Country Report: Tanzania

Managing Risk and Reducing Vulnerability of Agricultural Systems under Variable and Changing Climate

Soil-Water Management Research Programme
Sokoine University of Agriculture

September 2007

TABLE OF CONTENTS

List of Figures

List of Tables

List of Plates

List of Acronyms

ASDP	Agricultural Sector Development Programme
ASDS	Agricultural Sector Development Strategy
AEZ	Agro-ecological Zones
CARE	Cooperative for Assistance and Relief Everywhere
CCAA	Climate Change Adaptation in Africa
CERES	Crop Environment Resource Synthesis Model
CLIMAG	Climate Prediction and Agriculture
CO_2	Carbon Dioxide
DADP	District Agricultural Development Programme
DFID	Department for International Development
DMD	Disaster Management Department
DMTC	Disaster Management Training Centre
EM-DAT	The International Disaster Database
GCMs	Global Circulation Models
GDP	Gross Domestic Product
GHA	Greater Horn of Africa
GHG	Greenhouse Gas
GNI	Gross National Income
HFA	Hyogo Framework of Action
IDRC	International Development Research Centre
IIED	International Institute for Environment and Development
IK	Indigenous Knowledge
IPCC	Intergovernmental Panel for Climate Change
MAFSC	Ministry of Agriculture, Food Security and Cooperatives
MDGs	Millennium Development Goals
NAPA	National Adaptation Programme of Action
NEMC	National Environmental Management Council
NGOs	Non Governmental Organizations
NOG	National Operational Guidelines
NSGRP	National Strategy for Growth and Reduction of Poverty
OECD	Organisation for Economic Co-operation and Development
PRSP	Poverty Reduction Strategy Paper
RWH	Rainwater harvesting

TMA	Tanzania Meteorological Agency
UNCBD	United Nations Convention on Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
WRS	Warehouse Receipt Systems

Executive Summary

The effects of climate change and variability are undeniably clear with impacts already affecting ecosystems, biodiversity and people. Large-scale events, such as the recent droughts and floods in the Greater Horn of Africa (GHA), illustrate ways in which many communities are already suffering from less predictable – and more extreme – weather patterns. The projected climate change will have far-reaching, negative impacts on the availability of water resources, food and agricultural security, human health, tourism and biodiversity. In addition, climate change has the potential to undermine economic development, increasing poverty and delaying or preventing the realization of the Millennium Development Goals (MDGs).

In order to reduce current vulnerability to climatic hazards and stresses as well as to prepare for future climate change, the adaptive capacity of the GHA region needs to be strengthened. This requires, among other things, increased scientific understanding of the impacts of, and vulnerability to, climatic variability and change, and the options to respond to these changes through adaptation.

Tanzania's climate is generally variable in both time and space. Analysis of monthly minimum and maximum temperatures over the last 30 years showed an upward trend. The increasing trend was mostly associated with the months of January, July and December. The retreat of the glaciers of Mt. Kilimanjaro, the submersion of Maziwe Island in the Indian Ocean, decrease in water levels of Lake Victoria and increasing malaria endemicity in highland areas of the country could be linked to the observed temperature trend. The analysis of total annual rainfall in selected regions of Tanzania indicated that there is a decreasing trend with a greater variability in cycles.

Projections in temperature and rainfall changes are well documented in a study commissioned by the Government of Tanzania (Tanzanian Initial National Communication, Vice-President's Office, 2003) and a 2003 report by OECD. While OECD predicts an average annual increase of 2.2°C by 2100, Tanzanian Initial National Communication predicts mean annual temperatures to rise by 3-5°C by 2075. Both studies agree, however, that the rise in temperature will be greater during cooler months (June to August) than warmer ones (December to February). Rainfall predictions are less certain. Indeed, major discrepancies remain between climate models. However, the most commonly used projection for Tanzania foresees annual rainfall increasing by 10 % overall by 2100 (OECD 2003). Significant regional variations will also occur. Extreme events, in the form of drought, flooding, tropical storms and cyclones are expected to become more frequent, intense and unpredictable (IPCC 2003).

Agriculture is by far Tanzania's most important economic sector, in terms of both employment provision and contribution to GDP. Unfortunately, the large degree of dependency on this sector renders the Tanzanian economy particularly vulnerable to climate change. Regional predictions indicate that Tanzania may suffer a loss of over 10% of its grain production by the year 2080 (Parry et al., 1999). The cultivation of maize is going to be particularly hard hit. There is considerable uncertainty regarding the effects of climate change on the yields of most important cash crops such as coffee and cotton. However, according to Tanzania Initial National Communication (2003), the two cash crops are projected to experience increases in yield. The agriculture sector thus may have both negative and positive impacts. Climate change is expected to further shrink the rangelands which are important for livestock keeping in Tanzania.

Like the agriculture sector, climate change is projected to have both positive and negative consequences for Tanzania's water-resources. According to the Tanzania Initial National Communication (2003), the Wami-Ruvu basin could experience a 10% decrease in runoff, while annual basin runoff in the Pangani basin is estimated to decrease by 6%. The Rufiji River is expected to experience an increase in river flow by 5-11%. Floods in Rufiji and Pangani Rivers would cause damage to major hydropower stations and human settlements found along these river basins.

In response to climate variability and change, farmers have developed different farming systems finely tuned to many aspects of their environment. Adaptation measures include adjustments to planting dates, rainwater harvesting and selection of animal species. However, while local coping strategies may be able to deal with such shocks in the short-term, they are unlikely to be able to cope with more frequent and severe climate events (Orindi *et al*. 2005) and expected climate change. Most likely effective adaptation solutions can be provided by a combination of both local strategies and exogenous measures. Ongoing monitoring, documentation and dissemination of good agricultural practices, indigenous and newly developed ones, is therefore an essential part.

Internationally, Tanzania is a party to various international environmental agreements, including the UNFCCC, UNCCD, and UNCBD. At national level, the country has a number of national level sectoral policies and plans that are intended to increase its ability to cope with climate variability and long term climate change. Despite an increasing attention by the government of Tanzania on the implications of climate change, a number of deficiencies do still exist on the current adaptation strategies. Examples include; lack of interaction and collaboration between TMA and agricultural institutions and difficulties in interpreting and applying weather forecasts. Risk management strategies should therefore aim at addressing the existing adaptation deficit and be adjusted to face additional climate risks associated with climate change.

Acknowledgement

This project is being implemented through the financial support from the International Development Research Centre (IDRC). However, the ideas expressed and the content is solely the responsibility of the authors.

1. Introduction

The Greater Horn of Africa (GHA) is among the most vulnerable regions to the impacts of climate variability and change. The region's vulnerability arises from a combination of many factors, including extreme poverty, frequent natural disasters such as droughts and floods, and over-dependence on rainfed agriculture. Recent scientific evidence suggests that the frequency and severity of climatic extremes is increasing, making adaptation an absolute necessity (IPCC 2003). Though the occurrence of these events in most cases is beyond human control, opportunities exist to reduce the adverse effects of these events by formulating effective and efficient adaptation strategies. Adaptation to climate variability and change usually includes measures such as risk management practices aimed at addressing the existing "adaptation deficit"; better preparedness; well planned responses that promote self-reliance and reduce dependence on relief assistance; strengthened institutions and capacities that contribute systematically to enhanced resilience; and awareness raising campaigns to prepare all the stakeholders for appropriate actions.

Effective and sustainable adaptation to climate change and variability depends on, among other things, availability of adequate information base for decision-making. However, according to a number of reports, for example UNFCC (2006), DFID (2004), and IIED (2006), there is still a general deficiency of knowledge, expertise and data on climate change issues in Africa, including the GHA. This is also a constraint to better understanding of current and future climate variability (DFID 2004).

This report is part of on-going efforts to enhance the overall scientific understanding of climate variability and change in Tanzania, their impacts and vulnerabilities in agricultural systems, and strategies for managing climate risk and reducing vulnerability. The review has been carried out as part of the CCAA-IDRC project "Managing risk, reducing vulnerability and enhancing agricultural productivity under a changing climate". The project is implemented in Ethiopia, Kenya, Sudan, and Tanzania (Figure 1).

The report is divided into five sections. Following this introduction, section 2 provides the background information on the climate and agro-ecological zones of Tanzania, and also discusses the importance of the agriculture sector to the economy of the country. Section 3 presents the current status of understanding on climate variability and projections of climate change. It also discusses the impacts and vulnerability of climate variability and expected climate change on agricultural systems and the people dependent on them. In section 4, the report looks into how the people currently adapt to climate variability and change in order to manage risk and reduce vulnerabilities in their agricultural practices. This includes indigenous and exogenous technologies and policy and institutional strategies. The final part, section 5, summarizes the main conclusions from this report.

2. Country Background

2.1 Geographical Location

Tanzania is located on the eastern coast of Africa south of the equator between latitudes 1° 00’ S and 11° 48’ S and longitudes 29° 30’ E and 39°45’. Eight countries – Kenya and Uganda in the north, Rwanda, Burundi, Democratic Republic of Congo and Zambia in the west, Malawi and the Republic of Mozambique to the south—share boundaries with Tanzania. The eastern side of Tanzania is a coastline of about 800 km long marking the western side of the Indian Ocean.

Tanzania, with a total of 942,784 km^2, is the third largest country in the GHA region (after Sudan and Ethiopia), the others being Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, and Uganda. Out of the total area, water bodies cover 61, 495 km^2 (6.52%).

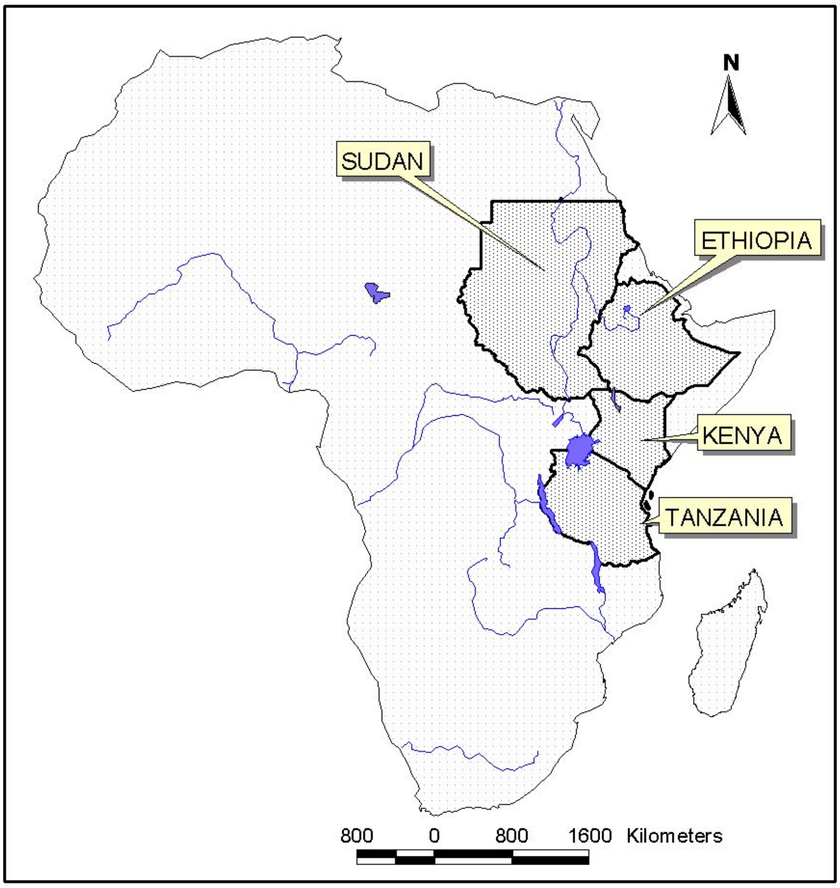


Figure 1: Location of Tanzania in relation to other countries in the CCAA-IDRC project

2.2 Climate

The climate of Tanzania is mainly influenced by its location close to the equator, the impact of the Indian Ocean and the physiography in general. As a consequence, Tanzania experiences a variety of climatic conditions ranging from humid coastal to alpine deserts crowning the high peaks of Kilimanjaro and Meru mountains to highland montane forest and moist tropical forest. The coastal area and all of the islands in the Indian Ocean experience a tropical climate, and most of the country is sub-tropical except for the areas at higher altitudes.

2.2.1 Temperature pattern

Average temperatures range between 17°C and 27°C, depending on location. The hottest period spreads between November and February (25ºC - 31ºC) (Figure 2) while the coldest period occurs between May and August (15 ºC - 20 ºC). However, in the mountainous areas and Plateaus, the temperature occasionally drops below 15^{o}C (Figure 3) at night during the months of June and July. In the Southern highlands temperature can even reach as low as 0°C - 6°C. Temperature variations have significant impact on the agro-ecological zones and the adaptation strategies in the agriculture sector.

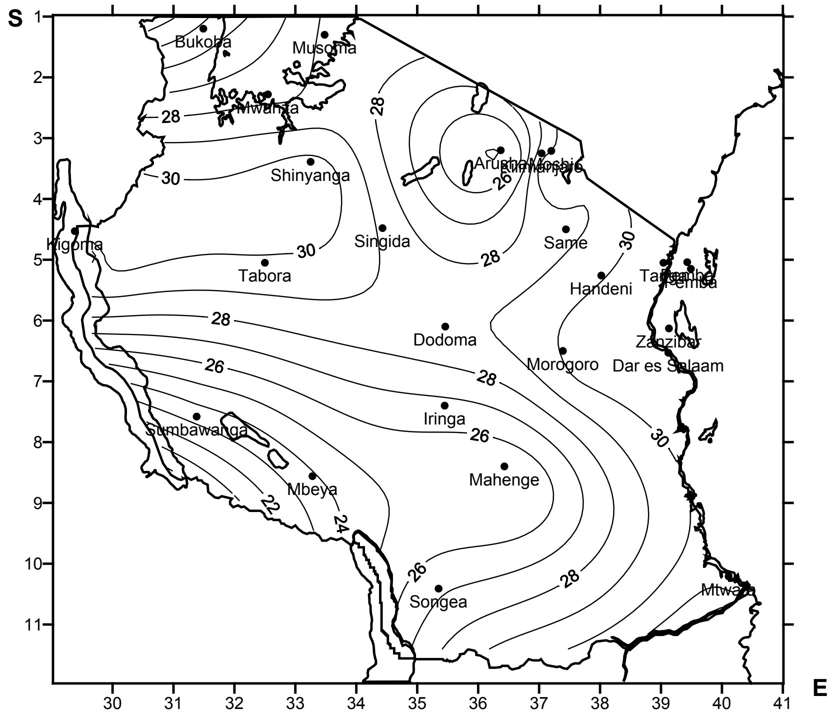


Figure 2: Annual mean maximum temperature in Tanzania (1971 – 2000) (Source: TMA 2007)

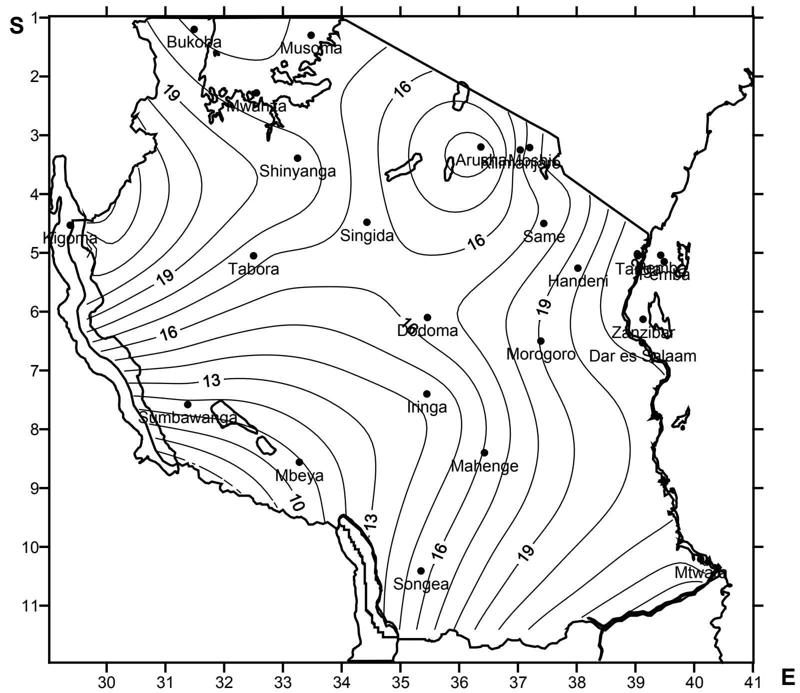


Figure 3: Annual mean minimum temperature in Tanzania (1971 – 2000) (Source: TMA 2007).

2.2.2 Rainfall pattern

Rainfall in about 75% of the country is erratic and only 21% of the country can expect an annual rainfall of more than 750 mm with a 90% probability. As a result, crop and livestock production under such conditions remain vulnerable to the vagaries of the weather. The mean annual rainfall varies considerably from place tom place ranging from less than 400 mm to over 2,500 mm per annum (Figure 4). Two rainfall regimes exist over Tanzania. One is unimodal (start as early as mid-November in some places and end as late as mid-May) and the other is bimodal (October -December and March - May). The former is experienced in southern, south-west, central and western parts of the country, and the later is found to the north and northern coast. In the bimodal regime the March - May rains are referred to as the long rains or "*Masika*", whereas the October - December rains are generally known as short rains or "*Vuli*".

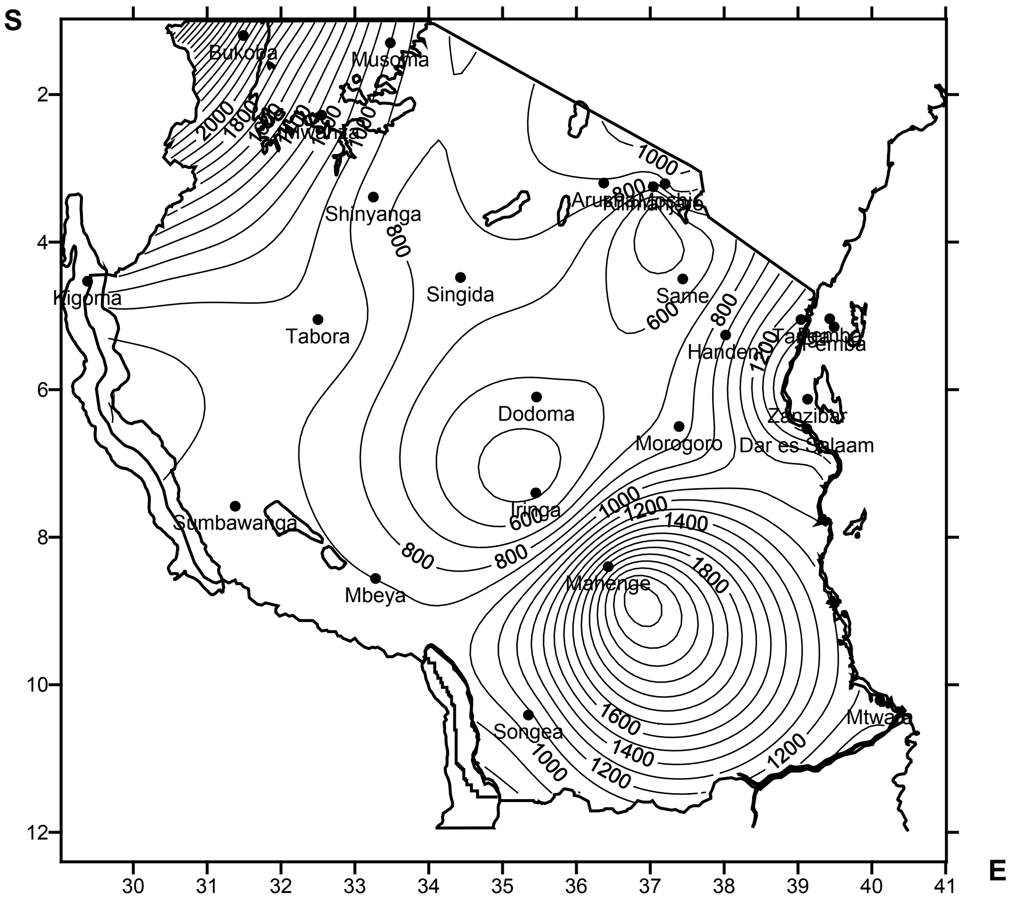


Figure 4: Total annual mean rainfall in Tanzania (1971 – 2000)
(Source: TMA 2007)

2.3 Agriculture Sector and Agro-ecological Zones

2.3.1 Agriculture sector

The agricultural sector is the leading sector of the economy of Tanzania and accounts for over half of the GDP and export earnings. Livestock production contributes about 15% of the agricultural GDP. Over 80% of the population live in rural areas and their livelihood depends on agriculture (URT 2001). The performance of agriculture is therefore a major factor in determining livelihood fortunes.

According to NAPA (2005), Tanzania has about 88.6 million hectares of land suitable for agricultural production, including 60 million hectares of rangelands suitable for livestock grazing. However part of this land is only marginally suitable for agricultural production and livestock grazing because of factors such as drought proneness and tsetse infestation. Currently, only 23% of the arable land is under cultivation, and of that about 97% is rainfed (World Bank, 2002). As for the rangelands, 50% is used for livestock grazing (URT 2001). Despite abundance of unutilized land, agriculture is dominated by small-scale subsistence farming. Approximately 85% of the arable land is used by smallholder farmers and traditional agro-pastoralists. It is estimated that the average per capital land holding in Tanzania is only 0.12 ha.

2.3.2 Agro-ecological zones

Based on altitude, rainfall pattern, dependable growing seasons and average water holding capacity of the soils and physiographic features, Tanzania has 7 main agro-ecological zones (Table 1 and Figure 5). These are Coastal; Eastern plateau and mountain blocks; Southern highlands; Northern rift valley and volcanic high lands, Central plateau; Rukwa-Ruaha rift zone; and inland sedimentary plateau, Ufipa plateau and western highlands.

Table 1: Agro-Ecological Zones of Tanzania

S/N	Zone	Altitude m/sea level	Rainfall pattern	Dependable growing season (months)	Physiographic
1	Coastal (C)	< 100 to 500	Bimodal and unimodal	3 to 10	Combination of coastal lowlands, uplands, undulating and rolling plains
2	Eastern plateau and mountain blocks (E)	200 to 2000	Predominantly unimodal	From < 2 to 7	Many physiographic types, ranging from flat areas, undulating and rolling plains, hilly mountain, plateau to mountain blocks
3	Southern highlands (H)	1200 to 2700	Unimodal l	5 to 10	Composed of flat to undulating rolling plains and plateau, hilly areas and mountains
4	Northern rift valley and volcanic high lands (N)	900 to 2500	Unimodal	< 2 to 9.5	Ranges from flat to undulating plains, hilly plateau to volcanic mountains
5	Central plateau (P)	800 to 1800	Unimodal	2 to 6	Composed of flat plains, undulating plains, plateau and some hills
6	Rukwa-Ruaha rift zone (R)	800 to 1400	Unimodal	3 to 9	Composed of flat terrain, rocky terrain and complex terrain
7	Inland sedimentary plateau , Ufipa plateau and western highlands (SUW)	200 to 2300	Unimodal	3 to 9	Composed of undulating plateau, strongly dissected hills, dissected hilly plateau and undulating rolling plains.

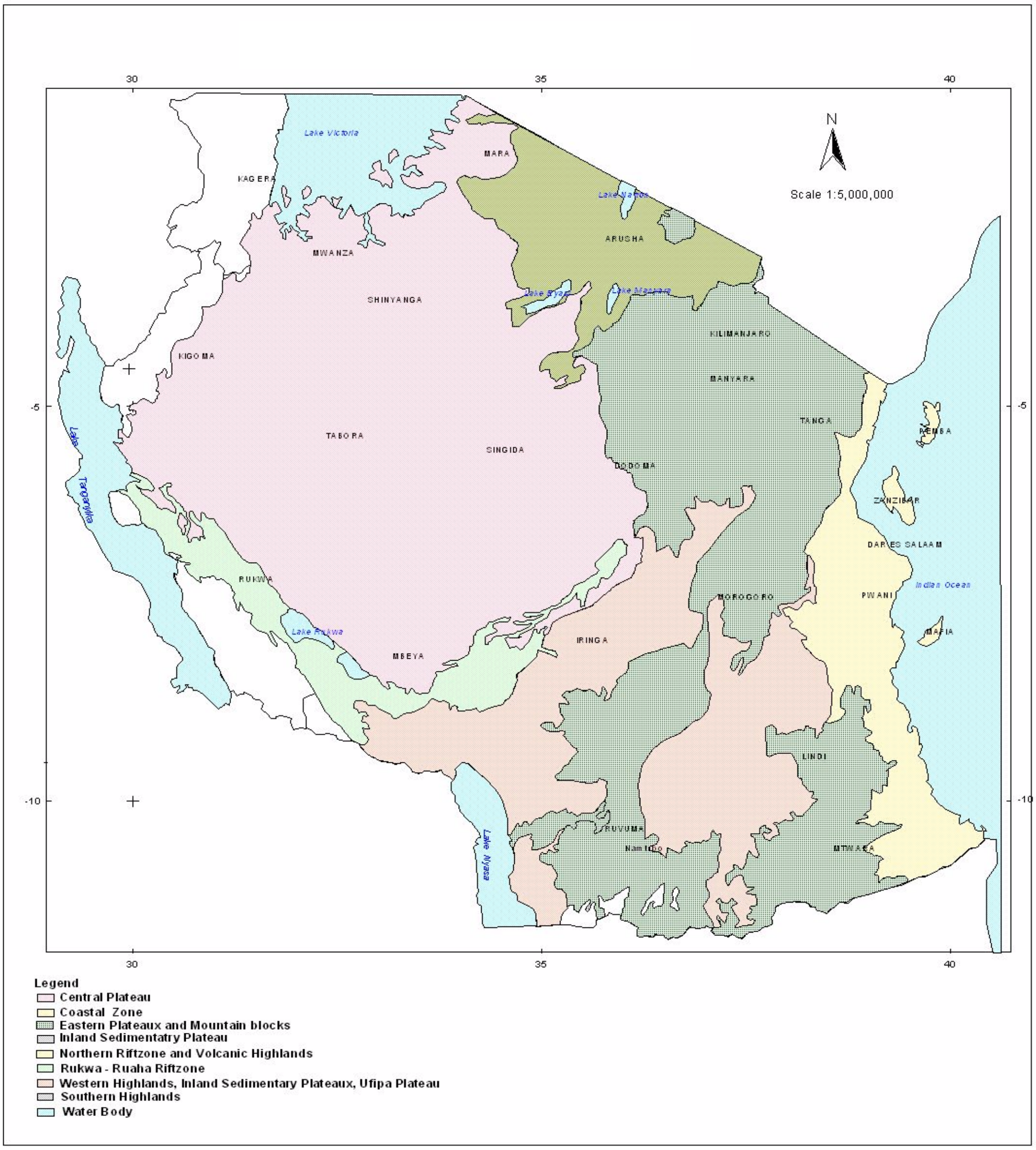


Figure 5: Agro-Ecological Zones of Tanzania.
(Source: AGRIFOR Consult 2006)

3. Climate Change and Variability

3.1 Introduction

Globally, climate change is real and happening now. The average global surface temperature has warmed by 0.8°C in the past century and 0.6°C in the past three decades (Figure 6; Hansen *et al*., 2006). According to National Research Council (2006), the last few decades of the 20th century were the warmest in the past 400 years. The Intergovernmental Panel on Climate Change (IPCC) has projected that if greenhouse gas emissions, the leading cause of climate change, continue to rise, the mean global temperatures will increase by 1.4 – 5.8°C by the end of the 21st century (IPCC 2001).

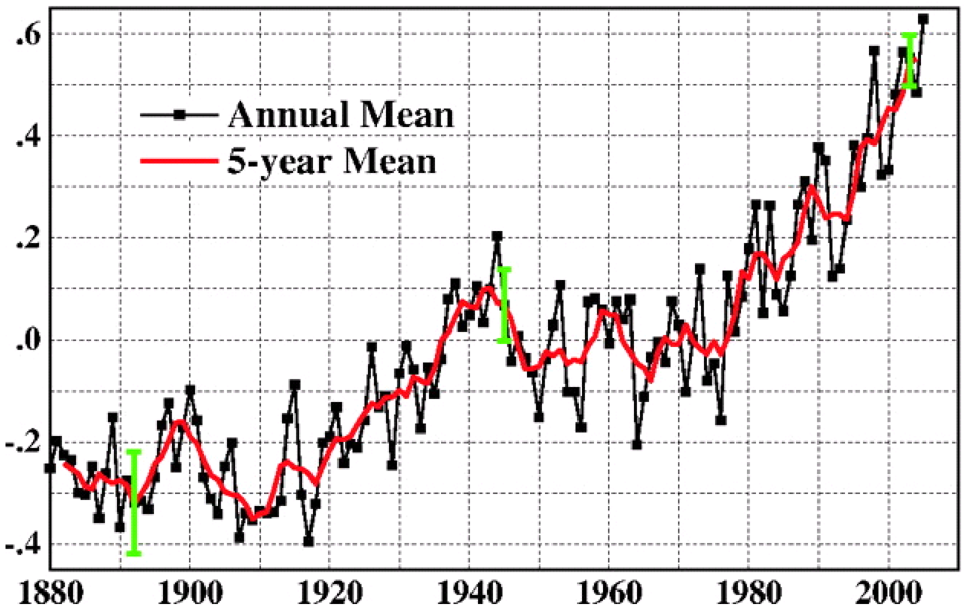


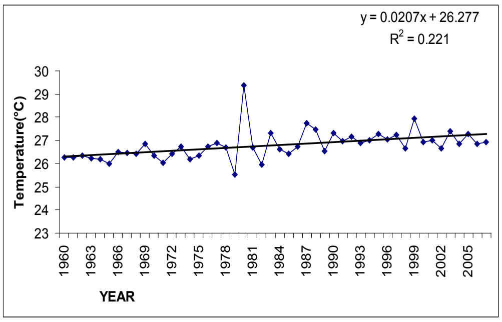
Figure 6: Global land-ocean temperature anomaly (°C). Base period 1951-1980. (Source: Hansen et al., 2006)

3.2 Climate Variability and Trends in Tanzania

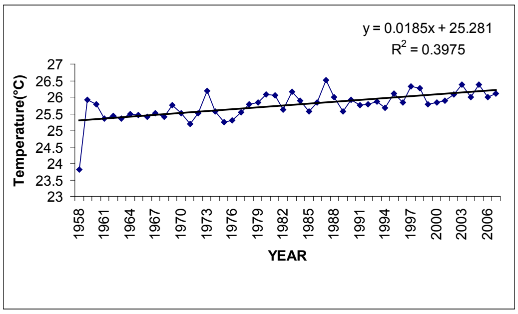
3.2.1 How climate has been changing for be past 30 years

i) Temperature

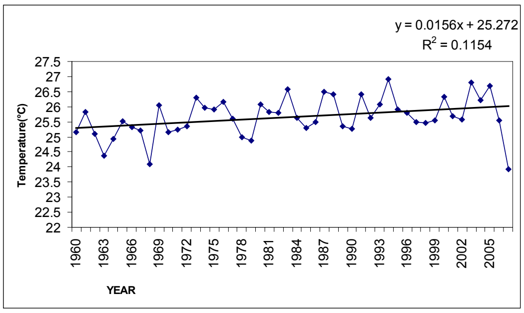
Analysis of monthly minimum and maximum temperatures over the last 30 years (between 1974 and 2004) for meteorological stations located in regions of Arusha, Bukoba, Dodoma, Iringa, Kilimanjaro, Mbeya, Morogoro, Mwanza, Songea, Tanga, Zanzibar and Shinyanga showed an upward trend (Figure 7). The increasing trend was mostly associated with the months of January, July and December. The retreat of the glaciers of Mt. Kilimanjaro, the submersion of Maziwe Island in the Indian Ocean near the coast of Tanga, and decrease in water levels of Lake Victoria and increasing malaria incidents in highland areas of the country could be linked to the observed temperature trend (NAPA, 2005).



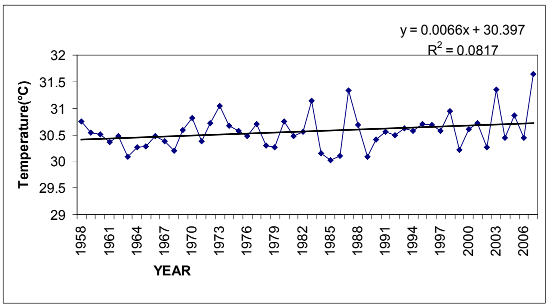
a) Songea station



b) Bukoba station



c) Arusha station

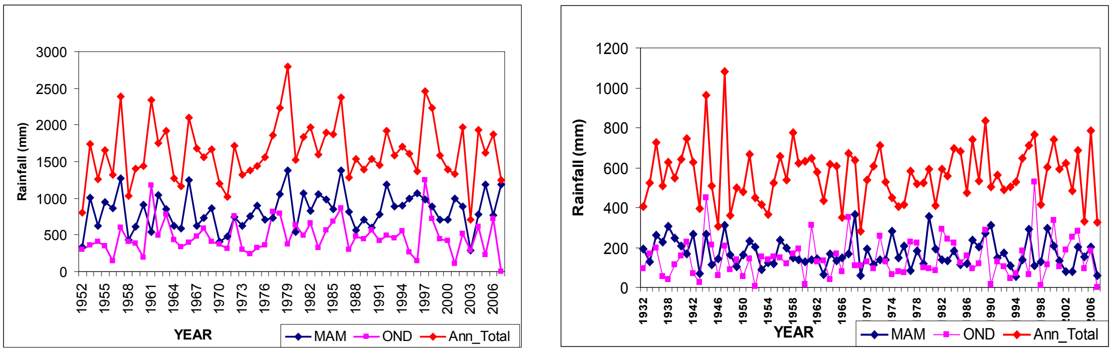


d) Zanzibar station

Figure 7: Mean annual maximum temperature time series for Songea, Bukoba, Arusha and Zanzibar stations (1958 – 2005)
(Source: TMA 2007).

ii) Rainfall

Analysis of annual rainfall time series by TMA (2007) indicated a decreasing rainfall trend for most of the stations, however the observed negative rainfall trend are not statistically significant. One common feature of the rainfall pattern was a greater variability in cycles. Figure 8 shows the trend of rainfall observed from 1952 to 2006 at Zanzibar and Dodoma meteorological stations and Figure 9 shows annual total rainfall differences between 1971-2000 and 1961-1990 epochs for the entire country.



a) Zanzibar station b) Dodoma station

Figure 8: Year to year rainfall fluctuations for Zanzibar and Dodoma stations (Source: TMA 2007). (It would have been more illustrative if a trend line had been fitted in the graph)

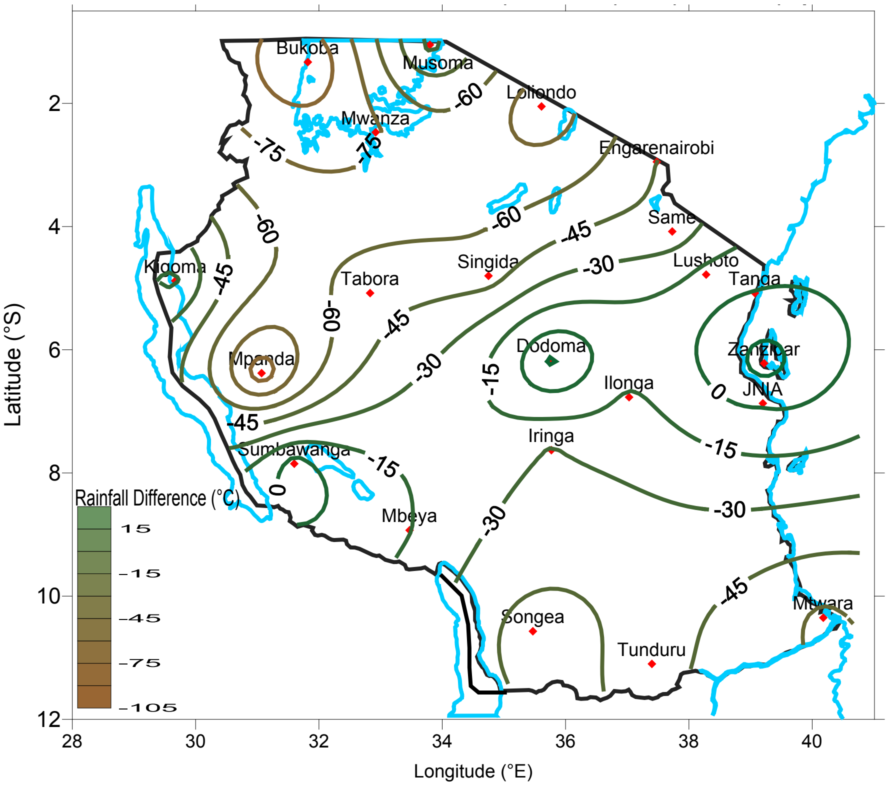


Figure 9: Annual total rainfall differences between 1971-2000 and 1961-1990 epochs (Source: TMA 2007). (Not very clear. For a layman, it may not be easy to understand the information in the map)

3.2.2 Drought and flood incidences in Tanzania

Droughts and floods are common features in Tanzania. Table 2, 3 and 4 present occurrences and impacts of major natural disasters in Tanzania since the last century.

Table 2: Top ten natural disasters and the number of people affected from 1960s to 1990s

(What about the 1997/98 Elnino?)

No.	Disaster type	Date	No Affected
1	Drought	1996	3,000,000
2	Drought	1984	1,900,000
3	Drought	1991	800,000
4	Flood	12-Feb-1993	201,543
5	Flood	3-Apr-1990	162,000
6	Flood	7-Apr-1989	141,056
7	Drought	1988	110,000
8	Flood	Jun-1979	90,000
9	Flood	May-1974	68,000
10	Flood	Mar-1968	57,000

Source: EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net

The cereal deficit was assessed at 916,000 metric tons – the same figure given by the President in September. The government appealed for additional food aid. The President declared a national food crisis in mid-September and farmers were given assistance for planting drought-resistant crops and early maturing varieties (CICERO 2000:3).

Table 3: Top ten natural disasters and their economic damage from 1960s to 1990s

No.	Disaster type	Date	Damage US* (000's)
1	Flood	12-Feb-1993	3,510
2	Flood	May-1974	3,000
3	Flood	Mar-1968	1,000
4	Flood	3-Apr-1990	280
5	Earthquake	19-May-1901	Nil
6	Earthquake	19-Jul-1908	Nil
7	Earthquake	13-Dec-1910	Nil
8	Earthquake	10-Dec-1913	Nil
9	Flood	May-1964	Nil
10	Earthquake	7-May-1964	Nil

Source: EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net

Table 4: Droughts and floods incidents in Tanzania from 1901 to 2007

	Number of Events	Killed	Injured	Homeless	Affected	Total Affected	Damage US$ (000's)
Drought	6	0	0	0	5,883,483	5,883,483	0
average per event		0	0	0	980,581	980,581	0
Flood	27	542	75	106,252	770,695	877,022	7,790

average per event	20	3	3,935	28,544	32,482	289

Source: EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net

Table 2 indicates that, in comparison to other disasters, drought has affected the largest number of people in Tanzania since the last century. However, as depicted by Table 3, economically, flood has been the most disastrous.

Droughts can be highly destructive, especially when prolonged. In recent years, the *Maasai* pastoralist community in the north of the country have been badly affected by the failed rains during the period. Forced to leave their villages, many walked up to 30km a day in search of water. Sometimes, forced to drive tens of thousands of cattle inside National parks and game reserves in search of pastures and water, risking attacks by wild animals. The incursion also threatens to spread diseases to wildlife whose immune systems are not used to infections carried by domesticated animals.

Plate 1: Weak and sick cattle have been dying because there has not been enough food and water

At the peak of the drought livestock keepers rushed to sell emaciated and dying stock (Plate 1) causing cattle prices to plummet. In addition, droughts have killed dozens of wild animals in Tanzania and neighbouring Kenya, and have partially disrupted the migration of more than 1.5 million wildebeests, zebras and other herbivores from Kenya's Maasai Mara to the Serengeti National Park in Tanzania.

Furthermore, prolonged drought has dried up rivers in Tanzania and left a number people on the verge of starvation, with much of the country experiencing daytime power cuts as hydroelectric plants faced water shortages.

On the other hand, flooding cuts off road and railway access to regions which faced food shortages due to drought (?). Travel is hardly possible over major roads linking one town to another. With the flow of commercial food restricted, prices in local markets become higher making people with average income unable to afford.
As a result of floods, outbreaks of common diseases, such as malaria, diarrhoea and intestinal worms increase rapidly.

3.3 Climate Change Projections in Tanzania

3.3.1 Temperature

Projections in temperature and rainfall changes over Tanzania are well documented in the Organisation for Economic Co-operation and Development (OECD) 2003 report. The assessment was based on outputs from over a dozen Global Circulation Models (GCMs) processed using MAGICC/SCENGEN.
The results indicate that mean annual temperatures are projected to rise by 2.2 °C by 2100, with somewhat higher increases (2.6 °C) over June, July and August, and lower values (1.9 °C) for December, January, February. The results are in agreement with the analysis done by TMA in 2007. The results by TMA (2007) indicated that the mean annual temperatures are projected to rise by between 1.7°C over north eastern areas of the country and 2.5°C over western parts of the country by 2100 (Figure 10). The Initial National Communication of Tanzania (2003) projected a temperature increase of between 3-5 °C under doubling of carbon dioxide, which is benchmarked to the year 2075. According to OECD (2003), the lower estimates of MAGICC/SCENGEN are likely from the use of more recent scenarios (SRES) and more recent GCMs with a better treatment of aerosols in the MAGICC/SCENGEN analysis, whereas, the Tanzania National Communication relied on four earlier generation models, as well as older emissions scenarios. Both sets of analyses however show temperature increases, and furthermore the patterns of seasonal temperature increase are consistent. Specifically, greater warming is projected for the

cooler months (June-August) compared to the warmer months (December-February).

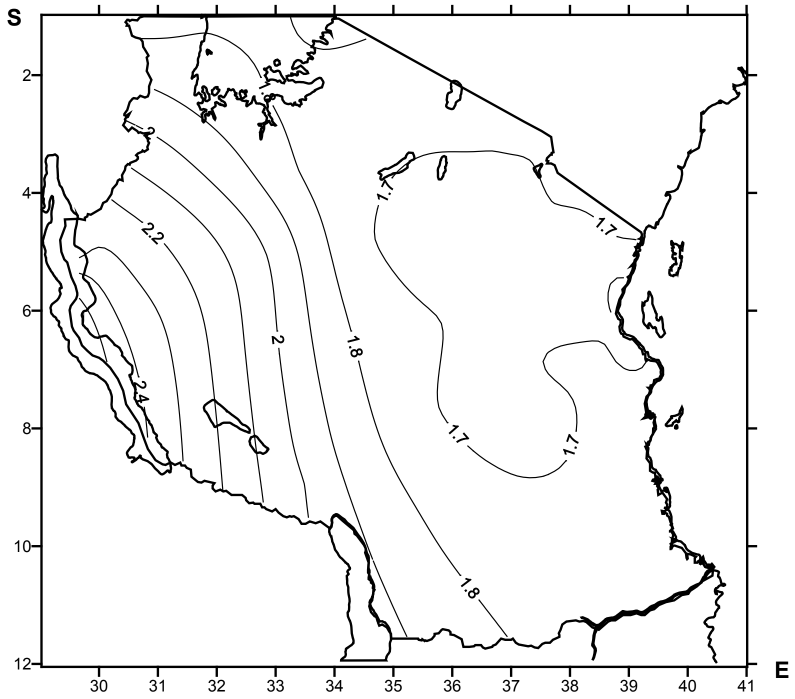


Figure 10: Mean temperature change due to doubling of CO_2 concentration by 2100 **(**Source: TMA 2007).

3.3.2 Rainfall

Rainfall predictions are less certain. Indeed, major discrepancies remain between climate models. The MAGICC/SCENGEN analysis projects annual precipitation over the whole country to increase by 10% by 2100, although seasonal declines of 6% are projected for June, July and August, and increasers of 16.7% for December, January, February. However, high standard deviations are indicative of low confidence in these projections across the various models used in the projections. Furthermore, averaged values for rainfall, as is done in the MAGICC/SCENGEN analysis, are of limited utility because the rainfall regimes across Tanzania vary considerably. The National Vulnerability and Adaptation Assessment of Tanzania (Reference?) estimates that northern and south-eastern parts of the country would experience an increase in rainfall ranging from between 5% and 45% under doubling of carbon dioxide. The central, western, south-western, southern, and eastern parts of the country might experience a decrease in rainfall of 10% to 15%. The southern highlands might similarly experience a decrease of 10%. The estimates by TMA (Reference?) shows that mean annual rainfall is projected to increase over North eastern areas by 15% and decrease westwards up to 6 % under doubling of carbon dioxide (Figure 11).

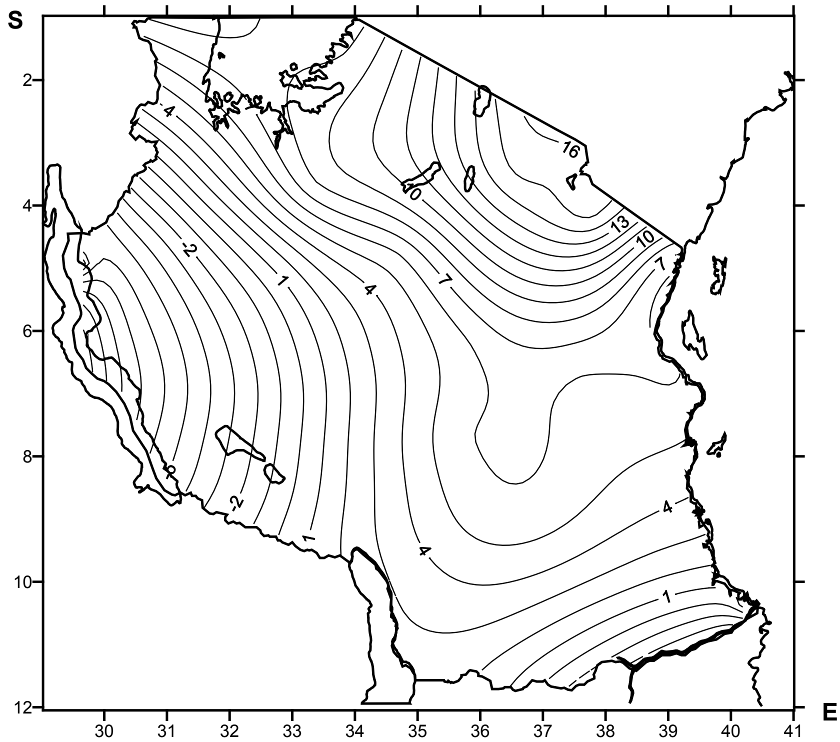


Figure 11: Change in mean annual rainfall (%) due to doubling of CO_2 concentration (Source: TMA 2007)

3.4 Impacts and Vulnerability of Climate Change and Variability on Agricultural Systems

The effects of climate change and variability such as rising temperature and changes in rainfall are undeniably clear with impacts already being manifested in ecosystems, biodiversity and people. Africa is among the most vulnerable regions to the impacts of climate variability and change (Fischer et al. 2005; IPCC 2001). Africa’s vulnerability arises from a combination of many factors, including extreme poverty, frequent natural disasters such as droughts and floods, and agricultural systems that are heavily dependent on rainfall. The high vulnerability of Africa to the impacts of climate variability and change is also attributed to its low adaptive capacity (UNFCCC 2006). The projected climate change will have far-reaching, negative impacts on the availability of water resources, food and agricultural security, human health, tourism, coastal development and biodiversity. The impacts have potential to undermine and even, undo the progress made in improving the socio-economic well-being.

The following sections discuss the impacts and vulnerability of climate change and variability on agricultural systems in Tanzania. The focus is on crops and livestock production, water resources, and the livelihoods of people.

3.4.1 Agricultural systems

i) Crop production

Rainfed agriculture is clearly the most important sector of the Tanzanian economy (refer to section 2.3). The three most important crops are: maize, coffee and cotton: with maize being a major food staple, coffee a major cash crop grown in large plantations (and contributing significantly to the GNI), while cotton is another cash crop grown largely by smallholder farmers.

Predicted changes in climate will have significant impacts on Tanzania's rain-fed agriculture and food production. Warming will shorten the growing season (How?) and, together with reduced rainfall, reduce water availability. In addition, the changes in climate would alter the distribution of the agro ecological zones. Consequently, areas that used to grow perennial crops would be suitable for annual crops. Warmer climate can also increase crop losses caused by weeds, diseases and pests.

Regional predictions indicate that Tanzania may suffer a loss of over 10% of its grain production by the year 2080 (Parry et al., 1999). The cultivation of maize is going to be particularly hard hit. Estimates from Crop Environment Resource Synthesis Model (CERES-Maize) (Jones and Kiniry, 1986) show that the average yield decrease over the entire country would be 33%, but simulations produced decreases as high as 84% in the central regions of Dodoma and Tabora. Yields in the north-eastern highlands showed decreases of 22% while in the Lake Victoria region decreases of 17% were indicated. The southern highland areas of Mbeya and Songea were estimated to have decreases of 10-15%. These reductions are mainly due to increases in temperature that shorten the length of the growing season and to decreases in rainfall. Consequently, the continued reliance on maize as a staple crop over wide areas of the country could be at risk. Change of staple crops to millet and cassava may be necessary in hinterland.

On the other hand, there is considerable uncertainty regarding the effects of climate change on the yields of most important cash crops such as coffee and cotton. However, according to URT (2003), the two cash crops are projected to experience increases in yield. For example, coffee yields are expected to increase by 18% and 16% for areas located within bimodal and unimodal rainfall, respectively. The agriculture sector thus may have both negative and positive impacts. However, maize production in particular might require particular attention for adaptation responses, given that it is a critical food crop.

ii) Livestock production

Climate change is expected to further shrink the rangelands which are important for livestock keeping communities in Tanzania and change the prevalence of vector-borne diseases. Currently, it is estimated that about 60% of the total rangeland is infected by tsetse fly making it unsuitable for livestock pastures and human settlements. According to IPCC (2001), expected climate change could result in a shift of the distribution of tsetse fly north-eastwards, which would further reduce the area of land suitable for grazing and human settlement. Milk and meat production are also likely to fall as climate change reduces the livestock carrying capacity of already over-stretched rangeland areas. In addition, shrinkage of rangelands is likely to exacerbate conflicts between farmers and pastoralists in many areas. Surveys have shown that existing number of cattle in Tanzania has already surpassed the normal carrying capacity in most of the areas. As a result, most livestock keepers are shifting their herd southwards in search for pastures.

3.4.2 Water resources

Like the agriculture sector, climate change is projected to have both positive and negative consequences for Tanzania's water-resources, specifically for the three major river basins: Wami Ruvu, Pangani, and Rufiji. The Wami Ruvu basin is upstream of Tanzania's major population center, Dar es Salaam. The Pangani basin supplies water to the Tanga, Kilimanjaro, and Arusha regions, supporting a number of economically important activities. These include the Arusha Chini sugar plantations in the Kilimanjaro region, the lower Moshi irrigation scheme, the Handeni District water supply, and a number of important power stations. The Rufiji basin is a large catchment in the south of the country. The basin is economically important to the nation because of the hydropower it generates at Mtera and Kidatu Dams, tourism in the Ruaha National Park, and irrigated agriculture in the plains.

According to URT (2003), the Wami Ruvu basin could experience a 10% decrease in runoff, while annual basin runoff in the Pangani basin is estimated to decrease by 6%. According to URT (2003), the Rufiji River, which houses Mtera and Kidatu hydropower stations, is expected to experience an increase in river flow by 5-11%. Floods on Rufiji and Pangani Rivers would cause damage to major hydropower stations and human settlements found along these river basins in the country. However, according to OECD (2003), all these estimates should be interpreted with some caution because they are based on scenarios from a single GCM. Nevertheless, decreases in runoff could potentially have serious effects on socio-economic activities in Dar es Salaam, Morogoro, Tanga, Coast, and Kilimanjaro Regions. Dar es Salaam might be particularly vulnerable because it is the largest industrial, commercial, and administrative center in Tanzania. The second Vulnerability Assessment Report (by whom? Reference?) indicates that civil conflicts have been occurring between livestock keepers and farmers over pasture and water in Morogoro, Mara and Kilimanjaro Regions. The cost of realising the UN Millennium Development Goals is likely to rise as poor access to water impacts adversely on livelihoods, health and productivity (CARE 2006).

3.4.3 Human health

Changes in climate will also have direct and indirect impacts on human health. Warming is predicted to increase the incidence of insect-borne diseases such as malaria, schistosomiasis and trypanosomiasis. The increased frequency of droughts and flooding is in turn likely to increase the frequency and magnitude of epidemics of water-borne diseases such as typhoid and cholera, as well as to influence the incidence of mosquito-borne diseases. According to NAPA (2005), under the current trend in both rainfall and temperature, the frequency of occurrences and impacts of malaria will further rise. Recently, malaria has been observed to occur in non-traditional areas found in high altitudes such as Kilimanjaro and Arusha, a pointer perhaps of the impact of climate change. As more areas receive more rains, it will in turn attract more malaria vectors, leading to increased incidence of malaria disease across the country.

4. Strategies for Managing Risk and Reducing Vulnerability

4.1 Existing Indigenous and Exogenous Technologies

4.1.1 Indigenous technologies

Understanding the historical interactions between society and climate hazards (including adaptations that have evolved to cope with climate hazards) is a critical first step in developing adaptations to manage possible future climate risks. Over time, societies have developed an understanding of climate variability in order to manage climate risk. People have learned to modify their behaviour and their environment to reduce the harmful impacts of climate hazards and to take advantage of their local climatic conditions. Through a process of innovation and adaptation, indigenous farmers have developed different farming systems finely tuned to many aspects of their environment. According to Kihupi (2000) and Mhita (2006), traditional knowledge, indigenous practices and identified local innovations contain valuable information that should be used as a basis for improved technologies and strategies to cope with projected changes. According to Stigter *et al*. (2005), traditional knowledge and indigenous technologies that mitigate consequences of variabilities need special attention. Drought being already a serious threat, indications for longer dry spells in rainy seasons and longer sequences or higher frequencies of abnormal rainfall seasons, with respect to total rainfall and rainfall distribution, make the indigenous ways of coping with drought situations even more important (Recast). Important information on traditional adaptation strategies of farmers can be described in terms of planting dates and their variability, irrigation practices, treatment of false starts of growing seasons, choice of varieties with different lengths of growing cycle. Examples of indigenous strategies include traditional water harvesting techniques (which include, among others, the excavated bunded basins locally called *Majaluba* for rice production in the Lake Zone, raised broad basins locally called *Vinyungu* in Iringa region and water storage structures locally called *Ndiva* in Kilimanjaro region). These interventions are aimed at improving water availability for crop production. The concept of "*Mashamba ya mbuga"* whereby farmers grow high water demanding crops in the lower parts of a landscape using rainwater from the surrounding high grounds has been practised since time immemorial in semi-arid areas of Tanzania. These traditional rainwater-harvesting systems have been perfectly sustainable for many years. The reason for this is that they are compatible with local lifestyles, local institutional patterns and local social systems (Mbilinyi *et. al.* 2005). A related technology, of which also the IPCC advocates more intensive use, is that of water impoundment. Several useful examples are given from Indonesia, Sri Lanka, Niger, and Burkina Faso. Permaculture, water harvesting and infiltration pits, together with the use of drought tolerant crops, have been more recently extended in Zimbabwe, particularly by women, with the help of NGOs, in response to recurrent droughts (Stigter *et al*. 2005).

Pastoral groups have dealt with recurrent drought and other extreme climate events in a number of ways. The techniques used include migration in search of pasture and water in neighbouring areas, depending on social networks and trusts, switching between capital assets, and migrating to other areas to look for work until droughts have passed and distributing their livestock among relatives and friends in other areas to ensure they are not all wiped out in a disaster (Victor Orindi *et. al.,* 2006). In addition, traditional silvo-pastoral practices, locally known as "*Ngitiri*", "*Ronjo*" or '*Mlimbiko*' in Shinyanga, Arusha and Kilimanjaro/Dodoma, respectively, are used by pastoralists to alleviate shortage of dry-season fodder supply. In this practice, either a farm is enclosed and pasture is left to regenerate or a rangeland is subdivided into pasture zones and some zones are reserved for only dry season grazing. Such systems rely on customary laws and institutions that are respected by community members (Victor Orindi *et. al.,* 2006). Indigenous knowledge (IK) also plays a significant role in early warning and weather forecast, forest and pasture conservation, soil and water conservation and disaster preparedness (Kihupi, 2000; Mhita, 2006).

Traditional agro and pastoral systems can cope effectively and in an environmentally sustainable manner with the prevailing harsh and erratic ecological conditions. Experience with these systems needs to be shared among communities. However a rapid change of the vulnerability context due to more frequent and severe climate events does not always allow for traditional coping mechanisms to take place and often results in an overall loss or severe ineffectiveness in the adaptive capacity of the communities. In this regard, new technologies may play a crucial role through their integration, where appropriate, into local strategies. It is also likely that the most effective adaptation solutions can be provided by a combination of both local strategies and larger scale adaptive measures. Ongoing monitoring, documentation and dissemination of good agricultural practices, indigenous and newly developed ones, is therefore an essential part.

4.1.2 Exogenous technologies

According NAPA (2005), the existing adaptation and coping strategies for Tanzania for the agriculture sector consist of small scale irrigation, research and development on drought tolerant seed varieties, agriculture extension activities, diversification of agriculture by growing different types of crops on different land units and water harvesting. The potential strategies for this sector include alternative farming systems; promote indigenous knowledge; change planting dates in some agro ecological zones; increase irrigation to boost maize production in selected areas; drip irrigation for specific regions; reduce reliance on maize as staple food by growing short-season and drought tolerant crops such as sorghum and millet; shift crop farming to more appropriate agro ecological zones; change crop rotation practices; integrated crop and pest management; make better use of climate and weather data, weather forecasts, and other management tools; create awareness on the negative effects of climate change; sustainable water management to boost food crop production; strengthen early warning system; follow standard agronomic practices and insist on annual and short term crops (NAPA, 2005).

Existing adaptation and coping strategies for the livestock sector include strengthening of cross breeding for resistant breeds; tick and tsetse control programmes; livestock extension services; livestock marketing infrastructure; research and development; and promotion of zero grazing. The proposed potential strategies comprise of change of land use patterns; tsetse fly control; integrated pest and disease control; sustainable range management; infrastructure development; research and development; education of farmers/livestock keepers; advocate zero grazing and control movement of livestock (NAPA, 2005).

4.2 Political Commitment and Institutional Aspects

4.2.1 Role of policy

The concern for the implications of climate change, in Tanzania and elsewhere in the world, has gained increasing attention. The high-profile scientific concern for climate change has also contributed to create awareness and commitment among the countries in the world. Tanzania is a party to various international environmental agreements, including the UNFCCC, UNCCD, and UNCBD. In 1997 Tanzania developed her first National Action Plan on Climate Change, and in July 2003 submitted its Initial National Communication to the UNFCCC and recently submitted its National Adaptation Programme of Action (NAPA). NAPA undertook climate change vulnerabilities assessment across key sectors (i.e. energy and industry; agriculture, livestock, forest, land use, tourism, health, wildlife and wetland; and coastal, marine, and freshwater resources), developed key adaptation options and strategies that would best address those vulnerabilities, and prioritize the fourteen top most possible adaptation activities that would address the country's most urgent needs from all sectors. NAPA is a valuable means of identifying impacts and vulnerabilities and building multi-stakeholder participation through joint problem solving exercises. However, according to CARE (2006), there has been little evidence of stakeholder consultation or civil society involvement. The actors involved have largely been government-based. In addition, according to Orindi *et. al.,* (2006), the current NAPA methodology of assessing climate change vulnerabilities takes scenarios of climate change rather than existing adjustments and sources of vulnerability to climatic changes as a starting point for analysis. This leads to a lack of emphasis on local coping strategies and adjustments. As a consequence, many of the options suggested in NAPA are technical and expensive, making them inaccessible to vulnerable groups including the poor, who are supposed to benefit from using them. The solution, therefore, lies in strengthening strategies that communities have been using. Furthermore, the methodology by NAPA regards climate parameters rather than social conditions as key determinants of vulnerability to climate change. Orindi *et. al.,* (2006) recommend the livelihood approach that involves present vulnerability assessments because it will help to identify measures that reduce vulnerability and increase adaptive capacity through understanding the causes and distribution of vulnerability.

In addition to country commitment to international environmental agreements, Tanzania has developed a number of national and district level sectoral policies and plans that are intended to increase its ability to cope with climate variability and long term climate change. Existing strategies aim most directly at climate adaptation and largely focusing on increasing agriculture's drought resistance. Drought-resistant crops are perceived in policies as a principal means of addressing problems related to climate variability and drought in particular. Promotion of such species is integrated into national and district development policies, multi-sectoral policies, and sectoral policies in Tanzania. Drought-resistant crops and technologies are even more explicit priorities in District Agricultural Development Programmes (DADPs). In Same District, for example, emphasis is on improving agricultural drought resistance by promoting early maturing seeds and drought resistant crops. However, efforts to promote drought resistant crops face several constraints. Farmers are reluctant to adopt certain drought-resistant species, in part due to low market and consumption values. It is likely that successful increasing cultivation (recast) of drought-resistant species requires numerous measures addressing social, economic and technical constraints. Warehouse Receipt Systems (WRS), whereby small farmers are assured of the market, input, and credits, could provide answers to some of the problems (Reference?). A further advantage of WRS, is that it offers stable prices, linking the small farm sector to sources of extension advice, mechanization, seeds, fertilizer and credit, and to guaranteed and profitable markets for produce. However, the system is currently limited to a small area and applied mainly on coffee and cotton production systems (Mukwenda 2005).

Another way of addressing drought vulnerability and reducing the sensitivity of farming due to erratic rainfall is to provide agricultural water from other sources. Irrigation is a central concern, particularly in development and agricultural policies. Improvement and expansion of irrigation as well as water harvesting are identified as important measures to increase agricultural production (URT 2001; URT 2006). The National Strategy for Growth and Reduction of Poverty (NSGRP) explicitly recognises the fact that poor people rely heavily on natural resources and are most vulnerable to external shocks and environmental risks, including drought and floods. As a result, the strategy stresses a need to have approaches to mitigate effects of natural disasters, halt desertification and promote water conservation practices.

However, some of these goals have been articulated in previous plans, but have not been successfully implemented. Therefore, despite the obvious synergies between such policies and climate change adaptation, a key obstacle facing successful "mainstreaming" is successful implementation (OECD, 2003).

Other relevant policies include National water policy (2002), National Disaster Management Policy (2004) and recent Review of Drought Preparedness (Reference?). However, according to Amani and Standen (2004), the policies do not explicitly mention climate change.

4.2.2 Institutional aspects

Better forecasting and early warning systems are obvious and efficient contributors that can facilitate adaptation to climate variability and change. For example, the application of climate forecasts by farmers can significantly improve their farming decision making and adaptation to the changing climate. In recognition of this, the government of Tanzania established the Tanzania Metrological Agency (TMA). The agency is responsible for provision of agro-meteorological services, including daily weather forecast, 10-days forecast, monthly forecast, seasonal forecast and agronomical advisory (such as when to prepare fields, what to plant). The information is also used in early warning and drought risk monitoring. Under the Ministry of Agriculture, Food Security and Cooperatives (MAFSC), the Government established the Early Warning Unit that gives information on rainfall for crop production, crop status and other externalities that might affect food security. However, lack of widespread use of this information and knowledge to improve farm management suggests that farmers have difficulty translating the information into tangible economic farm outputs. Difficulties in interpreting and applying the forecasts as they are currently expressed include, mismatch between the variables forecast and the operational needs of farmers, lack of trust or comprehension of the forecasts. Similar findings have been documented in other areas (Eakin, 2000; Phillips et al., 2001; Roncoli et al., 2002). In addition, lack of interaction and collaboration between the national meteorological agency and agricultural institutions has been identified as one of the reasons for not mainstreaming climate information by different users (including farmers). For effective use of climate information, TMA should interact and work closely with the users to promote the utilisation of their products while the agricultural departments should interact with TMA to make them produce appropriate products as required for decision making in agriculture.

As explained earlier, Tanzania has experienced a variety of natural phenomenon and disasters, including droughts and floods. These disasters have seriously disrupted development gains made over the years. In fighting the problem, the Government has taken various measures in line with the Hyogo Framework of Action (HFA) (Reference?). The government has established a Disaster Management Department (DMD), which operates under the Prime Minister's Office to coordinate disaster risk reduction activities in the country. It has also established a Disaster Management Training Centre (DMTC) located at the Ardhi University, in Dar es Salaam. Through this centre, it has managed to train a good number of Disaster Management Managers from the districts, regions, ministries and other related institutions. In implementing the Ten-Year Hyogo Declaration and Framework for Action (2005-2015) that targets Disaster Risk Reduction and make the world a safer place to live, the government has done a number of things, including formulation of the Disaster Management Policy, the blue print that elaborates in detail and identifies the roles of stakeholders in disaster management. In addition, the Government of Tanzania has already carried out assessment and identification of hazards in all regions and has come up with the National Operational Guidelines (NOG) on how to prevent, mitigate, get prepared and respond to disasters. The NOG also identifies the roles of each stakeholder in all stages of disaster management cycle. The other measures taken by the Government in favour of disaster risk reduction include establishment of the Division of Environment in the Vice-President's Office and the National Environmental Management Council (NEMC), a move aimed at strengthening the conservation of the environment in the country. However, the government still does not have adequate information for drawing up appropriate plans for disaster management. Disaster preparedness, especially at the household and village levels, is still low (Kiunsi and Meshack 2006).

5. Conclusions

The following conclusions can be drawn from this report:

1). Agriculture, which includes crop growing and livestock production, remains the most important livelihood strategy to the majority of the population in Tanzania. The sector needs to be strengthened to facilitate survival in a changing climate.

2). The effects of climate change and variability are undeniably clear with impacts already affecting agricultural systems. Given the low level of human development, extreme poverty, and high dependence on rainfed agriculture, Tanzania is quite vulnerable to projected climate change, making adaptation an extreme necessity.

3). While some adaptation to current climate variability is taking place, this is insufficient to cope with future changes in climate. In addition, a number of deficiencies do still exist on the current adaptation strategies. Risk management strategies should therefore aim at addressing the existing adaptation deficit and be adjusted to face additional climate risks associated with climate change. One effective option could be a combination of local strategies and "recommended" adaptive measures. Ongoing monitoring, documentation and dissemination of good agricultural practices, indigenous and newly developed ones, is therefore an essential part.

4). The agricultural sector is expected to experience both negative and positive impacts under climate change. For example, while production of maize is projected to decline, the production of coffee and cotton is expected to increase. The implication for adaptation therefore may be not to only focus on minimizing risk, but also to capitalize on opportunities associated with the changing climate.

6. Reference

AGRIFOR Consult. 2006. Tanzania - Country Environment Study Draft Report. (Unpublished)

Amani, H. and H. Standen (2004), Review of 2002/03 Drought Preparedness and Response, Tanzania, Economic and Social Research Foundation in Collaboration with the Disaster Management Department of the Office of the Prime Minister, the National Food Security Department of the Ministry of Agriculture and Food Security, and the Tanzania Food Security Information Team.

Blench, R. and Marriage, Z. 1998. Climatic uncertainty and natural resource policy: What should the role of government be? Natural. Resource. Perspectives 31: 8.

CARE. 2006. Climate Change and Poverty in Tanzania realities and responses. Background report for the CARE International Poverty-Climate Change Initiative September 2006.

Department for International Development (DFID), UK. 2004. Key sheet 10 Climate change in Africa/ Global and Local Environment Team, Policy Division, DFID.

Desjardins, R., Smith, W., Grant, B., Campbell, C., Janzen, H. and Riznek, R. 2005. Management strategies with particular emphasis on carbon sequestration to mitigate greenhouse gas emissions from agro ecosystem, Climate Change. 70: 283–297.

Fischer, Günther, Mahendra Shah, Francesco N. Tubiello, and Harrij van Velthuizen. 2005. "Socio-economic and Climate Change Impacts on Agriculture: An Integrated Assessment, 1990-2080." Philosophical Transactions of the Royal Society B: Biological Sciences 360 (1463): 2067–83.

Hansen J., M. Sato, R. R., Ken Lo, D.W. Lea, and M. Medina-Elizade, 2006. Global temperature change. Proceedings of National Academy of Sciences of United State of America (PNAS). Vol. 103, No. 39, Pg 14288-14293.

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). 2003. IPCC Press information on AR4 and emissions scenarios. Media release, 8 Dec, 2003. http://www.ipcc.ch/press/pr08122003.htm

International Institute for Environment and Development (IIED). 2006. Climate Change in Africa: Linking Science and Policy for Adaptation Workshop Report The Royal Society, London, March 30th 2006.

Jones, C.A. and J.R. Kiniry (eds.) 1986. CERES-Maize. A Simulation Model of Maize Growth and Development, Texas A& M Press, College Station.

Kihupi, 2000. Promotion and Integration of IK in seasonal climate forecasts, DMC, Harare, Zimbabwe.

Kiunsi, R.;Meshack,M.V. (2006):Disaster vulnerability assessment, the Tanzania experience. In: Measuring Vulnerability to Natural Hazards, Towards Disaster Resilient Societies. UNU-Press, Tokyo, New York, Paris.

Lemos, M. C., Finan, T. J., Fox, R. W., Nelson, D. R. and Tucker, J. 2002. The use of seasonal climate forecasting in policy making: Lessons from northeast Brazil, Climate Change 55: 479–507.

Mbilinyi B.P., S.D. Tumbo, H.F. Mahoo, E. M. Senkondo and N. Hatibu (2005). Indigenous Knowledge as Decision Support Tool in Rainwater Harvesting. Elsevier Journal of Physics and Chemistry of the Earth, Vol. 30, pg 792-798

Mhita, M. S. 2006. Nature Conservation and Natural Disaster Management-Role of IK in Tanzania. TMA, Dar es Salaam, Tanzania.

Mukwenda E.B.J. 2005. Potential for using the warehouse receipt system in financing maize marketing in Tanzania under market liberalization: case study of Mbozi and Babati Districts. Unpublished MSc. thesis, Sokoine University of Agriculture.

National Adaptation Programme of Action (NAPA) for Tanzania. 2005. Division of Environment, Vice President Office, Dar es Salaam, Tanzania

National Research Council of the National Academies. 2006. Surface Temperature Reconstructions for the Last 2,000 Years. Committee on Surface Temperature Reconstructions for the Last 2,000 Years, Board of Atmospheric Sciences and Climate, Division of Earth and Life Sciences. The National Academies Press, Washington D.C.

Organisation for Economic Co-operation and Development (OECD), 2003. Development and climate change in Tanzania: focus on Mount Kilimanjaro

Orindi V. A., E. Kibona and D.M. Moindi. 2006. Addressing climate change in the development process in Tanzania. African Centre for Technology Studies (ACTS), Ecopolicy Series No. 18, Acts Press, Nairobi.

Orindi, V.A. and L.A. Murray (2005), Adapting to Climate Change in East Africa: A Strategic Approach, Gatekeeper Series 117. International Institute for Environment and Development: London, UK.

Parry, M., Rosenzweig, C., Iglesias, A., Fischer, G. and Livermore, M. 1999. Climate Change and World Food Security: A New Assessment. Global Environmental Change. 9: S51-S67.

Stewart, J. I. 1988. Principles and Performance of Response Farming, in Muchen, R. C. and Bollany, J. A. (eds.), Climatic Risk in Crop Production: Models and Management for the Semi-Arid Tropics and Subtropics, CAB International, Wallingford', 361–382.

Stigter, C. J., Zheng Dawei,, Xurong, M. and Onyewoto, L. O. Z. 2005. Using traditional methods and indigenous technologies for coping with climate variability. Climate Change, 70: 255–271.

United Nations Framework Convention for Climate Change (UNFCCC). 2006. Documentation for the African regional workshop on climate change adaptation held in Accra, Ghana, in September 2006. Also available at http://unfccc.int

United Republic of Tanzania (URT). (2001). Agricultural Sector Development Strategy (ASDS). Ministry of Agriculture, Dar-es Salaam.

United Republic of Tanzania (URT). 1998. National Forest Policy. Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania.

United Republic of Tanzania (URT). 2002. National Water Policy. Ministry of Water and Livestock Development, Dar es Salaam, Tanzania.

United Republic of Tanzania (URT). 2003. Initial Communication under the United Nations Framework Convention on Climate Change (UNFCCC). Vice President's Office, Dar es Salaam, Tanzania, http://unfccc.int/resource/docs/natc/tannc1.pdf.

United Republic of Tanzania (URT). 2005. National Strategy for Growth and Reduction of Poverty (NSGRP). Vice President's Office, Dar es Salaam, Tanzania.

United Republic of Tanzania (URT). 2006. The Agricultural Sector Development Programme (ASDP), Dar es Salaam, Tanzania.

United Republic of Tanzania (URT). 2007. National Environmental Policy. Vice President's Office Dar es Salaam, Tanzania.

World Bank. 2002. World Bank Development Indicators. On CD Rom. World Bank, Washington, DC.