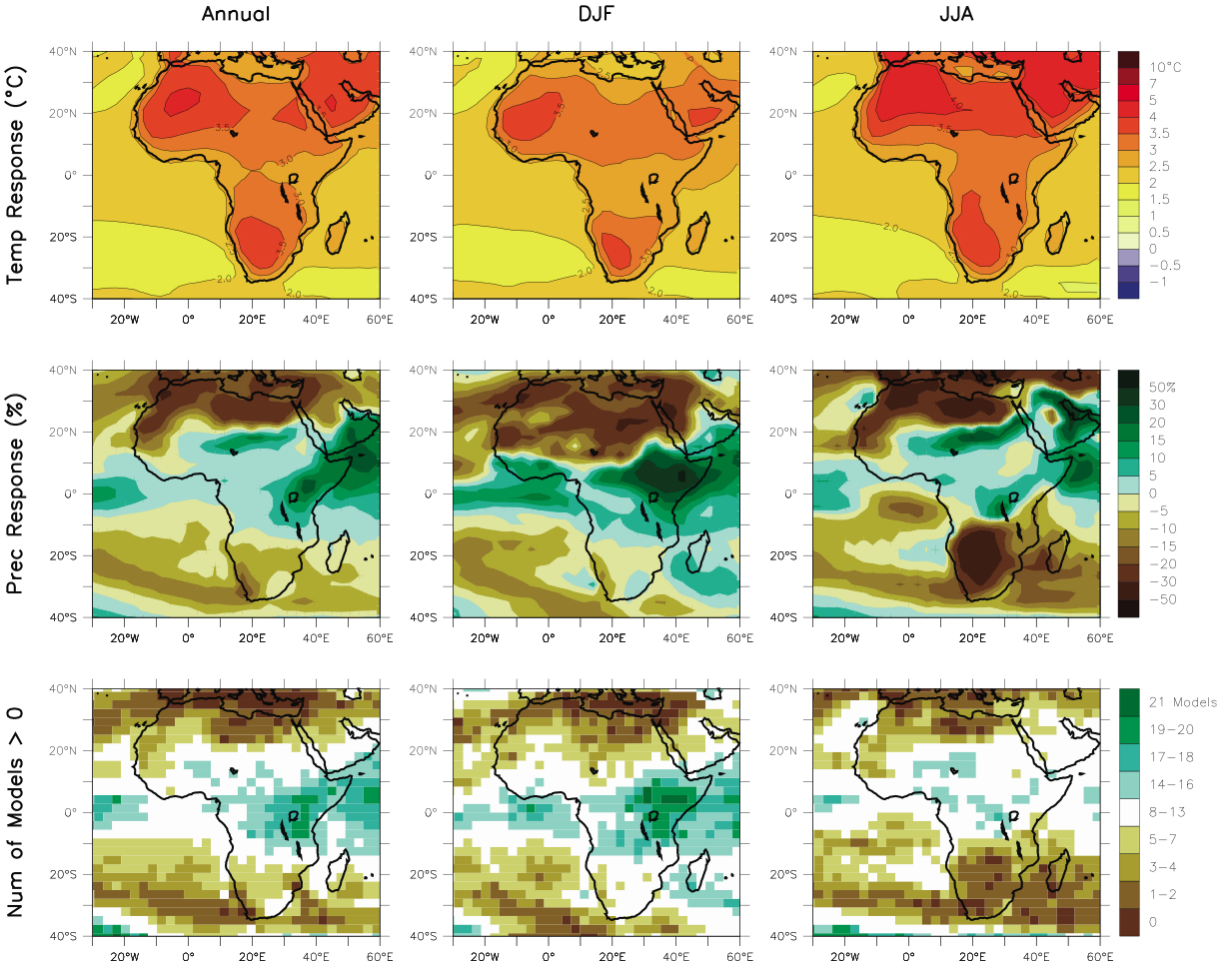


Figure 2.1: Temperature and precipitation changes for the 2080 to 2099 period in Africa, averaged over 21 models, based on A1B simulation (Source: IPPC, 2007)

[1] The projections are based on the Multi-model-dataset (MMD, averaged over 21 models) and the A1B-scenario. For more details about climate change models and scenarios, please refer to the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC).

Nevertheless, it is still unclear to what extent current regional models can successfully downscale precipitation over Africa. As a consequence of restricted computational facilities and lack of human resources (Hudson and Jones, 2002; Swart et al., 2002) as well as problems of insufficient climate data (Jenkins et al., 2002), very few regional to sub-regional climate change scenarios using regional climate models or empirical downscaling have been constructed for Africa (IPCC, 2007).

It would also be of particular interest to develop climate change projections which are closer to current generations, e.g. for the 2020 to 2030 period instead of the commonly used 2080 to 2099 period.

Furthermore, the often used A1B scenario gives a realistic but specific view of the potential climate changes. By using additional scenarios, climate change projections and the assessment of the corresponding impacts may be improved.

2.1 Temperature response

Regional temperature anomalies in East Africa observed from 1901 to 2000, and temperature projections from 2001 to 2099 are shown in Figure 2.2. Projections were made with reference to three scenarios. The orange envelope represents the range for temperature change under the A1B-scenario.

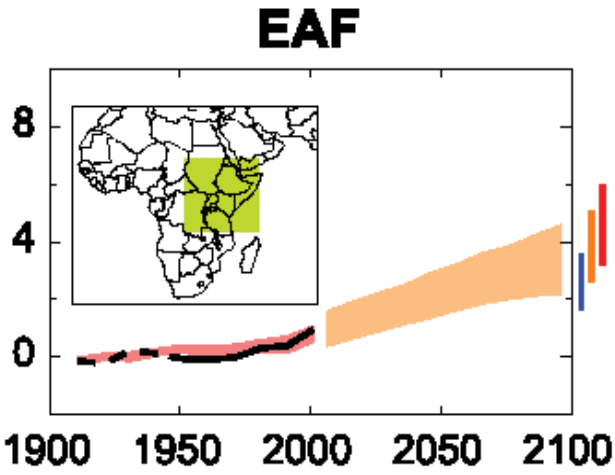


Figure 2.2: Temperature anomalies for East Africa (Source: IPCC 2007)[2].

The seasonal average temperature projections for East Africa are shown in Table 2.1.

The mean temperature rise is shown by the 50th percentile (column in bold). The minimum corresponds to the 10th percentile, while the maximum is represented by the 90th percentile.

[2] The orange envelope represents the range of projected changes for the 2001 to 2100 period (under the A1B-scenario.The bars at the end of the orange envelope represent the range of projected changes for 2091 to 2100 for the B1 scenario (blue), the A1B scenario (orange) and the A2 scenario (red). (Source: IPCC 2007)

Season	Min.	25%	50%	75%	Max.
DJF	2.0	2.6	**3.1**	3.4	4.2
MAM	1.7	2.7	**3.2**	3.5	4.5
JJA	1.6	2.7	**3.4**	3.6	4.7
SON	1.9	2.6	**3.1**	3.6	4.3
Annual	1.8	2.5	**3.2**	3.4	4.3

Table 2.1: Averages of seasonal temperature projections for East Africa (from a set of 21 global models in the MMD for the A1B scenario) for the 2080 to 2090 period (Source: IPCC, 2007)

Based on the multi-model-dataset (MMD) of 21 global models and on the A1B-scenario, the projections for East Africa indicate that the median near-surface temperature in the 2080 to 2099 period will **increase by 3°C to 4°C** compared to the 1980 to 1999 period. It has to be underlined that this increase is about 1.5 times the projected global mean response (IPCC, 2007).

2.2 Precipitation response

Averages of precipitation projections for East Africa based on the A1B scenario indicate quite clearly an **increase in rainfall for East Africa** for the 2080 to 2090 period (Table 2.2).

The mean precipitation response is shown by the 50th percentile (column in bold). The minimum corresponds to the 10th percentile, while the maximum is represented by the 90th percentile.

Season	Min.	25%	50%	75%	Max.
DJF	-3	6	**13**	16	33
MAM	-9	2	**6**	9	20
JJA	-18	-2	**4**	7	16
SON	-10	3	**7**	13	38
Annual	-3	2	**7**	11	25

Table 2.2: Averages of seasonal precipitation projections for East Africa (from a set of 21 global models in the MMD for the A1B scenario) for the 2080 to 2090 period (Source: IPCC, 2007)

The projected increase in rainfall in East Africa is steady across the ensemble of models, with 18 of the 21 models projecting an increase in the core of this region, east of the Great

Lakes (IPCC, 2007). This East African increase is also evident in Hulme et al. (2001) and Ruosteenoja et al. (2003).

However, other results based on an analysis of three precipitation time series indicate substantial dryness across most of eastern Africa during the Belg rains. Tanzania, Rwanda and Burundi, Kenya and Ethiopia have all experienced rainfall deficits ranging from 50 to 150 mm per season (Funk et al., 2005). The author states that “multiple sources of evidence converge on a post-1997 tendency towards lower rainfall, especially during the Belg (March-May) season. This finding appears to hold for many parts of eastern Africa.”

As the major part of the African continent has a tropical or subtropical climate, the seasonal migration of the tropical rain belts is one of the main phenomena. Small shifts in the position of these rain belts may result in large local changes in rainfall (IPCC, 2007).

The differences that seem to exist in the scientific literature regarding precipitation response to climate change in East Africa demonstrate that a detailed analysis at regional level is lacking.

2.3 Extremes

Scientific literature on extreme weather events in East Africa is almost lacking and research on changes in extremes specific to Africa, in either models or observations, is limited. It is expected that the intensity of high-rainfall events in Africa will increase, partly due to the increase in atmospheric water vapour. The IPPC AR4 states that "there is little modelling guidance on possible changes in tropical cyclones affecting the southeast coast of Africa. Thermodynamic arguments for increases in precipitation rates and intensity of tropical storms are applicable to these Indian Ocean storms as for other regions, but changes in frequency and spatial distribution remain uncertain" (IPCC, 2007).

The changes in precipitation are likely not to be uniform throughout the year, but will probably occur in sporadic and unpredictable events. Increased precipitation may come in a few very large rainstorms mostly during the already wet season thereby adding to erosion and water management issues. It is also expected that there will be less precipitation in East Africa during the already dry season, which may cause more frequent and severe droughts and increased desertification in the region (WWF, 2006).

The number of extreme wet seasons in East Africa in the 2080 to 2099 period is estimated to increase from about 5% to about 20%. In other words, 1 in 5 of the seasons are likely to be extremely wet by the end of 21st century, as compared to 1 in 20 in the control period in the late 20th century[3] (IPCC, 2007).

During the field visit, many stakeholders underlined that all East African countries have experienced unexpected severe droughts and floods in recent years.

Table 2.3 gives an example of recent meteorological disasters in Kenya (Muchemi).

Year	Type of Disaster	Area of Coverage	No. of people affected
2003	Flood	Budalang'I	28,000
2002	Landslide	Meru, Murang'a, Nandi	2,000
1999/2000	Drought	Widespread	4.4 million
1997/98	El Nino floods	Widespread	1.5 Million
1995/96	Drought	Widespread	1.41 million
1991/92	Drought	Arid/Semi Arid zones	1.5 million
1985	Floods	Nyanza/Western	10,000
1983/84	Drought	Widespread	200,000
1982	Floods	Nyanza	4,000
1980	Drought	Widespread	40,000
1977	Drought	Widespread	20,000
1975	Drought	Widespread	16,000
1971	Drought	Widespread	150,000

Table 2.3: Recent history of meteorological disasters in Kenya (Data extracted from the "National Policy on Disaster Management – Draft ")

[3] The projections are based on the Multi-model-dataset (MMD) and the A1B-scenario.

3 Climate change impacts in East Africa

3.1 Water resources

The water sector is considered to be very sensitive to climate changes. In many parts of the world, changes in the physical and chemical aspects of lakes and rivers, like higher water temperatures, shorter periods of ice cover and decreases in river- and lake-ice thickness have been documented in recent decades. In East African lakes (Edward, Albert, Kivu, Victoria, Tanganyika and Malawi), deepwater temperatures, which reflect long-term trends, have risen by 0.2 to 0.7°C since the early 1900s (IPCC, 2007).

Inter-annual lake-level fluctuations and lake-level volatility have been observed in East African lakes, such as Lake Tanganyika, Lake Victoria and Lake Turkana, since the 1960s. This is probably due to periods of intense drought followed by increases in rainfall and extreme rainfall events in late 1997 (Riebeek, 2006). It is reported that, after the 1997 flood, Lake Victoria had risen by about 1.7 m by 1998, Lake Tanganyika by about 2.1 m, and Lake Malawi by about 1.8 m, and very high river-flows were recorded in the Congo River at Kinshasha (Conway et al., 2005). The heavy rains and floods have been possibly attributed to large-scale atmosphere-ocean interactions in the Indian Ocean (Mercier et al., 2002), (IPCC, 2007).

Funk et al. also clearly link drops in the level of East African lakes to ENSO-events. Based on time series of satellite measurements of lake levels, it is stated that “following a large ENSO-related jump in 1998, levels in Lake Tanganyika, Victoria and Turkana have been dropping. Lake Tana, on the other hand, shows little trend, except perhaps for a recent drop in 2002-04.” (Figure 3.1) (Funk et al., 2005).

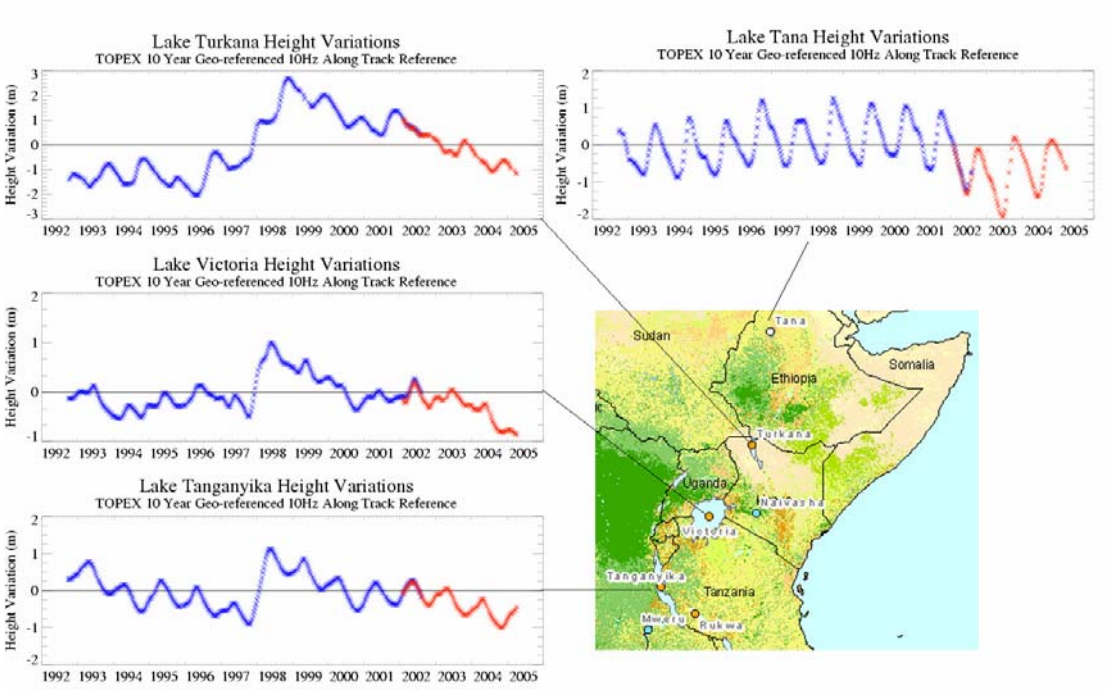


Figure 3.1: Lake levels in eastern Africa. Time series and imagery obtained from the USDA PECAD crop explorer: www.pecad.fas.usda.gov/cropexplorer/global_reservoir (Source: Funk et al. 2005)

Global warming is obviously also modifying natural mountain ecosystems and, in particular, causing glaciers and ice fields to retreat, particularly in the tropics. Environmental changes on Mt. Kilimanjaro can easily be observed. Since 1912, the area of Mt. Kilimanjaro's ice fields has decreased by about 80% (Figures 3.2 and 3.3). It has been estimated that, if current climatological conditions persist, the remaining ice fields are likely to disappear between 2015 and 2020 (Thompson et al., 2002).

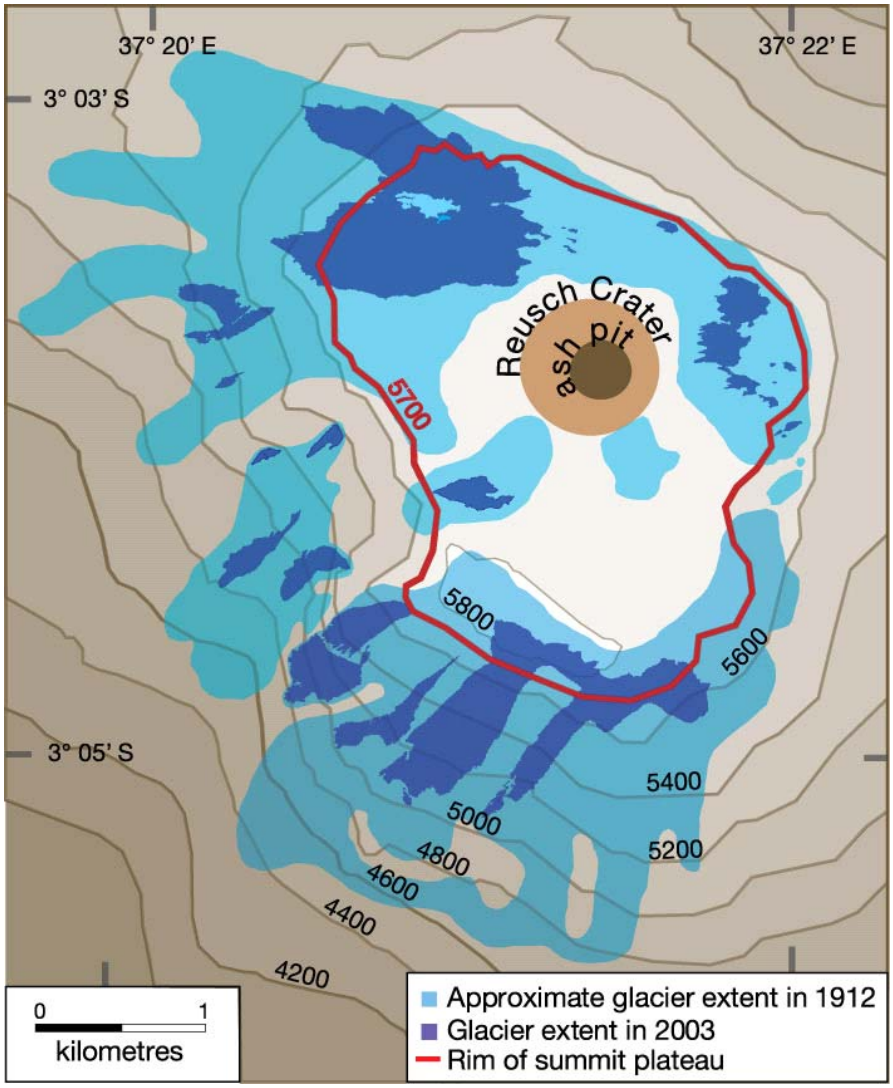


Figure 3.2: Glacier extent at Mt. Kilimanjaro in 1912 and 2003 (Source: IPCC, 2007)

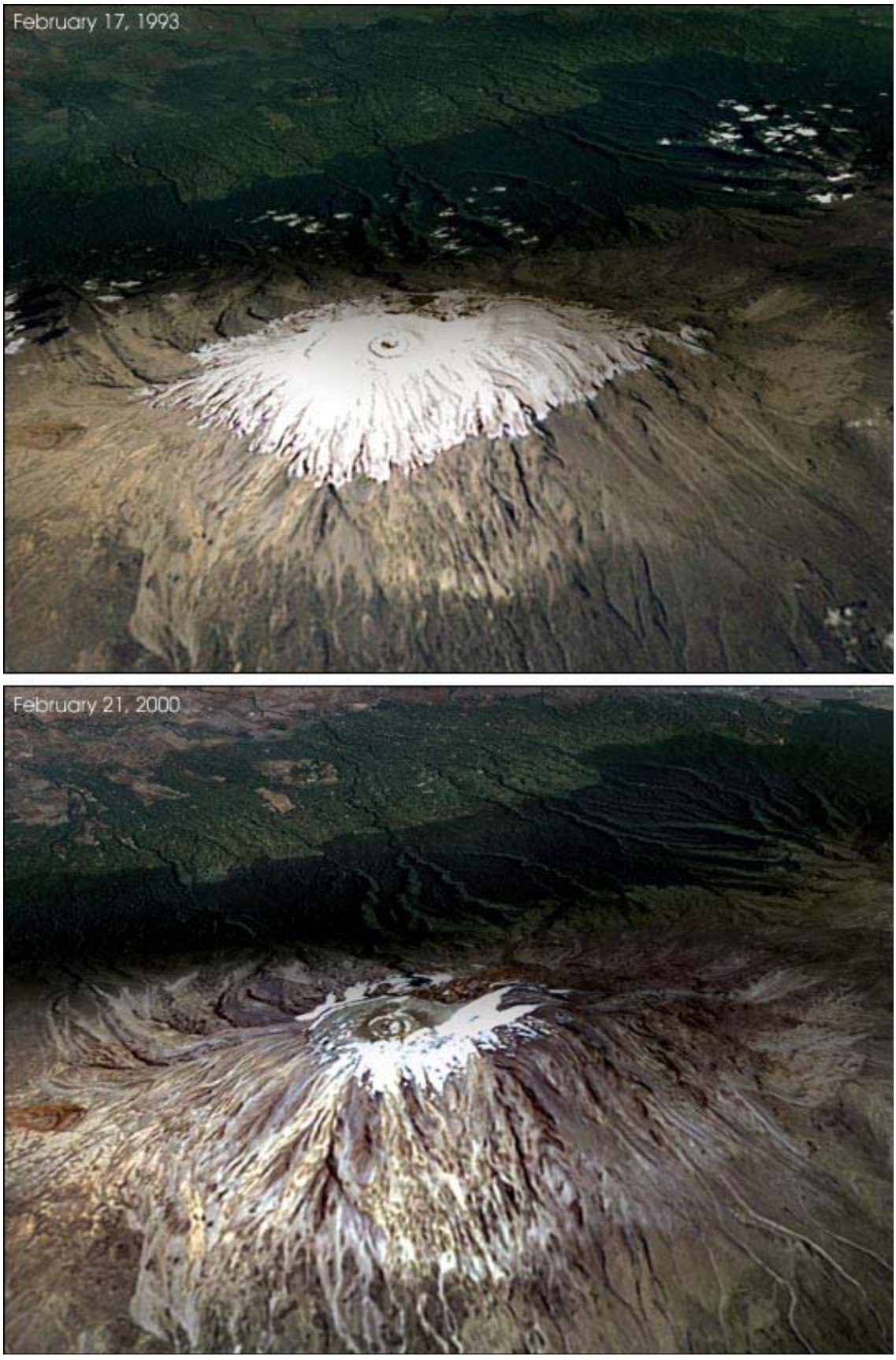


Figure 3.3: Glacier extent at Mt. Kilimanjaro in 1993 and 2000 (Source: VPO NAPA Tanzania, 2007)

In Uganda, the Rwenzori Mountains ice cover has retreated to about 40% of the value recorded in 1955 (Figure 3.4). A recent study carried out by researchers from University College London and their Ugandan partners suggests that all the glaciers in the Rwenzori Mountains could disappear within the next two decades (NAPA Uganda, 2007).

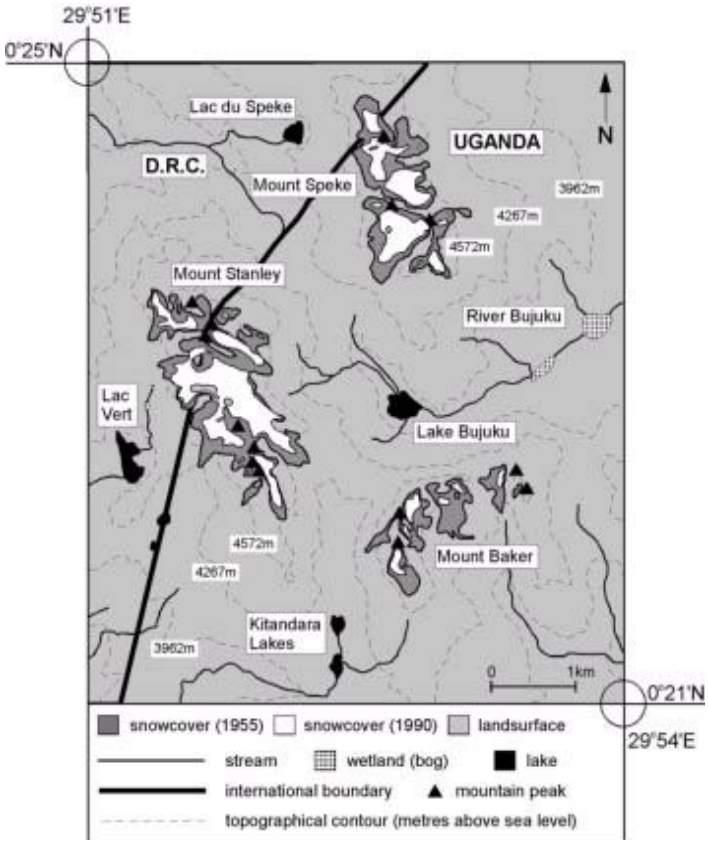


Figure 3.4: Melting of ice caps on Rwenzori mountains (Source: NAPA Uganda, 2007)

The NAPA Uganda gives an interesting example of the negative effect of the melting of the ice caps of tropical mountains on the water catchment areas and eco-tourism, as well as on the overall economy: Due to the melting of ice caps on the Rwenzori Mountains, the erosive power of river Semliki has increased. In consequence, river Semliki has disproportionately eroded the Ugandan side, literally blocked its original course and finally shifted almost one kilometre into Uganda. There is now an on-going dispute about the actual border between the Democratic Republic of the Congo and Uganda. This example demonstrates that climate change may be a potential source of regional conflict (NAPA Uganda 2007).

Similar observations have been made at Mount Kenya, where the Lewis Glacier is receding leading to water shortages, deterioration of water quality and increased competition for water. Water scarcity has already led to conflicts between large and small scale farmers and between humans and wildlife.
Figure 3.5 shows the glacier recession since the year 1947.

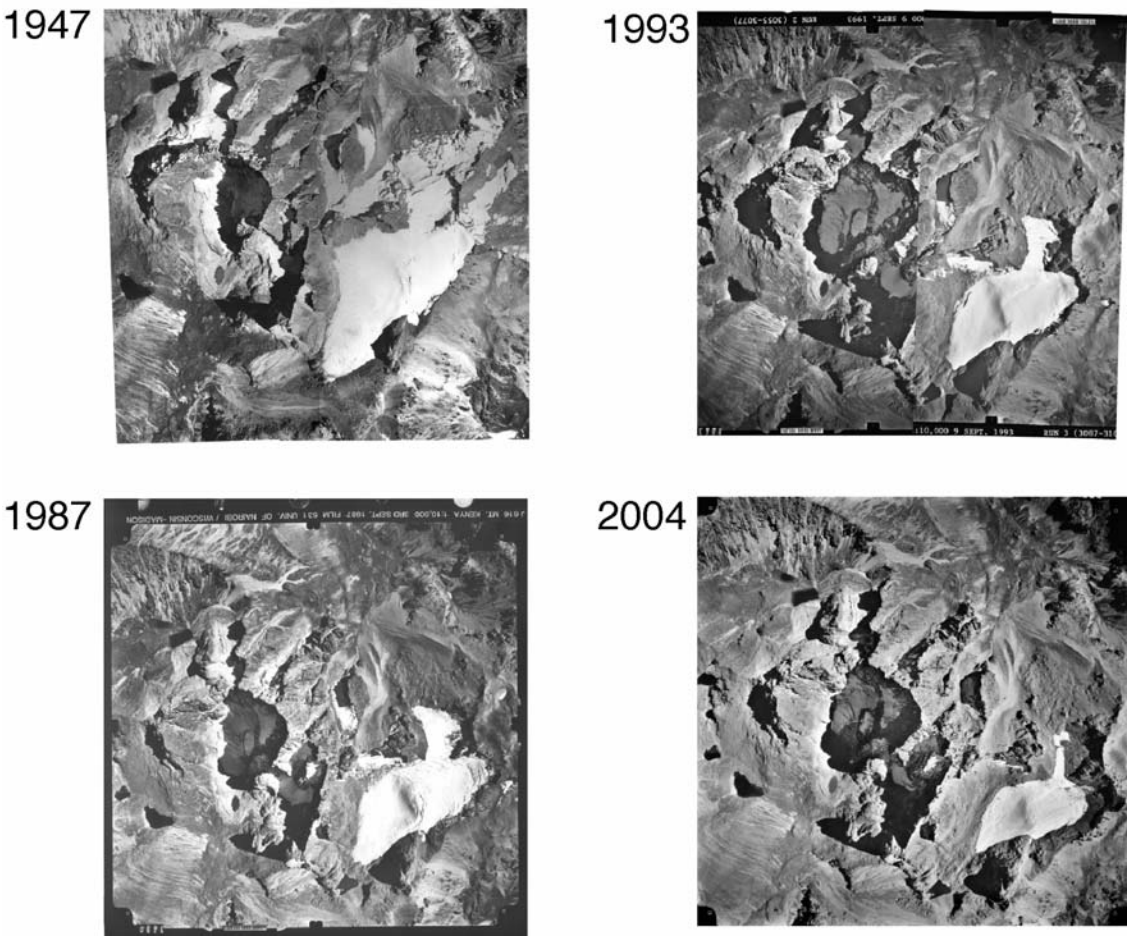


Figure 3.5: Disappearance of the Lewis glacier on Mount Kenya (Source: Kenya Meteorological Department)

Currently, two-thirds of rural Africans and a quarter of urban dwellers in Africa lack access to clean, safe drinking water (Simms, 2005). For instance, two out of three rivers in Tanzania have reduced flow due to declining regional rainfall, resulting in ecological and economic impacts such as water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity and variable hydropower production (Orindi and Murray, 2005). Due to high temperatures and less rainfall during already dry months in the Tanzanian river catchments, the annual flow to the River Pangani may be reduced by 6-9% and to the River Ruvu by 10% (VPO-URT, 2003). Considered as one of Tanzania's most agriculturally productive areas and an important hydropower production region, the Pangani Basin hosts approximately 3.7 million people. Climate change therefore threatens the productivity and sustainability of the entire region's resources (WWF, 2006).

Climate change and variability can impose additional pressures on water availability, water accessibility and water demand in Africa. An analysis of six climate models and the SRES scenarios (Arnell, 2004) shows a likely increase in the number of people who could experience water stress by 2055 in northern and southern Africa. In eastern and western Africa, however, more people will be likely to experience a reduction rather than an increase in water stress (Arnell, 2006a; IPCC, 2007).

It is nevertheless problematic to attribute sensitivity and vulnerability in the water sector to climatic variations only. Other impacts such as over-fishing, industrial pollution and

sedimentation are also degrading local water sources such as Lake Victoria (Odada et al., 2004). Present population trends and patterns of water use show that more African countries will exceed the limits of their "economically usable, land-based water resources before 2025" (Ashton, 2002).

With regard to groundwater and its climate interactions, few assessments of impacts and vulnerabilities are available. However, as the majority of East Africans depend on groundwater for their water supply, this interaction is obviously of great concern (IPCC, 2007).

3.2 East African eco-system

Recent research results clearly show that, historically, climate change has caused dramatic shifts in the geographical distributions of species and ecosystems. However, current rates of migration of species will have to be much higher than the rates during the post-glacial periods in order for species to adapt (Malcolm et al., 2002). Species which are capable of adapting to climate shifts may survive while others that cannot respond will probably suffer. As species struggle to adapt to changing conditions, climate change is expected to significantly alter African biodiversity (Lovett et al., 2005; WWF, 2006).

Changes induced by climate change may not only result in species range shifts, but also in changes in tree productivity, adding further stress to forest ecosystems (UNEP, 2004). Other ecosystems, such as grasslands, mangrove swamps and coral reefs, the main coastal ecosystems in Africa, will probably be affected by climate change (IPCC, 2007).

3.2.1 Wildlife

An assessment of the species sensitivity of African mammals was carried out in 141 national parks in sub-Saharan Africa by applying a simple IUCN Red List assessment of potential range loss (Thuiller et al., 2006). The study demonstrates[4] that, assuming no migration of species, 10-15% of the species are projected to fall within the IUCN Critically Endangered or Extinct categories by 2050, increasing to 25-40% of species by 2080.

Scientists agree, however, that observed changes in ecosystems cannot be attributed only to climate change. Additional factors, such as fire, invasive species and land use change, interact and also produce change in several African locations (Muriuki et al., 2005). Forest fires on Kilimanjaro, for instance, are already causing changes in the range of plant and animal species and may place additional pressure on ecosystem services (Agrawala, 2005). Since 1976, the loss of cloud forests through fire has reduced the generation of fog water by approximately 25% per year, which is the equivalent of the annual drinking water demand of 1 million people living on Kilimanjaro (Agrawala, 2005; Hemp, 2005, IPCC, 2007).

3.2.2 Forests

Recent research assessing biome sensitivity in Africa shows forests to be highly sensitive to climate change. Deciduous and semi-deciduous closed canopy forests, for instance, may be

4 by using two climate change scenarios (SRES A2 and B2 emissions scenarios with the HadCM3 GCM, for 2050 and 2080) (WWF, 2006)

very sensitive to small decreases in the amount of precipitation that plants receive during the growing season. This example illustrates the idea that deciduous forests may be more sensitive than grassland or savannah to reduced precipitation (Hély et al., 2006; IPCC, 2007).

East-Africa's forests are also under serious threat due to the population's high dependency on firewood and charcoal. It is estimated that these energy sources cover about 80 to 90% of the residential energy needs of low-income households in the majority of sub-Saharan countries (IEA, 2002). This was confirmed by several interview partners during the field visit.

Moreover, fire incidents also represent a huge threat to tropical forests in Africa. It is estimated that about 70% of detected forest fires occur in the tropics, with 50% of them being in Africa. More than half of all forested areas were estimated to have burned in Africa in 2000 (Dwyer et al., 2000; Kempeneers et al., 2002).

3.3 Coasts

Climate models show that, over the next several decades, sea level is expected to continue to rise. During 2000 to 2020, the rate of thermal expansion is projected to be 1.3 ± 0.7 mm per year[5] (IPCC 2007). The projected global average sea level rise at the end of the 21st century is 0.21 – 0.48 m compared to the 1980 to 1999 period[6].

Climate change and sea-level rise will affect coastal areas in several ways. A summary of climate-related impacts on socio-economic sectors in coastal zones is presented in table 3.1.

Coastal socio-economic sector	Temperature rise (air and seawater)	Extreme events (storms, waves)	Floods (sea level, runoff)	Rising water tables (sea level)	Erosion (sea level, storms, waves)	Salt water intrusion (sea level, runoff)	Biological effects (all climate drivers)
Freshwater resources	**X**	**X**	**X**	**X**	**-**	**X**	X
Agriculture and forestry	**X**	**X**	**X**	**X**	**-**	**X**	X
Fisheries and aquaculture	**X**	**X**	X	**-**	X	**X**	**X**
Health	**X**	**X**	**X**	X	**-**	**X**	**X**
Recreation and tourism	**X**	**X**	X	**-**	**X**	**-**	**X**
Biodiversity	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Settlements/ infrastructure	**X**	**X**	**X**	**X**	**X**	**X**	**-**

Table 3.1. Summary of climate-related impacts on socio-economic sectors in coastal zones.
X = strong; X = weak; - = negligible or not established.
(Source: IPCC, 2007)

In East Africa, sea-level rise and resulting coastal erosion is of particular concern for coastal Kenya and Tanzania. Due to the fact that highly productive ecosystems such as mangrove swamps, estuaries, deltas and coral reefs are located in the coastal zones, climate change also impacts the corresponding economic activities like tourism, mining and fisheries (IPCC, 2007). In particular coral reefs, which absorb the energy of ocean swells, are threatened by

[5] under the SRES A1B scenario and in the ensemble of AOGCMs. This rate is not significantly different under the A2 or B1 scenarios (IPCC 2007).
[6] under the A1B scenario

warm sea surface temperatures, extreme weather events and sea-level rise (IPCC, 2001). The potential impact of climate-change-induced ocean warming on coral reefs was clearly demonstrated by the coral bleaching which followed the 1997/1998 extreme El Nino (Lough, 2000; Muhando, 2001; Obura, 2001). In both Kenya and Tanzania, coral reef loss is a significant cause of coastal erosion and a major coastal management issue (Magadza, 2000).

The WWF stresses that productive mangrove ecosystems along coastal areas serve as a buffer against storm surges by providing protection from the erosion and rising tides associated with sea-level rise. Nevertheless, mangroves are at threat from deforestation, coastal erosion and extreme weather events and have been identified as the species most vulnerable to sea-level rise and inundation (IPCC, 2001, WWF, 2006).

Furthermore, sea-level rise is also threatening the availability of freshwater by causing salt water intrusion into Tanzania's aquifers and deltas (WWF, 2006). Kenya will very probably have to face the same challenge.

Other research results show that Indian Ocean islands may be threatened by potential changes in the location, frequency and intensity of cyclones. East African coasts may be affected by potential changes in the frequency and intensity of ENSO events and coral bleaching (Klein et al., 2002).

The economic impact of these climate-change-induced variations have not yet been quantified but in Kenya, for instance, losses for three crops (mangoes, cashew nuts and coconuts) are estimated to cost almost US$500 million for a 1 m sea-level rise (Republic of Kenya, 2002).

3.4 Human health

Health assessments demonstrate that many African countries are highly concerned by health stresses, which are caused by different factors, including poor nutrition (Sachs and Malaney, 2002; Sachs, 2005). With respect to Malaria, it is estimated that 700,000 to 2.7 million people die of malaria each year in Africa and 75% of those are African children (Patz and Olson, 2006) (IPCC, 2007).

The potential influence of climate change on malaria distribution has been widely discussed in recent years. The resurgence of malaria and its links to climate and/or other drivers of change, in particular in the highlands of East Africa, has recently been debated intensely (e.g. Hay et al., 2002a; Pascual et al., 2006). Some studies indicate, for instance, that in areas with two rainy seasons – March to June (MAMJ) and September to November (SON) – more rain is falling in SON than previously experienced in the northern sector of East Africa (Schreck and Semazzi, 2004). The SON season is relatively warm, and higher rainfall is likely to increase malaria transmission because of a reduction in larval development duration. The spread of malaria into new areas has also been documented (Chen et al., 2006, IPCC, 2007), e.g. observations of the malaria vector Anopheles arabiensis in the central highlands of Kenya, where no malaria vectors have previously been recorded.

However, the recent resurgence of malaria in the highlands of East Africa may involve multiple other causal factors, such as poor drug-treatment implementation, drug resistance, land-use change, and various socio-demographic factors including poverty (Githeko and Ndegwa, 2001; Patz et al., 2002; Abeku et al., 2004; Zhou et al., 2004; Patz and Olson, 2006). Land use changes, such as swamp reclamation for agricultural use and deforestation

in the highlands of western Kenya may contribute to changes in the micro-climate, thus creating suitable conditions for the survival of Anopheles gambiae larvae and leading to an increase in malaria risk (Munga et al., 2006).

The average ambient temperature in the deforested areas of Kakamega in the western Kenyan highlands, for example, was 0.5°C higher than that of the forested area over a 10-month period (Afrane et al., 2005). Moreover, mosquito pupation rates and larval-to-pupal development are significantly faster in farmland habitats than in swamp and forest habitats (Munga et al., 2006; IPCC, 2007).

Climate is obviously a major limiting factor in the spatial and temporal distribution of malaria. Nevertheless, many non-climatic factors such as drug resistance and HIV prevalence, cross-border movement of people, agricultural activities, emergence of insecticide resistance, and the use of DDT for indoor residual spraying, may alter or override the effects of climate (Craig et al., 2004; Barnes et al., 2005; IPCC, 2007).

Future trend analyses estimate that, by 2100, malaria distribution may increase by 5-7%, mainly by extending to higher altitudes (Tanser et al., 2003). Previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi may experience modest incursions of malaria by the 2050s, with conditions becoming highly suitable for transmission by the 2080s (IPCC, 2007). The highlands of eastern Africa are likely to become more suitable for malaria transmission (Hartmann et al., 2002). Due to the lack of protective genetic modifications in the newly-affected populations, the frequency of epidemics is also likely to increase. In areas of low to moderate transmission, such as the highlands of East Africa and other areas of seasonal transmission, severe malaria-associated disease is more common. An epidemic in Rwanda, for example, led to a four-fold increase in malaria admissions among pregnant women and a five-fold increase in maternal deaths due to malaria (Hammerich et al., 2002; IPCC, 2007).

With respect to climate variability and change, other diseases must be taken into account. Links between variations in climate and other diseases, such as cholera and meningitis, have also been observed. For instance, about 162 million people in Africa live in areas with a risk of meningitis (Molesworth et al., 2003; IPCC, 2007).

4 Vulnerability to climate change in East Africa

Economic development, and in particular poverty alleviation, is a major issue for many African countries, which may consider climate change as a negligible problem compared to the huge challenge of hunger and poverty. But in recent years it has become evident that climate change impacts might hinder the achievement of development goals in developing countries.

Several arguments for integrating climate change issues into development policies and thus reducing vulnerabilities have been framed by Davidson et al (2003):

- Food production needs to double to meet the needs of an additional 3 billion people in the next 30 years. Climate change is projected to decrease agricultural productivity in the tropics and sub-tropics for almost any amount of warming.
- One third of the world's population is now susceptible to water scarcity. Populations facing water scarcity will more than double over the next 30 years. Climate change is projected to decrease water availability in many (semi-)arid regions.
- Wood fuel is the main source of fuel for one third of the world's population. Wood demand is expected to double in the next 50 years. Climate change will make forest management more difficult, due to increases in pests and fires.
- Today, 1,6 billion people are without electricity. Electricity demand in developing countries will increase three to five times over the next 30 years. Fuel based electricity production will exacerbate climate change.

The following chapters try to give an overview of possible vulnerabilities of economic sectors in East Africa to climate change.

4.1 Primary production

4.1.1 Agriculture, crop production and food security

Various assessments of climate change impacts on agriculture in Africa state that certain agricultural areas might undergo negative changes (Mendelsohn et al., 2000b).

The UNFCCC states with respect to food security in Africa that, due to climate change, yields from rain-fed crops could be halved by 2020 in some countries. Net revenues from crops could fall by 90% by 2100 (UNFCCC, 2007).

Detailed scientific research on potential crop losses due to climate change in East Africa is still lacking. However, East Africa's strong dependence on rain-fed agriculture and the resulting vulnerability to climate change makes crop impact assessment a top priority.

In East Africa, the link between climate and livelihood is very strong. As East Africa depends heavily on rain-fed agriculture, rural livelihoods are highly vulnerable to climate variability such as shifts in growing season conditions (WWF, 2006; IPCC, 2001). Furthermore, agriculture contributes 40% of the region's GDP and provides a living for 80% of East Africans (IFPRI, 2004). Due to temperature increase in the region and precipitation decrease

in some areas, impacts can already be observed. For instance, from 1996 to 2003, a decline in rainfall of 50-150 mm per season (March to May) led to a corresponding decline in long-cycle crops (e.g. slowly maturing varieties of sorghum and maize) across most of eastern Africa (Funk et al., 2005). Long-cycle crops depend upon rain during this typically wet season and progressive moisture deficit results in low crop yields in the fall, thereby impacting the available food supply (WWF, 2006).

According to the FAO State of Food Insecurity Report (2004), all East-African countries suffered from weather-related food emergencies in 2003-2004, and can therefore be considered as vulnerable to the impact of climate change on their agriculture (Figure 4.1). Uganda also had to face the same challenge, but the food insecurity in Uganda was caused more by conflicts than by weather events (FAO, 2004; Funk et al., 2005).

Figure 4.1: Shaded regions indicate weather-related food insecurity hotspots for 2003-04, as defined in the FAO State of Food Insecurity Report for 2004. The rectangle encloses the equatorial and subtropical eastern African nations. (Source: Funk et al. 2005)

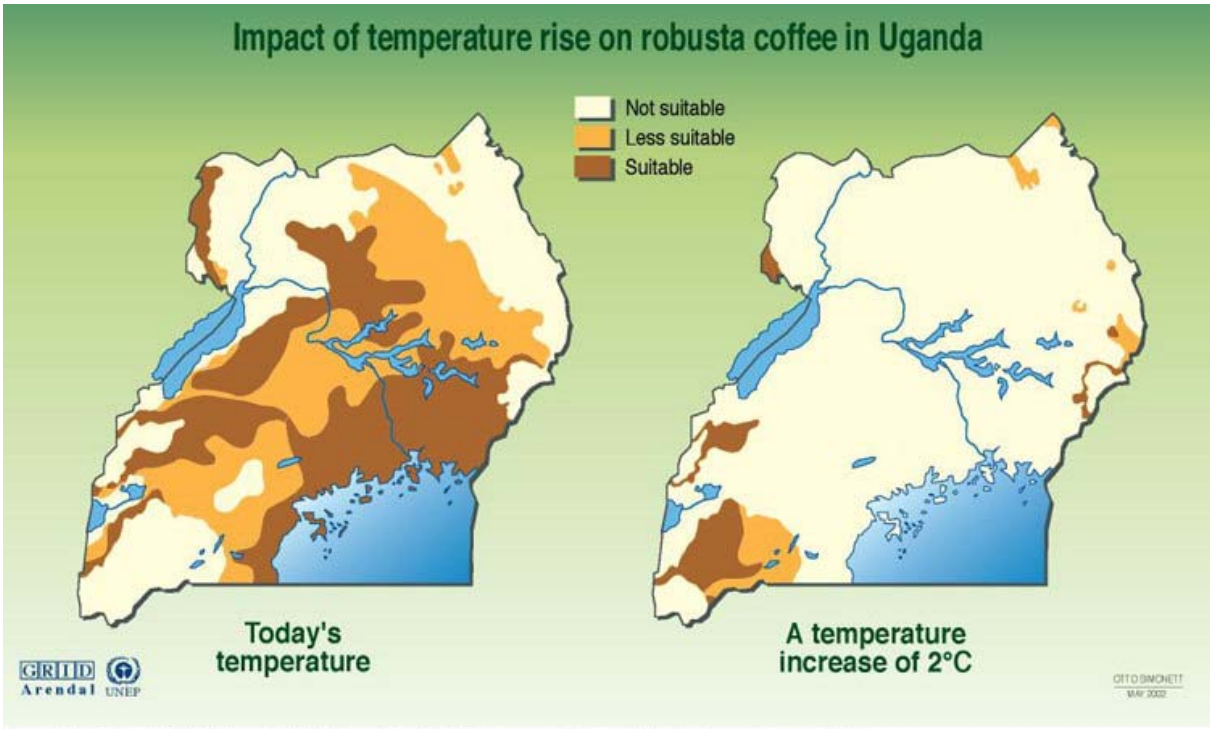
Some specific studies and analysis on potential impacts of climate change on crops in East Africa are available.

It is reported for Tanzania that, in the same farming system, positive and negative impacts may occur on different crops. It is suggested that impacts on maize, the main food crop, will be strongly negative for the Tanzanian smallholder, while impacts on coffee and cotton, significant cash crops, may be positive (Agrawala et al., 2003).

In Kenya, a 1-m sea-level rise would cause losses of almost US$500 million for three crops (mangoes, cashew nuts and coconuts) (Republic of Kenya, 2002). In the tea-producing

regions of Kenya, a small temperature increase of 1.2 °C and the resulting changes in precipitation, soil moisture and water irrigation could cause large areas of land that now support tea cultivation to be largely unusable. As Kenya is the world's second largest exporter of tea and as tea exports account for roughly 25% of Kenya's export earnings and employs about three million Kenyans (10% of its population), the economic impact could be tremendous (Simms, 2005, WWF, 2006).

The Ugandan National Adaptation Programme for Action demonstrates the dramatic impact that a 2°C temperature rise might have on coffee growing areas in Uganda (Figure 4.2). The analysis indicates that most areas could become unsuitable for coffee growing.



Source: Otto Simonett, Potential impacts of global warming, GRID-Geneva, case studies on climatic change. Geneva, 1989.

Figure 4.2: Impact of a 2°C temperature rise on coffee production in Uganda
(Source: NAPA Uganda, 2007; Otto Simoneit, GRID-Geneva, 1989)

4.1.2 Livestock production

Research on the impact of climate change on livestock farming in Africa has recently been conducted by Seo and Mendelsohn (2006a, b, cited in IPCC, 2007). Their results show:

- in case of a 2.5°C°temperature rise, the income of small livestock farms could increase by 26% (+US$1.4 billion), in particular due to stock expansion;
- further increases in temperature, however, would then lead to a gradual fall in net revenue per animal;
- a warming of 5°C would probably increase the income of small livestock farms by about 58% (+US$3.2 billion), largely as a result of stock increases;
- however, a warming of 2.5°C would be likely to decrease the income of large livestock farms by 22%(–US$13 billion);
- a warming of 5°C would probably reduce income by as much as 35% (–US$20 billion), resulting both from a decline in the number of stock and a reduction in the net revenue per animal;

- increased precipitation of 14% would be likely to reduce the income of small livestock farms by 10%(–US$ 0.6 billion), mostly due to a reduction in the number of animals kept;
- the same reduction in precipitation would be likely to reduce the income of large livestock farms by about 9% (–US$5 billion), due to a reduction both in stock numbers and in net revenue per animal.

The study by Seo and Mendelsohn (2006a) also indicates that higher temperatures are beneficial for small farms that keep goats and sheep because it is easy to substitute animals that are heat-tolerant. Large farms, however, are more dependent on species such as cattle, which are not heat-tolerant. Increased precipitation is likely to be harmful to grazing animals because it implies a shift from grassland to forests and an increase in harmful disease vectors, and also a shift from livestock to crops (IPCC, 2007).

Detailed research on livestock vulnerability in East Africa is lacking and impact assessments should be carried out.

An example for the impact of climate change on livestock in East Africa is given in the NAPA of Uganda. The subdivision of the Ugandan climate is reflected in the distribution of natural resources such as water, forest and vegetation. The so-called “Cattle Corridor” lies in the semi-arid climate and is predominantly a pastoral area although the rainfall is sufficient to support the growing of food for consumption in the area and neighbouring regions (Figure 4.3).

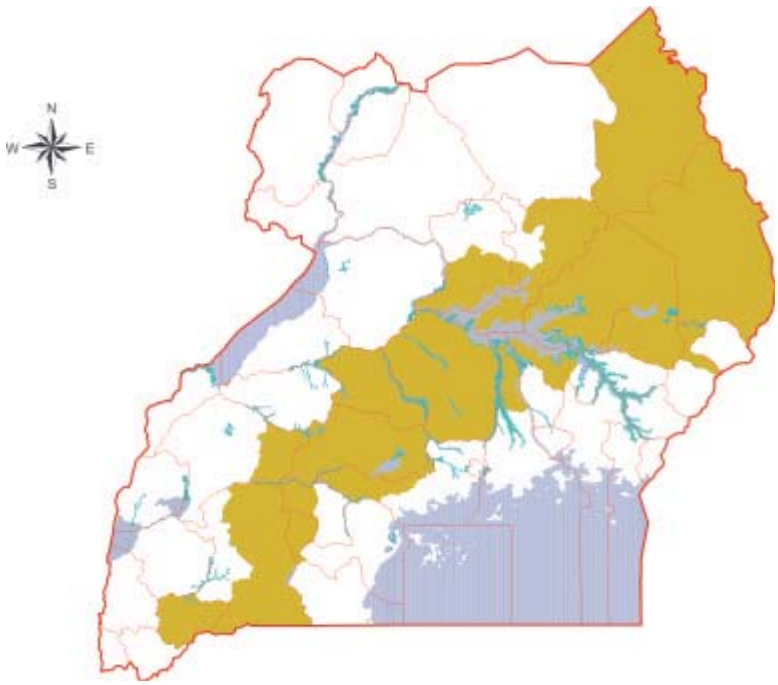


Figure 4.3: The cattle corridor in Uganda (Source: NAPA Uganda, 2007)

The cattle corridor, stretching from the northeast to the southwest of Uganda, is a fragile ecosystem and depends on rainwater for human consumption and production. The prolonged and severe drought of 1999/2000 and the resulting water shortage, led to loss of animals, low production of milk, food insecurity, increased food prices and generally negative effects on the economy (NAPA Uganda, 2007).

Figure 4.4 illustrates the impact of the 2005 drought on cattle in Nakasongola (in the Cattle Corridor).

Figure 4.4: Impact of the 2005 drought on cattle in Nakasongola (in the Cattle Corridor) (Source NAPA Uganda, 2007)

4.1.3 Fisheries

Fisheries represent a significant source of revenue, employment and proteins for all East African countries. Climate change may have an impact on fisheries as has been demonstrated for Lake Tanganyika by O'Reilly et al. (2003). They conclude that primary productivity in Lake Tanganyika may have decreased by as much as 20% over the past 200 years. Recent declines in fish abundance in East African Rift Valley lakes have also been linked to climatic impact on lake ecosystems (O'Reilly, 2007).

As many tropical fish have a critical thermal maxima beyond which they are unable to survive, climate change may also impact fisheries in East Africa (WWF, 2006). Many tropical fish can indeed endure temperatures that are close to their temperature threshold. A 1 to 2°C increase, however, may exceed these limits, in particular for populations that currently exist in thermally marginal habitats (Roessig et al., 2004). However, because there is little data on the ability of these species to adjust their tolerance to water temperature, their response to climate change is largely unknown (WWF, 2006).

Although the impact of climate change on fisheries is likely to be significant, it clearly needs to be assessed together with other human activities, including impacts that may arise from governance of fresh and marine waters (AMCEN/UNEP, 2002). Furthermore, other factors depleting fish resources should be taken into account, such as pollution and overfishing.

4.2 Other sectors

4.2.1 Tourism

Tourism is a major resource of revenue for East African countries, particularly in terms of game watching, coastal tourism and eco tourism. Climate-change-related impact on natural resources therefore has direct effects on the East African tourism industry. Climate change could thus place tourism at risk, particularly in coastal zones and mountain regions (IPCC, 2007).

For instance, the 1997/1998 coral bleaching episode observed in the Indian Ocean and Red Sea was coupled with a strong ENSO. In the western Indian Ocean region, a 30% loss of corals resulted in reduced tourism in Mombasa and Zanzibar, and caused financial losses of about US$12-18 million (Payet and Obura, 2004, IPCC, 2007).

Moreover, tourism in developing countries, including East Africa, might be subject to changes in the behaviour of tourists due to increasing environmental awareness. Although scientific evidence is still lacking, it is probable that flood risks and water-pollution-related diseases in low-lying regions (coastal areas), as well as coral reef bleaching as a result of climate change, could have a negative impact on tourism (McLeman and Smit, 2004, IPCC, 2007). However, modelling climate changes as well as human behaviour, in particular personal preferences, choices and other factors, is exceedingly complex.

4.2.2 Energy

Due to extreme poverty and the lack of access to other fuels, 80% of the overall African population relies primarily on biomass to meet its residential needs. This fuel source supplies more than 80% of the energy consumed in sub-Saharan Africa (Hall and Scrase, 2005; IPCC, 2007). In Kenya, Tanzania, Mozambique and Zambia, for example, nearly all rural households use wood for cooking and over 90% of urban households use charcoal (IEA, 2002; van Jaarsveld et al., 2005; IPCC, 2007). It is clear that dependence on biomass as a primary energy resource can increase the removal of vegetation.

There is also a strong link between climate change and hydropower generation which might be impacted by reduced rainfall and river flow rates. Decreasing East African lake levels are likely to have a direct negative influence on hydropower generation. Thus, East African countries should consider climate change impacts and integrate potential vulnerabilities into their energy policy planning.

4.2.3 Infrastructure and Industry

Regarding the impact of climate change on infrastructure and industry, IPCC summarizes that “climate variability, including extreme events such as storms, floods and sustained droughts, already has marked impacts on settlements and infrastructure (Freeman and Warner, 2001; Mirza, 2003; Niasse et al., 2004; Reason and Keibel, 2004). Negative impacts of climate change could create a new set of refugees, who may migrate into new settlements, seek new livelihoods and place additional demands on infrastructure (Myers,

2002; McLeman and Smit, 2005). A variety of migration patterns could thus emerge, e.g. repetitive migrants (as part of ongoing adaptation to climate change) and short-term shock migrants (responding to a particular climate event). However, few detailed assessments of such impacts using climate as a driving factor have been undertaken for Africa" (IPCC, 2007).

Climate change primarily manifests itself in terms of temperature increase, sea level rise, variability of precipitation pattern, change in the frequency and intensity of extreme events. These secondary changes along with primary manifestations of climate change act as the main force causing impacts.

The East African transport system was designed and built for local weather and climate conditions, predicated on historical temperature and precipitation data. This report notes that climate predictions used by planners and engineers may no longer be reliable in the face of new weather and climate extremes. Infrastructure is vulnerable to flooding and landslides rather than temperature changes. Detailed modeling of frequency and intensity of rainfall impacts on infrastructure in the local and regional context is still a challenge.

4.3 Vulnerability of social groups and conflict related risks

Broadly a society's vulnerability to climate variability reflects its degree of exposure and its capacity to adapt. Exposure has two basic elements: the climatic conditions themselves and the extent and character of the population, wealth and development exposed to them. Capacity is a society's ability to adapt to changing climatic conditions, whether by reducing harm, exploiting beneficial new opportunities or both. The ability to adapt is in part a function of a society's level of wealth, education, institutional strength and access to technology. The nature and the extent of a society's development therefore heavily influence both its degree of exposure to climatic risk and its capacity to adapt.

While vulnerability to climate change varies from country to country it is highest in developing countries. First latitudes, where impacts such as increased disease and extreme heat and drought are more pronounced. The East African community countries derive a large proportion of their economic output from climate sensitive sectors such as agriculture, fishing and tourism. In addition, EAC countries generally have weak institutions, lower per capita incomes and less access to technology, credit and international markets, hence lower adaptive capacity. Absorbing the impacts of climate change will hamper achievement of UN Millennium Development Goals (MDGs) including those on reducing poverty, child mortality and combating HIV/AIDS, malaria and other diseases.

Because not all communities are equally endowed with environmental and social assets, disaster vulnerability differs between regions, countries and socio economic groups. The economic losses stemming from disasters can consume a significant proportion of their GDP and set economic development back for several years. The indirect economic impacts of climate related disasters are substantial in terms of poverty alleviation and sustainable development. Disasters create unemployment and lead to a loss in investor confidence, increased foreign indebtedness and depletion of capital reserves. They also cause diversion of funds away fro social programs and infrastructure investments towards less productive relief and reconstruction efforts. East Africa is highly vulnerable because it is located in hazard prone areas. Already under stress from the forces of poverty, population growth, environmental degradation, the EAC stands to suffer and lose because of climate change.

Within East Africa, certain sectors of the population are particularly vulnerable to disasters and natural hazards. Defined by their structural and non- structural disadvantages these sectors lack the resources to live in safer areas and secure lifestyles and employment less exposed to risk. Coastal communities are particularly vulnerable to disasters as they lack the capacity to protect themselves and recover from impact of hazards.

4.3.1 Women and children vulnerability

Climate change has particular implications for women who are responsible for gathering fuelwood and water and for tending fields. When hit by crop failure and livestock deaths, men tend to migrate leaving women and children. These events cause higher economic losses, contributing to higher food prices and undermining food security with ever greater frequency. Additionally, women and children are disproportionately affected by the impacts of climate related disasters. For women biological factors such as lactation and childbirth can increase vulnerability due to an increased need for food and water as well as limited physical mobility.

Social factors that create vulnerabilities for women in East Africa include inferior social positioning, which can translate to limited access to income, education and communication. All these conditions prevent women from learning about appropriate protective measures. As the primary care givers to children and the elderly disabled, women are expected to cater for a large number needs during crisis. This calls for an understanding that vulnerability to natural disasters is socially constructed. Tackling sources of vulnerability-poverty and marginalization, ecological destructive practices require the integration of vulnerability in development planning.

4.3.2 Conflict-related risks

Climate change will create conflicts over the shared environmental resources such as water, grazing and land across the EAC countries, (Vorosmarty et al., 2005). In pastoral areas severe drought will be accompanied by increased violence and insecurity as people struggle to access scarce grazing resources, Progressive drought interspersed with floods will increase disease incidence.

Some shared resources such as water and pasture have been negatively affected in the recent years as a result of climate change. The result has been conflicts between humans themselves as well as conflicts between humans and wildlife. Examples:

Year 2001:	Fight between monkeys and human beings in Mandera area. Cause was scramble for limited water resources for drinking and other domestic uses.
Year 2002:	Clashes between pastoral and farming communities in Tana River district. Cause was limited water resources and dwindling pasture
December 2004:	Clashes between pastoral and farming communities in Samburu and Laikipia districts. Cause was limited water and grazing areas
January 2005:	Clashes between communities living in Naivasha region of Nakuru district. Cause was scramble for limited available water for use by pastoralists on one hand and a large scale farmer on the other hand.
January 2005:	Clashes between farming and pastoral communities living in Trans-Nzoia district. Cause was limited pasture for pastoralists

4.4 Conclusion

It may be concluded for this chapter that all the sectors discussed obviously require much more detailed investigation. Despite the uncertainty of the science and the huge complexity of the range of issues outlined, initial assessments show that several regions in East Africa may be heavily affected by various impacts of climate change. As detailed assessments are lacking, however, adaptive measures might point in the wrong direction.

5 Economic Impact Assessment

5.1 Background

Climate change is an important global problem that has been extensively discussed in recent years. Focus on identification and prediction of the economic impacts of climate change on different economic sectors has increased. In this review and analysis we use time series of national rainfall and macro economic indicators to discern the impacts of climate variability and extremes (basically drought), on the economies of East African Community (EAC). We focus on major drought events and also some recent floods.

The East African Community (EAC) is one of the least developed regions in the world, with a combined GDP of 149 billion USD and a population of 125 million in 2008. The structure of EAC economies is such that they are highly exposed to climate variability and its extremes. Agriculture is the main source of livelihood to an overwhelming majority of East Africans and accounts for up to 45% of total GDP and about 85% employment in some countries such as Burundi and Rwanda. The share of GDP is much lower in some countries such as Kenya and Uganda accounting for about 26% of GDP and 70% of employment. Agriculture is the main source of export earnings and raw materials for local agro-industry. The nature of EAC's agriculture, that it is primarily rainfed, with a large number of agro-pastoralists and pastoralists, implies that production is highly sensitive to fluctuations in rainfall. Rainfall in many parts of East Africa falls in two seasons and shows high levels of variability.

Major droughts result in sharp reductions in agricultural output, related to productive activity, and employment. This in turn can lead to lower agricultural export earnings and other losses associated with decline in rural income, reduced consumption and investment and destocking and may have additional multiplier effects on the monetized economy.

Major droughts have been recorded in East Africa in 1970, 1975, 1979-80, 1989-90, 1999/2000 and 2005. When weighted by impact on GDP it appears that drought poses a substantially higher impact risk than floods.

Fluctuations in rainfall lead to output and price volatility and periodic risk of famine. A 10 percent reduction in rainfall in a particular year reduces growth 4-5 years later by one percentage point, (World Bank 2005). During the consecutive years 1984 and 1985, in Kenya there was a decline in crop production leading to a 12 percent drop in agricultural GDP leading to a decline in overall growth rate of GDP.

5.2 Droughts, Floods and the EAC's Economy

Climatic variability and extremes are a great concern for East African countries where they may significantly affect GDP and employment. EAC countries are very agrarian nations as close to (26-45%) of GDP comes from agriculture and roughly 80% of the labour force works in the sector. For the most part export earnings are generated from agriculture, while agriculture remains a big supplier of raw materials and purchasing power for industry. The economies are dependent on rain-fed agriculture; about 95% of EAC's crop land is rain-fed.

Metrological drought can be defined as "a reduction in rainfall supply compared with a specified average condition over some specified period" (Hulme 1995). An economic

drought is considered to involve low rainfall that is outside the normal expected parameters with which an economy is equipped to cope, i.e. an event that brings economic consequences.

In East Africa climate variability may have devastating impacts on the economies. Major droughts typically result in sharp declines in agricultural output, related productive activity, and employment. In turn, this will lead to lower agricultural export earnings and other losses associated with a decline in rural income, reduced consumption and investment, and destocking (World Bank, 1998). Significant droughts also have additional multiplier effects on the monetary economy, the rate of inflation, interest rates, credit availability, levels of savings, the government budget deficits, and external debt stocks.

Of the top ten disasters in East Africa between 1970 and 2003, most were caused by droughts (1969, 1979, 1980, 1984, 1989, 1990, 1992, 1999 and 2000). The greatest numbers of people affected by drought were in 1999-2000 which affected 4.4 million people in Kenya alone and about 14.2 million in other EAC countries (World Bank, 2007). Many drought years (1966-70, 1979-84, 1990-92, and 1999-00) in East Africa have been associated with the El Nino-Southern Oscillation (Ogallo 2007).

The rainfall and temperature data used in the study is derived from the major food producing regions of the East African countries. It is difficult to aggregate national temperature and rainfall data figures owing to differences in weather patterns and growing seasons. However, using regional data from regional stations, we have derived averages which are assumed here to represent national figures. Using the national figures for the years 1965 to 2006, we derive averages for East Africa, which are then used in the analysis here. The average national rainfall series for East African countries shows that between 1965 and 2000 negative anomalies were recorded in 19 years out of which the biggest shortfalls were in 1965 (-9%), 1969 (-14%), 1973 (-15%), 1978 (-22%), 1984 (-29%), 1990 (-10%), 1994 (-12%), and 1999 (-11%). These years generally fit with the years identified as dry years in East Africa although droughts are generally regional in extent and may not appear in national figures.

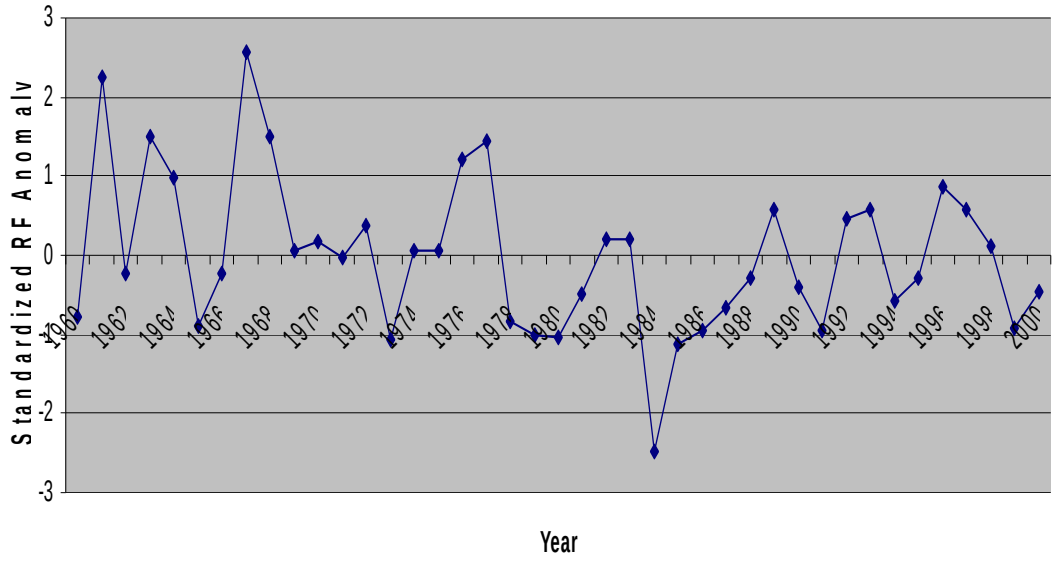


Figure 5.1: Standardized rainfall anomaly (Regional averages)[7]

[7] Calculated from annual average rainfall precipitation

In the following sections drought impacts on macroeconomic indicators are discussed.

5.2.1 Drought and GDP

A World Bank report asserts that agriculture in sub Saharan Africa is failing to cope with population growth resulting in zero growth in agricultural GDP per capita. This picture, it argues, is further characterized by huge fluctuations from year to year, largely in response to erratic rainfall (World Bank, 2008). It is often seen that fluctuations in rainfall lead to output and price volatility and periodic risk of famine. A 10% lower rainfall in a particular year reduces growth 3-4 years later by one percentage point. In East Africa currently on average some 10% of the rural population is classified as chronically food insecure.

Observations on major rainfall deficient years and the major macro variables show a significant relationship between rainfall amount and GDP. Focusing on major drought years, a negative rainfall anomaly, mainly if it is more than 10% brings a loss in agricultural GDP. When the 1999-2000 drought affected an estimated 13.2 million people, destroyed crops, caused deaths of animals, and affected millions of people the rainfall anomaly was about 29% based on the annual average figures though the rainfall distribution was not uniform. The crop production loss was (-16.8%). In the two consecutive years of 1999 and 2000 agricultural GDP in EAC declined by 11% and 14% leading to a GDP growth rate of -5% and -5.8% (Own estimation from Various EAC Annual Country Reports).

To get indicative comparisons between rainfall variability and macro economic variables, we aggregate agricultural GDP and annual GDP for the East African countries, covering the period 1962 to 2004 and from those values we generated annual averages for GDP growth rate and agricultural GDP. These values were then mapped on to the rainfall values derived in the previous section. Figure 5.2 shows the graphic relationship between rainfall, agricultural GDP and GDP in EAC. Since GDP figures after 1980/81 are based on factor cost of 1980/81, seemingly disproportional growth is seen on the graph. The pre-1980/81 figures are at 1970/71 factor cost (World Bank). Due to the dominance of agriculture in the economies, agricultural growth is clearly correlated with overall GDP growth. In many cases, both agricultural and total GDP growth rates are also correlated to rainfall variability; this is apparent especially around the drought years of 1984/85, 1999/2000.

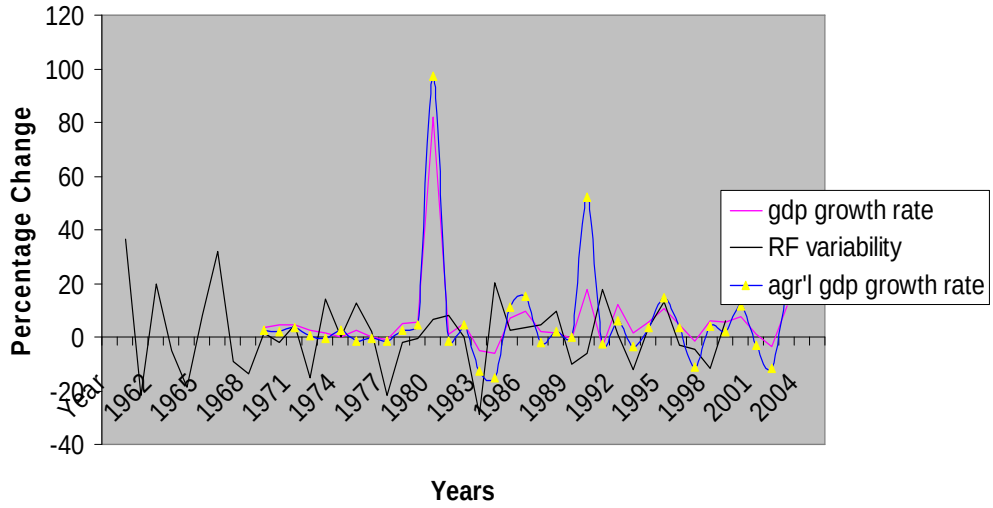


Figure 5.2: GDP and agricultural GDP growth rates and rainfall variability in East Africa

Table 5.1 summarizes the year-to-year fluctuations of major macro variables along with select drought years and rainfall anomalies. The figures show that rainfall deficiencies of certain years seem to cause reductions in agricultural output and GDP. While the nature and scale of drought varies from one year to the other, some of the events left huge economic disasters (1971-74, 1984/85, 1987/88, 1999/00). These drought years caused huge losses of GDP and left tremendous macroeconomic crises. On the other hand, GDP growth rates were not significantly affected in some years despite rain deficiencies. This is partly because the events were regional and/or intra annual; for example, if the significant decline in rainfall happens in regions that are not important producers of agricultural products, the average rainfall figures will fall much more than agricultural GDP. Similarly, if the rainfall shortfall happen in those seasons of the year where agricultural output will not be significant affected, reported mean rainfall figures will drop much more than crop production. Despite rain shortage, some years show a positive growth rate, shown in brackets in Table 1, possibly explained by changes in other variables. For example, a positive growth rate of GDP in 1992/94, despite the rain deficiency of 12%, might have been caused by the liberalization policy in most of EAC economies. Similarly, exports of 1992/94 grew probably as a result of price liberalization.

Some of the drought effects were not felt at regional scale since they affected only some parts of East Africa. It is obviously very important to isolate the effects of other factors – like the forex fluctuations, political events – affecting agricultural and total GDP growth. These figures are merely indicative and in addition to the shortage of other relevant data and time, the exercise would entail a difficult methodological challenge.

Drought year	Rainfall deficiency (%)	Agricultural GDP loss in %	GDP loss in %	Loss on export earning
1970/71	15.2	0.50	0.07	17.00%
1979/78	22.0	1.58	1.13	7.98%
1980/83	29.0	27.00	10.00	20.00%
1990/91	10.2	(0.22)	0.43	17.50%
1992/94	11.9	3.64	(1.60)	(9.00%)
1999/00	7.0	11.18	1.44	(8.48%)

Table 5.1: Major drought years and changes in GDP in EAC countries (Source: Computed from Rainfall data and Various Country Accounts Bulletins)

These estimates should be interpreted with caution as they are based on a univariate analysis where other confounding factors are not controlled for. In order to disentangle the pure impact of climate variability (which is defined in general terms as an increase or reduction in mean annual rainfall and/or temperature from the long term average), a multivariate analysis where all the explanatory factors are taken into consideration should be conducted. One such case study that looks into the impact of climate change (both rainfall and temperature variability) on mean and variance of yield (both at national and regional level) should be considered for the future.

5.2.2 Drought and the External Sector

The last column of Table 5.1 presents loss of export earnings during typical drought years, which are consistently larger than the percentage losses of agricultural GDP; this is expected since 80% of the EAC region's exports come from agriculture. For instance, in 1979 when there was a rainfall deficiency of 22%, export loss was 8%, while agricultural GDP decreased by about 1.6%. The 1980/84 drought years with a 29% deficiency brought about a 20% reduction in export earnings and a successive slump of 18% and 9% in the drought years that followed. The overall implication of the link is that downward variation leads to a substantial reduction in export earnings. Volumes of the main export items, namely coffee, tea etc. invariably depend on the amount of rain just like the food grains that expose the region to critical food shortages.

Interestingly, while EAC is categorized as an agrarian region, food imports into East Africa have increased significantly. Food imports as percentage of merchandise imports were only ranging between 2% and 10% until 1970s which grew, to an average of 12% after 2000 (World Bank calculations).

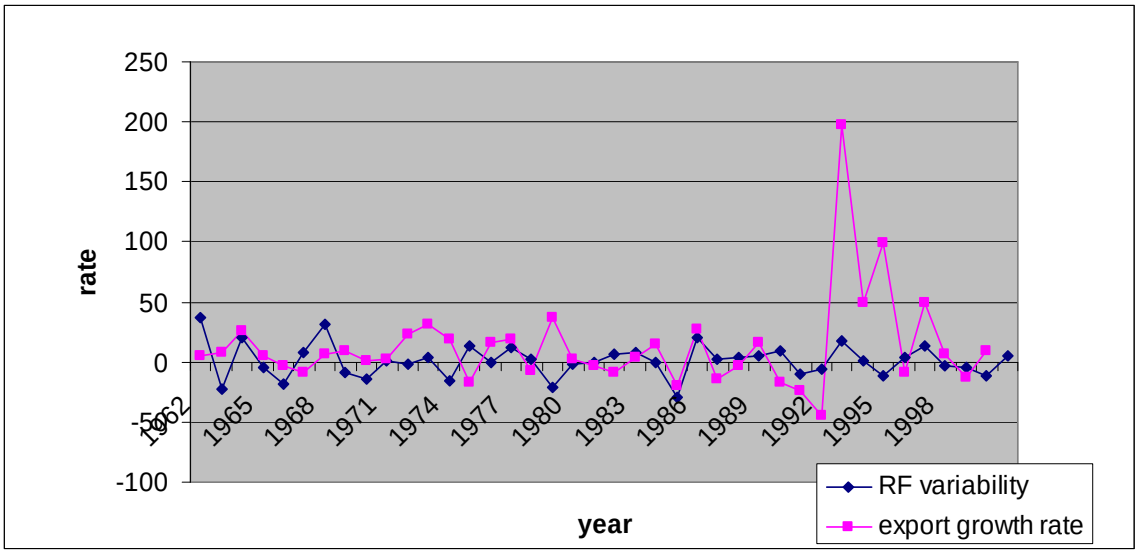


Figure 5.3: Rainfall variability and export growth rate

Due to flawed data and/or limitation of statistics, it is difficult to compute the correlation between current account deficits and rainfall, the impact on the visible trade deficit are traceable as summarized above. However, there is no doubt that the EAC's growing demand for imports coupled with fledgling exports is causing an expanding trade deficit; as indicated above, the growth of agricultural exports – constituting the bulk of EAC's exports – is highly sensitive to climatic variability.

5.2.3 Drought and Prices

One of the immediate effects of a drought year is increase in consumer prices as food shortage occurs. Where food consumption constitutes the lion's share of household expenditure, food shortage would cause a major upward swing in the consumer price index (CPI). Historical droughts in the various countries have left a traceable record of significant

inflation not only immediately after events but also over successive years. Using the regional rainfall data derived in the previous sections, we map that with the CPI data for Nairobi.

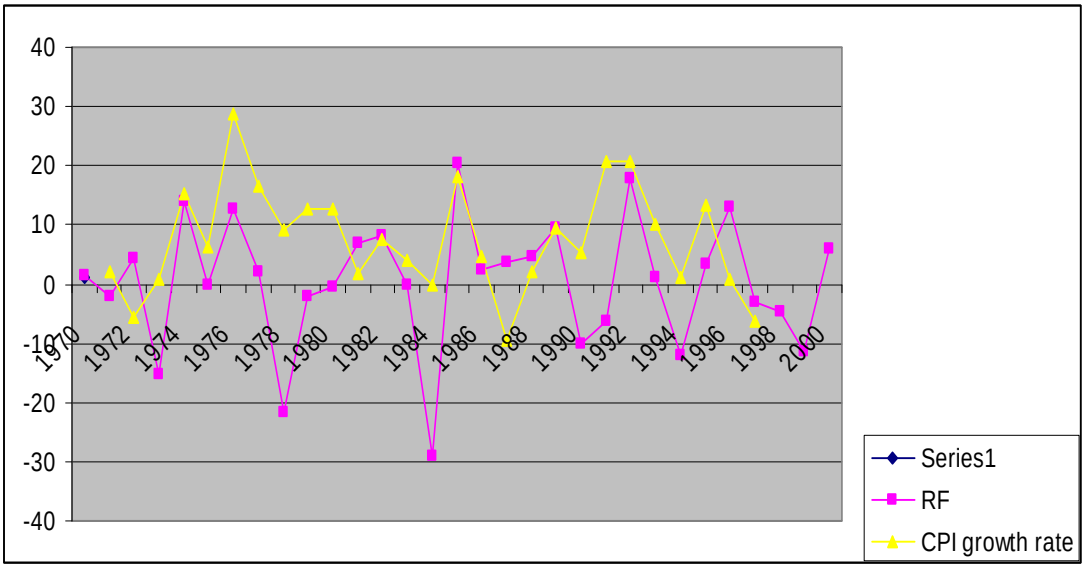


Figure 5.4: Rainfall and consumer price indices

Taking Nairobi's consumer price index against the regional annual rainfall variability of major years, Figure 5.4 shows a negative relationship between the two, mainly on lagged observations. It is discernible that exceptional price increases follow major drought years. Apart from the CPI, drought is also expected to affect prices in factor and foreign exchange markets. Data on factor markets is not available and hence it is difficult to study the link between drought and factor prices. In drought years and after, the migration of farm labour to urban areas can increase, creating downward pressure on wages. Decrease in exports and increased demand for food imports following droughts are expected to create pressure on exchange rates at least for countries with liberalised exchange rate regimes. Sophisticated modelling is required to examine the link between drought and exchange rate fluctuations as this would involve controlling for other factors affecting the exchange rate and taking the institutional set ups of the foreign exchange markets in the region. These are issues that should be looked at in the future.

5.2.4 Drought and Government Accounts

In terms of expenditure, as governments react to reduce drought effects and deal with the food security, either government spending increases or adjustments are made on other priorities, implying an economic and social cost, under both cases. The development cost of budget shifting from capital projects to recurrent budget is likely to be significant in major drought years. We did not get such information to provide some links.

In general one would expect that expenditures show a major leap in the periods of all drought years. Obviously, revenues that come from agriculture would indicate a decline although the total effect on the government revenue may be compensated by other sources. This may be true for a diversified economy whose reliance on agriculture is minimal.

Currently, one of the biggest challenges of the EAC governments is how to cope with the huge resource demands for guaranteeing food security to the chronically food insecure people and those facing transitory food insecurity problems whose estimates are not really

known. No doubt, the EAC governments are under pressure to raise these resources on top of other development needs over the coming years.

5.3 Estimating Impacts of Climatic Variability on the Economy

5.3.1 Modelling

A production function indicates the relationship between the maximum possible level of output and levels of inputs used in production. This is can be extended to the GDP and climate variables of a country. The stochastic production function specification developed by Just and Pope (1978) is used to estimate the effect of temperature and precipitation on mean and variability of GDP[8]. The stochastic production function provides a convenient and flexible representation of the effect of inputs on means and variances of GDP. This approach has been applied in a previous study that analyzes the effect of climate change on crop productivity and yield variability (see Cheng et al., 2004).

The stochastic production function has the following form:

$$Y = f(X, \beta) + h(X, \alpha)\varepsilon \qquad (1)$$

Where Y denotes crop yield (for maize, tea, coffee, wheat, banana), X is a vector of inputs including temperature and precipitation for EAC. The functional form $h(.)$ for the error term is an explicit representation of heteroskedastic errors allowing the estimation of the effects variance. The function $f(.)$ gives the average effect of the independent variables on yield whereas $h(.)$ provides the effect of each independent variable on the variance is the variance of GDP. Given variance of $\partial f(.)/\partial X = h(X)$ it follows that $\partial h/\partial X > 0$ identifies inputs that are risk increasing while $\partial h/\partial X < 0$ identifies inputs that are risk decreasing.

Just and Pope (1978) described both maximum likelihood (ML) and feasible generalized least squares (FGLS) procedures to estimate the production function. For each of the EAC countries except Burundi whose data we did not have access to, we use time series GDP, temperature, rainfall values from 1968 to 2006 to show the impact of climate variability on economic activity.

5.3.2 Estimation Results and Discussion

The regression results for GDP change by country are reported in Table 5.2. The results show that increased rainfall has a positive impact on GDP for Kenya and Tanzania. For Uganda and Rwanda the effect is negligible, perhaps because these countries have historically had high rainfall. Increased variation in rainfall significantly reduced value of output for Kenya. In the event of increased variability in rainfall Kenya is likely to be most affected.

[8] It can be conveniently assumed that output is largely derived from agricultural production given its large share in economic activity.

Country	Acreage	Rainfall	Temp	Trend	Var Rain	Var in Temp	Const
Kenya	0.054***	0.176**	-0.878**	0.017**	-0.24**	0.94**	6.46**
Tanzania	0.087**	0.194*	0.195	0.020***	-0.224	0.44	0.27
Uganda	0.013	0.201	-1.84***	0.021**	-0.31	2.12**	6.13**
Rwanda	-0.012	-0.08	-1.43**	0.014*	0.14	1.55**	7.05**

*,**,*** significant at 10%, 5% and 1% levels respectively

Table 5.2: Regression results of Climatic Variables on GDP by Country

An increase in temperature significantly lowers value of output for Kenya, Uganda and Rwanda. However, increased variation in temperature results in significantly higher value of output for the Kenya, Uganda and Rwanda. The results also show that the time trend coefficients are significant and positive for all EAC; this indicates that production technology may have improved over the period of observation.

Based on the parameter estimates in Table 5.2, one can compute elasticities in mean GDP associated with changes in rainfall and temperature variables. These results are presented in Table 5.3.

Country	Rainfall	Temp
Kenya	0.176**	-0.878**
Tanzania	0.194*	0.195
Uganda	0.201	-1.84***
Rwanda	-0.08	-1.43**

Table 5.3: Elasticity estimates of average GDP with respect to Climate Changes

According to our elasticity estimates, a 10 percent increase in annual rainfall results in a 1.7 and 1.9 percent increase in GDP in Kenya and Tanzania respectively. However, a 10 percent increase in temperature results in a decrease in GDP of 8.7%, 18% and 14% in Kenya, Uganda and Rwanda respectively. According to these estimates, the impact of change in mean annual temperature is more pronounced and adverse to the economy than a similar change in annual precipitation.

There foregoing results should be treated with caution since variables such as labour, capital, and other inputs that influence crop yield are not included. In addition, aggregation of the data by country averages for these variables may have masked important variation on lower levels.

6 Adaptation

Adaptation is defined as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation” (IPCC, 2007)

In order to assess the developing countries’ needs to adapt to climate change more precisely, the UNFCCC organized several workshops and meetings at regional level during 2006-2007. In general, the workshops and meetings highlighted the necessity for reliable climate data if vulnerability and adaptation to climate change in developing countries is to be assessed effectively. Addressing climate change impacts and improving adaptive capacity adequately requires precise data, and enhanced data collection capacity and technical expertise (UNFCCC, 2007). This is seriously lacking in East African countries. Existing climate change models are not precise enough for detailed climate change scenarios to be developed at regional or national level in East Africa. In consequence, adaptation policies may still remain approximate. The development of a high resolution climate change model for East Africa would help to downscale climate change projections and impact assessments. A regional model could also provide relevant information on transboundary impacts and set the basis for the development of transboundary or even regional adaptation strategies.

Participants at the Africa workshop moreover agreed that, besides the need to develop specific regional climate models, the lack of accurate socio-economic data is almost as important (UNFCCC, 2007).

The report specifies that “useful methodologies for assessing adaptation options include both top-down and bottom-up approaches. Both methodologies need to be linked to promote integrated adaptation assessments. Top-down methodologies include the use of modelling and scenario analysis. This can provide useful background to decision making and is strong in terms of the biophysical aspects of impacts. However the models do not perform well in representing human interactions and local abilities to adapt” (UNFCCC, 2007).

Therefore, complementary to the top-down approach, UNFCCC suggested using a “vulnerability-based, bottom-up, approach, which recognizes and builds upon local coping strategies and indigenous knowledge and technologies, and the capacity and coping range of communities, local institutions and sectors in responding to current climate variability. This approach helps to incorporate human and economic dimensions of the local communities, particularly livelihood aspects and inter-sectoral relationships. It is useful in developing specific strategies and policy implementation. However, it exhibits a weaker attribution to future climate change. An example of this approach is the UNFCCC’s National Adaptation Programmes of Action (NAPAs) for use by least developed countries to prioritize their urgent adaptation needs” (UNFCCC, 2007).

6.1 National Adaptation Programmes of Action (NAPA)

The National Adaptation Programmes of Action (NAPA) aim at addressing urgent and immediate needs caused by climate change impacts in the least developed countries. This new approach “would focus on enhancing adaptive capacity to climate variability and thus help these countries directly address their urgent needs arising from the adverse effects of climate change. The NAPAs use and build upon existing coping strategies at the grassroots

level, rather than focusing on scenario-based modelling, to assess future vulnerability and adaptive responses at local and state level. Involvement of different stakeholders (national, sectoral, local) and including existing coping strategies are an integral part in the assessment process“ (UNFCCC, 2007).

In the specific context of East Africa, NAPAs have been set up by Tanzania, Uganda, Rwanda and Burundi in accordance with the LEG guidelines.

The following chapters will summarize the most important outcomes of the NAPA, in particular regarding the prioritization of vulnerabilities and sectors impacted. For further details, please refer to the respective reports.

6.1.1 NAPA Tanzania

The National Adaptation Programme of Action (NAPA) of Tanzania was published in January 2007. After formation of the multi-sectoral NAPA team, composed of 20 experts, by the National Climate Change Focal point (Vice President’s Office - Division of Environment), four groups of the NAPA team were assigned a task of consulting stakeholders of different sectors namely:

- energy and industry;
- agriculture, livestock, forest, land use, tourism, health, wildlife and wetland; and
- coastal, marine, and freshwater resources.

The approach is described as follows: “The sectoral vulnerability and adaptation tools were the main approach used in the country-wide consultation to obtain vulnerability and adaptation information from relevant sector. This approach was adopted because of the size of the country, making it difficult for community approach, except in some sectors like agriculture and water. Thus, the four groups analyzed impact of climate change in the country and came up with a NAPA synthesis report based on past and present studies. The synthesis report was followed by a public consultation (using interviews and questionnaires) with stakeholders including government officials in different ministries, private sectors such as industries, and some communities. Among other areas, consultation with stakeholders was undertaken in 13 districts and 52 villages at local communities” (NAPA Tanzania, 2007).

Information gathered on climate change impacts and coping strategies including past climate change studies, sectoral policies and plans, and national strategies for sustainable development, was then synthesized and reviewed by the NAPA Team.

The stakeholder consultation process conducted by the NAPA team helped to obtain a ranking of the sectors in their order of importance (Table 6.1)

Sector	Rank order
Agriculture and food security (including livestock)	1
Water	2/3
Energy	2/3
Forestry	4
Health	5
Wildlife	6/7
Tourism	6/7
Industry	8
Coastal and marine resources	9
Human settlements	10
Wetlands	11

Table 6.1: Ranking of sectors according to priorities (Source: NAPA Tanzania 2007)

The report specifies that "After identification of vulnerabilities in each sector, key adaptation options and strategies that would best address those vulnerabilities were developed. The consultations were undertaken at national, regional as well as district levels. The consultations allowed for exchange of information on climate change hazards and created an opportunity for the NAPA Team to learn and gain insight on the sector specific hazards and adaptation techniques that were translated into proposed project activities. Furthermore, the invaluable stakeholder consultations at grassroots level helped to prioritize the fourteen top most possible adaptation activities that would address the country's most urgent needs from all sectors" (NAPA Tanzania, 2007).

After stakeholder consultation, the following project activities were proposed by the NAPA team (ranked in terms of priorities):

i. Increase irrigation by using appropriate water efficient technologies to boost crop production in all areas
ii. Alternative farming systems and relocation of water sources including wells along the low lying coastal areas
iii. Develop water harvesting and storage programs for rural communities particularly those in dry lands
iv. Community based catchments conservation and management programs
v. Explore and invest in alternative clean energy sources e.g. Wind, Solar, bio-diesel, etc.
vi. promotion of application of cogeneration in the industry sector
vii. A forestation programmes in degraded lands using more adaptive and fast growing tree species
viii. Develop community forest fire prevention plans and programmes
ix. Establishing and Strengthening community awareness programmes on preventable major health hazards

x. Implement sustainable tourism activities
xi. Enhance wildlife extension services and assistance to rural communities in managing wildlife resources
xii. Water harvesting and recycling
xiii. Construction of artificial structures, e.g., sea walls, artificially placing sand on the beaches and coastal drain beach management system
xiv. Establish good land tenure system and facilitate sustainable human settlements

Based on these activities five project Profiles were prepared.

For further details, please refer to the original document.

6.1.2 NAPA Uganda

Uganda published its NAPA in 2007. During the preparation process "commitments addressing the eradication of extreme poverty and hunger, ensuring environmental sustainability, gender equity and combating major diseases" were of major concern.

Implemented by UNEP and executed by the Department of Meteorology in the Ministry of Water, Lands and Environment, the NAPA process adopted a multi-sectoral approach by including key stakeholders in the steering committee and National NAPA Team (NT).

Policy guidance for the project implementation was provided by a high profile Project Steering Committee (PSC), chaired by the Permanent Secretary of the Ministry of Water, Lands and Environment.

At the operational level, the process was organized as follows: "The Project Management Unit, made of two project managers and chairs of the task forces, drawn from different disciplines, were responsible for planning of activities. This proved to be very useful because of the wide range of issues based on ecosystems and sectors. The Project Manager chaired meetings of the Project Management Unit.

A broad-based NAPA Team (NT), composed of technical officers drawn from key stakeholders, and in line with the guidelines for preparation of the NAPAs, was established. The NT was responsible for executing the NAPA activities. However, during project design the large size of the NT was recognized and therefore the concept of task forces was built into the project design. The Task Forces carried out literature review, data collection and analysis but submitted their outputs at every stage to the NT to ensure active participation of the NT in the entire process." (NAPA Uganda, 2007).

The NAPA Team used a participatory rural appraisal (PRA) approach for data and information collection from communities in selected districts. The selection of study areas, collection of data and information, analysis, interpretation and prioritization of the adaptation activities were conducted in a consultative way.

The top priority intervention areas for addressing climate change impacts in Uganda are ranked in table 6.2.

Intervention area	Rank
Land and land use	1
Farm forestry	2
Water resources	3
Health	4
Weather and climate information	5
IK documentation and awareness creation	6
Policy and legislation	7
Infrastructure	8

Table 6.2: Prioritized interventions areas for addressing climate change impacts in Uganda (NAPA Uganda, 2007)

Identified intervention strategies were then prioritized in accordance with the ranking procedure. The final list of prioritized intervention strategies is shown in table 6.3)

Sector	Intervention strategy	Urgency	Immediacy	Magnitude	Total score	Rank
Forestry	Promote tree-growing in farmland	4	4	4	12	1
	Strengthen Community sensitization and advocacy on climate change-related issues	4	4	4	12	1
Weather/climate information	Expansion of weather observing infrastructure (networks)	4	4	4	12	1
	Promotion of multimedia approach to dissemination of weather and climate information	4	4	4	12	1
Water resources	Scaling-up of safe water supply and sanitation using appropriate technologies	4	4	3	11	2
Water resources	Promote community best practices of collaborative water resource management	3	3	3	9	3
	Develop and promote drought.tolerant and early maturing plant varieties and animal breeds	3	3	3	9	3
Forestry	Integrate climate change issues into the sectoral planning and implementation	3	3	3	9	3
Water resources	Promote appropriate and sustainable water harvesting, storage and utilization technologies	3	3	3	9	3
Agriculture	Promote community best practices of collaborative natural resource management	3	2	4	9	3
Wildlife	Promote use of trees in demarcation of PAs	2	2	4	8	4
Wildlife	Enhance water supply to communities adjacent to PAs	3	1	3	7	5
Health	Improvement and expansion of health infrastructure	2	2	3	7	5
Forestry	Promote the cultivation of forest medicinal and edible plant species outside PAs	2	2	3	7	5
	Promote the cultivation of forest medicinal and edible plant (e.g. Malewa) species outside PAs	2	1	3	6	6
	Promote use of IK as coping mechanism	2	1	2	5	7
	Study and promote traditional food preservation technologies	1	1	1	3	8

Table 6.3: Final list of prioritized intervention strategies for adaptation in Uganda (NAPA Uganda, 2007)

On the basis of the prioritized ranking, nine NAPA projects were identified.

For further details, please refer to the original document.

6.1.3 NAPA Rwanda

The National Adaptation Programme of Action (NAPA) of Rwanda, published in December 2006, is the result of a process of study, concertation and consultation carried out by a multi-sectoral NAPA national team from January 2005 to July 2006. The process also involved national experts, numerous stakeholders, regional and local partners, namely local communities and women's and youth associations.

The process of identifying adaptation options was conducted as follows: “A first list has been prepared and comprises 40 identified options from 6 most vulnerable sectors including: Agriculture and animal husbandry, lands, water resources, forestry and health. After analysis of these potential options, a second list comprising 20 options taking into consideration the

necessity to implement integrated and transversal projects within these sectors was prepared. NAPA team formulated key adaptation options which adequately respond to most immediate and urgent needs of most poor local communities and hence, most vulnerable in socio-economic and climatic point of view" (NAPA Rwanda, 2006). After the selection and prioritization process, a final list of 6 top priority options was drawn up (table 6.4)

Priority	Option	Aim
N° 1	Integrated water resources management (IWRM)	Reduce the vulnerability of ecosystems, population and sectors due to the quantitative and qualitative shortage of water resources and the damages caused by the runoff due to the climate change.
N° 2	Set up information systems of hydro agrometeorological early warning system and rapid intervention	Improve information system of hydro agro meteorological early warning system and rapid intervention and reduce the exposure of the population and sectors at risk of extreme events and climate catastrophes.
N° 3	Promotion of income-generating activities	Improve the adaptation capacity of rural populations vulnerable to climate change through the promotion of income-generating non-agricultural activities.
N° 4	Promotion of intensive agriculture and animal husbandry	Improve the adaptation capacity of farmers and pastoralists to climate change through setting up agro-sylvo-pastoral systems adapted to real land vocation.
N° 5	Introduction of varieties resisting to environmental conditions	Improve adaptation capacity of farmers and adapt to climate change through promotion of appropriate cultural techniques and the introduction of varieties resisting to environmental conditions.
N° 6	Development of energy sources alternative to firewood	Reduce the pressure of woody combustible and hence reduce the overexploitation and degradation of forests through the promotion of energy sources alternative to firewood. This aim contributes at the same time to reducing the vulnerability to the energy crisis of the country especially the poor rural population.

Table 6.4: Final list of top priority adaptation measures in Rwanda (NAPA Rwanda, 2006)

By using a generic logic framework of the six priority options, a series of activities or urgent and immediate projects have been developed.

Please refer to the original document for further details.

6.1.4 NAPA Burundi

The NAPA of Burundi, published in January 2007, was also developed by using a participatory approach. Some options proposed refer to adaptation to the periods of rainfall deficit with subsequent dryness, while others concern periods of precipitation above the normal.
Altogether, a list of 14 options was obtained that underwent a selection and prioritization process. The final top priority list for adaptation options in Burundi is shown in table 6.5.

Ranking by priority	Score	Ranking
Improve seasonal early warning climate forecasts	0.75	1
Safeguard existing woodlots and reforest stripped areas	0.70	2
Enhance the management of existing protected areas and transform into protected areas the natural ecosystems identified as threatened or vulnerable	0.68	3
Popularise rainwater harvesting techniques for agricultural or domestic use	0.68	4
Set up mechanisms to control erosion in sensitive areas	0.67	5
Establish and protect strategic buffer zones in Lake Tanganyika floodplains and around the lakes of Bugesera	0.63	6
Identify and popularise dryness resistant forest species	0.59	7
Popularise short cycle and dryness resistant food crops	0.59	8
Popularise zero grazing techniques	0.58	9
Identify and popularise improved techniques of use of wood and renewable new energies	0.53	10
Control river dynamics of watercourses and torrents in Mumirwa, including the city of Bujumbura	0.50	11
Train and inform the decision makers and other actors, including local communities, on methods of adaptation to climate variability	0.45	12
Identify and popularise the breeding of species adapted to local climate conditions	0.43	13
Increase hydropower micro stations	0.38	14

Table 6.5: Ranking of top priority adaptation options in Burundi (NAPA Burundi, 2007)

6.2 Adaptation in Kenya

As a consequence of not being considered as a least developed country, Kenya did not have to develop a National Programme of Action for Adaptation (NAPA). Nevertheless, there are many ongoing activities and projects with a strong focus on adaptation.

For instance, the project “Increasing Community Resilience to Drought in Makueni District”, funded by the Global Environment Facility and the governments of the Netherlands and Norway, addresses the threat of climate change to the water resources and lands upon which farming smallholders rely for their livelihoods, health and well being.

The project seeks to:

- increase food security by enhancing the drought resilience of local agriculture practices;
- reduce poverty through diversification of livelihoods;
- facilitate the integration of adaptation to climate change into Kenya's sustainable development plans and policies.

The project aims at reducing vulnerability by implementing activities at the field and policy level. The main activities at field level include:

- downscaling climate forecasts to guide the choice of crops planted and the timing of agricultural activities;
- improving agronomic practices by providing access to fast maturing and drought-resistant crop varieties;
- building sand dams, shallow boreholes and drip irrigation systems to improve access to water for use in crop production;
- increasing local self-help groups' access to income-diversification activities.

At policy level, the project has already produced some outcomes regarding the integration of adaptation to climate change into Kenya's sustainable development plans and policies, for instance:

- Integration into Kenya's draft National Disaster Management Policy
- Integration into the Management of arid and semi-arid lands.

The project is one of three pilot projects being implemented as part of the regional project "Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Eastern and Southern Africa (ACCESA)" (Parry, 2008).

Kenya has adopted various mechanisms that enhance the country's capacity to adapt to climate variability and climate change (Muchemi). These mechanisms include:

- formation of the National Disaster Management Authority;
- dissemination of weather and climate information to rural communities via the Radio Internet project (RANET);
- development of climate reporting in Kenya by forming the Kenya Network of Journalists and Meteorologists (KENJOM);
- adoption of a strategy for enhancement of the capability of the Kenya Meteorological Department (KMD).

6.3 Assessment of adaptation costs and benefits

The assessment and comparison of adaptation costs and benefits is a significant element for the economic evaluation of policy options. Nevertheless, IPCC states: “The literature on adaptation costs and benefits remains quite limited and fragmented in terms of sectoral and regional coverage. Adaptation costs are usually expressed in monetary terms, while benefits are typically quantified in terms of avoided climate impacts, and expressed in monetary as well as nonmonetary terms (e.g., changes in yield, welfare, population exposed to risk). There is a small methodological literature on the assessment of costs and benefits in the context of climate change adaptation (Fankhauser, 1996; Smith, 1997; Fankhauser et al., 1998; Callaway, 2004; Toman, 2006). In addition there are a number of case studies that look at adaptation options for particular sectors (e.g., Shaw et al., 2000, for sea-level rise); or particular countries (e.g., Smith et al., 1998, for Bangladesh; World Bank, 2000, for Fiji and Kiribati; Dore and Burton, 2001, for Canada).”

In the case of East Africa, no specific literature regarding the assessment and comparison of adaptation costs and benefits is available. As such an assessment clearly represents a very valuable policy evaluation tool, it is suggested that this specific question should be analyzed in detail in a separate study.

7 Policy options and recommendations

Climate change is a global problem and its impacts do not stop at national borders. Although many consequences of climate change such as floods and droughts will have transboundary implications, the corresponding prevention and adaptation measures mostly remain at national level. Developing national adaptation programmes is essential to address specific national vulnerabilities. Nevertheless, transboundary impacts may be better addressed by a regional approach. Furthermore, the exchange of experience between countries, e.g. on adaptation strategies and national policies, may create synergies amongst member states.

The following chapter describes some of policy options and recommendations that resulted from the literature review and the field visits in Kenya, Tanzania, Uganda, Rwanda and Burundi. It also contains conclusions from a Climate Change Expert Meeting held in August 2008 in Arusha. This chapter should be considered as a collection of ideas and suggestions that still need to be discussed with all stakeholders.

The implementation of the following recommendations will need the mobilization of human, technical, financial and institutional resources from the five member states and partner organizations (donor organizations, research institutes, etc.).

I. Development of a regional climate change strategy:

It is recommended that an integrated climate change strategy should be developed for the East African region including institutional, technical, financial and communication aspects.

➢ Strengthen the Regional Climate Change Working Group

A first step may consist in creating a regional working group on climate change composed of representatives from all key sectors. This regional working group should group together institutions and experts from all five member states. It is recommended to use the existing EAC working groups and strengthen them further (technical, expertise, human resource). Technical assistance may be provided by international donor organizations.

➢ Complement the Regional Climate Change Working Group with sectoral working groups

In order to address the specific points of the priority sectors concerned with climate change, it is recommended to complement the Regional Climate Change Working Group with sectoral working groups.

➢ Enhance the process of developing the EAC Climate Change Master Plan

Aware of the urgent need to address the climate change issue at a regional level, the East African Community Secretariat organized a first “Climate change expert meeting” which was held from 27th to 29th August 2008 in Arusha/Tanzania. The meeting was organized following a recommendation of the 5th meeting of the Sectoral Council on Transport, Communications and Meteorology (held in Arusha on 9th – 13th June 2008) that decided that the EAC - in consultation with the Partner States and other stakeholders – should develop a Climate Change Master Plan for the region.

The main objective of the expert meeting, which brought together 12 participants coming from all five member states, was to prepare a “Road Map” towards the development of the Master Plan.
There was a general agreement amongst the participants that the member states, although developing their national programmes on coping with climate change, need to harmonize their efforts. The meeting produced several recommendations and a draft road map for the development of the Climate Change Master Plan (Annex 2).

The EAC intends the Regional Climate Change Master Plan to “lay a strategy for identifying vulnerabilities in the region, define mitigation strategies as well as put in place adaptation measures to climate change”. The most relevant key elements in the Master Plan refer to:

- climate change detection,
- vulnerability to climate change,
- impacts of climate change,
- mitigation of climate change, and
- adaptation to climate change.

As the development of the EAC Climate Change Master Plan is an ongoing process, it is recommended to strengthen it further and integrate the findings of this study into the Master Plan.

➢ Involvement of civil society and NGO’s

By integrating the civil society and NGO’s into the development of a regional climate change strategy, valuable information, for instance regarding adaptation strategies at the community level, could be made available. NGO’s working in several countries of the EAC-region could also contribute their region-wide point of view and experience.

➢ Complementation of the strategy by Sectoral Climate Change Strategies

It is highly recommended that the regional climate change strategy for East-Africa should be complemented by regional climate change sector strategies specific to the most relevant and vulnerable sectors, in particular:

- agriculture (including sustainable land management),
- water management,
- energy,
- forestry,
- marine and coastal eco-systems,
- and cross cutting issues.

➢ Integration of climate change into regional sector strategies

For various economic sectors in the EAC-region, regional strategies have already been developed. However, these regional sector strategies may not yet fully take climate change aspects into account. The energy sector, for instance, should consider climate variability and the resulting fluctuations in rainfall patterns for the planning of hydropower generation. It is therefore recommended that the results of climate change vulnerability assessments should be integrated into regional sector strategies.

➢ **Integration of mitigation into the Climate Change strategy**

During the stakeholder workshop in July 2009, the participants recommended to integrate the mitigation issue into the Regional Climate Change Strategy, in particular measures with adaptive capabilities.

II. Regional cooperation in vulnerability assessment and adaptation at regional level:

➢ **Regional in-depth vulnerability assessments**

The field visits and literature review clearly showed that detailed information about the vulnerability of the key sectors in East Africa is still lacking. It is therefore recommended that in-depth vulnerability assessments should be carried out in the region for already identified priority sectors:

- agriculture and food security
- water management and irrigation (including groundwater)
- energy
- shared eco-systems (mountains, national parks, etc)
- tourism
- infrastructure

Detailed scientific research on potential losses of food crops due to climate change in East Africa is still lacking. East Africa's strong dependence on rain-fed agriculture and the resulting vulnerability to climate change makes the potential impact assessment a top priority. A detailed macro economic analysis by economic sector would help the EAC to focus resources on those sectors that are most affected and vulnerable to climate change.

➢ **Organisation of regional workshops on vulnerability and adaptation options by sectors**

In order to foster the exchange of experience and knowledge in the region, it is recommended that regional workshops should be specifically organized for each key sector. These Sectoral Climate Change Workshops would give the opportunity to discuss vulnerability issues and adaptation options.

➢ **Setting up of regional sector working groups**

The organization of Sectoral Climate Change Workshops may then lead to the setting up of Regional Sector Working Groups composed of sector experts from all member states.

➢ **Capacity development**

It is recommended that existing local, national and regional capacities regarding climate change should be developed or enhanced, particularly with respect to vulnerability assessments.

III. Climate Change research

➢ Setting up a Regional Centre of Excellence

It has been noted that information on climate change in East Africa is still inadequate and scattered in a few institutions all over the region. In order to upscale the knowledge level regarding Climate Change in East Africa, it is recommended to set up a Regional Centre of Excellence for Climate Change. The main objectives of the centre are to:

- centralize existing information,
- conduct studies and generate new information,
- regroup existing capacities and competencies.

➢ Regional Early Warning System

Early warning systems provide countries and regional organizations with the means to manage the risk of food insecurity. These systems are used to monitor desertification and, more recently, have become an instrument in monitoring climate change impacts. In a more proactive approach, early warning systems are being developed to provide farmers with essential information about timing of soil and crop management activities. Establishing a regional early warning system may be a first step in preparing for climate-related disasters.

➢ Enhancing regional cooperation in disaster management

Extreme weather events such as droughts and floods may cause natural disasters with transboundary impacts. Enhancing regional and transboundary cooperation in disaster management might improve the existing national response capacities.

➢ Development of a high resolution climate model for East-Africa

Climate change projections for African countries or sub-regions are based on climate change models and scenarios which generally use the African continent as a reference. Existing climate change models are not precise enough for developing detailed climate change scenarios at regional or national level in East Africa. In consequence, adaptation policies may still remain approximate. The development of a high resolution climate change model for East Africa would help to downscale climate change projections and impact assessments.

A regional model could also provide relevant information on transboundary impacts and set the basis for the development of transboundary or even regional adaptation strategies.

➢ Develop climate change projections for the 2020 to 2030 period

It would be of particular interest to develop climate change projections which are closer to the current generations, e.g. for the 2020 to 2030 period instead of the commonly used 2080 to 2099 period.

➢ **Study on rainfall patterns in East Africa**

East Africa depends heavily on rain-fed agriculture and is therefore highly vulnerable to rainfall variations. There is evidence that rainfall patterns in East Africa have already undergone significant alterations. It is therefore recommended that a specific study should be made of this highly sensitive issue.

➢ **Enhance research on climate change detection**

The Climate Change Expert Meeting, held in August 2008 in Arusha, made the recommendation that the EAC Partner States enhance research on climate change detection and strive to publish the corresponding results. The lack of observational climate data in EAC is a constraint to understanding current and future climate variability. Significant gaps in current data exist at all levels in the region.

➢ **Rescue existing climate data**

The Expert Meeting also recommended that EAC and Partner States should undertake climate data rescue in order not to lose the climate data already observed.

➢ **Monitoring stations**

Furthermore, the experts recommend that the Partner States should collaborate to strengthen the existing meteorological, hydrological and volcanic monitoring stations in the region. Efforts should also be made to enhance the existing monitoring infrastructure.

IV. Conflict prevention

➢ **Enhance regional cooperation in conflict prevention**

Climate change impacts, in particular droughts, may result in decreased availability of natural resources such as water or grassland and therefore lead to increased competition for natural resources, rising migration flows or even conflicts. It is recommended that regional cooperation and transboundary activities on conflict prevention should be enhanced, in particular regarding:

- water resources (Nile river, Lake Victoria)
- grassland management.

➢ **Organisation of conflict prevention workshop**

In a regional workshop on “climate change and conflict”, stakeholders might:

- present existing examples for regional and transboundary cooperation,
- discuss the challenges of “climate change and conflict", and
- examine possible prevention options.

V. Communication

The impacts of climate change are not yet well understood in the East African region. Therefore, efforts should be made to increase the state of awareness, in particular with respect to vulnerabilities and adaption options.

➢ Development of a communication strategy for climate change

It is recommended to develop a communication strategy which addresses the various aspects of climate change at the different levels of the society in East Africa.

➢ Awareness raising amongst decision makers and governments

It was found during the field visits that some decision makers and governments may not yet be fully aware of potential climate change impacts and vulnerabilities in their countries. In particular, the strong relationship between climate change and food security still seems to be underestimated. It is therefore recommended that action should be taken to promote awareness amongst decision makers and governments regarding climate change and its potential impacts.

➢ Exchange of experience

In all partner states of the EAC, national initiatives regarding climate change detection, climate change impacts and vulnerabilities have been developed. Moreover, parts of the population have already started to adopt coping strategies. It is recommended that the exchange of experience and the sharing of lessons learned should be promoted between partner states.

➢ Awareness raising amongst population

Although some parts of the population in East Africa have already developed strategies to cope with climate change impacts, others are not yet fully aware of its implications. It is therefore recommended that awareness raising campaigns should be undertaken and existing coping strategies promoted amongst the population. NGO's could play an essential role in this context.

➢ Creation of a website

As information about vulnerabilities and adaptation options is scattered and not readily accessible, it is recommended to create a specific website, which collects and provides information concerning:

- coping strategies,
- best practices and
- lessons learnt.

VI. Institutional aspects

All EAC partner states have set up national climate change focal points and created multidisciplinary working groups, for instance on adaptation. In order to deal with the regional aspects and stakes of climate change, a regional institution such as the East African Community, could play a major role and add value to the climate change governance in East Africa. Some recommendations, which also refer to the policy options developed in the section “climate change strategy”, include:

- **Set up a Climate Change Commission at the EAC**
- **Set up a Climate Change Unit/Desk at the EAC-Secretariat**
- **Set up sectoral Climate Change/Adaptation Working Groups at the EAC**
- **Establish cooperation with existing regional and international institutions in order to create synergies and avoid overlapping of institutional competencies**
- **Establish mechanisms of inter-regional cooperation on climate change**
- **Study about existing capacities on climate change in the region (institutional, technical)**

Annexes

Annexe 1: List of representatives contacted during the field visit

Uganda

Stakeholder	Representative	Contact
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Other stakeholders

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Annexe 2: Road Map for the Development of the EAC Climate Change Master Plan

	Tasks	2008				2009									
		S	O	N	D	J	F	M	A	M	J	J	A	S	O
1	Participate in an inception meeting for elaboration of the scope of work and methodology		**												
2	Refine the draft Road Map for use in the development of the Master Plan against the agreed time lines		**												
3	Create awareness on the development of the EAC Climate Change Master Plan at all levels	**	**	**	**	**	**	**	**	**	**				
4	Review global, regional, and national initiatives on climate change impacts, vulnerability, adaptation and mitigation so as to guide the preparation of CC Master Plan/ Strategies			**	**										
5	Produce status and key issues report				**										
6	Consult relevant stakeholders to generate information for development of the Master Plan based on status and key issues report				**	**									
7	Propose climate change adaptation activities to constitute the Master Plan / Strategies in the context of various COP decisions and the NAPAs of Partner States as well as other adaptation initiatives from Partner States					**	**	**							
8	Propose climate change mitigation activities to constitute the Master Plan / Strategies with due consideration of the mitigation options that can assist Member States promote their sustainable development, particularly in energy, forestry, agriculture, water resources, and other relevant sectors					**	**	**							

9	Produce second draft report							**							
10	Identification of possible sources from where to mobilize funds to develop and implement the climate change Master Plan		**	**	**	**	**	**	**	**					
11	Produce final draft report									**					
12	Present the draft report for approval									**					
13	In collaboration with the EAC Secretariat, to undertake in country- and regional consultations for validation of the Master Plan									**	**				
14	Produce and submit final report										**				

Annexe 3: References

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