# Combating Climate Change in Kenya: Efforts, Challenges and Opportunities

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**Abstract:** Increase in emissions of $CO_2$ gas and other greenhouse gases (GHG) such as methane, nitrous oxide, CFC, HCFC and halogens into the atmosphere has led to the overall rise in mean global temperature over the years and the resultant climate change. Key anthropogenic activities responsible include fossil fuel combustion and land-use changes especially tropical deforestation. For developing countries such as Kenya, climate change is a threat to livelihood support systems. Kenya is currently experiencing the effect of climate change especially variation in weather patterns. Prolonged drought and famine has currently left over 10 million people faced with starvation, while floods and resurgence of pests and diseases have been noted in other parts of the country. Widespread poverty, inadequate socio-economic resources and a large climate-dependent agricultural sector makes the country vulnerable to the vagaries of climate change and ill-equipped to adapt to the long-term changes in climate. In spite of these, Kenya has embarked on various measures to mitigate climate change such as adoption of clean development mechanism, re/aforestation and spread of green technology. This research focused on Kenya's effort hitherto in combating climate change, the challenges thereon and opportunities for improvement. [Report and Opinion. 2009;1(6):65-76]. (ISSN: 1553-9873).

**Key words**: Climate change; Impacts; Adaptation; Mitigation; Kenya

## 1.0. Introduction

According to the International Energy Agency (IEA), world emissions of carbon dioxide ($CO_2$), the leading GHGs responsible for climate change, mainly emitted from fossil fuel combustion, has increased tremendously over the past 2 decades with a rise from 20.8giga tons in 1990 to 26.6 gigatons in 2004(IEA, 2006). IEA projections show that non-annex 1 countries (including Kenya) and other developing nations will soon surpass Annex 1 countries in $CO_2$ emissions with China contributing a quarter of this emission in the 2020s (IEA, 2006; World Bank, 2008). The Earth's mean global temperature has been rising steadily since the pre-industrial period before 1750 with a notable rise of 0.55$^{o}$C in the 1990s. 11 of the 12 hottest years on record occurred in the past decade (IPCC, 2007b).

Historical climate data show that the African continent is already undergoing climate change where temperature rose by 0.7$^{o}$C in the 20$^{th}$ century with a projected increase of between 0.2 to 0.5$^{o}$C degrees in the next decade (see Figure I). The changes have led to reduced precipitation in the Sahel and a net increase across Eastern and Central regions. Impacts of climate change will not be felt in the same magnitude across the globe. According to the Inter-governmental Panel on Climate Change's (IPCC) Regional Climate Change Index(RCCI), Africa ranks lower than Central America (which ranks highest) and the highlands of Central Asia (IPCC, 2001). {RCCI is the IPCC's comparative index designed to identify regions which will be most affected by climate change. It is based on regional mean precipitation range, mean surface air temperature and change in precipitation and temperature inter-annual variability (Ibid)}. Although Africa ranks lower, her impacts may be more widespread and severe due to widespread poverty; low infrastructure development; recurrent droughts, inequitable land distribution and overdependence on rain-fed agriculture making it highly vulnerable to the impacts of climate change. For Kenya, climate change is a threat to national development, community livelihood support mechanisms and a threat to environmental management thus combating climate change is indispensable.

## 1.2. Country Description

Kenya lies within co-ordinates 1 00 N and 38 00 E in East Africa. She borders Ethiopia to the North, Somalia to the East, the Indian Ocean to the South East, Tanzania to the South, Uganda to the West and Sudan to the North West. She has an area of 582,646km$^2$ of which 11,230km$^2$ is the water mass while 80% of

terrestrial land is arid and semi-arid. The population is 33.4 million people (Kenya, 2006).

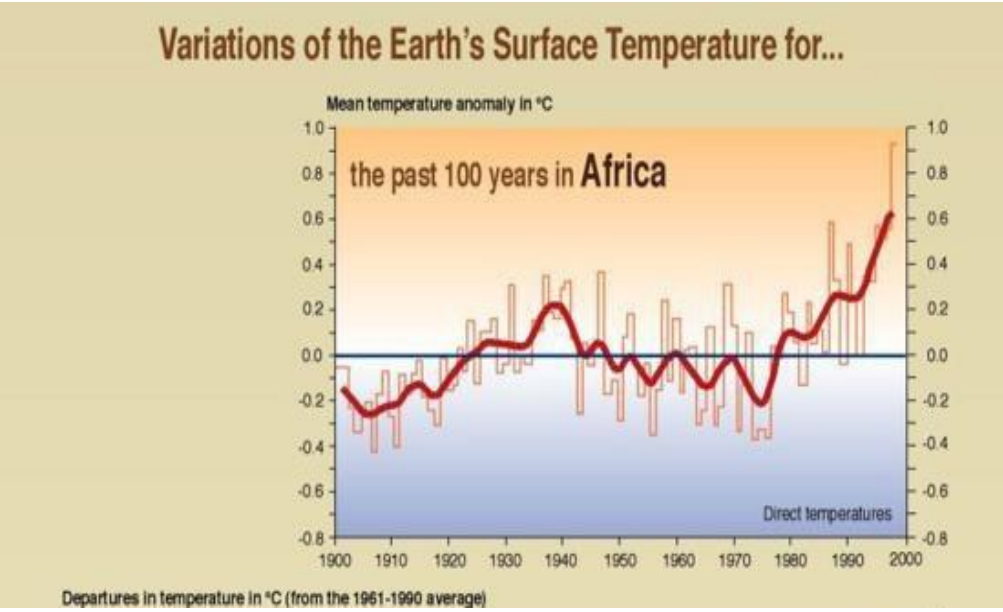


Figure I: Variations of the Earth's Surface Temperature for the past 100 years in Africa ( Image adopted from WMO, UNEP, 2001)

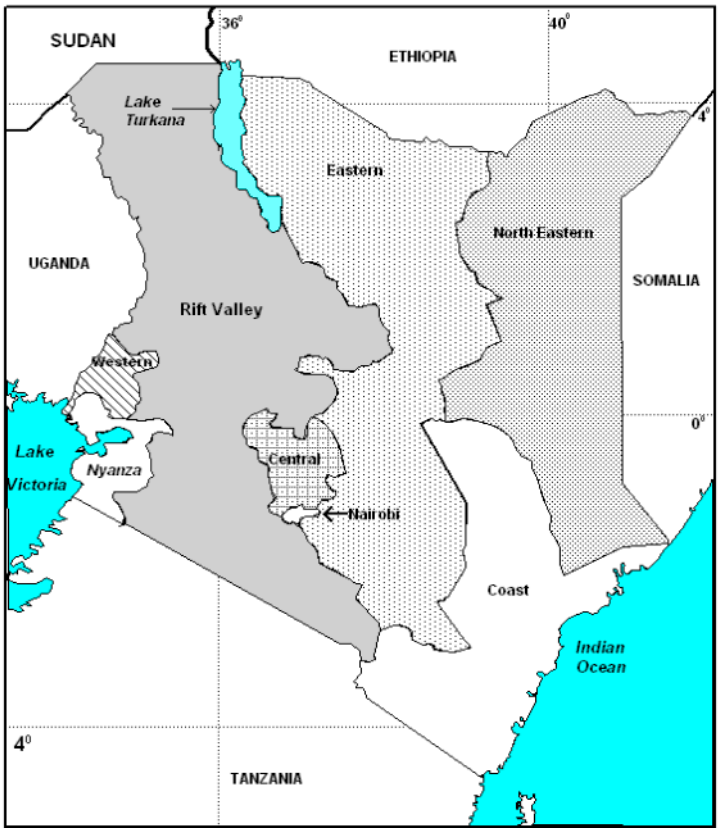


Figure II: Administrative map of Kenya showing provinces

### 1.2.1. Climate

Metrologically, Kenya lies in one of the most complex sectors of the African continent. Its climate is influenced by large-scale tropical controls which include several major convergence zones including the Inter-tropical Convergence Zone(ITCZ) that are superimposed upon regional factors associated with lakes, topography and the maritime influence. Thus, the climatic patterns within the country are markedly complex and change rapidly over short distances (Wandiga, 2006). Annual temperature range is 2 $^{o}$C with the lowest value in March and April and the highest is in July and August. Diurnal temperature range is in the order of 10-20$^{o}$C, far exceeding the annual temperature range. Mean annual net radiation received on a horizontal surface is between 450-550 cals/cm$^{2}$/day. Mean annual bright sunshine amounts to over 7-8 hours per day in the highlands and 8-9 hours per day in the lowlands (Ibid).

Rainfall is distributed in short and long rainy seasons with the former received in October to December and the latter in April to June while July and August are the coldest months. Rainfall is influenced by conventional and relief microclimates depending on location. In addition, the rainfall variability is closely linked to the El-Niño Southern Oscillation (ENSO) phenomenon and the Sea-Surface Temperatures (SSTs) fluctuations in the equatorial Indian and Atlantic Oceans. The rains are normally enhanced during the ENSO years which occur every 5 to 6 years. Thus, such high climate variability is likely to enhance due to climate change in turn enhancing climate change impacts both at regional and local scales.

## 2.0. Anthropogenic impacts contributing to climate change in Kenya

Major impacts contributing to climate change in Kenya include:- overutilization and degradation of natural resources; reduction in tree cover on farmlands, soil erosion and deforestation; industrialization; rapid urbanization with a projected 60 percent of total population bound to live in the cities by the year 2030(Kenya, 2007); and all foregone are driven by rapid population increase. This paper will expound the impact on the deforestation and wetland degradation since their conservation and management acts as major opportunities for carbon sinks.

### *2.1. Wetland and water resource degradation*

Wetlands are defined as areas of marsh, fern, peatlands or water whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salty, including areas of marine water the depth of which at low-tide does not exceed six meters (http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1_4000_0). Wetlands play an important role in the global carbon cycle and contribute 15 percent of total terrestrial carbon storage (Zhou, et al, 2007). However, the ability of wetlands to act as carbon reservoirs depends on their management state since they can also act as carbon sources by emitting carbon dioxide and methane into the atmosphere. Wetlands are highly dynamic ecosystems, changing with seasons and over long periods of time. They are also influenced by factors that lie far beyond their boundaries since they transcend private, communal and public property regimes where property management may enhance or undermine the state of the wetlands. Thus, the major impact on wetlands as a sink of carbon is anthropogenic, where changes in land use and agricultural drainage affect the hydrological regime of the wetlands in-turn affecting their ability to sequester carbon.

In Kenya, wetlands are additionally defined as areas of land that are permanently or occasionally water-logged with fresh, saline, brackish or marine waters, including both natural and manmade areas that support characteristic biota (Kenya, 2005). Such areas cover about 3-6% of the Kenyan land surface and they are irregularly distributed countrywide. Major wetlands lie within the major lakes and along the Coast. Kenya has 6 identified Ramsar sites of International Importance namely Lake Nakuru, Lake Baringo, Lake Bogoria, Lake Naivasha and Lake Elementiata, all in the Rift Valley province (NEMA, 2006). There are also hundreds of small wetlands such as swamps, small lakes, soaks dams and riverine flood plains that are distributed throughout the western and central Kenya highlands. In addition, of more valuable significance are the small wetlands that occur in the drier Arid and Semi Arid Lands (ASALs) as a result of occasional flows of ephemeral rivers and the output of springs from distant water sources. These are a lifeline to the people, livestock, wildlife and other biodiversity as a refuge in times of drought in such areas.

However, as development progresses, there is a rising dire threat to water resources especially freshwater wetlands. These are faced with pollution, drainage, encroachment, misuse, overexploitation and the threat of extinction. Coupled with these anthropogenic challenges are issues of policy and regulation in Kenya where the utilization and management of wetlands is sectoral scattered in various legislature. The Wetlands Sessional Paper is yet to be in effect. Alongside these is climate change, with the most visible impact globally, regionally and locally being the alternation of the hydrological regimes, affecting water

supply, quantity and increasing vulnerability among the poor. In addition, by virtue of their tropical location and hydrological regimes, shallow lakes and wetlands of Kenya are more susceptible to the damaging influence of oxygen-demanding pollution which is bound to rise with increase in temperature due to climate change hence their catastrophic degradation is imminent (Kipkemboi, et, al; 2007).

*2.2. Deforestation and loss of tree cover on farmlands*

Rapid deforestation and land use change of the world's forests especially tropical rain and dry-land forests contribute 15 percent towards global warming and the resultant climate change. Kenya's forest cover now stands at 1.7 percent, way below the recommended minimum of 10 percent (Kenya, 2007). Her main forests and water towers are The Aberdares Ranges, Mount Kenya Forest, Mount Elgon, Mau Forest Complex and The Cherenganyi Hills. Other forests include dry-land forests, community forests, local authority forests and coastal forests including the Coastal Mangrove and the *Kaya* Forests. The country has indigenous forests which are found in all the afore-mentioned forests and also plantation forests. Some of the indigenous forests such as the Mau Forest Complex belong to the great African tropical rainforests that stretch to the Democratic Republic of Congo. Plantation forests are mainly found in part of the Mau Forest Complex and the Nyayo Tea Zones.

High loss of forest cover in the country occurred in the last one and a half decades that were characterized by legal and illegal expansion of human settlements into gazetted forest lands; forest excision; expansion of farmlands due to high population pressure and unsustainable extraction of timber and non-timber forest products. Weak land-use and forest policies and regulations; corrupt practices and macro-economic policies that favored cash crop production for export – (tea and pyrethrum) are also to blame. Abuse of the *Shamba* system is also largely blamed for deforestation in Kenya.

The *shamba* system is a plantation forest management method in Kenya which is an adaptation of the *Taungya* system of South America and the Plantation System of Myanmar. This system allows communities surrounding a protected gazetted forest to plant short-season food crops within the forest's patches while at the same time planting and maintaining trees within the patches. When the trees mature (usually 3-5years), they shift to other patches and repeat the cycle. The community is not paid any wage for offering labor in tree planting and maintenance but they benefit by planting food-crops for their households. Poor implementation and enforcement of this system led to massive deforestation of protected forests and illegal settlement of communities within forest patches. The government banned the *Shamba* system in 1986 but it has now been re-introduced in the Forest Act of 2005.

Hitherto, logging and human settlement within the Mau Forest complex has resulted in reduction of water volume and/or drying up of key feeder rivers which drain into the Rift Valley Lakes – Nakuru, Baringo, Naivasha, Natron and Bogoria plus Lake Victoria in western Kenya threatening livelihoods and ecosystems far beyond the Kenyan boundary. Degradation of the Mau, Cherenganyi Hills and Mt Elgon Forests has resulted in annual flooding of regions around River Nzoia especially in Budalangi District.

Within the farm lands, loss of tree cover is attributed to land fragmentation for human settlement and agriculture, high demand for timber for the construction industry and wood-fuel for industrial use. In addition to these is the increasingly high demand for arable land to plant bio-fuel-generating crops in plantations to meet the global demand. In addition, 85 percent of domestic energy in Kenya is woodfuel where charcoal meets 80 percent of urban needs while in rural areas over 90 percent of energy is from firewood (Mugo and Ong, 2006). This is complicated with the fact that regulating the production and sale of charcoal which has been slow hence the trade has now become unsustainable especially in the ASALs where it has greatly contributed to loss of land cover and land degradation. In fact, the demand for woodfuel currently outstrips supply (Gichu, 2008). The new Forest Act of 2005 now addresses issues concerning charcoal trade but its implementation depends on proper enforcement and public education.

**2.3. Impacts of climate change in Kenya**

Africa is one of the most vulnerable continents to climate change - a situation aggravated by the interaction of multiple stresses occurring at various levels and as a result of its low adaptive capacity (IPCC, 2007a). Kenya is already experiencing the impacts of climate change and more are anticipated to occur with increased warming of temperatures. Direct impacts include changes in weather patterns with decreased rainfall, increased temperatures and higher evaporation rates in the dry areas. Under conservative warming estimates, rainfall is expected to increase by 5 to 20 percent during the months of December to February while a decrease of between 5 to 10 percent will occur in June to August. Under more rapid warming scenarios, Kenya and other East African

countries may receive up to double precipitation while arid areas are likely to receive even less than at present (IPCCC, 2001).

Indirect impacts of climate change concern socio-developmental strategies such as health, livelihood support, education and conflict. Frequent drought spells over the years have led to severe water shortage, increased risk of food shortage and expansion of aridity and desertification into marginal lands and changes in the planting dates of annual crops. There will be notable increase of fungal outbreaks and insect manifestations due to changes in temperature and humidity along with reduction in ecosystem integrity, its resilience and decline in biodiversity.

Other impacts include increase in human, crop and animal vector-borne diseases such as malaria, cholera and Rift Valley Fever; sea level rise resulting to inundation of low-lying areas along the coast and islands while increase in ocean acidity will result in coral reef bleaching along the Kenyan Coast. Melting of glaciers on Mount Kenya is already occurring while extreme weather events will increase; *inter alia* (Case, 2006; Githeko, et al, 2000; IPCC, 2007a; NEMA, 2008; Orindi and Murray, 2005; UN, 2001; Wandiga, 2006). Loss of biodiversity, spread of disease margins and inundation of low-lying coastal areas will severely affect the tourism sector which is Kenya's second foreign exchange earner.

**2.3.1. Water availability**

Kenya is a water scarce country with over 80 percent of the total land area regarded as ASAL. The country has a freshwater per capita of $647m^3$ against the United Nations' recommended minimum of $1,000m^3$ with a projected decline to $235m^3$ by 2025 unless effective measures are implemented to address the challenge (Kenya, 2007). Water abstraction rate is only 5.5 percent of which 84.7 percent is surface water and the rest is groundwater. Surface waters are threatened with pollution from industrial and domestic sources as well as high sediment load from farmlands due to soil erosion. Climate change is predicted to cause changes in the frequency, intensity and unpredictability of precipitation with adverse effects on water availability, agricultural production, health and widespread food shortages (Case, 2006). Reduction in water availability will in-turn affect all sectors of development especially agriculture which is mainly rain-fed and health of which 80 percent of Kenya's illnesses are water-related (Kenya, 2007). In the rural areas, water scarcity will increase conflict since all economic and social activities have a water dimension. This is especially so among the pastoral and nomadic communities.

**2.3.2. Impact on development and the economy**

The economic sector is vulnerable to climate change sensitivity with huge economic impacts. This vulnerability is exacerbated by existing developmental challenges of endemic poverty; complex governance and institutional dimensions; limited access to capital including markets; inadequate infrastructural and technological development; ecosystem degradation and complex natural disasters (IPCC, 2007a). In Kenya, the economic sector is mainly agriculture-driven thus sensitive to change in this sector. Climate change is/will negatively affecting/affect food production especially tea production in the Kenya Highlands which is sensitive to temperature and rainfall in turn affecting income from the leading foreign exchange earner.

**2.3.3. Melting of glaciers on Mt Kenya**

The Mountain's glaciers are retreating rapidly where, in 1990, there were 18 glaciers on the mountain, now only 7 are left (Kenya, 2007). This is attributed both to climate change and seasonal aridity within the Mountain microclimate. This in turn has affected the water levels in Tana and Athi Rivers among several rivers that originate from this mountain. Tana and Athi Rivers are the main sources of water for the Seven Folk Dams, Kenya's principal hydroelectric power generation stations. Tana River, the longest river in Kenya is 650 kilometres long and has a catchment area of 94,700 square kilometres while Athi has smaller catchment of 38,000 square kilometres (Rowntree, 1990). Originating from the southeastern slopes of Mt. Kenya, they flow eastwards towards their mouth in the Indian Ocean. These rivers encompass all or parts of over 20 districts within 5 provinces of North Eastern, Eastern, Central, Rift Valley and the Coast. Reduction in water volume of these two rivers due glacier disappearance on Mount Kenya as a result of to climate change will threaten the lives of over half of the Kenyan population.

**2.3.4. Extreme events and natural disasters**

Over 70 percent of natural disasters in Kenya are weather-related and their frequency has increased over the years with drought and floods being the main disasters. The drought oscillation period in past years recurred every 5 years but has now reduced to every 2 to 3 years. The worst drought since independence was in 1991-92 while the 1997-2000 was the worst in the past 40 years. During the latter drought, nomadic communities incurred over 50 percent losses in livestock while food shortages were felt countrywide.

Currently (2008/09), Kenya is facing one of the worst droughts that has left over 10 million people without food and access to drinking water. This disaster

has been exacerbated by a combination of other factors including the 2007/8 post-election violence that affected agricultural production in Kenya's bread basket areas, current global economic recession that has affected the purchasing power of the people, inadequate disaster response mechanism which is often disaster response rather than prevention and other governance issues.

The worst floods in Kenya occurred in 1997/98 El-Nino rains that resulted in displacement of persons, damage of physical infrastructure such as roads, bridges and railways, spread of human and livestock diseases *viz* cholera, malaria and Rift Valley diseases respectively, damage to agricultural produce and economic fiscal inflation (Kenya, 1998). Climate change is predicted to enhance drought, flood, fire, ENSO and tropical storms within the country and along the Coastal zone.

### 2.3.5. Health

Various vector-borne human and animal diseases are likely to rise with increase in climate change. These include malaria, dysentery and cholera in humans and Rift Valley Fever in livestock. Kenya has an infant mortality rate of 77 deaths per 1,000 while the under five years old mortality rate lies at 115 deaths per 1000. The total fertility rate is 77 with a 1:1.1 male to female ratio (Kenya, 2006). Changes in climate are bound to affect the health of the nation increasing morbidity, mortality and general vulnerability to other vagaries of nature.

*Malaria:* More than 90 percent of global mortality due to malaria occurs in Africa accounting for up to 1 million deaths per annum. In Kenya, Malaria is the leading cause of morbidity and mortality in children and adults, responsible for over 40,000 infant deaths per annum (Wandiga, 2006). The disease is endemic in Kenyan lowlands but is unstable in the highlands where, before the 1980s, highland malaria was intermittent and was mainly triggered by sensitive climate variability and environmental change. However, in the last two decades, resurgence of highland malaria epidemics has been largely associated with climate change, socio-economic change, deterioration of health care and food production systems, poverty and modification of microbial/vector adaptation.

Land clearance in the highlands for human settlement due to population pressure has led to elevated temperature in the highlands and provided ideal vector-breeding grounds. Research (Githeko and Ndegwa, 2001) indicates that the prevalence of highland malaria is differential by elevation with 70%, 40% and 30% in valley bottom, hillside and hilltop respectively for those living 1,100m above sea level. With climate change, the malaria belt is gradually moving towards higher altitudes threatening the lives of highland dwellers most of whom have not developed resistance to the disease.

## 3.0 Efforts made towards combating climate change in Kenya

*Ratification of the Kyoto Protocol:* Kenya ratified the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) in August 1994 and has over the years actively participated in and hosted the Conference of Parties. The country has also operationalised the implementation of target objectives and agreements albeit at lower scale due to socio-economic challenges. The Government has also set modalities for participation in the Clean Development Mechanism (CDM), one of the flexible mechanisms of article 12 of the Kyoto Protocol that allows industrialized countries (Annex I countries) to finance investment projects for greenhouse gas emission reduction in developing countries so as to generate credits which can be used to meet their own commitment to the Protocol. In this regard, relevant ministries and state corporations in Kenya are in charge of major components of the CDM through licensing, inspection, monitoring and approval of related projects. Thus, 1) National Environment Management Authority is the Designated National Authority of the CDM; 2) Kenya Forest Department is in charge of all CDM-re/aforestation and agroforestry projects; and 3) the Ministry of Energy is in charge of all energy conservation and alternative energy projects.

## 3.1. CDM Projects in Kenya

### *3.1.1. Kenya Electricity Generating Company (KenGen) CDM projects*

KenGen, Kenya's main electricity generating company is the leading organization in the country that has embarked on various CDM projects. Key among these are re-development of existing hydropower and gas-power projects to produce clean energy in turn reducing $CO_2$ emissions into the atmosphere and also participating in carbon trading within the CDM. In 2006, KenGen developed Project Idea Notes (PINs) for nine of its many power generating projects and submitted them to the World Bank, 6 of which were accepted for emission trading. As at 2008, Olkaria II Geothermal Project and Sondu Miriu Hydropower Project's Project Design Documents (PDDs) had been submitted to the UNFCCC website for public comments (Kollikho, 2009).

By participating in CDM, KenGen will earn approximately USD 6.5 million per annum from the World Bank up to the year 2012. In addition, most of these projects will earn an additional USD 1 per ton of

$CO_2$ from the carbon fund as direct benefit to the communities surrounding the projects. After 2012, that is, after the expiry of phase 1 commitment period of the Kyoto Protocol, the World Bank will purchase the carbon emissions of these 6 projects as Verified Emission Reductions (VERs) at a reduced price of USD 2 (Ibid). By participating in CDM, KenGen is enhancing the production of clean energy while at the same time increasing the cumulative number of clean energy projects in the country. KenGen is also involved in water catchment conservation in all the 5 water towers of Kenya through a tree planting partnership with local communities under the Kenya Sector Environment Program.

| **Project** | **CER per ton of $CO_2$ to be paid to KenGen by World Bank(US$)** |
|---|---|
| Tana Redevelopment Hydropower Project | 13.9 |
| Kiambere Optimization Power Project | 13.9 |
| Kipevu Combined Cycle Plant | 12.9 |
| Olkaria II Geothermal Project | 10.5 |
| Eburru Geothermal Project | 13.9 |
| Sondu Miriu Hydro-Power Project | 10.9 |

Table I: Kenya Electricity Generating Company's CDM projects accepted by the World Bank for Certified Emission Reduction (CER)

*3.1.2. The International Small Group and Tree Planting Program (TIST)*

Working in collaboration with Carbon Footprint Limited (United Kingdom-based on-line commercial enterprise trading in carbon offsets and offering consultancy services), TIST has a tree planting project based in Laikipia and Meru Districts, Central Kenya taking advantage of the Voluntary Emission Reductions(VERs). 1,415,715 trees have been planted by 2,650 small groups funded by USAID (Murray and Dey, 2009). The groups are closely monitored and trained which has enhanced the groups' capacity in participating in carbon sequestration projects and use of new technologies. The woodlots planted by the groups can be observed from Google map since the trees are planted in groves with clear GPS co-ordinates. Carbon offsets are sold to Carbon Footprint Limited which purchases them based on only the primary footprint with an estimate that 1 tree offsets approximately 730 kg of $CO_2$ in its full lifetime of 100 years. The offsets are then purchased on E-bay by online traders (Ibid). One challenge that this group has faced is high investments costs in establishing and running the project hence minimal benefits are trickling to the community.

*3.1.3. Kiambu Community Group*

This group is located on the Kikuyu Escarpment in Central Kenya and has an aforestation project that has hitherto planted over 300 hectares of trees and has been officially licensed by the Kenya Forest Service (KFS). Even though the group has not yet been officially registered as a CDM project due financial constrains, through KFS's support, it offloads carbon benefits to the Group through provision of tree seedlings and other community services. In addition, the group is selling carbon offsets to a British-based enterprise which is paying them for activities carried out thus far.

*3.1.4. The Green Belt Movement (GBM)*

GBM, the brainchild of Nobel Laureate Professor Wangari Mathaai, is an organization that has successfully conducted massive aforestation and reforestation in farmlands, community lands and schools in central and western Kenya and part of Eastern Africa by collaborating with women groups over the past two decades. Currently, GBM is still working with women groups in a CDM-Aforestation/Agroforestry project spread around Mount Kenya Region and the Aberdares Ranges. Hitherto, the groups have been able to collectively plant over 2,000 hectares of trees in pockets in the target area. Although they haven't yet been registered officially as a CDM project, registration is underway through the support of the World Bank. Thus far, the community is accessing some benefits from the World Bank that cover the cost of tree planting.

**4.2. Renewable Energy Technology**

Kenya has a high potential for utilizing renewable energy from biomass. Such energy is considered carbon neutral under the CDM since the $CO_2$ released into the atmosphere through biomass combustion is subsequently taken up by growing stock through the carbon cycle (Gichu, 2008). Various medium to large institutions such as schools, colleges, church-based mission centers, private and government organizations utilize solar and biogas energy as a cost-saving measure. These can be expanded countrywide to earn the additionality factor of $CO_2$ emission reduction that is necessary in climate change mitigation. At the same time, the rate of biomass extraction should match replacement. One such institution is the Kenya Tea Development Authority that has switched from using

crude oil to fuel wood for tea curing in most of its tea factories countrywide. The challenge however is that the switch to woodfuel was made prior to establishment of the tea companies' own tree plantations hence their usage of fuel wood from private suppliers is contributing to loss of tree cover on farm and community lands.

The country has also a vast potential for wind and solar energy if the cost of installation, technology transfer, and research and development in this area can be lowered in the global market. Currently, a 300MW wind power energy project in Lake Turkana has been constructed and will be commissioned in 2012. Funded by the African Development Bank, the project's output will contribute a quarter of the country's current electric power to the national grid – regarded as one of the largest wind energy projects in Africa. Solar power is widely used in industrial and domestic settings although installation the costs are prohibitive for widespread usage.

*Biofuel: Jatropha species:* The shrub is seen as one of the potential producers of biofuel that can be used as a substitute for diesel in industrial processing and transport. The species is well adapted to grow in harsh environments and can thus be widely grown in Kenya's unproductive and unutilized ASALs hence it will not interfere with food security while at the same time rehabilitating the degraded lands (Gichu, 2008). Magadi Soda Ash and Salt Mining Company have initiated a *Jatropha species* biofuel project in Magadi (Ibid). However, in-depth research is needed into the potential viability of the plant species versus its known negative characteristics such as toxicity of its leaves and nuts that necessitates careful handling by farmers and industrialists. It also has low productivity and is labor-intensive.

## 4.0. Challenges to combating climate change in Kenya

### 4.1. Economy

Kenya is a developing country whose growth model like many developing nations is based on the economic growth model that largely favors economic, industrial and physical development at the cost of environmental management. Thus, the current economic situation and state of the environment in Kenya has weakened the capacity of the country to adjust to the drastic economic and ecological changes are/will be induced and/or enhanced by climate change (Ominde and Juma, 1991). Coupled with this is the fact that over 80 percent of the population depends on agriculture as their livelihood. Hence, the challenge is how to share the insufficient economic resources to combat climate change and shift the overdependence of such a large populace from agriculture to alternative livelihood support mechanisms.

### 4.2. Poverty

Over 40 percent of the Kenyan population is food poor while another 30 percent is absolutely poor living on less than USD 1 per day(see figure III below showing the poverty head count(%) by province). The poor are often located in high-risk marginal areas and their lack of socio-economic resources means that they are ill-equipped to adjust to the long-term changes in climate. In addition, poverty undermines the health status of the people. Therefore, climate change will increase the poor's vulnerability and also reduce their adaptive capacity.

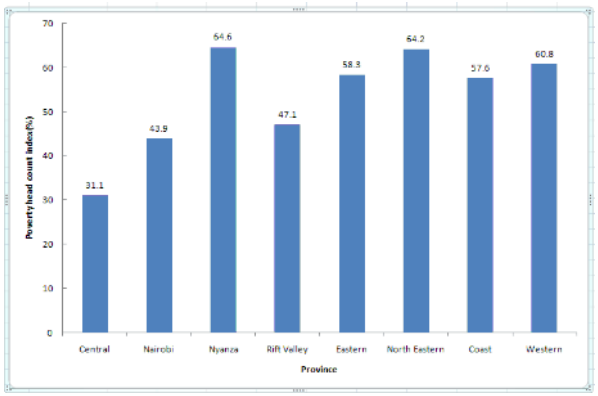


Figure III: Poverty head count index (percentage) by Province in Kenya (http://www.cbs.go.ke/downloads/pdf/Kenyafacts2006.)

### 4.3. Food insecurity

Demand for bio-fuels poses a threat to forest lands and arable land thereby increasing food insecurity. With increased GHG emissions, high energy costs of fossil fuel and energy insecurity, the world is turning to alternative sources of energy to meet their energy needs. Although the past two decades have seen increased progress in developing alternative energy, these technologies have not reached a level where they can replace conventional sources of energy.

## 5.0. Opportunities

### *5.1. Local adaptive capacity*

Kenyan communities like many African communities have developed long traditions of social and community networks that have been used as livelihood coping strategies to climate changes and disasters for many centuries. Such strategies include switching to non-farm activities during dry spells, brick making, off-farm labor, transhumance, change in diet, shifting cultivation and

dependence of social networks and trust. Although such synergies are gradually weakening as a result of rural-urban migration, networks such as traditional land rights and systems of management are vital in reducing vulnerabilities of communities. Local adoptive mechanisms should be enhanced through capacity building and community support to enable communities utilize and manage natural resources in a sustainable manner in the face of climate change. Research (Orindi and Murray, 2005) suggests that understanding, documenting and strengthening of existing livelihood coping strategies rather than imposing new high-tech solutions will yield better results. However, other schools of thought (IPCC, 2007a) reckon that such adaptation options will cope with current changes for a while but will not be sufficient for future changes in climate.

Climate change adaptation strategies should be integrated into all levels of government so that climate change policies and development policies will not undermine but reinforce one another. Knowledge sharing through collaborative efforts between government, private sector, civil society and local communities will promote adaptation to climate change and enhance sustainable development. With regard to environmental management especially of natural resources, adaptation should be based on an ecosystem approach, which is a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences and developing appropriate management responses. Existing disaster management mechanisms should be enhanced across all relevant sectors in addition to capacity building of target communities since the frequency and aggressiveness of the drought is bound to increase with climate change.

*5.2. Policy*

Kenya needs to formulate a comprehensive climate change policy to tackle climate change. The country is a signatory to several multilateral environmental treaties including the Agenda 21, Montreal Protocol, Basel Convention, Stockholm convention, Ramsar Convention , CITES and most importantly with regard to climate change, the Kyoto Protocol. Efficient and effective adoption and implementation of the various treaties and local policies will collectively contribute towards mitigating climate change.

*5.3. Aforestation and re-forestation*

Deforestation, soil erosion and loss of wetlands contribute 20 percent of the total anthropogenic carbon into the atmosphere. Forests and forest soils store vast amounts of carbon estimated to be 1 million tons, almost twice the amount found floating in the atmosphere. As critical components of the global carbon cycle, increase in forest cover in Kenya is thus a key way in enhancing carbon sequestration. As an equatorial country, her climate favors rapid growth of vegetation hence trees can sequester carbon from the air within a relatively short growth period (Gichu, 2008). In this regard, current efforts in forest conservation and management should be enhanced to include protection, restoration and sustainable use of forests and forest products. In well conserved and managed forests, trees can store up to 15 tons of $CO_2$ per hectare per year in their biomass and wood (Glenday, 2005). Forestry programs may aim for projects that can have the "additionality" factor stipulated in the CDM mechanism so as to gain from carbon trading and also increase the country's tree cover.

*5.4. Voluntary Emission Reduction (VER)*

VERs sprang up parallel to the CDM spearheaded by international nongovernmental organizations and other agencies in order to beat the bureaucracy in the CDM that has stringent rules and regulations that are often costly and time-consuming. The costs with the VER system are lower hence affordable to small scale projects. In Kenya, projects that can be accepted into the VER system include re-forestation programs within gazatted, local authority and community forests that have a canopy cover of more than 30 percent and do not qualify for the CDM under the Kenyan definition of a forest (Gichu, 2008).

*5.5. Reduced Emission from Deforestation and Degradation in Developing Countries (REDD*

This is an initiative which was discussed by the scientific and technical advisory body of the UNFCCC in May 2007 in Bonn, Germany. The program aims to reduce loss of forest cover and land degradation in developing countries in turn enhancing carbon sinks in soil and trees and cutting emissions from loss of forest cover and land degradation (Coomes, et al, 2008). Participating developing countries are rewarded for environmental services they provide such as environmental conservation, biodiversity protection, watershed management, carbon sequestration and landscape beauty at local and global levels.

According to ICRAF (http://www.icraf.net/downloads/publications/PDFs/PP08444.PDF), success of the REDD program hinges on taking a landscape approach to reducing carbon emissions and increasing carbon stocks through landscape management and sustainable agriculture. With the right policy incentives, mechanisms for

encouraging REDD could bring significant benefits to smallholder famers, to ecosystems and to the global climate. This is because it cuts the high costs of CDM - Aforestation project costs and is thus more likely to be adopted by low-income rural farmers. Kenya has been selected as one of the countries on which base-line survery for the REDD program will be based upon. Concerted effort in implementing the initiative will prove worthwhile in combating climate change.

Other opportunities include:-

- Investing in technologies on the supply side, such as clean electricity generation so as to increase efficiency and reduce carbon emissions.
- Carbon capture and geological storage for cement companies, petroleum refining factories and other large point sources of $CO_2$ may be an option in the near future although the technology is currently expensive. These include industries include Bamburi and East African Portland Cement Companies, Kenya Oil Refinery, *inter alia.*
- Carbon market: by participating in the carbon market, developing countries such as Kenya gain additional financial resources and cut their baseline carbon emissions by a big margin.
- Alternative livelihood sources that reduce pressure on the land resource base
- Lobby for user compensation in the global market for environmental services accrued by conserving the environment as an incentive for communities to participate in conservation and climate change mitigation.

## Conclusion

Although developed countries will remain the largest per-capita emitters of greenhouse gases, the growth of carbon emissions in the next decades will come primarily from developing countries including Kenya. This is because these countries will be approaching their peak in industrial and economic development hence they will have a high energy utilization demand. That notwithstanding, climate change and its associated hazards will exert a heavy toll on Kenya threatening national social and economic development, environmental management and livelihoods support mechanisms. It will also widen the gap between the country's exposure to risks and her efforts to prepare for and manage them due to their frequency and intensity. The impacts will be felt more strongly on the poor especially in the ASAL regions of Kenya. The thrust therefore is to formulate adaptation and mitigation mechanisms tailor-made for the country that build up on existing adaptation strategies at all levels.

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