

**Online Publication Date: 5 February 2012**  
**Publisher: Asian Economic and Social Society**



**Climate Change and Agricultural Development In Africa: Solutions And Challenges To Persistent Famine**

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**Citation:** Josephine K. W. Ngaira, Morgan Musiambo (2012): “ Climate Change and Agricultural Development In Africa: Solutions And Challenges To Persistent Famine ” International Journal of Asian Social Science , Vol.2, No.2,pp.153-168.



## **Climate Change and Agricultural Development In Africa: Solutions And Challenges To Persistent Famine**

### **Abstract**

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Global Warming is the biggest challenge facing humanity in the 21<sup>st</sup> century. While Scientists are busy modeling and predicting the pace and degree of future atmospheric interactions to warming, humanity has woken to the harsh reality that global warming today is caused by anthropogenic greenhouse gas emissions which must be halted with diligence in order to save the Planet Earth and its inhabitants from extinction. Africa whose lifeline is rain fed agriculture is one of the most vulnerable Continents to the impacts of climate change caused by her vulnerabilities which include; varying landscapes and climates, fragile agro-ecological zones, low natural resource base and social and political upheavals, all of which make it difficult to find common solutions that address climate change impacts. To come up with agricultural development, solutions and challenges facing Africa in the changing climate scenario; (i) the researcher attended workshops on “agricultural water and climate change” conducted by the World Bank in Kenya, (ii) analyzed researches on agriculture in a changing world in Rwanda, agro-pastoralists in Ethiopia, in Kenya and Tanzania and Climate data from “Drought Monitoring Center Nairobi ” 1996-2008, (iii) analyzed researches on “agriculture at crossroads in sub-Saharan Africa” and working papers on “adaptation action after Copenhagen” (iv) the researcher evaluated climate change and food security reports from ICRISAT, and (v) conducted research on “ climate change and sustainable livelihoods in Eastern Africa”. It was established that Africa is warming up very fast as evidenced in droughts, floods, sea level rise and increased temperatures, erratic rainfall patterns, and threatened agricultural systems in Sub-Saharan Africa. However, both the Scientific and local Community based adaptation and mitigation solutions including; green energy options, soil moisture conservation, rainwater harvesting , irrigation, poly cropping, greenhouse farming and indigenous dry land crop farming are being employed to counter the adverse climate change impacts at both local and country levels, though with complex challenges.

**Keys words:** Water conflicts, Conservational farming, Cattle rustling, fragile soils, poly cropping, greenhouse agriculture, staggered cropping, Indigenous Knowledge

## **Introduction**

Climate change is with us now, the earth is warming, seasons are shifting, and species are either migrating to various geographical ranges or getting extinct, while water scarcity is a reality. From the 19<sup>th</sup> century to date, the earth is tending towards a warm climate caused mainly by anthropogenic activities and characterized by frequent prolonged droughts and devastating floods (Ngaira, 2004). Dealing with the inevitable threats and impacts of climate change is now the 1<sup>st</sup> global development agenda (Ngaira, 1999 ). Climate change therefore, is one of the greatest challenges facing humanity in the 21<sup>st</sup> Century.

The Earth's climate is a result of a complex interaction of the sun's energy with the Earth's atmosphere, land, oceans and ice sheets. Over time, the Earth's atmosphere has built up gases such as carbon dioxide, methane, Ozone, Chlorofluorocarbons and nitrous oxide, which together are called "greenhouse gases." On global scale, about 65% of greenhouse gas emissions come from energy production and industrial, transport and construction emissions while 30% come from agriculture and deforestation. These gases trap the sun's heat and only allow the required amount to reach the Earth, thus making the Earth habitable. For many years, these gases remained within acceptable levels. However, since the Industrial revolution, greenhouse gases have significantly increased in the atmosphere and are now increasing at a faster rate for example, levels of carbon dioxide in the atmosphere increased by 25% in 1992 and were expected to increase by a further 30% by the year 2040 (Nkemdirim, 2003) The current predictions indicate that the greenhouse gases will cause temperature increase of between 1.5 and 4.5°C. These figures are expected to cause devastating effects on Africa where 80% of the land surface is ASAL. Many human systems are already affected by these changes, particularly agriculture and livestock production, water resources and human health.

The main causes of the increase to temperature include the burning of fossil fuels such as coal, petroleum, natural gas, widespread

deforestation and agriculture all over the globe (IPCC, 2007).

For example, atmospheric carbon dioxide has steadily been increasing. Human activities such as burning of fossil fuels (coal, oil), charcoal with deforestation, overgrazing and Industrial emission are the major cause. The increased presence of carbon dioxide is the cause of local, regional and global warming since it absorbs the long wavelength infra-red component of earth's radiation and re-radiates it back to the earth surface (Ngaira, 1999). The 20<sup>th</sup> century was the warmest in the last 1000 years (Nkemdirim, 2003), most of the increases in the global temperatures observed over the last fifty (50) years are due to human emissions of greenhouse gases. Table 1 indicates the steady increase in atmospheric carbon-dioxide since 1900.

**Table-1** Year Carbon dioxide in parts per million (ppm)

1900	280 parts per million (ppm)
1980s	335 parts per million (ppm)
2000	380 parts per million(ppm)
2050	400 parts per million (ppm)

Source; Machta, 1972, [http:// www.climate change](http://www.climatechange).

Though the climatic history of the globe is not well understood, it is known that during the last 55 million years, the earth underwent cooling and that during the last one million years, there have been alternating glacial/cooling and inter glacial/ warming episodes evidenced by the Little Ice Age 1645-1715 and the Tropical Age 1870-1930 (Ford, 1982). The most important components of the atmosphere are; water vapor, carbon dioxide, ozone and methane collectively called greenhouse gases which act like the glass roof of a greenhouse by trapping heat and warming the Planet Earth. The natural levels of these gases are being supplemented by emissions resulting from human activities, such as burning of fossil fuels, farming activities and technologies, and land use changes. As a result, the Earth's surface and the lower atmosphere have been warming and rising levels of greenhouse gases are the causes of the changing climate. Evidence of changes in the Earth's

climate are indicated from (a) fossil records; fossils of species such as the equatorial forests are found in petroleum rich and arid Northern Africa, (b) topographical evidence, still in North Africa largely arid now, it can be seen where rivers once passed, an indication that the area received high rainfall sometime in the past, (c) historical records; the freezing of River Thames was reported during the Little Ice Age and (d) meteorological records of weather patterns indicate changes in some areas, for example, the Little Ice Age and the Tropical Age and (e) the geological evidence shows changing landscapes of many physical features and agricultural systems due to glaciations, erosion and aridity. Climate change today represents one of the worst and greatest environmental, social and economic threats of the 21<sup>st</sup> century facing the planet Earth and agriculture which is the main source of livelihood for 75% of the world's rural poor is also the human activity most affected by climate change.

#### **Characteristics of Africa's changing climate**

The climate of Africa is both highly diverse and variable. It consists of the extreme aridity of the arid and semi-arid lands on one end and the extreme humidity of the equatorial Congo rainforest on the other end. Plate 2 shows a typical arid environment in Kenya.



Plate 2, Moisture stressed arid Turkana district, Kenya.

The deepening impacts of climate change will affect the poor in developing countries who already face economic and environmental stresses and living on the margins of the continent such as Africa. It is estimated that

African Countries will face some of the worst effects of climate change by 2080 causing severe stress on water resources and agriculture (CCAA, 2006). 60% of Africa's poor depend directly for their livelihoods upon agriculture which is highly sensitive to climate change; Rain fed subsistence crop cultivation, forestry and, fishing make the basis of 60% of Africa's rural livelihoods. These are commonly referred to as "the wealth of the poor". Climate change is making these resources less reliable in the tropics thus, lowering the prospects of many poor communities to escape from poverty and food insecurity. The poorest communities in Africa which have contributed least to global GHG emissions are amongst the most vulnerable to climate change. Indigenous peoples in the ASAL such as those in Eastern Africa who constitute the biggest percentage of poor communities are not only located in high-risk areas, but their lack of economic and social resources mean they are ill-equipped to adjust to the long-term changes in climate and therefore exposed to frequent famines. The already arid Sahel region is expected to expand in desertification towards the south bringing a gradual decrease in vegetation cover leading to rainfall dropping drastically from the average normal of 500 mm per year to 250 mm resulting into soil degradation and increased number of dust storms. Agricultural capacity in East and Central Africa will decline, with increased incidences of highland malaria, decline in fisheries from the big rivers and lakes. Longer and frequent dry periods will cause crop failures and devastating famines. The coastal zones will be affected by the rising sea levels leading to intrusion of salt water into inland freshwater resources thus affecting both pelagic and dermal fishing (DMCN, 2002).

Anthropogenic factors such as deforestation, overgrazing, burning fuels and Industrialization have been identified as the contributors of greenhouse gases and they add to the carbon load (GHGs) into the atmosphere, with subsequent changes in the Earth's temperature and weather systems. The current signs of global climate change have resulted from an average increase in the world temperatures of just 0.6°C since 1945 (IPCC, 2006). As a result of global warming, the climate in Africa is predicted to become more variable, and extreme weather events are expected to be more

frequent and severe, with increasing risk to health and life. This includes increasing risk of drought and flooding in new areas ( Few et al. 2004 Christensen *et al.* 2007) and inundation due to sea-level rise in the continent's coastal areas (Nicholls 2004; McMichael *et al.* 2006). The 2009 IPCC report states that Africa faced the most direct consequences of extreme weather conditions exacerbated by global climate change. For example, global temperatures are expected to rise by 1.4C<sup>0</sup> in the 21<sup>st</sup> century compared to 0.7<sup>0</sup>C in the 20<sup>th</sup> Century. The projected temperature increases for southern Africa (SADC) by 2020-2029 are between 1.5 and 2<sup>0</sup> C; these will result in between 75-250 million people exposed to water scarcity, famine and water stress for agricultural production. By 2050, if the current levels of carbon dioxide production is not halted, the mean global temperature will rise to 2-3°C representing a climatic change greater than ever experienced on the globe (De Wit and Jacek, 2006). Continuing increase in greenhouse gas emissions at the current rates without any additional mitigation measures would cause a further increase in global temperature from 1.8°C in the 1980s to 4°C towards the end the 21<sup>st</sup> century, the projected mean global temperature increase from 1.1 to 6.4 degrees Celsius by 2100 if no action is taken to reduce greenhouse gas emissions (IPCC, 2007).

Africa is a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate change. Many areas in Africa are recognized as having climates that are among the most variable in the world on seasonal and decades time scales. Floods and droughts can occur in the same area within months of each other. These events can lead to famine and widespread disruption of socio-economic well being. For example, estimates reported at the workshop indicate that one third of African people already live in drought- prone areas and 220 million are exposed to drought each year and by 2020, up to 250 million people in Africa could be exposed to greater risk of water stress (IPCC, 2007). Many factors contribute and compound the impacts of current climate variability in Africa and will have negative effects on the continents ability to cope with climate change. These include poverty, illiteracy and lack of skills, weak

institutions, limited infrastructure, lack of technology and information, low levels of primary education and healthcare, poor access to resources, low management capabilities and armed conflicts such as cattle rustling. The overexploitation of land resources including forests, increases in population, desertification and land degradation pose additional threats (UNDP 2006). In the Sahara and Sahel, dust and sand storms have negative impacts on agriculture, infrastructure and health.

### **Characteristics of Africa's agriculture**

Agriculture is the most important sector in the economies of all non-oil exporting African countries. However, the major threats to agricultural development in Africa include: anthropogenic induced climate change, land use changes such as deforestation and over exploitation of natural resources for example, forests, dry land ecosystems and water abstraction for small scale self-help irrigation. Agriculture constitutes approximately 30% of the continent's Gross Domestic Product, and contributes about 50% of the total export value with 70% of the population depending on the sector for their livelihoods. Over 50% of the workforce in Africa is employed in Agricultural production and many countries in Africa depend on the sector for economic development, for example, in East Africa, agriculture contributes 40% of the region's Gross Domestic Product (GDP) and provides livelihoods for up to 80% of the population, Kenya derives over 20% of the GDP (Gross Domestic Product) from agriculture (IGBP, 2008). Agriculture offers direct and indirect employment to 80% of Kenyan population, 70% of Tanzanians and 50% of Ethiopian population. The UN Food and Agricultural Organization (FAO) observe that the number of African food crises per year tripled between 1980s and 2005. The nature of agriculture is mainly subsistence rain fed with isolated commercial/cash crop irrigation farming in the East Africa highlands. Any variations in climate resulting from floods and droughts impact negatively on the sector and livelihoods of majority of the population. Agricultural production and food security in many African countries is projected to reduce. For example, projected reduction in yields could be 50% by 2020 and crop net revenues could fall by as

much as 90% by 2100 with small scale farmers being the most affected. UNDP (2008) Report on Human Development states that 17% of the world's population is malnourished and of these, 36% of them are in sub-Saharan Africa.

The 4<sup>th</sup> Assessment Report of the (IPCC) Intergovernmental panel on climate change 2007 confirmed that "Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capability. The diversity of the people, varying ecosystems, natural resources (minerals, plants, water availability) social and political histories (the Arab North, the Black South of the Saharan Africa and the "white" Southern Africa makes it difficult to find common solutions about the threats posed by the pressing "climate change phenomenon, on the African continent." African people face serious social and economic challenges due to diseases and high poverty and poor nutrition levels with ten (10) poorest nations in the world being located in tropical and sub-tropical Africa.

The good news for Africa is that, the inherent resilience of African ecosystems gives hope for sustainable development pathways into the future. In 2005, the population of Africa stood at over 880 million people with a growth rate of 2-4% twice the global average. This population is projected to double in the next 22 years even with the prevalence of HIV/AIDS which reverses and lowers life expectancy. The growing population will exacerbate the existing problems of food security, water scarcity and health services. Contemporary Africa is vulnerable to floods and droughts, degradation in the dry lands and coastal zones, 60% of Africa is Arid and semi – arid (ASAL) for example the Sahara, Kalahari, Namib and arid Northern Kenya, Northern Uganda and Tanzania. In southern Africa where the staple food is maize grown in the maize Triangle is susceptible to droughts which will worsen the food supply. Wetlands and wildlife will be under great threat (IGBP, 2008).

On the whole, Agriculture will be affected by five major climate change drivers; temperature, precipitation, sea level rise, atmospheric carbon dioxide content and incidences of extreme

events (drought, floods and storms) all leading to devastating famines.

Increase in temperature will be conducive for proliferation of pests that are detrimental to crops e.g. earthworms, increased temperatures will increase drought period frequencies, reduce soil moisture, soil fertility, moisture storage capacity and soil nutrients which are important for crops, increased temperatures will affect the availability of livestock feed and fodder, increase in temperatures will create ideal conditions for malaria, sleeping sickness, tuberculosis, lower human immune systems, asthma and water related diseases such as diarrhea which will directly affect the availability of human resources to work in the agricultural sector ([http://www.leepa.co.za/climate\\_change](http://www.leepa.co.za/climate_change)).

#### **Vulnerabilities of agriculture to climate change in Africa**

Africa is particularly vulnerable to climate because of existing pressures on its ecosystems and its low capacity to adapt. The most vulnerable people are the poor, since their livelihoods are dependent on agriculture which is in turn dependent on climate. More than four-fifth (4/5) of agricultural land is affected by soil moisture stress which limits the uptake of nutrients. This is because 33% of the global land area is used for food production and agricultural ecosystems can be found in almost all climatic systems. Vulnerabilities of agriculture to climate change in Africa are projected under the following facts:

a) Crop failures and livestock deaths leading to higher economic losses, higher food prices and increased food insecurity problems manifested in hunger, starvation and malnutrition related diseases such as marasmus, kwashiorkor and dysentery in the Sahel and sub-Saharan Africa.

b) Threatened nomadic pastoralism, a system that over the Centuries had been resilient and able to cope with unpredictable weather patterns and regular droughts through Transhumance, overstocking, migration and fixation sites is now threatened by population pressure, prolonged and widespread droughts caused by climate change.

c) Dry land farming in the arid and semi-arid lands where drought resistant crops such as cassava, millet, cowpeas were grown, are today threatened by prolonged droughts lasting for over 5 years ( 1968-1973) and rain failures for over 2-3 growing seasons.

d) The newly introduced hybrids or Genetically Modified Organisms (GMOs) will be vulnerable to lack of artificial conditions, such as scarcity of water for irrigation due to droughts while they cannot inter-breed (Carter, 2007).

e) The severe food scarcity impacts which are frequently addressed by Humanitarian food aids of the affected governments, Red Cross and FAO do not provide a permanent solution to the problems of agriculture and climate change and famine; rather they encourage a sense of hopelessness and sustained dependency on food “hand outs”.

f) Over 3 billion people live in the rural areas of developing countries; they live on ecologically fragile land and depend on agriculture, mainly crop farming and livestock keeping. These rural people lack the financial and institutional capacity to adapt to or mitigate against the impacts of climate change and family food security, at the same time, women who make up majority of the poor and who are responsible for producing 80% of subsistence food do not own land and do not make decisions on matters related to land and food storage (Kalibata, 2006).

g) Monoculture characterizes commercial farming in Africa, for example Tea and Coffee grown in the East African highlands, Cocoa in West Africa and Maize in the Maize Triangle in the Republic of South Africa. There is little mechanization but largely labor intensive, for example, tea picking, sugar cane weeding and harvesting are manually done. Productivity is often low and it has been diminishing due to rainfall fluctuations and frequent drought episodes (see table 1). Most industries in the tropics are agro-based, mainly processing commercial agricultural produce for example sugarcane in Lugazi (Uganda) Mumias (Kenya), Tea in the Kenya highlands ( Kalibata, 2006). These crops occupy large pieces of

farmland at the expense of subsistence food crops which can be grown to cushion rural populations against famines.

h) Rapid population growth has led to a change from traditional agricultural systems where about 7,000 plant species with varieties that could cope with changing climate were cultivated for food since agriculture began about 12,000 years ago to intensive modern agricultural systems with only about 15 plant species and 8 animal species supplying 90% of food. Many traits from wild relatives were incorporated into the modern crop varieties to improve productivity and tolerance to pests, diseases and difficult growing conditions. Unfortunately, many wild races of staple food crops are endangered and are predicted to die out within 50 years which could make it difficult for future plant breeders to ensure that commercial varieties can cope with a changing climate, this will worsen the already famine stricken populations in Arid Africa. i) The majority of agricultural research and technology does not reach or benefit small farmers in the developing countries. In sub-Saharan Africa, agriculture employs 60% of the population but accounts for only 4% of government spending (Bill and Melinda Gates foundation).

Agriculture constitutes about 30% of Africa’s Gross Domestic Product, provides only 60% of food supply to the population, implying that food demand is lower than supply. The food balance sheet is characterized by food imports and food aids from the developed countries such as the 1984 yellow maize import from USA by Kenya.

j) Subsistence agriculture is practiced on highly fragile ecosystems such as hilly areas, dry lands and wetlands. Frequent price fluctuation and fall due to droughts and floods lead to food crisis for example, in Kenya, due to 2008-2009 droughts the price of goats fell from Kshs.3,500/= to Kshs.200/= Women who provide 80% of the labour force on farms, such as planting, harvesting, processing and who are responsible for both food production and food preparation for their families, have no land ownership rights, they receive only 5% of extension services, they are underrepresented in research, training and policy-making positions.

Most agricultural systems in the tropics are rain fed, that is climate depended, such that yields fluctuate with fluctuating rainfall patterns (droughts lead to crop failure and low yields, ample rainfall lead to good crop and high yields) The problem of aridity, land degradation due to over cultivation as a result of population pressure is prevalent. Duplication of cash crop farming due to same conducive climatic conditions for example; coffee in Brazil, Kenya, Tanzania and Uganda, Maize in Kenya highlands and Maize Triangle in South Africa. This type of duplication makes agricultural economies vulnerable at the slightest change in climate patterns. The tropics are characterized by poor internal and external markets due to duplication and exportation of semi- processed goods. There is very low input investment in the agricultural sector, for example, Africa as a Continent invests only 4%, in agriculture, Mali invests 11%, Burkina Faso 15% and Ethiopia 17%, Kenya invests only 6%.. The use of fertilizer is very low in Africa with 8 kg/ha compared to the global average of 100 kg/ha resulting in low crop yields in tons per hectare. Food import prices fluctuate with changing climate for example, the food import bill doubled to Kshs. 15 billion in the 2008 financial year in Kenya (Akalibata,2008).Table 3 summarizes some of the notable effects of climate change on agriculture in Africa.

#### **Methods of data collection.**

Data for this study was collected from the following sources;

- (i) Analysed case studies on agriculture and climate change from Rwanda, Ethiopia, Kenya and Tanzania, analysed climate data from Drought monitoring Center Nairobi, ICRISAT and working papers of “action plan after Copenhagen”
- (ii) Attended Climate Change and agriculture based workshops conducted in Entebbe, Dar Es Salaam, AICAD- Juja, by World Bank,
- (iii) Structured questionnaire, focused group discussions and participant research Appraisals administered to farmers and pastoralists in semi-arid Kitengela location in Kenya while
- (iv) Documentary data on the subject was collected from Journals, Session working papers, Internet and text books. Analyzed data was presented in the form of discussions, tables, photographs and percentages.

## **Results And Discussions**

### **Indicators of climate change in Africa**

The study established that major indicators of climate change are best illustrated in: Frequent drought occurrences, steady increases in atmospheric carbon dioxide , increased temperatures, sea level rise, floods, El Niño occurrences collapsed agricultural systems, increased Malaria incidences.

### **Droughts**

The term drought implies an absence of precipitation for a period long enough to cause moisture deficiency, crop failure, water shortages, hunger, starvation and general hardship. Droughts in Africa are caused by deforestation, over cultivation, overgrazing and failure of ITCZ to move far from Equator. Studies of tree rings in the United States have identified drought occurring as early as 1220. The longest drought identified by tree ring method began in 1276 and lasted 38 years. Tree ring method identified twenty one (21) droughts lasting five (5) or more years during the period 1220 to 1958. The most well known American drought was the Dust Bowl on the Great Plains that occurred between 1931 and 1936. Almost the entire continent of Africa suffered from droughts in the last quarter of the 20<sup>th</sup> century. Ethiopia was hit by severe drought in the 1980's. Between 1968 and 1974, the Sahelian- Africa suffered from drought where an estimated 50,000-200,000 people died from starvation caused by food shortages ( Ford, 1982). Of all the decades in the 20<sup>th</sup> century, the 1970's was seen as a period of unusual and extreme climate conditions which caused 1968-1973 Sahel droughts, 1974 failure of monsoon in India, 1975 frosts in Brazil and 1977 highest rainfall and floods in the semi arid lands of Kenya. The 1<sup>st</sup> decade of the 21<sup>st</sup> century was seen as the driest in 100 years. The 2008-2009 failure of rains in Kenya's ASAL put 10 million Kenyans at severe risk of starvation and possible death with a loss of over 90% of the livestock due to acute water scarcity. Plate 1 shows the dead livestock during the severe 2009 drought in Turkana, Kenya and table 2 shows some major drought years and effects on the environment in Africa.





Plate 1. Drought effect on livestock in Turkana district, Kenya, in 2009.

### **Increased temperatures**

The projected increase in temperature would cause the following impacts on agriculture in Africa; Collapse of rain fed agriculture in the tropics caused by frequent droughts and floods resulting to extreme poverty, grain yields would decrease, diminishing the food security issue in food importing countries, increased heat stress in livestock and wildlife and drying of crops (DMCN, 2002). Major rivers for example; the Nile, the Zambia, the Zambezi, the Volta which are used for irrigation, hydro-electric power production and domestic purposes are highly sensitive to climate change. Droughts would lead to a decrease in water volume affecting Irrigation farming (Cotton in Gezira, Groundnuts in Sudan), reduced hydro-power production and water scarcity for domestic use. Desertification will be widespread especially in Northern, Western and Southern Africa due to reduction in average rainfall; this would severely affect pastoral farming activities of the Karayu in Ethiopia, Tueregs in the Sahel and the Masaai in Kenya and Tanzania, the Karamojong in Uganda (Tearfund, 2007).

### **El Nino Episodes and Agriculture**

El Niño is the intensive warming of the upper ocean in the tropical Eastern Pacific which lasts up to one (1) year and normally has a cycle of 2-5 years. El Niño is generally associated with excessive rainfall (floods) and the areas frequently affected by El Niño include: Central and Eastern Pacific, Ecuador and Brazil and Greater Horn of Africa (Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan Tanzania and Uganda.). The La Niña is the cold phase of El Niño. It is associated with

below average rainfall (droughts) and areas frequently affected include: Australia, Indonesia, India, West Africa and Zimbabwe and the Greater Horn of Africa (DMCN, 2002, Ngaira, 1999). 24 El Niño episodes were recorded on the globe between 1871 and 1997, they include: 1877, 1899, 1972, 1982, 1993-4 and 1997-98. Table 1c shows notable El Niño episodes and the impacts on agriculture.

### **Notable El Niño Episodes and effect on agriculture in Africa.**

**1997-1998** i) The worst and strongest ever recorded in 150 years, in the greater Horn of Africa, (ii) Somalia experienced its worst floods in 37 years which destroyed farmlands, (iii) Kenya experienced the worst floods in 36 years which swept away farms, Killed people and caused collapse of infrastructure and (iv) there were devastating floods in Morocco which swept farmlands and displaced thousands of people.

### **1992-1993**

i)- Severe La Niña droughts in South Eastern Africa, Western North America and Zimbabwe Where the economy shrunk by 12%,  
ii) Decreased agriculture and rangeland productivity in drought prone regions on the globe  
iii) Severely reduced Hydro electricity power production in drought prone tropical regions thus affecting the processing of agricultural products e.g. sugar processing (DMCN,2001).

### **1982-1983**

The worst in 100 years with severe droughts in Australia, Indonesia, Bolivian highlands and Kodoma farming district in the Republic of South Africa (WMO, 1985).

### **Sea level rise and effects on Africa**

Global sea-level rise caused by water expansion due to warming of oceans, and melting of glaciers and ice sheets are projected to rise from 18 cm in the 1980s to 59 cm by 2100. This warming could cause acidification of oceans, reduced snow cover and polar ice, frequent heat waves and intense tropical cyclones and increased storm surges affecting many coastal communities. These projected changes are expected to negatively impact human health, society and the environment, in particular,

agriculture, water resources, fresh water ecosystem and coastal zones and human resources that work in the agricultural sector in Africa (IPCC, 2007).

Future sea level rise has the potential to cause huge impacts on the African coastlines including the already degraded coral reefs on the eastern coast. National communications indicate that the coastal infrastructure in 30 per cent of Africa's coastal countries, including the Gulf of Guinea, Senegal, Gambia, and Egypt and along the East-Southern Africa coast is at risk of partial or complete inundation due to accelerated sea level rise. In Tanzania, a sea level rise of 50 cm would inundate over 2,000 km<sup>2</sup> of land, costing an estimated USD 51 million in infrastructure and humanitarian catastrophe (UNEP 2002a). Future sea level rise also threatens lagoons and mangrove forests of both eastern and western Africa, and is likely to impact urban centers and ports, such as Cape Town, Durban, Maputo, Dar Es-salaam and Mombasa. If the Warming persists, it could lead to a complete melting of the Greenland ice sheet and increasing global sea-level by about 7m.

#### **Impacts of climate change on agricultural Africa**

Globally about 65% of greenhouse gas emissions come from energy production and use for industry, transport and construction and 30% from agriculture and deforestation. Our actions need to target these sources and large emitting countries. The current effects of climate change have reached a scale which puts urgency to the efforts aimed at preventing additional greenhouse emissions through such measures as; first, improve and develop technologies to increase energy efficiency, to use renewable energy, and capture and store carbon. Second, put in place regulations and standards that help move towards low fossil fuel use (green energy options). Third, use instruments, such as carbon finance, carbon trade and markets, to help reduce emissions. Fourth, change behavior and lifestyles, for example, use more public transport, lower energy consumption at home by switching off all bulbs in un used rooms. In agriculture, key mitigation actions to include conserving and increasing soil carbon, increasing forest and

vegetation cover to capture carbon, and reducing emissions from livestock.

Even if greenhouse gas emissions were to stop now, there would still be a significant time-lag before temperatures and sea level rises would stabilize. Therefore efforts aimed at adapting to the already occurring impacts mainly droughts, floods, melting of polar and equatorial ice and snow and sea level rise must be put in place. (IGBP, 2008) This means adaptation is essential and a must, not an option. Adaptation is about changing behavior and practices to manage climate impacts. There are the so called "no-regrets" adaptation actions, and the longer-term "climate justified" adaptation actions. The "no-regrets" actions are those that strengthen resilience against climate variability. Examples include, improving water use efficiencies, mulching to conserve soil moisture, managing evapo-transpiration to achieve real water savings, and improving water management institutions as in expanding the area under irrigation. The "climate justified" actions are those taken solely for the purpose of coping with climate impacts. Examples include adjustments to technical design standards, regulations, and investment priorities, introducing new crop varieties to address the changes in cropping seasons, building additional water storage facilities to reduce the damage of and from extreme events such as floods and droughts. In addition, agricultural water management is one area that can offer co-benefits between adaptation, mitigation and poverty reduction. Many major food - production areas are projected to become significantly drier, therefore, good soil-water management, watershed management and agro forestry practices can greatly help capture carbon in the atmosphere, increase soil fertility and water storage, and enhance productivity to help meet human livelihood needs (Ashton 2002, De Wit and Jacek 2006 ).

Agricultural production relies mainly on rainfall for irrigation and will be severely compromised in many African countries, particularly for subsistence farmers and in sub-Saharan Africa. Under climate change much agricultural land will be lost, with shorter growing seasons and lower yields. National communications report that climate change will

cause a general decline in most of the subsistence crops such as sorghum in Sudan, Ethiopia Eritrea and Zambia; maize in Ghana; millet in Sudan; and groundnuts in Gambia. Of the total additional people at risk of hunger due to climate change, Africa will account for 80%



Plate 3, Scrambling for scarce water in ASAL Laikipia , in Kenya.

Africa is vulnerable to a number of climate sensitive diseases including malaria, tuberculosis and diarrhea. (Guernier *et al* 2004). Under climate change, rising temperatures are changing the geographical distribution of disease vectors which are migrating to new areas and higher altitudes, for example, migration of the malaria mosquito to higher altitudes will expose large numbers of previously unexposed people to infection in the densely populated East African Highlands (Boko *et al.* 2007). Future climate variability will also interact with other stresses and vulnerabilities such as HIV/AIDS (which is already reducing life expectancy in many African countries to an average of below 45 years) and conflict and war (Harrus and Beneth 2005), resulting in increased susceptibility and risk to infectious diseases (mainly cholera and diarrhoea) and malnutrition for adults and children (WHO 2004)

In the period 1996-2000, the number of countries affected by climate related disasters rose from 28 to 46 mostly in the developing world leading to an increase in the problems of food security, poverty and land degradation. For example, major storms and floods affected southern Africa, Central America, India, Viet Nam and the Caribbean. The cost of floods in

by the 2080s (Fischer *et al.* 2002). Africa will face increasing water scarcity and stress (plate 3) with a subsequent potential increase of water conflicts as almost all the 50 river basins in Africa are transboundary .

Mozambique caused by tropical storms *Elyne* and *Gloria* in February and March 2000 respectively were estimated at USD I billion compared to the country's export earnings of USD 300 million in 1999.

Hydro meteorological disasters resulting from climate variability have increased in frequency in Africa over the past 35 years. While the continents' major concern was drought and related humanitarian crises in the 1970s and 1980s, its concern with other climate change related events such as floods, landslides and tropical cyclones has increased since mid 1990s (ISDR, 2003) while the Sahel region (Burkina Faso, Senegal, Chad, Cape Verde, Gambia, Niger, Mali) have always suffered drought related disasters, the Eastern Africa (Eritrea, Djibouti Kenya, Ethiopia Uganda, Rwanda Burundi, Tanzania, Sudan, Somalia and southern Africa (Zambia, Zimbabwe, South Africa and Mozambique) and the Indian ocean regions such as Malagasy have suffered the impacts of floods and strong winds. For example, the 1997/1998 El Nino floods destroyed parts of Kenya, Tanzania and Somali. In 2000-2002, Mozambique, Malawi and Zambia suffered El Nino floods which claimed lives, caused extensive damage to infrastructure, agriculture and other economics. Mozambique was affected by strong winds, cyclones and excessive rain, which destroyed houses and farmlands of rural communities leaving hundreds of people at the mercy of humanitarian assistance (Bojang, 2003).

In the Sahel region (Burkina Faso, Cape Verde, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal and Chad), climate change is expected to intensify the already existing threats against people and the environment because of widespread poverty, periodical droughts, over dependence on climate sensitive agriculture and livestock, high population growth and serious deforestation (ISDR, 2003)

Climate change has impacted negatively on indigenous people particularly in Eastern

Africa. This is evidenced by mean climatic conditions such as increases in temperatures in Kakamega forest, Kenya highlands, Kilimanjaro and Mbeya regions with increased incidences of malaria in areas which did not have malaria before (*highland malaria*) (b) reduced rainfall (c) irregular rainfall seasons (d) re-current severe droughts (1992-94, 1998-2000 2003-2004, 2005-2006, 2009), high poverty index of 60 percent, tribal conflicts due to scarce water resources and devastating famines, for example, frequent cattle rusting between the Pokots and Tugens in Kenya in 1984, 1992, 1999, 2001, 2006, 2009-2010. Population pressure is also pushing more people to occupy and over exploit the scarce ASAL resources thus reducing their resilience and sustainability. The most exploited resources are; the Neem tree, aloe, sandal wood and acacia for charcoal burning.

#### **Solutions to persistent famine in Africa.**

Listening to the voices of the rural poor people who depend on agriculture for their livelihoods while planning adaptation and mitigation solutions, we can reduce risks of climate change to agriculture and provide food to 75% of Africa's rural poor and accelerate progress towards food security and a world with minimized poverty levels (<http://www.ifad.org/pub.htm>)

The following strategies are being employed to adapt to and mitigate against climate change impacts and alleviation of persistent famines;

1) Increasing use of pesticides and herbicides, use of inorganic fertilizers such as nitrogen are being used to increase production, Hybrid seeds which are high yielding and mature fast such as hybrid maize, new cassava species, mwezi moja beans, and Genetically Modified Organisms are today replacing the indigenous germ plasm in the changing climate scenario. Irrigation farming by flooding of fields in rice farming as practiced Mwea scheme in Kenya, is another method of agricultural development used to increase food production.

2) Farmers in Africa practice a number of agricultural techniques as coping strategies to enable sustainable food production and deal with the extreme climate events. The techniques include intercropping and crop diversification, mixed cropping and poly cropping ( plate 4)

which ensures that the farm is never left bare because crops are harvested at different times within the year, for example, a farm is intercropped with beans, maize and coffee or tea bushes, poly-cropping increases plant diversity and attracts several other plant species and herbivores. 3) Agro-forestry, animal husbandry and developing of new seed varieties that cope with the changing climate by KARI and ICRISAT, diversification of herds and incomes in the ASALs such as introduction of camels in place of goats practiced in Koste Division of Baringo Central district in Kenya and land use conversion , for example, a shift from livestock farming to dry land maize, sorghum cultivation and bead making in Kitengela division of Kajiado district in Kenya ensures that there is household food despite cattle mortality caused by droughts.



Plate 4, Poly cropping of Bananas, Maize, cassava and vegetables in the same farm ensures household food security in semi-arid Kitengela, Kenya.

3) Greenhouse agriculture is a farming technology which ensures food security for the urban poor. It is spreading fast among small scale farmers near urban centers in Kenya. The technology offers an environment in which temperature, humidity and pests are easily controlled. The greenhouses are made of wood and polythene; they measure 240 square metres and the cost of putting up such greenhouse including the installation of drip irrigation pipes ranges between Kshs 100,000-300,000 Crops grown are mainly horticultural crops such as; tomatoes, cucumbers, cabbages, spinach, carrots and capsicum (green pepper/ *pilipili*)



*hoho*), throughout the year. Crop diseases and water use are controlled. A combination of drought, increased food prices, growing food demand from an expanding urban population and proximity to ready urban markets is a big benefit to many greenhouse farmers in Ongata Rongai, Kitengela and Kiserian near Nairobi city. Farmers in Nyandarua, Bungoma, Machakos, Bomet, Kitale and Narok have started greenhouse agriculture. The technology was researched and developed by International Crop Research Institute for the Semi-Arid Tropics (ICRISAT).

4) Re cycling of post harvest residues back to farms to keep the soil nutrients and use organic fertilizers from animal manure, and planting and using the traditional food crops adapted to local climatic conditions is a method of providing a solution to famines in sub- Africa. For example, dry land cereals mainly; sorghum, pearl millet, pigeon peas, groundnuts and cowpeas are important in ending hunger and malnutrition in drought prone areas of Africa.

5) Conservation farming, staggered cropping; water harvesting and catchment restoration through aggressive afforestation and tree planting, for example, under the 2009/2010 budget, the government of Uganda allocated 1 billion shillings through the National Forestry Authority ( NFA) for national tree programme which was launched at Lwamunda Central Forest Reserve in Mpigi District in September, 2009 (Kalibata,2006). A good example of forest restoration is the Mau forest initiative in Kenya where 7 billion trees are earmarked to be planted by 2020 starting in 2010; this is aimed at restoring the flow of the Mara and Sondu Miriu rivers. Trees are also planted as fences, hedges and for firewood in homesteads in the Lake Victoria Basin to mop up the carbon dioxide in the atmosphere and reverse the impacts of climate change caused by deforestation. Plate 5 shows trees making a fence for a homestead in Maseno division, Kisumu district in Kenya (Omwayi, 2008) personal communication.



Plate 5 Planted tree hedge, a forestation initiative to provide carbon sinks and mitigate climate change impacts in Maseno division, Kisumu, Kenya.

6) Ground water resource tapping for irrigation, rain water harvesting during excess rain for use during droughts, use local water harvesting technologies and consolidating of highly fragmented ancestral farms for large scale farming will ensure adequate food production.

7) Empowering women in agriculture by allowing them access to land ownership rights, involving them in training, research and policy-making positions, for example, the current constitution of Kenya, *Chapter five, Article 60 (1a and 1f) gives both women and men equitable access to ownership and practices on issues related to land.* This ensures food security since 80% of women in Africa are involved in subsistence food production and they are the family food providers.

8) Through agricultural research, Kenya has developed and adopted high yielding crop varieties suitable for all types of climatic conditions which ensure food availability all the time. For example, the recently developed H6213 maize variety by Kenya Agricultural Research Institute (KARI) is very high yielding with an output of 52 bags per acre, each weighing 90 kgs. This variety does well in the warm highlands such as Kitale, Lugari, and Nandi districts. The crop is resistant to water logging, ear rot and leaf blight during excessive

rains. The H6212 is other high yielding late maturing hybrid maize that does well in Nandi, Kisii, Kericho, Bungoma and Kiambu (KARI, 2008).

9) African countries are investing more in agricultural research to improve yields in crop varieties and animal breeds adaptable to the changing climatic conditions. Examples of such research institutes include; International Livestock Research Institute (ILRI), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and Kenya Agricultural Research Institute (KARI).

### **Challenges to solutions in famine reduction in the wake of a changing climate.**

i) Greenhouse agriculture threaten to remove pastoralists from their traditional lands by taking up grazing land (ii) temperatures in the greenhouses have to be maintained at 24<sup>0</sup>C for Tomatoes, carrots and spinach, (iii) greenhouse construction are very expensive for poor peasant farmers in rural areas.

ii) Prolonged droughts lasting for over 3 consecutive years usually dry up both the rain harvested water and the ground water reserves and cause the lowering of the water table for ground water, this may in future cause soil desiccation and infertility.

iii) Development of high yielding hybrid adaptable varieties calls for big investment in agricultural research, a venture which many developing countries do not have the political will to invest in. Africa invests only 4% on agricultural development and research.

iv) Using modern inorganic fertilizers on water stressed food gardens can lead to soil degradation and poor crop yields and sometimes leads to soil salinisation (Plate 6).

livelihoods in Africa. Since the poor farmers in the villages are the most vulnerable to droughts, floods and famine, adaptation strategies need to adopt a bottom up approach where the community is empowered to draw up acceptable and achievable solutions to their food baskets. Community Based Solutions to Famine(CBSF). The local people have always had strategies of adapting to various environmental calamities; they know the adaptive capacities of their food crops and animals to rainfall, to pasture and to food availability. It is therefore through starting at the grass roots that meaningful and helpful adaptation solutions can be developed and sustained which can reduce climate caused famines in Africa.



Plate 6 - Drying of food crops in Naivasha township due to fertilizer application on a water stressed soil.

### **Conclusion**

The impacts of Climate change are real, severe and adversely affecting the people and their

**Table-2** Notable drought years and the effects in Africa.

<b>Year</b>	<b>Regions affected</b>
1968-1974	Severe droughts in Ethiopia and the Sahel region of Africa which caused crop failure, famines, desertification and loss of between 50,000-200,000 human lives.
1980	
1984	Hottest and driest summer in South Eastern and Western USA where 1000 people died of heat wave.
1990-1993	Severe drought in Ethiopia and Kenya caused 80% crop failure in the ASAL and led to Introduction of “Food for Work Programmes.
2002	
2009	Severe droughts in Kenya caused the drying of water resources and 70% of livestock deaths in the dry lands (ASAL).
2011	Droughts caused 15 million people in Ethiopia, 3 million in Kenya, 3 million in Sudan and 1.5 Million in Eritrea to face starvation due to crop failure.
	Droughts caused 10 million people in Kenya to face starvation due to crop failure, loss of 90% livestock due to lack of pasture and acute water Scarcity in the arid and semi-arid lands (plate 2).
	Droughts caused 12 million people in Djibouti, Ethiopia, Kenya, Somalia and Uganda to face acute starvation and malnutrition, with food prices rising as much as 270% within the year.

Source; DMCN, 2002, Tearfund, 2010, Ngaira, 1999. ICRISAT 2011.

**Table-3** Notable effects of extreme climate episodes on agriculture in Africa

<b>Year</b>	<b>Effects</b>
1961	Extremely high equatorial rainfall in East Africa led to East African great lakes rising above all twentieth century record within a few month. This led to loss of both animal and human life through drowning, washing away of farmlands and infrastructure.
1964	Heaviest and most widespread snowfall on the highlands of South Africa and Namibia destroyed crops.
1968-73	Severe phase of drought in Ethiopia and the Sahel region caused crop failure, famine, and starvation, human and animal deaths.
1980-84	Severe drought in ASAL of Kenya led to crop failure, livestock loss and 274% increase in food prices in the super markets.
1984	Severe droughts in Ethiopia and Kenya led to the introduction of “Food queues” in supermarkets and the importation of yellow maize from USA as a coping strategy in Kenya.
1990-92	Serious drought in the ASAL of Kenya caused: <ul style="list-style-type: none"> <li>i) 70% of the pastoralists in Wajir, West Pokot and Mandera lost all their livestock.</li> <li>ii) Total crop failure caused many people to die after eating dead dog meat.</li> </ul>
1995	Marrakesh region in Morocco experienced the worst flash floods in more than 50 years which killed over 2500 people in two days and washed away huge hectares of farm land.
1997	Somalia experienced the worst El Nino floods in 37 years. The Juba river normally 13 m wide merged with the Shebelle river and widened its bank to 12km sweeping away farmlands, livestock and seriously damaging infrastructure.
2000	Mozambique experienced the worst floods in 100 years with water levels rising to 8m within few days. Farm lends and livestock were swept away.
2000-02	Severe droughts in Ethiopia caused the pastoral Karayu community to loose 70% of their livestock’s.
2005-06	Severe droughts in ASAL Kenya and Uganda led to 90% livestock loss, making the pastoral Maasai community to migrate to Nairobi city with their animals in search of water and pasture.

Sources; Ford, 1982, Lamb, 1976, Darkoh, 1990.

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