KENYA CLIMATE-LAND INTERACTION PROJECT (CLIP)

Adaptation to Climate Change: A Case of Kenya

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Acronyms

ASAL	- Arid and Semi Arid Land
AU	- African Union
BBC	- British Broadcasting Corporation
CBO	- Community Based Organization
CDA	- Coast Development Authority
CIMMYT	- International Maize and Wheat Improvement Centre
COP	- Conference of Parties
EA	- East African
EEA	- European Environment Agency
EMOP	- Emergency Operation
ENNDA	- Ewaso Nyiro North Development Authority
ENSDA	- Ewaso Nyiro South Development Authority
ERS	- Economic Recovery Strategy for Wealth and Employment Creation
FMD	- Foot and Mouth Disease
GDP	- Gross Domestic Product
GoK	- Government of Kenya
ICPAC	- IGAD Climate Prediction and Application Centre
IGAD	- Inter-Governmental Authority on Development
IISD	- International Institute for Sustainable Development
ILRI	- International Livestock Research Institute
IPAR	- Institute of Policy Analysis and Research
IPCC	- Inter-Governmental Panel for Climate Change
IRIN	- Integrated Regional Information Networks
IUCN	- World Conservation Union

KARI - Kenya Agricultural Research Institute

KBC - Kenya Broadcasting Corporation

KFSM - Kenya Food Security Meeting

KM - Kilometers

KSHS - Kenya Shillings

KVDA - Kerio Valley Development Authority

MDG - Millennium Development Goal

MoA - Ministry of Agriculture

MOE - Ministry of Energy

MOH - Ministry of Health

MoLFD - Ministry of Livestock and Fisheries Development

MOPND - Ministry of Planning and National Development

MoWR - Ministry of Water Resources

MPER - Medium Term Expenditure Framework

NASA - National Aeronautics and Space Administration

NEAP - National Environment Action Plan

NEMA - National Environment Management Authority

NEPAD - New Partnership for Africa's Development

NGO - Non Governmental Organization

SRA - Strategy for Revitalizing Agriculture

TARDA - Tana and Athi Rivers Development Authority

UN - United Nations

UNEP - United Nations Environment Programme

UNFCCC - United Nations Framework Convention on Climate Change

USA - United States of America

Abstract

Climate change has over the past two decades taken centre stage in the World Economy. The fact that it is expected to have more significant negative impact on poor nations has made it necessary for developing countries to take keen interest in the global warming and more so what they can do to adapt to the changes.

This study was therefore aimed at examining how climate change has impacted on Kenyans and what has been done to adapt to the climate change.

The study shows the multifaceted nature of the adaptation strategies adopted by Kenya, and more so the vulnerable groups. These range from agriculture, environmental, health, water management, and disaster response strategies. However, it is noted that with the new evidence of the patterns of climate change which shows that in overall, Kenya may in future receive higher precipitation as a result of climate change and that even the Arid and Semi Arid areas may by 2050 become much wetter, some of the adaptation strategies may change focus in future.

1.0 INTRODUCTION

More than three decades since scientists blew the whistle on the possible effects of global warming, debate is still raging on the implication of these changes on biophysical systems and people's livelihoods. In this paper, we examine how a developing country like Kenya is adapting to impacts of climate change and the challenges that the poor face in their attempts to adapt.

Various researchers have different definitions of adaptation to change. In our case, adaptation will be taken to mean adjustments on ecological, social or economic systems in response to actual or anticipated climatic changes. We will also examine how production processes and practices are changing in order to moderate potential damages of climate change (Barry Smit and Olga Pilifosova 2001). Focus will be made on adaptations undertaken by governments or individuals/communities in various sectors such as agriculture, livestock, settlement, environment, business enterprises, health, and education. We will therefore be looking at what some people refer to as 'autonomous' and 'planned' adaptations (Leary, 1999). We define autonomous adaptations as activities initiated by the public and private sectors, including farmers, to adapt to actual or anticipated change while planned adaptations are deliberate government policy decisions aimed at minimizing losses arising from the change (Pittock and Jones, 2000).

Under the autonomous adaptations, it would be interesting to know the extent to which the private individuals will be able to adapt to the climate change with or without the support from the public sector. This is because, some researchers have noted that adaptations depend on the capacity of the affected to cope with the impacts or risks of climate change (Barry Smit, 2001). In essence, the ability to adapt to climate change depends on factors such as wealth, technology, education levels, access to information, skills acquired, availability and quality of infrastructure, and access to any other resources (IPCC, 2001). This would therefore mean that the poor may not be able to effectively adapt to the changes and would need significant support either to enable them adapt to the changes or mitigate against climate change. Failure to support the poor to adapt may seriously affect sustainable development and may even "hurt" the environment further through increased degradation.

Among the possible adaptation methods that have been reported in some countries are changes in crop planting date, application of additional fertilizer, irrigation development in areas where rainfall was otherwise sufficient, research on drought and pest tolerant crops, and reclamation of arable land (Parry et al 2004). Other adaptation methods include rain water harvesting, silage bulking and storage even where pasture never used to be a problem, agro-forestry and energy saving technologies.

1.1 Objective of the Study

Debates have been going on over the impacts of climate change on economies of developing countries. Kenya, being an agriculture dependent country is bound to be hard hit by the negative impacts of the change and possibly gain from the positive impacts. Since the changes are inevitable and may take time to reverse, it is important to know to what extent Kenyans are adapting to the climate change.

This prompted the Kenya Climate-Land Interactions Project (CLIP) to initiate a study on adaptation to climate change in East Africa. The objective of this study was particularly to examine the impacts of climate change on the vulnerable groups in Kenya and the adaptation strategies being implemented to mitigate the climate change impacts.

1.2 Methodology

This study was carried out in Kenya and involved collection of data on adaptation strategies being used by various stakeholders in the country. The data was collected from various government departments that are involved in implementation of various adaptation projects.

These included the Office of the President, Ministry of Agriculture, Ministry of Livestock and Fisheries Development, Ministry of Environment and Natural Resources, Ministry of Water Resources, and Ministry of Planning and National Development. Materials collected included: official ministerial reports such as the Ministerial Public Expenditure Review (MPER), Sectoral Medium Term Expenditure Framework (MTEF), and policy documents. Others documents included Acts of Parliament, project documents, and newspaper reports. Also used were various global reports and research papers on climate change.

The study also involved consultations in CLIP Workshops as well as formal and informal interviews with officers in ministries named earlier. One of the major sources of information was the Kenya Climate-Land Interaction Project Adaptations Workshop held on July 19th 2007 at the International Livestock Research Institute, Nairobi. Interviews and consultations were also made with officers in the Ministry of Agriculture and Ministry of Environment and Natural Resources, more so the Climate Change Secretariat. Some local farmers in Machakos and Rachuonyo districts were also interviewed on their adaptation strategies. The District Agricultural officers in the two districts were also interviewed.

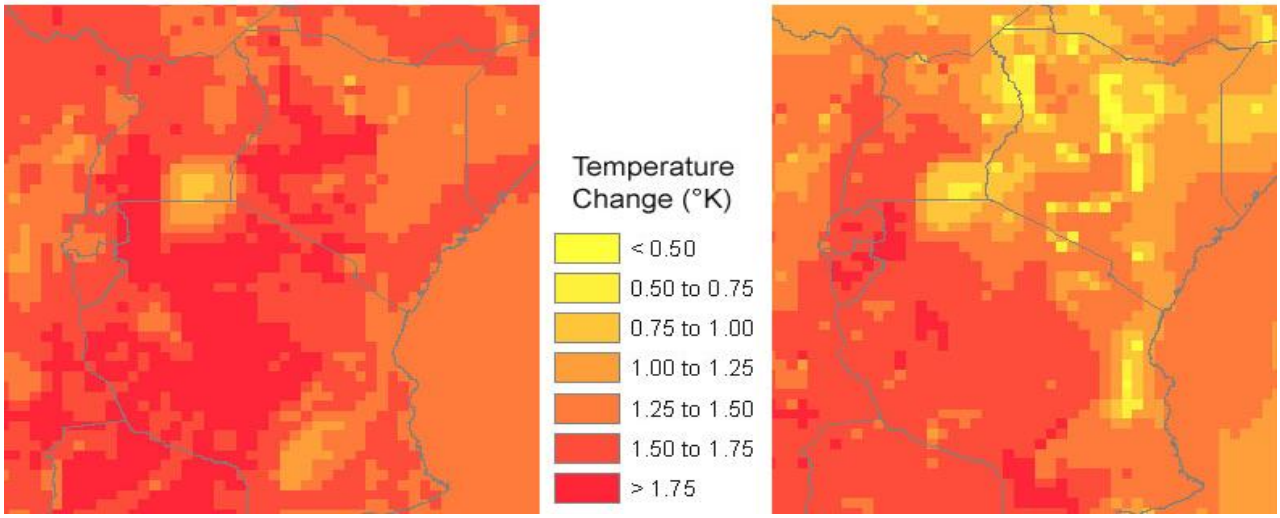
Qualitative techniques were used to analyze data. This involved examining the various climate change and adaptation strategies reported in each of the selected reports and making necessary verifications before putting them into perspective.

2.0 CLIMATE CHANGE, A MYTH OR REALITY?

The debate on global warming has been going on for decades, with some people still wondering whether it is a myth or a reality. Some researchers such as James Hansen of NASA's Goddard Institute for Space Studies in New York estimate that the earth has been warming at a rate of 0.36 degrees Fahrenheit each decade for the past 30 years. This they argue has driven the overall world temperature to the warmest in 12,000 years (Fraser 2006).

The Inter-Governmental Panel on Climate Change (IPCC) estimates that globally, average surface temperatures have increased by 0.6-8^{o}c over the 20th century and projects that these temperatures may become warmer by 1.8 – 4.0^{o}c by 2100 relative to 1980 – 2000 average temperature levels. Consequent to this warming, the IPCC reports that there is rapid ice melting in the temperate regions, particularly the Greenland and Antarctica (EEA, 2007; IPCC 2001; and IPCC, 2007). 1998 was the warmest year since 1800s. Other scientists such as Thomas Karl, director of National Climate Data Centre (NOAA) estimate that the temperature rises by 5.4-6.3 degrees Fahrenheit per century (EcoBridge 2006a). This is also confirmed by recent studies undertaken under the Climate-Land Interaction Project (CLIP) in East Africa. Preliminary results of this study show that temperatures are generally on an upward trend, especially since the 1950s. (Gopal et al in 2007).

Figure 2.1: Impacts of global climate change (2000 to 2050) on temperature



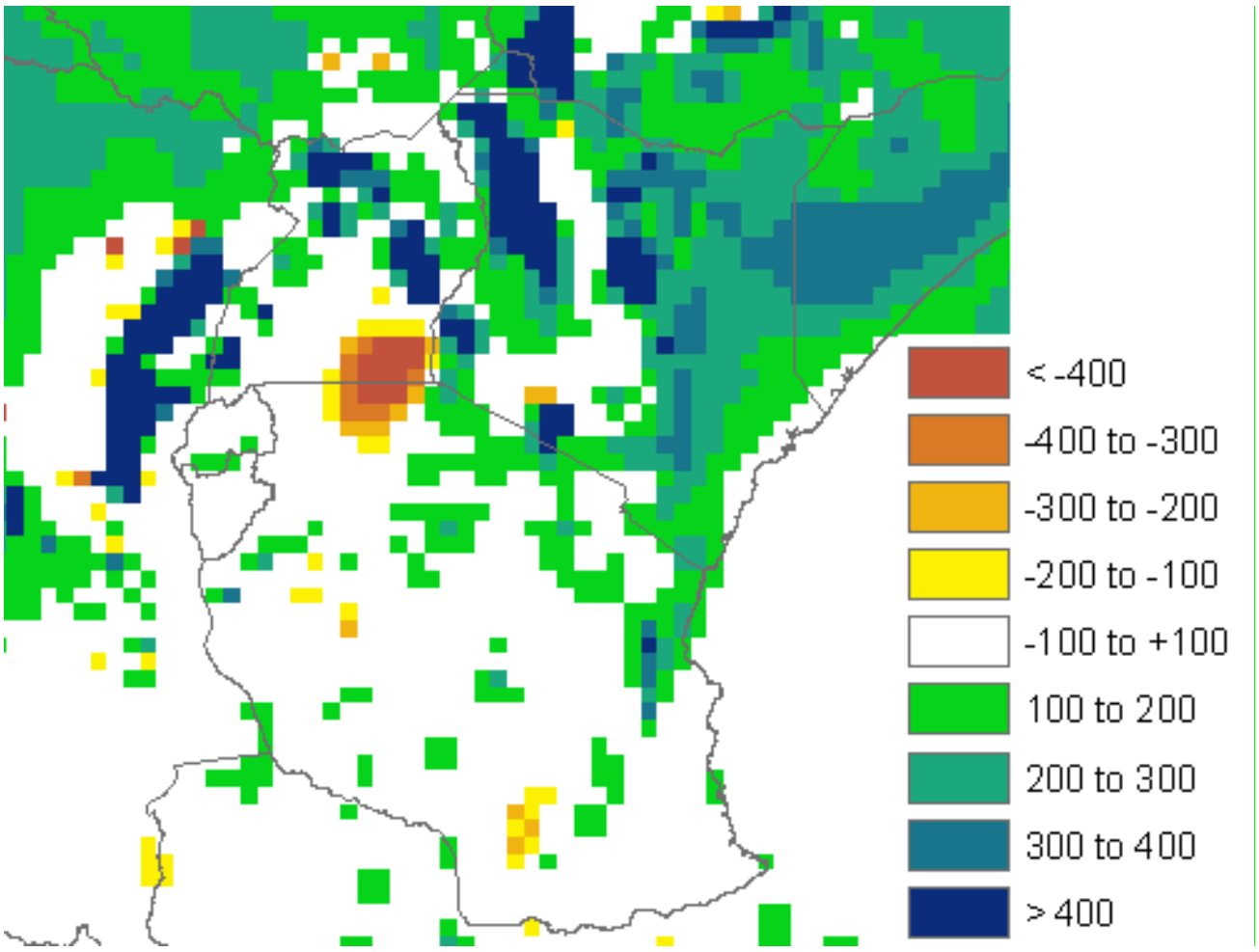
Change in max. temp

Change in min. temp.

Studies carried out under the Climate Land Interaction Project (CLIP) show that the ongoing global warming will not uniformly affect geographical regions. It notes that some regions will become warmer faster than others. In Kenya, for example, parts of the highlands and western Kenya will experience higher increases in average temperatures, with most places having temperatures rising by more than 1.5^0 c by the year 2050 (Figure 2.1). North Eastern Kenya will experience lower changes in temperature.

With this change in temperatures, the Study shows that some regions will register increase in rainfall while others will have significant drop in rainfall. The study shows that large parts of the currently arid lands of north western and north eastern parts of Kenya will experience higher rainfall that what is currently registered (Figure 2.2).

Figure 2.2: Impact of future global climate change (2000 to 2050) on precipitation



Source: CLIP, 2007

These temperature changes are also confirmed by the World Watch Institute that argues that the earth's ice cover is melting in many temperate regions at higher rates than ever before and that these are caused by human-induced global warming. The Arctic sea ice, for example, has been losing an average of 34,300 square kms of ice per year. Consequently, it shrunk by an estimated 6% between 1978 and 1996. In addition, the Arctic sea ice has thinned dramatically from an average thickness of 3.1 meters to 1.8 meters over the past 30 years (Mastny, 2000). In New Zealand, glaciers shrunk by 26% between 1890 and 1998. In the same country, the Transman Glaciers have thinned by more than 100 meters in the past century. In India, the Gangotri Glacier has accelerated its retreat from 7 meters per annum between 1842 and 1935 to the current 30 meters per year. All these are blamed on global warming.

Following melting of ice in the temperate regions, the IPCC projects that sea level will rise 0.18 – 0.59 m by 2100. This is based on observed rates of ice flow from Greenland and Antarctica (EEA, 2007; IPCC, 2001). The melting of ice is expected to lead to rise in sea levels in various parts of the world. In the African coast, for, example, the sea level is projected to rise by 25 cm by the year 2050 (McCarthy and Brown, 2005).

There are also evidence of global warming in the tropics where it is reported that mountains are already losing their icy peaks. Good examples are Mt. Kilimanjaro which is believed to have lost 82% of its ice cover over the past 80 years and Mt. Kenya that has lost 92% of its permanent glaciers over the past 100 years (The Times of India, 2006). Besides overall increase in temperature, evidence has been deduced that temperature extremes are more intense and frequent than some decades ago. In northern Kenya and parts of Tanzania, for example, dry periods have become longer and more intense (EEA, 2007).

Global water temperatures are believed to have risen owing to climate change. Over the last century, the water temperature in European rivers and lakes is reported to have increased by 1-3%. This has serious implications such as reduced oxygen in water, alteration of habitat, less ice formation and changed nutrient cycling in aquatic systems (EEA 2007).

Other evidence of climate change is in the area of precipitation, though no clear trend has been observed. However, available records show that in northern Europe, precipitation has increased by 10-40% while that in the south and east Europe dropped by 20% over the recent past (EEA, 2007).

Recent reports also show that weather related disasters are becoming frequent, as climate change becomes evident. One of these disasters is the killer heat waves that have become more frequent and severe. In June 2003, for example, up to 1,700 people in India were killed by the heat waves. This was followed in

August by death of another 35,000 people in Europe under conditions blamed on killer heat waves (EcoBridge, 2006b). In July 1999, more than 250 people died from heat waves that seared the eastern USA.

3.0 CAUSES OF GLOBAL WARMING

Global warming is perceived to be caused by accumulation of the greenhouse gases that form a blanket around the earth thereby making it warmer than expected. One of these gases is carbon dioxide emitted through burning of fossil fuels such as coal and oil. Natural gas is also another key source of carbon emissions. Besides these sources, deforestation has been recognized as the second major cause of atmospheric carbon dioxide (EcoBridge 2006a). This may be due to the key role played by forests as carbon sinks.

Human activity is viewed as the major cause of increase in carbon dioxide in the atmosphere. In fact some researchers estimate that human activities such as combustion of fossil fuels, cement production and land use changes have led to carbon dioxide concentration in the atmosphere increasing by almost 30% since the 18^{th} century (Eriksen 2001). It is estimated that the concentration of carbon dioxide in the atmosphere has increased by 34% since pre-industrial times from 280 parts per million (ppm) to 377.5 ppm in 2006 (EcoBridge, 2006a).

The second most important cause of greenhouse effect, after carbon dioxide, is methane which is produced from among other sources, rice paddies, bovine flatulence, bacteria in bogs and production of fossil fuel. It is estimated that concentration of methane has more than doubled since pre-industrial times and increased by 145% in the last 100 years (Eriksen, 2001; EcoBridge, 2006a).

Nitrous oxide is another key source of greenhouse effect. Although it is naturally produced by oceans and rainforests, it also has man-made sources such as nylon and nitric acid production. Other sources include use of fertilizers and burning of organic matter. The rapid change in land use, especially in developing countries that has culminated in increased area under cultivation and more intensive use of fertilizers has made the situation worse.

4.0 EFFECT OF CLIMATE CHANGE ON VULNERABLE GROUPS

The current discussions on climate change indicate that poor nations are likely to suffer more from the climate change than developed temperate countries. While addressing an African Union (AU) Summit in February 2007, President Yoweri

Museveni of Uganda did not mince words on this. He termed the developed nations as aggressors who by abating emission of greenhouse gases inflict grave harm on poor nations while they sit back believing that they can cash in on the global warming that he observed would "turn icy Alaska and Siberia into granaries" (Daily Nation, 2007). His argument is based on experts' prediction that global warming will enable some parts of temperate countries to have longer and warmer cropping season thus making them increase crop production. We highlight some of the effects of climate change on vulnerable groups in this section.

4.1 Increased incidence of diseases

Heavy rains and warmer environment that are attributed to global warming is believed to favor the breeding conditions and site vectors allowing them to thrive in higher altitudes where they were hitherto non-existent. The spatial distribution of these diseases is a function of climate, with disease prevalence generally increasing with temperature and rainfall. A good example is mosquito that transmits malaria. In Kenya, malaria cases are now rampant in the highlands where mosquitoes never used to exist. In October 2006, Dr. Andrew Githeko was quoted as saying that for the first time, and apparently due to global warming, malaria transmitting mosquitoes had been reported on the slopes of Mt. Kenya, Karatina and Naro Moru areas (EA Standard, 2006b).

This has "created" highland malaria which occurs at high altitude limits of the disease and where the epidemic never used to occur due to low temperatures. The incidence of this disease has also been increasing in these highlands. For example, studies carried out in Kilgoris, Kisii and Tabaka hospitals show significant increase in cases of highland malaria in these areas since 1981 (Hay et al, 2002).

The epidemic of highland malaria has been breaking periodically when weather changes favour vector spread. In 2002, for example, the outbreak of the epidemic in Nyanza and Rift Valley provinces was reported to have killed at least 300 people and infected another 158,000 in one month, June/July (Rowan, 2002).

In Rwanda, malaria cases in the highlands have increased by 337% in the recent years with 80% of the increase being attributed to changes in temperature and rainfall which improve breeding conditions for mosquitoes (UNEP, 2001). This is supported by studies carried out by the World Health Organization (WHO) and the London School of Hygiene and Tropical Medicine that show that 160,000

people die yearly from effects of global warming, with the key causes being malaria and malnutrition (EcoBridge, 2006c).

Even though we cannot fully attribute the emergence of highland malaria to climate change, it should be noted that malaria is an extremely climate sensitive tropical disease. Researchers have established that a mere half degree centigrade increase in temperature trends can lead to 30-100% increase in mosquito abundance (Pascal et al, 2006).

Besides malaria, incidence of other diseases such as cholera, yellow fever, dengue fever, Rift Valley Fever and hemorrhagic fever have increased over the years and researchers attribute this partly to global warming. Following the 1997-98 El-Niño rains, excessive flooding caused cholera in Djibouti, Somalia, Kenya, Tanzania, and Mozambique (UNEP, 2001).

Associated with drought is meningitis that was reported in the drought stricken northern Kenya in February 2006. In Western Pokot, at least 57 cases of the diseases were reported in January that year, 12 of them fatal (Terra Daily, 2006).

The distribution and recurrence of Livestock diseases such as animal trypanosomiasis transmitted by tsetse flies, and Rift Valley fever transmitted by mosquitoes have also increased lately and are thought to be as a result of changes in habitat brought about partly by climate change.

4.2 Species threatened by global warming

It is estimated that globally, one million species are threatened with extinction by climate change. Among these species are: birds such as Sooty Shearwater in USA, Spoon-billed Sandpiper in North America, the Caperceillie of UK, Scottish Crossbill, and Emperor Penguins. Animals such as polar bears, walrus, caribou, alligators, whales, pacific coast crabs, seals, and turtles also face extinction thanks to global warming (EcoBridge, 2006c; Rhett, 2006; Kirby, 2004).

Some of the cold water fish that are under danger of extinction due to global warming are salmon, brook trout and brown trout. Some species of duck, owls, warblers and moose in Canada are not spared either. Also facing the threat of global warming are Edith's Checkerspot Butterfly, Adelie penguin, California quail, New England's Sugar Maple, Southwestern Willow Flycatcher, Loggerhead Turtles and Big Horn Sheep (Kelleher, 2007).

Recent studies show that some species have gone extinct due to global warming. These include the Golden toad and Gastric Brooding Frog that are regarded as the first victims of climate change (Mulama, 2007).

In Kenya, as a result of population pressure on rain-fed crop lands and increasing encroachment by cultivators and other users, there is decline in the amount of land under specific habitats like wetlands, rangelands, remnants of indigenous forests, and riparian woodlands. These reductions are partly associated with climate change and partly with changes in land use although the two are interrelated causes of land degradation. For example, in Kenya, conservative estimates suggests that the forest cover has reduced to 2.8% of the total land cover (National Action Programme – a Framework for Combating Desertification in Kenya, 2002). Given that forests habitats act as carbon sinks, any decline in forest cover has a contribution to climate change. Further, as areas under specialized habitats reduce, the numbers and abundance of rare species reduce as they get replaced by the more common ones. The best example for these is the birds and small mammals.

Global warming favours some species over others, making them to be more widespread replacing others that are less favoured by the changes (invasive species). Spread of invasive plant species causes a major threat to biodiversity in areas with natural habitats.

4.3 Floods

A report by Britain's Meteorological office warned in 1999 that flooding will increase about threefold over the next few decades (EcoBridge, 2006c). It predicted that South and South East Asia will be the hardest hit. The warming of the oceans will also lead to moist air thus fueling incidence of hurricanes. In Kenya, Hon. Prof. Kivutha Kibwana, the then Minister for Environment and Natural Resources argued in 2006 that melting of the glaciers will result in a rise in sea levels that will consequently submerge the fancied coastal beaches (EA Standard, 2006). This will have far reaching consequences on tourism dependent nations such as Kenya. In additional, the rise in sea level will result in substantial inundation and erosion of valuable coastal lands (Smith and Lazo, 2001).

Climate change may alter rainfall patterns such that in some places the rain may come in short durations but in heavy downpours resulting in floods. Over the past decade, severe floods have been reported in various parts of the country with devastating results. In May 2002, 46 people were killed, 8 injured and

150,000 displaced by floods that affected many parts of Kenya with the death toll being highest in Eastern Province (Table 4.1; Horekens and Geteta, 2002).

Table: 4.1 Effects of the 2002 Drought on humans.

Province	Deaths	Injuries
North Eastern	0	0
Central	6	0
Eastern	19	0
Rift Valley	5	4
Nyanza	6	3
Western	3	1
Nairobi	7	0
Total	**46**	**8**

In 2003, floods that affected 17 districts of Kenya claimed lives of 77 people and displaced over 60,000 people (Nduna, 2003; Kuria et al 2004). One of the flood prone areas that were seriously affected was Budalangi division. Official reports showed that during that year, 25,000 out of the 53,000 population of Budalangi were displaced by the floods. Schools were submerged thereby interrupting education of children in the area (Mwangi, 2003). In the year 2004, floods continued with its devastating effects, killing at least 50 people in various parts of Kenya and displacing another 10,000 (Kuria et al, 2004).

The effect of floods continued in 2006 when at least 44 lives were lost and 30,000 people displaced by floods that hit Isiolo, Garissa, Turkana, Lodwar, Moyale, Wajir, Mandera all of which are in the ASAL areas. Other areas affected were Nyanza, Coast and Western Provinces. In Budalangi Division, more than 10,000 people were displaced following collapse of dykes constructed to control the floods (Planet Ark, 2006; Gullet et al, 2006). In October alone, 9 people were killed by the floods in Isiolo town and several others reported missing when the floods submerged and swept away their homes (KBC, 2006).

In Baringo, an arid and semi-arid district, the incidences of floods have increased unlike in the recent years. As recently as October 2007, many people were displaced by raging flood waters arising from off-season heavy rains.

4.4 Coral bleaching and disintegration

In 2005, a study by World Conservation Union (IUCN) reported that 50% of the world's coral reefs may be lost within the next 40 years unless urgent measures are taken to protect them from global warming. The coral death can come by way of increased ocean temperature resulting in coral bleaching. Increase in the temperature leads to loss of the symbiotic algae that gives the coral colour and nutrients (EcoBridge, 2006; Pomerance, 1999). Researchers show that

temperatures above 30^0C could activate the disassociation of coral/algal symbiosis thereby making the coral to lose algae and turn white, thus bleached. Prolonged bleaching may lead to death of the corals (Buchheim, 1998). Death of the corals robes the coastlines of the protection provided by these creatures thus exposing the coastal areas to erosion and flooding by the ocean.

Worldwide, the 1998 El Nino that caused warming of oceans in various parts of the world destroyed 16% of the coral reefs through widespread bleaching. Earlier, in 1992, about 10% of the corals were destroyed due to bleaching arising from warming of the oceans (Wilkinson, 2000).

Kenya is one of the countries that have been experiencing widespread coral bleaching and mortality due to the warming of the Indian Ocean. Such bleaching was particularly reported in 1987, 1991 and 1994. The worst global bleaching occurred in 1998 following the El Nino that produced one of the warmest years in recent records (McClanahan and Mangi, 2001). It is estimated that the 1998 sea warming caused at least 80% of Kenya's corals to be affected by bleaching. The impact is particularly serious because the bleaching hit harder some of the protected marine parks. For example, over 90% bleaching and mortality was recorded in Kananai, Mombasa and Malindi Marine Parks (Mdodo, 1999).

4.5 Crop production to drop in some countries

Research on the impact of climate change on developing countries show that 29 African countries face imminent aggregate loss of 35 million tons of cereals production as a result of the of global warming. Some of the countries pointed out as possible victims are Tanzania, Sudan, Cote d'Voire and Angola (Fisher et al 2001; and Kituyi and Eriksen 2002).

It is estimated that if temperatures rise by 2^0C, large areas of Kenya currently suitable for tea production will become unsuitable (McCarthy and Brown, 2005). Since tea is the second largest foreign exchange earner in Kenya, the impact of this on the economy will be enormous.

In the temperate countries, researchers predict that global warming will extend the length of the potential growing season, allowing early planting of crops, earlier maturity and harvesting and possibly allowing two cropping cycles to be completed within a year (Rosenzweig and Hillel, 2004). However, in the warmer tropical areas, global warming may have negative impact on crop growth leading to lower yields. Most researchers however believe that higher temperatures and droughts caused by climate change will depress crop yields in many parts of the world in coming decades (Pearce, 2005).

Recent studies under CLIP - East Africa show that climate change will not affect any particular country in a uniform way. Some parts of a country may receive higher rainfall while others may face depressed rainfall. In Kenya for example, most parts of the currently arid Eastern and North Eastern provinces and the lake region are projected to receive higher rainfall in the future as some parts in the Rift valley may have a slight drop in rainfall.

4.6 Drought to increase in frequency and severity

During 2005/06, about 25 million people faced famine across the Sahel, 11 million of them in East Africa (EcoBridge, 2006b). This followed other Sahel drought cycles of the 1970s and 1980s that had equally devastating effects. The increase in frequency of drought is particularly worrying because extended drought may result in desertification (Mortimore and Adams, 2001).

Kenya experiences mild cyclical drought every 3-5 years, with severe drought on the 10 year cycle. However, there is no indication that it is increasing in frequency. Recent studies show that due to global warming, any drought condition may be very severe. When it occurs, drought seriously affects the ASALs where about 12 million people reside. During 2005-2006, such drought affected 6 million Kenyans, 3.5 million of them from the ASAL areas. The drought claimed livestock worth Kshs. 16.7 billion, of which cattle were worth Kshs. 12.8 billion; sheep - Kshs. 1.3 billion; goats - Kshs. 1.9 billion; and camels - Kshs. 0.67 billion. Besides the starvation following severe drought, livestock diseases claimed even more livestock during and after the drought. This is because climate change alters the dynamics of livestock diseases especially those that are vector borne due to changes in the habitats.

In health, about 73,000 children under five years and 7,200 pregnant and lactating mothers suffered severe malnutrition in the ten most affected districts of Mandera, Wajir, Garissa, Ijara, Tana River, Isiolo, Marsabit, Moyale, Samburu, and Turkana. In education, famine threatened retention of about 1 million primary and pre-primary pupils and 316,193 secondary school children in 27 affected districts. This forced the government to provide an additional Kshs. 3 billion bursary funds to 1,243 secondary schools to keep the children in schools.

4.7 The number of water scarce countries to increase

In Africa, 14 countries, Kenya included, are already subject to water stress and water scarcity. With global warming, it is estimated that 11 more countries will join this category over the next 25 years. Moreover, it is predicted that rainfall will decline by as much as 10% by 2050 in the horn of Africa and some parts of

the south. This will significantly affect crop production (McCarthy and Brown, 2005).

In Kenya, despite predicted general increase in precipitation, water scarcity continues to be reported in various parts of the country. In Laikipia district, local communities confirm that the ground water table has continued to drop thereby leaving a large number of boreholes and shallow wells dry (Obunde et al 2004). In parts of Eastern, Central and Rift Valley Provinces, rivers and springs that used to be permanent have become seasonal, with the water flow being significantly lower than they were three decades ago.

In Lokitokitok, research conducted over the last 25 years show that water is becoming increasingly scarce. This has been blamed on among others severity of drought and clearing of available vegetation for settlement and other economic activities. Consequently, dependable water sources such as river Nolturesh in Kuku Group Ranch have evidence of reduced water flow (Campbell et al 2003).

5.0 WHY KENYANS ARE VULNERABLE TO CLIMATE CHANGE

Land is the main asset for sustainable development, more so in a country that is agriculture dependent. The smaller productive land a country has, the higher the challenge to attain sustainable agricultural development. Kenya is among the nations that have limited arable land. It has an area of about 587,000 square kilometres, of which 11,000 square kilometres is water. Out of the remaining 576,000 square kilometres landmass, only about 16% is of high and medium agricultural potential with adequate and reliable rainfall. The remaining 84% of the country is arid and semi-arid and not suitable for rain-fed farming due to low and erratic rainfall. These are mainly used by ranchers, semi-pastoralists and pastoralists as rangelands, with a large section being used for wildlife conservation (SRA, 2004; Obunde et al, 2004; Omiti and Obunde, 2002).

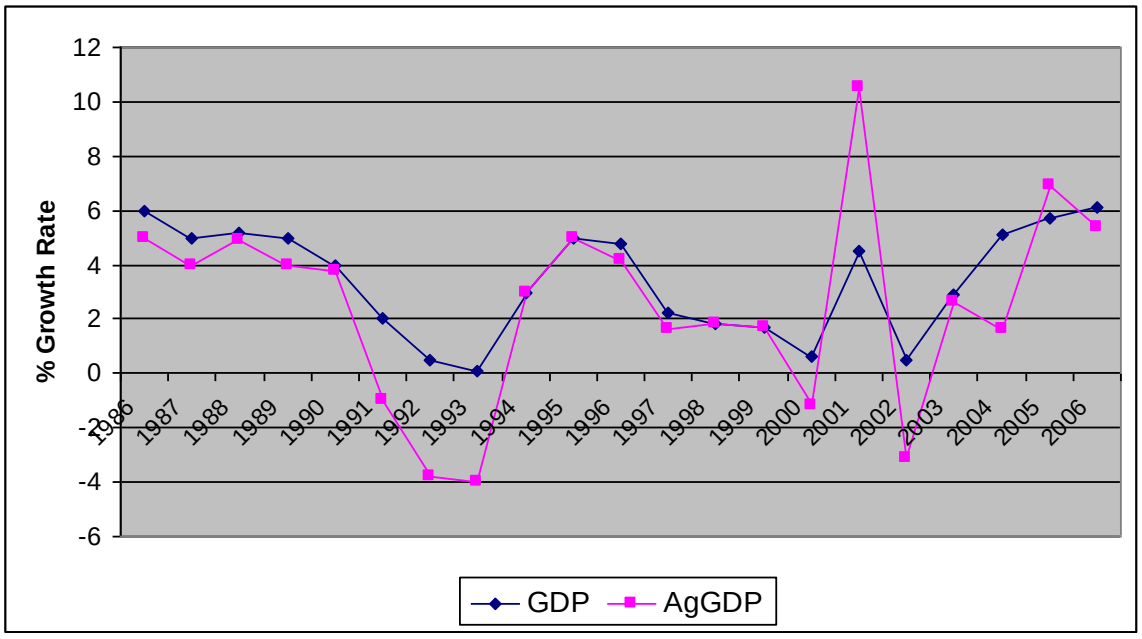
In terms of geographical location, the equator almost bisects Kenya into two equal parts. It lies between about 5^0 north and 5^0 south of the equator. In longitudes, it lies between 34^0 and 42^0 east of Africa. Being located in the tropics makes Kenya vulnerable to climate change.

The ASAL, which currently has unreliable rainfall and poor vegetation cover is vulnerable to climate change. Additionally, unprecedented increase in population size in the recent decades has led to excessive pressure on arable land and the subsequent spill-over into marginal arid and semi-arid lands has led to accelerated land degradation. Indeed, it is considered that such spill-overs have

led to deforestation, poor land use, and inappropriate farming practices that are the major factors that have contributed to accelerated desertification in Kenya. Currently, some of the households living in these areas are food insecure and have to rely on famine relief food on an annual basis. This means that any further fluctuation in rainfall will seriously affect communities living in these lands.

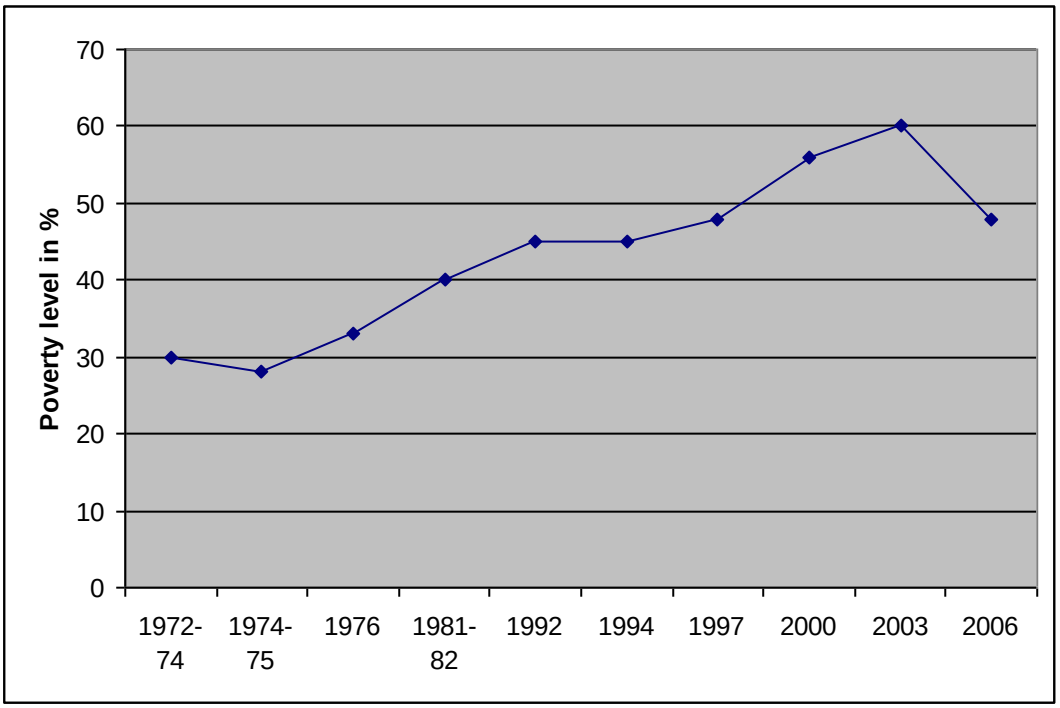
Kenya's economy is agriculture dependent, with 80% of people living in rural areas and depending directly or indirectly on agriculture for their livelihood. The sector directly contributes 24% of GDP and another 27% through linkages with other sectors such as manufacturing and distribution. Thus there is a close linkage between growth of the agricultural sector and that of the national economy. This therefore means that any unfavourable change in climate may have serious effect on the overall economic performance.

Figure 5.1: Trend of GDP and AgGDP growth rates, 1986-2006



Adaptation to climate change requires financial resources. This means that the high poverty levels estimated at 60% in 2003 makes majority of Kenyans vulnerable to climate change.

Figure 5.2: Poverty Levels in Kenya (1972-2006)



Source: Human Development Report 1999; KNBS 2007

In Kenya, there is already high prevalence of malaria. The climate change has already been recognized as leading to extension of malaria to highlands where it never used to exist. Any further rise in temperature will therefore increase prevalence of the disease.

Tourism is currently the leading foreign exchange earner in Kenya bringing in US$ 875 million in 2006. Most of the tourist hotels are based at the Kenyan coast where beaches are major resort areas. With global warming, it is predicted that the sea level will rise, submerging the beaches. This will be exacerbated by bleaching and death of the coral reefs arising from warming of the oceans. These will also expose the coastal population to flooding and erosion.

6.0 EFFORTS TO REDUCE THE GLOBAL WARMING

The global response to climate change commenced with the formation and adoption of the United Nations Convention on Climate Change (UNFCCC) in 1992. This was followed with the third Conference of Parties (COP 3) held in Kyoto Japan in December 1997 where delegates from developed countries and those making transition to market economy signed a Kyoto Protocol that commits all signatory countries to achieve quantified emission reduction targets. These countries, also known as Annex I Parties agreed to reduce their overall emissions

by an average of 5.2% below the 1990 level by 2008-2012, with specific targets varying from country to country. The Protocol also established three flexible mechanisms to assist these countries meet their national targets. These are: an emission trading system; joint implementation of emissions reductions projects between Annex I Parties; and the Clean Development Mechanism, which allows for projects to be implemented in non-Annex I Parties. Only four developed countries have not ratified the Kyoto Protocol. These are: the United States, Australia, Liechtenstein and Monaco (IISD, 2006)

Though the Protocol was agreed upon in 1997, it only came into force on 16th February 2005 when two conditions that were set for its operationalization were fulfilled. These were that it had to be: (i) ratified by 55 target countries – a condition that was fulfilled by 2002; and (ii) ratified by nations accounting for at least 55% of emissions – fulfilled on 18th November 2004 following ratification of the Protocol by Russia. As at August 2006, a total of 165 countries had ratified (Wikipedia, 2006).

The Kyoto Protocol set emission targets for various countries, with some having higher reduction targets than others while there are some allowed to increase their emission levels by a specific percentage. For example, the EU is expected to reduce its emission levels by 8% between 2008 and 2012, though individual countries in EU have different targets. The target for Japan is 5% over he same period (BBC, 2005). This gives room for emission trading under which the higher polluters may buy the unused credits from countries allowed to emit more than they actually do.

Through the Kyoto Protocol, the industrialized countries that have contributed significantly to the accumulation of greenhouse gases are being encouraged to invest in forest and protection of forests in developing countries. This is because forests act as carbon sinks and may contribute to reduction of the volume of greenhouse gases in the atmosphere.

In Africa, adoption of the New Partnership for Africa's Development (NEPAD) in October 2001 by heads of states and governments was followed by adoption of NEPAD's Environmental Action Plan in Maputo in July 2003. Key in this Action Plan is emphasis being laid on programmes aimed at combating climate change in Africa and development of adaptation strategies.

In this connection, the NAPAD Science and Technology Programme which is aimed at combating drought and desertification has been initiated. The goal of the programme includes improvement of information on the causes and extent of drought and desertification in Africa and promoting drought and desertification research.

Kenya is one of the countries that ratified the United Nations Framework Convention on Climate Change (UNFCCC) at its initial years. By ratifying the Convention in August 1994 and the Kyoto Protocol in February 2005, Kenya showed her commitment to joining the international community in combating the problem of climate change. To this end, she has been giving reports on her efforts towards achievement of goals spelt out in the Kyoto Protocol and the UNFCCC. The first report that detailed an inventory of greenhouse gas emissions in Kenya, climate change impacts, adaptation options and climate change related policies and strategies was produced in 2002 for the UNFCCC.

Kenya is also party to various global Conventions and Protocols that are aimed at combating climate change and loss of biodiversity. These include the United Nations Convention to Combat Desertification (UNCCD) and the Convention on Biodiversity (CBD). In this connection, the government prepared National Action Plan (NAP) to combat desertification.

In Kenya, the National Environment Management Authority (NEMA) has been formed to ensure effective adherence to the environment regulations. Various relevant policies have also been implemented to achieve the global commitment on environmental sustainability. These include the Forestry Policy and Act. Other strategies include exploitation of cleaner sources of energy such as hydroelectric power generation, geothermal power and solar energy.

Consumers are increasingly becoming aware of the effect of air pollution on health and sustainable development. It is in this connection that consumers in the EU are now demanding eco-labeling of products, including bringing in the issue of carbon miles. By so doing, they would like to know what extent any product they are purchasing has contributed to air pollution.

7.0 ADAPTATION TO CLIMATE CHANGE IN KENYA

Over the last decade, Kenya has faced a number of calamities ranging from droughts to floods. This has affected sectors such as agriculture, livestock production, energy (hydro-electric power generation), roads, tourism, wildlife, education and health. The call for adaptation to the change has therefore been echoed at all levels. We highlight some of the steps that have been taken both by the public and private sectors to enhance adaptations to climate change. Most of these strategies are crucial and may only need to be popularized and the vulnerable groups facilitated to effectively implement them.

7.1 Reviewing policies to address challenges of climate change

Our review of existing policy documents revealed that the Kenya government has since 1990s been making deliberate efforts aimed at adaptation to climate change. One of the early attempts towards addressing the challenges of climate change was formulation and implementation of the National Environment Action Plan (NEAP) in 1994, just about the time Kenya ratified the UNFCCC. This Plan highlights key activities that must be carried out if sustainable development is to be achieved. It also recognizes the need to establish some key institutions and the legal framework that should be put in place to curb environmental degradation and ensure Kenya meets her climate change obligations under the UNFCCC (MOENR, 1994; MOENR, 2002).

Implementation of this Plan culminated in development of the National Environmental Policy in the form of the *Sessional Paper No. 6 of 1999 on Environment and Development* and the accompanying legal framework, the National Environmental Management and Coordination Act, 1999. It also resulted in establishment of the National Environment Management Authority (NEMA) whose mandate is to facilitate implementation of the Act.

Other institutions that have been operationalized together with NEMA are: the National Environmental Council, NEMA Board of Management, Public Complains Committee, National Environmental Tribunal, Standards Review Enforcement Task Force, Technical Advisory Committee on Environmental Impact Assessment (EIA), Provincial and District Environment Committees, and National Action Plan Committee.

The government has also established an Inter-Ministerial Committee on Environment (IMCE) to ensure that environmental issues, including those emanating from climate change are addressed. Among the thematic sub-committees established under IMCE is the National Climate Change Activities Coordinating Committee (NCCACC) which handles issues relating to climate change. The day to day activities of this Committee is handled by the Climate Change Secretariat based at the Ministry of Environment and Natural Resources.

Since the Environmental Act came into force, all policies and projects that may have any impact on the environment must show how environmental issues will be addressed. Thus it is mandatory for such projects to carry out detailed environmental impact assessment (EIA) before they are approved for implementation.

One of the key policies that have since been formulated with environmental issues and climate change in mind is the Economic Recovery Strategy for Wealth

and Employment Creation (ERS). This Strategy provides policy guidelines to ensure environmental conservation and sustainable development, including fight against desertification and flood control (GoK, 2003).

The most recent Kenya government policy document, the Vision 2030, has recognised climate change as one of the key challenges facing sustainable development in Kenya and specifically undertakes to "Improve the capacity for adaptation to global climate change". However, this undertaking is not reflected in the list of flagship projects for the environment that will be implemented up to the year 2012 (GOK, 2007).

Under the sub-sector policies, in order to address the problem of deforestation, the government enacted the Forest Act (2005) and formulated the Forest Policy that will ensure sustained protection of the forests and reduce encroachment into the forests.

In the agricultural sector, the Strategy for Revitalizing Agriculture (SRA) was formulated and launched for implementation in March 2004. Unlike the previous agricultural policies, the SRA lays emphasis on sustainable exploitation of the arid and semi arid lands through various adaptation strategies. These include: irrigation development; water harvesting; development and promotion of early maturing, drought and pest tolerant crop varieties; and improved livestock marketing in the ASALs. This Strategy is being implemented by the Ministries of Agriculture, Livestock and Fisheries Development and Cooperative Development and Marketing.

7.2 Extension service delivery

Extension has been recognized as the motivating factor in adoption of appropriate environmental conservation methods. This is particularly so in Machakos district where women groups singled out training, education and advice from extension staff as the greatest motivating factors in their success in environmental conservation (Kamar, 2001). They reckoned that they could have not succeeded in *fanya juu* terracing and water harvesting techniques that they have implemented were it not for efforts from the extension staff.

The challenges from the climate change are making the government work closely with farmers to ensure adaptation to the change as well as addressing the causes of global warming, more so, environmental degradation. As people extend cropping into semi arid lands, possibly due to population increase and increase in precipitation in these areas, the government has been extending crop extension services into ASAL areas. This has, in some cases, resulted in staff

training on new technologies such as minimum tillage, supplementary irrigation, dry land farming, water harvesting, water saving, new crop varieties, among others.

This is in line with the National Agricultural Extension Policy (NAEP) under which information packages to farmers are based on individual needs of the target groups. This policy, which is being implemented through various projects such as the National Agriculture and Livestock Extension Project (NALEP) – Sida, NALEP – GoK, Agricultural Sector Programme Support (ASPS), and Promotion of Extension Services – GTZ, are based on this framework. In Moyale district, priority extension packages are livestock marketing, environmental management, soil and water conservation.

In Garissa, Marsabit and Voi districts, priority is on community based water programs and increasing the number of operational community water points. In Kitui, extension priority is on climate change adaptation strategies such as construction of water harvesting, construction of sand dams, and off-take wells. In higher rainfall areas such as Trans Nzoia and Uasin Gishu districts, emphasis is on disseminating information on agro-forestry, soil conservation, sustainable agriculture, soil fertility improvement, among others.

Due to importance of extension services on adaptation to climate change, the government has been putting emphasis on strengthening these services. One of the ways is increased funding to the agricultural sector from Kshs. 12.95 billion in 2002/03 to Kshs. 20.01 billion in 2005/06 and further to Kshs. 29.588 billion in 2007/08. These funds mainly cover the core programmes that include research, extension, livestock disease and pest control, forestry development and environmental conservation and management (MOPND, 2006; MOF, 2007).

The increased funding has enabled extension service delivery to be strengthened through modernization of field offices, provision of modern equipment and improvement of transport facilities to facilitate staff mobility. In addition, a total of 300 new graduates were recruited in 2006 to enhance service delivery and address the staff succession problem. More innovative methods of extension delivery were also introduced. These include setting up of agricultural information desks, adopting demand driven extension service, and re-engineering the Agricultural Information Resource Center (AIRC) to effectively provide information services to the sector.

Among other changes include adoption of more participatory delivery systems such as Focal Area Development Approach (FAA), Farmers Field Schools (FFS), and Promoting Farmer Innovations (PFI). Under the National Agriculture and Livestock Extension Project (NALEP) and Kenya Agricultural Productivity Project (KAPP), Common Interest Groups (CIGs) are being used as media for delivering

extension packages to farmers and other target groups (MOA, 2004). Research-extension-farmer linkages have also been improved. This includes introduction of wholistic research-extension approaches through projects such as the Kenya Agricultural Productivity Project (KAPP).

Following institutionalization of the National Environment Management Authority (NEMA), environmental officers have been posted at the district level to provide the necessary technical support in environmental conservation and awareness. Consequently, environmental issues are now increasingly incorporated into all extension packages. Issues relating to agro-forestry, soil erosion control, water conservation, water harvesting, minimum tillage, are being promoted.

7.3 Adaptation to drought

Kenya increasingly experiences droughts that are more severe with time. These largely affect the Arid and Semi Arid Lands (ASALs) where 12 million people live. When droughts strike, pastoralists suffer huge livestock losses due to lack of reliable alternative market for their livestock. With climate change, it is expected that the rising temperatures in pastoral areas will make droughts more severe thereby seriously affecting the lives of pastoral communities.

In order to facilitate the pastoral communities to adapt to droughts, the Government has rehabilitated and re-opened the Kenya Meat Commission (KMC) at Athi River and Mombasa (Kibarani Slaughterhouse) to provide reliable market for livestock, especially during droughts. At the same time, two international level abattoirs have been constructed one at Mombasa and another at Lokichogio. An aggressive promotional exercise was launched by the Ministry of Livestock and Fisheries Development in 2004 in order to improve access to external markets, particularly the Middle Eastern Markets with notable success. In 2004, for example, 5,128 beef cattle were exported to the Middle East.

Global warming has been blamed for increase in prevalence of livestock diseases and pests. A lot of effort has been put towards control and eradication of notifiable epizootic diseases in collaboration with stakeholders. In 2004-2006, achievement of 90% of the planned target was recorded in the reduction of Foot and Mouth Disease (FMD). Recently, the government embarked on a campaign to eradicate trypanosomiasis in collaboration with other countries in the African Union.

During drought periods, some pastoralists adapt to the change in weather through moving livestock to wildlife zones, particularly the national parks and game reserves where they may still be some grass thereby fueling human-wildlife conflict. This also results in spread of diseases from wildlife to livestock and vice versa.

Livestock marketing was improved further through creation of Disease Free Zones at the Coast, the North Rift and Laikipia district. This has significantly improved access to lucrative markets of Mauritius and the Middle East. To improve on the marketing of live animals further, livestock holding grounds that were long dead are being re-opened. The new proposals are Bachuma and Maritini in the Coast Province that are earmarked for rehabilitation to handle screening and export of live animals.

Climate change related droughts have reduced availability of feed resources for livestock especially in the systems depending on rain fed pastures. This has forced farmers to reduce their herd sizes and some alter the composition of the herds to more shoats than cattle among the pastoralists who traditionally are cattle herders. Among the mixed crop-livestock keepers open grazing practices have turned into tethered grazing subsidized with cut and carry feeds.

Following loss of their livestock to drought, some pastoral communities adapt to the losses through illegal re-stocking of their livestock. This leads to bloody clashes. In April 2006, for example, at least 15 people were killed in a period of 3 weeks following the 2005/06 drought that left thousands of livestock dead (Gullet et al, 2006). Most affected districts were Marsabit, Moyale, Samburu, Baringo, Laikipia and Trans Nzoia. In July 2005, 70 Kenyans were killed within a week by cattle rustlers in North Eastern Kenya. A similar incident was reported in April 2003 when at least 30 people were killed (Meera, 2005).

In May 2007, violence related to cattle rustling in Laikipia and Samburu districts forced thousands to flee their homes and closure of 12 schools. During the same month, 15 people were killed in Turkana district and thousands fled their homes (IRIN, 2007a; IRIN, 2007b).

Besides forcing some people to adapt through illegal re-stocking, drought also makes some communities to violently secure watering points for their livestock. During the 2005 drought, for example, at least 22 people were killed in fighting over a water point on Ewaso Kedong river in Naivasha. Similar incidence was reported in Marsabit district where in July 12 2005, 56 people were killed in Turbi village over access to water and grazing land. In December the same year, scramble for water in Sambarwawa of Northern Kenya led to death of at least 7 people and left several others injured as water conflict took an ethnic dimension. Oxfam estimated the number of people killed from water and pasture conflicts during the beginning of 2006 at 40 (Oxfam, 2006).

In order to reduce losses of cattle when drought strikes, farmers are creating strategic feed reserves for their cattle. One way of creating the feed reserve is making forage or hay that may be stored for use during the drought period. Though large scale farmers have machines for baling hay, poorer farmers are

using more labour intensive technologies for silage making. Among places where this has been observed is Mukurwe-ini in central Kenya (Winston 2006).

In order to reduce the livestock losses that arise from lack of pasture during drought period, the government through the Ministry of Livestock and Fisheries Development is planning to establish National Livestock Feed Reserves that will involve storing feeds for use during the drought periods.

Recognizing the high vulnerability of African countries to the impacts of climate change, the United Nations Environment Programme (UNEP) with the support of the Global Environment Facility initiated a project, "Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Eastern and Southern Africa" (ACCESA) in which Kenya is a beneficiary. The project is providing support for community-level actions that enhance resilience to climate change in the short and long-term. It is also supporting the development of strategic approaches for integrating adaptation to climate change into policy- and decision-making at the national and sub-national level. Execution of this project is being led by the African Centre for Technology Studies and the International Institute for Sustainable Development.

The specific goal of the project is to reduce the vulnerability of communities in Eastern and Southern Africa to the impacts of climate change, thereby improving their well-being and protecting their livelihoods. The objective of the programme is to promote the mainstreaming or integration of vulnerability and adaptation to climate change into sustainable development plans and planning processes through pilot projects undertaken in the beneficiary countries (Kenya, Mozambique and Rwanda).

In Kenya, the pilot project is being implemented in Makueni District where the focus is on increasing the community's resilience to drought. The project is promoting actions that reduce vulnerability of farming communities' to the current and future drought conditions (IISD, 2007) through actions aimed at increasing food security, reduction of poverty by improving livelihoods and facilitating the integration of adaptation to climate change in policies related to disaster management and sustainable development of arid and semi-arid lands. Implementation of this project is led by the Centre for Science and Technology Innovation in Partnership with the Arid Lands Resource Management Project (ALRMP).

7.4 National Food Security Initiatives

In order to address the problem of famine arising from climate change related crop failure, the Kenya government has set up an elaborate institutional framework to address all issues relating to food security. One of the key institutions is the Kenya Food Security Meeting (KFSM) that comprises UN agencies, NGOs, donors, and government officials. All disciplines are represented here, including provincial administration, agriculture sector ministries, meteorological department, early warning experts, Office of the President, Ministry of Finance, and grain traders such as the National Cereals and Produce Board. Besides KFSM, the Kenya Food Security Steering Group (KFSSG) has also been established to coordinate various food security activities in the districts and ensure all cases of food insecurity are addressed. At the district level, the District Steering Group (DSG) has been formed to facilitate information sharing and planning at the district level. It is where all proposals and action plans are agreed upon. Other management units that have been set up to assist in effective disaster management are:- National Committee on Disaster Management; Cabinet Sub-Committee on Disaster Management; and the Inter-Ministerial Committee on Disaster Management.

Adaptation to climate change has also been carried out through emergency response services by the above named committees. During 2005/06 drought, the KFSM estimated that at least 3.5 million people including 0.5 million school children were in need of emergency assistance. Consequently, appeals were sent out that resulted in positive response from a number of agencies. Some of these were the USA that provided relief assistance amounting to US$ 36 million, Kenya government provided US$ 18 million, UK US$ 7.8 million, Multilateral organizations US$ 6 million, Japan US$ 4 million, Canada US$ 2.7 million, and Sweden US$ 1.27 million.

Pupils receiving food in Narok

In order to reduce loss of life arising from drought, floods and other calamities, the Government has established a National Food Reserve to be managed by the KFSM. This comprises: 3 million bags of maize and hard currency adequate to import another 3 million bags of maize. Of late, other food stuff like powdered milk, beans, rice, have been incorporated into

the food reserves. There are also plans to establish a National Livestock Feeds Reserves to be used for feeding starving livestock during drought periods.

High incidence of food insecurity, indirectly blamed on climate related changes has resulted in the government introducing school feeding programme in various parts of the country. One of these is Narok district.

7.5 Water harvesting

Kenya though classified as water scarce country experiences heavy rains and flush floods in almost all parts of the country. Thus there may be a period of heavy rains accompanied with flooding followed with dry weather and even famine. It is for this reason that emphasis is being laid on harvesting water that goes to waste during the rainy season.

The increase in water scarcity in Kenya, and more so in the ASAL areas has prompted, the Government, NGOs, CBOs, and even some religious organizations to promote and facilitate water harvesting in various parts of the country. This is being done through roof top rain water harvesting, construction of dams, water pans and other structures to tap run-offs. The government has recently reported an expenditure of Kshs. 1.5 billion on building water pans and boreholes in the arid zones of Turkana, Samburu and Baringo districts. In addition, various regional development authorities have over the past five years carried out construction of water pans and dams in their areas of jurisdiction. In the northern Rift, for example, the Kerio Valley Development Authority (KVDA) in 2004 constructed Kimao water dam in Baringo district and water pans in East Pokot and Koibatek.

There is remarkable increase in the number of manually dug shallow wells around homes that provide water for domestic purposes and watering of kitchen vegetable gardens.

In the ASAL areas, most projects initiated under various government departments have water harvesting components. These include projects such as the Agricultural Sector Programme Support (ASPS) that covers 16 districts mainly in the ASAL areas and the recently launched ASAL Based Livestock and Rural Livelihoods Project that covers 22 ASAL districts and has major activities such as water harvesting, effective water management, construction of water pans and dams as well as drilling of boreholes. The other project whose key components are water harvesting, water saving and management is the Community Agricultural Development Project in Semi-arid Lands (CADSAL) covering Kerio

Valley and Marakwet. There is also the Njaa Marufuku Kenya (NMK) covering over 50 districts in Kenya (MOA, 2007; MOALFD, 2007).

In ASAL areas, people have adapted to water scarcity by scooping into sand beds of the dry streams to get water for domestic and livestock use. Clean drinking water that accumulated in the beds during the rainy season and prevented from evaporating by the layer of sand is received from such beds. In this connection, the local residents in the ASAL areas, and more so Kitui, Turkana, Machakos and Samburu now develop sand dams that mimic the sand beds. This involves cementing some ditches (dams) in the pathways of floods or streams. These are then filled with sand to trap water for use during the dry periods.

Construction of infiltration ditches is one of the technologies being used to harvest water from roads or other sources of runoff into ditches constructed along the contours, upslope from the crop land. The ditches are normally 0.7 – 1.5 meters deep. Water trapped in these ditches seep into the crop land down the slope thus supplying it with water through the dry period.

Also related to this is the water retaining pits that is used to harvest runoff and allowing it to seep into the soil for crop use. In this case, series of pits are dug where runoff normally occurs. A furrow is dug to carry any excess water from one pit to another. In most cases, fruit trees, especially oranges and mangoes are planted in the shallow pits with remarkable results. This method is more commonly used in Kitui, Machakos and Makueni districts.

Cut off drains are also increasing in popularity due to their dual purpose of water harvesting and protecting cultivated land, homesteads and roads from floods. These drains are constructed across a slope to intercept surface run-off and carry it to an outlet such as a stream, dam or water pan.

Under the programme, "Promoting Farmer Innovation – Harnessing Local environmental Knowledge in East Africa", SIDA's Regional Land Management Unit and UNDP developed and implemented an initiative that promotes sustainable water management in the dry-lands which involved; pastoral land-use systems, small-scale irrigation, and promotion of farmer innovation in rain-fed agriculture. The basic objective of the programme was to sustainably improve rural livelihoods and improve ecosystem dynamics through the identification, verification and diffusion of local innovations related to soil and water conservation, water harvesting and natural resource management (RELMA, UNDP, 1999).

7.6 Irrigation Development

Another way Kenyans adapt to increased frequency of drought is irrigation development. Various agriculture related policies have laid emphasis on irrigation to reduce possible losses that may result from erratic rainfall. These include the National Policy on Water Resource Management and Development, Economic Recovery Strategy for Wealth and Employment Creation and the Strategy for Revitalizing Agriculture (MoWR 1999; GoK, 2003; SRA, 2004).

Small-scale Irrigation - Bondo District

Consequently some pastoral communities have moved into irrigated agriculture. Examples may be drawn from Narosura Irrigation Scheme in Narok district where the Maasai have taken to production of high value horticultural crops under irrigation. A similar example is found in Loitokitok and Nguruman areas of Kajiado district where some of the wetlands have been turned into irrigation farms. In the marginal areas where rainfall may be inadequate, farmers have adopted supplementary irrigation to stabilize crop production, including parts of the lake region, like Bondo district.

Despite limited water resources, area under irrigation in the arid areas has expanded rapidly. In Kilimanjaro/Kenya, for example, irrigated land expanded from 245 ha to 4,768 ha between 1973 and 2000. This expansion has had a number of implications that include reduced volumes of water flowing down stream thereby affecting viability of activities there.

7.7 Water Saving Technologies

With the rising incidence of global warming, some local communities have adopted innovative water saving technologies to mitigate against water stress. These include adoption of locally made low-head drip irrigation system that save water and reduce the possibility of soil salination. In this case, farmers use small water reservoirs such as used oil drums or buckets as header tanks while perforated plastic piping convey water to the plants. These techniques are being

used in both semi arid areas and high rainfall areas of Kenya. In northern Kenya, for example, these methods are used for small scale vegetable production in Marsabit (Ngutu and Recke, 2006).

Research has established that minimum tillage saves soil water from evaporation thus retaining it to crops whose yields increase significantly compared to conventional tillage (Gicheru et al, 2006). This is the reason why in Kenya, farmers in semi arid areas such as Isiolo, Narok and Laikipia districts have adopted minimum tillage as a way of farming cereals such as wheat, barley and maize.

Consequently, yields for wheat have remained fairly stable at 25 - 29 bags per ha despite increase in frequency of drought. For other crops such as vegetables and fruits, farmers use other water retaining technologies like mulching and application of manure. The small scale farmers also use this practice to restore soil fertility. As water becomes scarce, some coping mechanisms such as recycling and reuse have been adopted. More and more households have started using domestic water wastes to irrigate their vegetables in their kitchen gardens.

In order to ensure effective water use, especially during drought periods, most water supplying agencies such as the Nairobi Water and Sewerage Company resort to water rationing. In such cases, residents are restricted to 4-5 days of water supply per week thus promptly all residents to save water for essential purposes.

Promotion of conservation agriculture is also taking root in Kenya. The country participates actively in the African Conservation Tillage Network (ACT) to promote conservation farming. It is for this reason that the country in partnership with NEPAD hosted the 3rd World Congress on Conservation Agriculture in October 2005 with the theme: "Linking Production, Livelihoods and Conservation."

7.8 Environmental Conservation

Climate change is one of the factors that have contributed to environmental degradation in Kenya. In particular, the heavy flash floods arising from climate change in parts of the country have partly been blamed for the high rates of erosion in parts of the country. Similarly, the rising average temperatures have aggravated the water stress conditions.

In this respect, various government departments and other stakeholders are involved in environmental conservation and combating possible effects of environmental degradation. The Regional Development Authorities, for example,

are implementing catchment conservation programmes covering vast areas such as the Upper Turkwel under the Kerio Valley Development Authority (KVDA), Upper Masinga/Kiambere under the Tana and Athi Rivers Development Authority (TARDA) and Mau Summit under the Ewaso Nyiro South Development Authority (ENSDA). The Coast Development Authority (CDA) has trained communities in afforestation and management in Kwale, Kilifi and Mombasa. Ewaso Nyiro North Development Authority (ENNDA) successfully negotiated for financial support from ADB to facilitate conservation programmes covering natural resource catchment areas in the northern parts of the country.

In some parts of Kenya, farmers have adopted environmental conservation methods that not only address soil erosion but also water loss. Of particular interest is the "*fanya juu*" and the cut off drains that were adopted in drier parts of Machakos, Makueni and Kitui districts in Eastern Province and have since spread to other parts of the country.

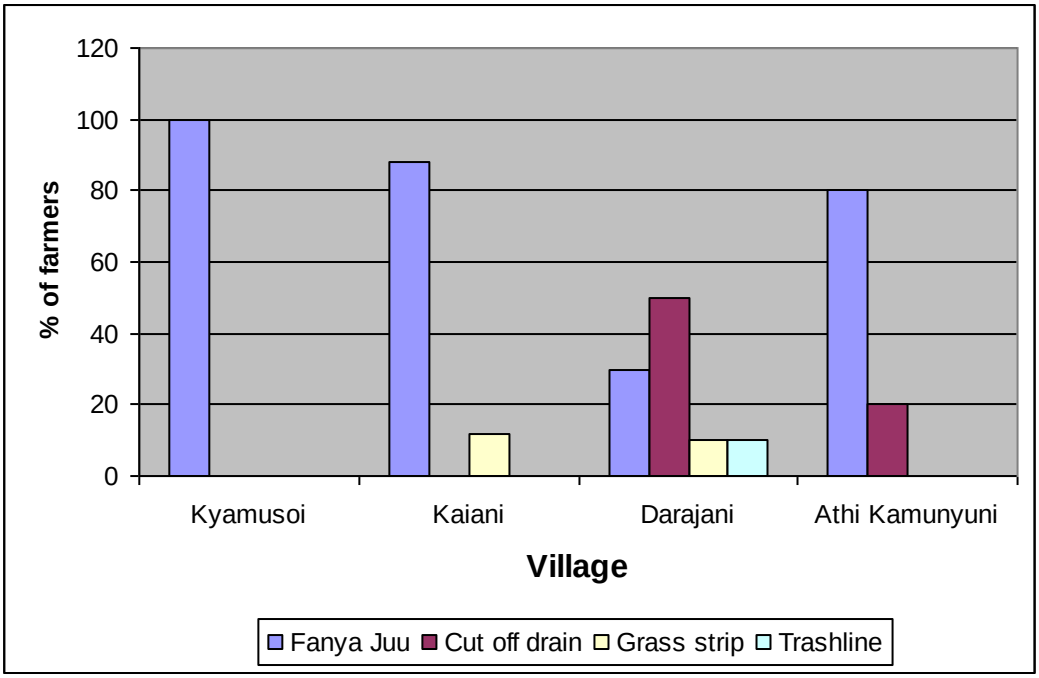
Table 7.1: Some key soil and water saving technologies used in Kenya

	Achievements made in 2006 for selected technologies			
Province	Fanya juu (Km)	Grass Strips (Km)	Un – ploughed strips (Km)	Retention ditches (Km)
Nyanza	73	89.95	99.35	30.37
Western	61.34	113	75.9	43.5
R/Valley	237	749	984.3	174.2
N/Eastern	12	7.2	3.5	3
Central	405	376	122	200
Nairobi	2	0	0	0
Eastern	312	401	65	340
Coast	23	10	22	42
TOTAL	**1,125.34**	**1,746.15**	**1,372.05**	**833.07**

Source: MOA

Fanya juu terraces are constructed by digging a contour trench and scooping the soil to the upper part of the trench which then forms an embankment on which fruit trees, Napier grass or bananas are planted. The trench traps and holds water that is gradually released to the farmland through natural seepage. This has worked wonders in areas that would otherwise be bare lands. In Machakos, this conservation method is particularly popular among women groups who through their united force have constructed most of the terraces in the district. The same has been reported in Makueni district where the *fanya juu* is preferred due to its ability to trap and store runoff in this low rainfall district (Gichuki, 2000).

Figure 7.1: Conservation Technology Ranking in Makueni District (% of farmers)



7.9 Floods control

Kenya has over the last decade been experiencing higher frequency and intensity of floods, a calamity blamed largely on climate change. This has necessitated adoption of adaptation strategies by local communities, the government and other stakeholders.

One of the key activities the government has been carrying out to control floods, especially in Budalangi and Nyando is construction of dykes along rivers Nzoia and Nyando. Some funds have also been provided for maintenance of the dykes. However, construction of dykes has not been very successful in Kenya due to their inability to sustainably control the floods.

In 2004, the government constructed dykes along river Nzoia to control Budalangi floods. However, these were damaged in the 2006 and 2007 floods with devastating effects on thousands of local residents who never expected such a calamity (Gullet et al, 2006; Bulemi, 2007).

This new development has necessitated search for a more sustainable adaptation method. It is therefore critical to explore the possibility of constructing water dams along Nzoia and Nyando rivers that will besides controlling the floods, be used for irrigation and domestic water supply. In this connection, the Kenya Government, with the support from the World Bank has unveiled a plan to

implement Kshs. 10.815 billion (US$ 154.5 million) projects to counter flooding and improve natural resource management in western Kenya. The Western Kenya Community Development Project and Flood Mitigation Project with a total cost of Kshs. 6.02 billion is aimed at empowering local communities to address the recurrent floods in Western and Nyanza provinces. The Natural Resource Management Project will enhance Kenya's capacity to manage natural and forest resources and reduce the incidence and severity of drought, floods and water shortages (Kenya Times, 2007).

Due to poverty and low funding from the government, local communities continue to bear the burden of annual flooding. These include annually migrating to higher grounds, bearing the cost of rebuilding or renovating damaged buildings and replacing lost livestock and other assets. A number of these communities have adopted various practices to avoid or reduce the negative impacts of frequent floods. In Kano plains for example, the major household adaptive practices against floods include:- clearing and digging of trenches around the homesteads; piling mud around homesteads; sealing lower door entrances with mud; raising the floor of houses; planting trees and sisal around homesteads to slow down floods; evacuation to higher grounds when floods strike; and storing medicine in readiness for disease outbreak.

For a number of years the government with the help of local communities has been promoting development of gabions in areas prone to flash floods where excessive surface runoff causes soil erosion. This was particularly strengthened in the 1980s when the former President of Kenya, Daniel a rap Moi took personal initiative to participate physically in development of gabions.

In order to reduce the effect of floods on residents, the Nairobi City Council has over the past three years been improving on drainage systems in the city. This involves replacing existing drainage pipes with larger ones and cementing open drainage systems, including river banks. There is also regular maintenance of the drainage system to remove any materials that may cause flooding.

7.10 Research on drought and disease tolerant crops

As the severity of drought increases, the challenges of achieving food security in drier parts of Kenya have been increasing. Policy documents such as the National Food Policy 1994, ERS, SRA and NEAP explicitly encourage development of drought and pest tolerant crop varieties. This has further been translated into the Strategic Plan of the Kenya Agricultural Research Institute (KARI), (GoK, 2003; MOA, 2004b; MOENR, 1994).

The Kenya Agricultural Research Institute (KARI) has taken up this challenge and embarked on research on early maturing, drought and diseases tolerant crops. This has since been stepped up with KARI Katumani centre being dedicated to this important research.

In 2004, at least 10 maize varieties were released for the low rainfall parts of Kenya. Among these varieties were: KVC-0, KVC-H, and KAPT-941 all of which were bred at Katumani research Centre in Eastern Province. Other varieties released were ECA-KB-6, ECA-KB-13, ECA-KB-18, Taita Taveta, ECA-KB-21, ECA-KB-45, and ECA-KIBZIM-18 all of which are open pollinated varieties developed by KARI and CIMMYT (KARI, 2004).

In 2006, another 4 maize varieties were released for the dry areas. These are: KAT2005-1, KAT2005-2, CKIR04-002 and CKIR04-003 (Ininda, 2006).

Efforts are now being made to strengthen research into other crops such as sorghum, millet, peas and pasture crops.

7.11 Improve soil fertility

Recent studies show that fertility of Kenya's soils have been dropping over the years. This though blamed also on poor agronomic practices, has been associated with the level and frequency of rainfall (Obunde et al, 2004; Campbell et al 2003). Consequently farmers in Kabondo division in Rachuonyo district, in an interview with the researcher in February 2007 lamented that they can now barely get any maize yields if they fail to apply fertilizer or compost manure.

Due to drop in soil fertility, farmers are turning to mixed cropping from mono-cropping and where idle land is still available, shifting cultivation is practiced leaving the land with poor soils fallow. However, due to increasing demand for land that has partly been necessitated by increase in population, the length of fallow periods has declined significantly (Maitima, 2004).

To reduce the problem of soil fertility, the government through its extension services has been educating farmers on better farm management practices especially on re-cycling of crop residues into the soil rather than burning. Application of animal manure is also widely used especially in the mixed crop-livestock production areas.

In order to improve on soil fertility on a sustainable basis, agro-forestry is widely being promoted as evident in the next section.

7.12 Agro-forestry

Agro-forestry has over the years evolved to be one of the critical climate change adaptation methods in Kenya. Besides providing adequate wood for domestic use, agro-forestry protects soil from erosion and is used to enhance soil nutrient content.

This follows introduction of nitrogen fixing trees that are currently used in the agro-forestry projects. In western Kenya, agro-forestry is being promoted particularly for shrubs that significantly add nutrients to the soil. Researchers have discovered that leaves of the *tithonia* shrub, which is commonly found in many parts of Kenya, can be used to double or triple maize yields (Niang and Palm 1998). This has culminated in both government and other organizations promoting use of the shrubs in enhancing soil nutrient content.

Besides *tithonia*, some leguminous nitrogen fixing shrubs and trees have been introduced in the same region. It has been reported that six months fallow of these shrubs have tripled maize yields in some villages in western Kenya (Sanchez, 1999; Bationo et al, 2007).

A number of organizations are supporting government effort towards promoting agro-forestry in Kenya. These include the World Agroforestry Centre (ICRAF), various NGOs, CBOs, and Christian Organizations such as Christian Community Services (CCS) which operates in Busia, Teso, Mt. Elgon and Vihiga districts.

7.13 Fight against malaria

Being the leading killer, with a death toll of over 1 million in the world annually, massive campaigns aimed at eradicating malaria have been going on in Kenya supported by the government, International community and NGOs. Millions of insecticide treated mosquito nets are distributed annually to vulnerable local communities. In 2006, a massive campaign was launched in Kisumu that culminated in distribution of 5.2 million insecticide treated mosquito nets within a two month period, July – August 2006 (MoH, 2006). This has reduced the malarial deaths by more than 50% among children of five years and below. The deaths reduced from 34,000 children in 2005 to 16,000 children in 2006 (WHO, 2007).

Besides encouraging people to sleep under treated mosquito nets, awareness creation has been intensified to urge people to seek medical attention whenever they suspect malaria attack. However, the wide use of the drugs has resulted in emerging resistance of malaria parasite to chloroquine based drugs. This

prompted the government in 2004 to introduce other malaria drugs such as the chlorproguanil – Dapsone (Amukoye, 2004). The continued resistance forced the Kenya government in 2006 to replace the use of sulphur based drugs in the treatment of malaria with the more effective artemisinin based combination therapies (ACTs). These are now widely used, with the government meeting the bulk of treatment expenses, particularly for children and expectant mothers.

As climate change continues to increase, prevalence of malaria, some agencies have initiated projects aimed at cutting the mosquito population. This includes the BioVision Project in Nyabondo, Western Kenya that in 2005 succeeded in cutting mosquito population by 90% within one year and consequently reduced malaria cases by 50%. The participatory approach of the project involved draining of water pools in the project area and treating with environment friendly insecticides any pools that could not be drained. This was aimed at curbing mosquito breeding. The project also involved distributing insecticide treated mosquito nets. In some rice growing villages of Mwea, some biological control agents have been introduced into stagnant water to destroy mosquito larvae (IDRS, 2005).

7.14 Energy saving technologies

One of the major contributors to global warming has been deforestation that results from felling of trees for various uses, wood-fuel included. In the semi arid areas, clearing of the bush for charcoal burning and wood-fuel has been rampant, rendering some areas bare. This is more so because in Kenya, almost 70% of the population rely on biomass for their energy needs.
This prompted Kenyans to explore ways of adapting to depletion of the biomass and saving the environment through development and promotion of energy saving technologies. One of these is the energy saving stove introduced in 1996 through the "*Upesi Project*" implemented in Trans Nzoia, Mumias, Kisumu, Rachuonyo, and Bondo districts. The new *jikos* (stoves) use 60-70% less firewood compared to the traditional stoves. This initiative has since been taken up by a large number of NGOs, CBOs, donor funded projects and government departments that are popularizing it in various parts of Kenya. Installation of such jikos has resulted in over 60% drop in energy bill in schools that adopted them.

In homes, one of the energy saving *jiko* being widely adopted is the *kuni mbili* stove. The Kenya government, in collaboration with other relevant agencies, has stepped up promotion of the *kumi mbili* and other improved firewood stoves. In this connection, the government intends to increase the percentage of people using these stoves from the current 4% to 15%, a strategy that will save about 7.7 million tonnes of wood per year (MOE, 2006).

The Ministry of Agriculture, through the Njaa Marufuku Kenya programme has stepped up production and installation of energy saving stoves in various parts of Kenya. Among the districts where installation has been intensified are Butere-Mumias, Narok, Maragwa, Homabay, Marakwet, Garissa, Mwingi, Kwale and Malindi.

In urban areas, the energy saving Kenya Ceramic *Jiko* has been widely adopted and almost entirely replaced the traditional metal stoves. It burns 25-40% less charcoal compared to the traditional stove.

In order to save trees further, some of the stoves that utilize plant leaves (e.g., dry Eucalyptus leaves), crop waste, including maize stokes as well as wastes from commercial processing of timber like saw dust, have been developed and are widely being promoted. This will ensure that fewer trees are cut down for energy purposes.

7.15 Clean Energy

Having regard to the recent environmental concerns that have focused on the link between global warming and carbon dioxide and other green house gas emissions, a direct link between energy consumption with efficiency and carbon dioxide emissions could be established. Energy efficiency must therefore be regarded as a primary means of stabilizing these emissions. Some practical measures to reduce energy use in industry are being undertaken in Kenya.

Co-generation

Implementation and planned development of co-generation of electricity by the sugar industry would result in clean fuel with minimal impact on the environment. Mumias Sugar Company is already co-generating power and selling to the national grid. Other sugar companies such as SonySugar, Nzoia and Chemelil are already seeking funds for investment in power co-generation through use of bargase.

Bio-ethanol Production

Ethyl alcohol, which is a by-product of sugarcane processing, is produced for a variety of uses. It is also increasingly being recognised as a potential source of alternative to fossil fuel for internal combustion. The Agro-chemical and Food Company and the Spectra International have been in the business of producing this product except for the policy space which has been lacking for its use as an

alternative or blending with fossil fuel. There is, however, planned additional production of the product by other sugar processing factories and development of the necessary policy and legal framework to facilitate its wide usage.

7.16 Forestation and Protection of Forests

Kenya's forest cover has declined rapidly over the last five decades from 16% to less than 2% as a result of unplanned excision for settlements and excessive harvesting without adequate replanting. This has been attributed to increase in population that increased demand for land leading to the landless illegally settling in forest reserves. Consequently, forest reserves have been depleted and water catchment areas destroyed.

Some researchers estimate that Kenya has lost 2 billion trees since independence (Mburu, 2003). This has contributed to the increased rates of run-off and hence flooding and soil degradation leaving some of the previously forested areas such as Laikipia bare. The increase in rainfall and temperature anticipated under the climate change will make things worse.

A number of strategies have been adopted to reverse this trend, one of which is development and implementation of the Kenya Forestry Master Plan by the agriculture sector ministries. The intention of the Plan is to check the uncontrolled deforestation and excision of land and to protect the rare, threatened and endangered species of trees and animals.

At the global level, Kenya is a signatory to the Ramsar Convention that protects designated wetlands from destruction by man. In this connection, laws governing exploitation of wetlands have been enacted and being enforced through NEMA. In the same light, Kenya has formulated laws protecting riparian habitats.

One of the adaptation strategies of the government is to settle forest intruders in alternative suitable areas where they can continue with their economic activities with minimal negative implication on the environment. In this respect, one of the core mandates of the Ministry of Lands and Settlement is resettlement of persons internally displaced from previous forested areas such as Molo, Narok, Enosupukia, Tran Nzoia, Uasin Gishu and Burnt Forest. These resettlements however require large sums of money that has been difficult to come by.

In addition, emphasis is laid on strengthening the forest department to curb encroachment into forests, illegal harvesting, overgrazing and fire outbreaks that require a rapid response and well-equipped forest guards. The department is being strengthened through provision of training, uniform, telecommunication equipment, protection camps, transport (vehicles, motor bikes and mountain bikes) and firearms.

On realizing the importance of forests in environmental conservation and as carbon sinks, the Kenya government has been spearheading tree planting. Since 1980s, campaigns dubbed "cut one tree plant two" have been going on. This, together with powers given to local administration to regulate tree cutting, has slowed down the rate of drop in forest cover in the country (MOENR, 2001).

In support of this policy direction, various government departments have been carrying out tree planting campaigns annually. For example, the Kenya Army planted at least 160,000 trees both during Army Tree Planting Week and Recruits Tree Planting Drive in 2007. The Kenya Commercial Bank during the same year mobilized its employees to plant over 60,000 tree seedlings across the country during its Community day.

Various organizations such as the Green Belt Movement have been spearheading not only protection of existing forests but also reclaiming of forest reserves and increasing area under trees. This movement carries out tree planting campaigns that culminate in planting of thousands of trees annually. In 2006, for example, Prof. Wangari Maathai pledged to plant at least 2 million trees in Kenya annually through her Green Belt Movement. This was accomplished in 2007 when at least 2 million trees were reportedly planted through the Green Belt Movement Initiative. What remains is to ensure the trees and taken care of (EA Standard, 2006c).

Private sector companies such as Bamburi, East Africa Portland Cement and Kakuzi, are currently involved in tree planting as a mechanism not only for general conservation but also for tackling green house gas emissions and global warming by providing the necessary "carbon sinks" to sock carbon dioxide.

Other organizations such as Plant for the Planet work closely with the United Nations Environment Programme (UNEP) and Kenya government departments to plant trees throughout the country. In 2006, it supported 149 schools in Kisumu district to plant 50,000 tree seedlings.

Following realization of the impact of charcoal burning on the environment, Kenya has a legal framework regulating trade in charcoal. This is reinforced through regular bans on charcoal production and movement from areas deemed threatened by charcoal burning activities (Barnett, 2003). For example, in May 2006, ban was imposed on movement of charcoal from Turkana to neighbouring districts in an attempt to protect forests that were being depleted by charcoal burners. Among these were Kangatosa, Napusmoru, Kaptir, Kalemungorok, Kakong, Eliye Spring and Lomopus forests. These bans are reviewed regularly by the District Environment Management Committee (Daily Nation, 2006). In June 2007, another ban was imposed on charcoal burning in West Pokot

following a public outcry over wanton destruction of trees in the district (Muoki, 2007).

7.17 Use of Natural Carbon Dioxide

A number of industries in Kenya, Uganda and Tanzania still use imported carbon dioxide when in reality the region is endowed with abundant supply of natural carbon dioxide that only needs filtration to the required standard. Some mining of the gas for use in industry is already being undertaken by the Carbacid Company (now part of the BOC Group) in Lari Division in Central Province.

7.18 Programmes to improve range management

In order to facilitate adaptation of the range management to the climate change, the government has introduced pilot programmes that will ensure sustainable production in the rangelands. In 2006, for example, a 6-year Range Improvement Programme that covered 5 pilot ASAL districts, each with 4 components namely: range reseeding, pasture/fodder banks, promotion of multipurpose trees and shrubs was introduced. Other components included grazing management and training of herders and extension staff.

7.19 Diversification of income source

Unlike the 1960s and 70s when policies emphasized on back to land, the current policies are aimed at de-congesting farms by providing alternative sources of income, other than farming. This was stipulated in among others the Sessional Paper No. 1 of 1996 on Industrial Development to the Year 2020. The energy policy that culminated in initiation of Rural Electrification Programme was aimed at ensuring that the rural areas are facilitated with power source so that the informal sector (jua kali) can thrive and provide alternative and supplementary income to farmers. Besides this, local communities have already started investing in micro-power plants that generate hydro-power for the communities use.

As the climate change affects the existing household livelihoods like pastoralism, some people have already changed their sources of income. An interesting case is that of Maasai community that have been known to be pastoralists taking to crop farming. Some of these pastoralists have moved into production of basic foodstuffs such as maize while others have gone into commercial production of horticultural crops in areas such as Narosura irrigation scheme in Narok district.

Many other places, including Loitokitok, Kimana, Rombo and Namalok in Kajiado district experience similar developments (Campbell et al 2003).

This was further confirmed in the July 19th CLIP Workshop held in Nairobi, where participants reported that herders in southern rangelands of Kajiado, Narok and Taveta have diversified their income sources into tree planting, eco-tourism, working in mines fields such as Madadi, carrying out small scale mining, harvesting forest products such as honey and medicine, charcoal burning and trade, small scale businesses and so on. Some have also taken to education in an attempt to seek salaried employment. In the northern rangelands, participants reported that the pastoral communities have diversified their income sources to providing labour to commercial farmers. Others also carry out illegal exploitation of forest products, small scale mining, fishing, poaching and eco-tourism.

7.20 Human migration

With the increase in severity of drought, some of the formally pastoral and nomadic communities are moving to towns in search of alternative means of livelihood. Some of the migrants are people who lost their entire herd to drought and have no other ways of re-stocking. Consequently some pastoral communities such as the Maasai are migrating into towns to take up various forms of employment and businesses. These include trade in curios, Maasai cloths, herbal drugs and other traditional items. They also take up available jobs, including that of security guards.

During the July 19th CLIP Workshop held in Nairobi, stakeholders agreed that in the southern rangelands of Kajiado, Narok and Taveta districts, climate change is leading to migration of herders to wetter areas thereby causing even higher environmental degradation there. Some move to urban areas and towns either on temporary or permanent basis. In the northern rangelands of Laikipia, Samburu and Turkana, herders are migrating from the dry areas into the forests around Mt. Kenya and Aberdare ranges while others move into urban areas and towns such as Nanyuki. At the same time, stakeholders reported that in the mixed farming regions, some farmers are migrating into the ASAL areas where they introduce crop farming. It is expected that the anticipated increased rainfall in the ASAL will increase further the rate of migration into the ASAL areas.

7.21 Strengthening of Early Warning Systems

When natural disasters strike, fingers have often been pointed at the Kenya Meteorological Department for not warning about the pending calamity. This

prompted the Kenya government to look for ways of strengthening the early warning system to enable the department make accurate and more specialized weather predictions. To this end, the government purchased more advanced meteorological equipment and provided the necessary capacity building to staff.

In addition, the government formed the National Disaster Management Authority, which brings together experts from all relevant sectors such as public administration, planning, agriculture, livestock, meteorology, trade, water and environment.

To strengthen the early warning system further, more effective means of disseminating early warning information to the local communities has been established. This is through the use of radio and internet. Climate change has been factored into food security and disaster preparedness and response through involvement of the Climate Change Secretariat in the disaster management efforts.

In order to strengthen the early warning system further, the seven eastern Africa countries, Djibouti, Eritrea, Kenya, Uganda, Sudan, Somalia and Ethiopia, that are members of the Inter-Governmental Authority on Development (IGAD) have established a regional climate monitoring institution to help effectively predict climate related disasters. The IGAD Climate Prediction and Application Centre (ICPAC), which was launched in April 2007 and is based in Nairobi will give information on a minute-by-minute basis (Abwao, 2007). The major objective of ICPAC is to contribute to climate monitoring and prediction services for early warning and mitigation of adverse impacts of extreme climate events on socio-economic sectors of the region. Among other things, its objective is to develop scenarios of future climate change and examine how these would impact on key sectors such as energy.

7.22 Introducing environmental courses in school curriculum

The continued environmental degradation and the global awareness of the impact of these on sustainable development has prompted the Kenya government to lay emphasis on environmental education. Consequently, the school curriculum has been revised to reflect this new development.

The Ministry of Education, for example, introduced courses on environmental studies aimed at increasing awareness among the younger generations on processes, impacts, and consequences of climate change. This is expected in the long run to increase community awareness and contribute to better adoption of environmental friendly technologies.

In schools, students are being sensitized on environmental issues and how to protect the environment from degradation. The curriculum in colleges and universities has equally changed and now reflect the important role of the environment. Besides introducing several courses on environmental science, environmental management and environmental economics, a large number of the other courses have some environmental units embedded in them.

7.23 Improved Road Construction

Kenya has experienced frequent floods over the past decade that seriously destroyed the road network. The 1997/98 El Nino, for example, destroyed several bridges and an estimated 100,000 kms of both rural and urban road network thus calling for better ways of adapting Kenya's roads to floods and El Nino like calamities. The 1998 damage was estimated at US$ 670 million (Karanja et al, 2007). Since 2000, Kenya has adopted new strategies of road construction that are geared towards withstanding the frequent floods. Roads within Nairobi and Kisumu cities as well as the Northern Corridor are particularly built with these in mind.

8.0 FACTORS HINDERING ADAPTATION

Despite knowledge of changes in changes in climate that seriously affect rural development and attainment of the MDGs, not much has been achieved in Kenya. Some of the key factors that have contributed to low adaptability are highlighted in this section.

8.1 Lack of Capital

Most adaptation strategies discussed earlier require financial resources to effectively implement. This has been the major reason for the slower adaptation because most of the affected communities are poor and have no resources to implement the strategies. Some of these strategies include water harvesting, irrigation, fanya juu, soil conservation and application of appropriate inputs.

8.2 Inadequate Research

Low funding of research has been the key problem facing development of drought and pest tolerant crop varieties in Kenya. In particular, the key research institutions such as the Kenya Agricultural Research Institute (KARI) rely heavily

on donor funding for its research activities. The government provides mainly funds for personnel emoluments. This makes research biased towards crops and livestock covered by projects financed by the donors, with little or no coverage of other commodities that do not interest donors. These include more adaptive traditional crops such as sorghum, millet, pigeon peas, cassava and sweet potatoes.

In addition, there is still inadequate research on climate change issues in Kenya. This may be blamed on the lower general awareness about climate change and how it will impact on Kenya. Consequently, most local communities are not aware of the appropriate adaptation strategies and have to rely on traditional best practices.

8.3 Weak extension services

Even if research was effective and producing good results, any weakness in dissemination of the findings to the target group can grossly affect adaptation to climate change. In Kenya, low funding of extension services has been a major problem, with extension workers becoming invisible to the disappointment of farmers. This has been exacerbated by low staffing levels and weak research-extension-farmer linkages. This however is changing with adoption of new extension policy, recruitment of more staff and increase in funding for extension services.

8.4 Inadequate involvement of beneficiaries in decision making

Studies have shown that beneficiaries' ownership of any project is crucial for its success. Projects that are "imposed" on beneficiaries have higher chances of failure than those initiated and implemented by beneficiaries.

It has therefore been recognized that beneficiaries must be involved in every stage of the project cycle, starting with design to implementation and monitoring.

8.5 Information gaps

Information gaps have played a serious role in reducing the rate of adaptation to climate change. In Kenya, lack of knowledge of the appropriate and sustainable methods of adaptation has affected the level of economic development. Moreover, there is inadequate information on issues relating to climate change, especially for those who do not have access to the internet facilities.

8.6 High Tariffs on Imported Industrial Equipment and Materials

Industrial plants and equipment generally are very expensive and attract high import duties. Unless the Ministry of Finance is lobbied to lower such duties, investment in technologies which can foster adaptation to climate change will be curtailed.

8.7 Bureaucratic Procedures

Bureaucratic procedures in authorizing investments are normally a common feature in the developing world, Kenya included. Attempts at a one-stop shop for approving investments by the establishment of the Investment Authority and reduction in the number of licenses required would facilitate such investments.

8.7 Policy Space

Government policies at times have hindered taking up of adaptation measures for climate change. For example, for a long time, there was no policy supportive of co-generation of electricity and its subsequent supply to the national grid until the Energy Bill (2006) was enacted.

9.0 CONCLUSION AND RECOMMENDATIONS

In this paper, we have looked into the adaptation strategies that have been adopted to reduce the impact of global warming in Kenya. Though some of these strategies are coping well with the climate change, such strategies may in themselves have detrimental impacts. For example, expansion of irrigation may have serious environmental consequences and hence the need to carry out environmental impact assessment before their implementation. Similarly, use of more crop inputs, including pesticides may have serious implications on the environment.

It is therefore critical that care be taken to ensure that adaptation does not compromise sustainable development. In this respect, there is need to strengthen NEMA and provide it with supportive policy and legal framework to ensure that adaptation does not negatively affect environmental sustainability.

Although this study has noted with appreciation some efforts made by the government towards strengthening the early warning system, it is still evident that more still needs to be done. In essence, there is need to strengthen the early warning system further and more so put in place structures that will ensure prompt action to reduce casualties of calamities such as floods and drought. Something should also be done to ensure effective dissemination of early warning information to all stakeholders to enable them take necessary action.

With the evidence of climate change being prominent, water flow in Kenya's rivers, especially in western Kenya is bound to increase, albeit with wide variations. This will provide an opportunity to invest in hydro-power generation in these rivers and reduce reliance on rivers flowing into the Indian Ocean that are already overexploited for power generation.

This study shows that various parts of Kenya, including the ASAL, may in future receive higher levels of precipitation. Water harvesting will therefore be crucial to ensure availability of water for domestic, irrigation and livestock use.

The government should facilitate development and dissemination of effective adaptation measures. This should include research into existing and new effective adaptation strategies and more so in:

i). Water harvesting;
ii). Water saving, including recycling, drip irrigation and minimum tillage;
iii). Crop production;
iv). Livestock production;
v). Environmental improvement and conservation; and
vi). Agro-forestry.

There is need to identify and promote traditional adaptation methods that have proved successful. This will further enhance the rate of adoption of these technologies.

Recognizing that high poverty levels seriously affect adaptation to climate change, it is important that efforts be made to reduce the overall poverty. This can be done through creation of jobs and ensuring rapid economic growth. At the same time, efforts should be made to facilitate diversification of income sources of the vulnerable groups. This requires facilitating local communities to set up business and agro-processing units in rural areas through rural electrification, development of rural road infrastructure and market facilities.

At the international level, the government should push for funding of adaptation measures by industrial nations. This could be done through identifying a number of carbon sinks projects that can be 'sold' to the polluters.

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