CLIMATE CHANGE AND DEVELOPMENT

CONSULTATION ON KEY RESEARCHABLE ISSUES

SECTION 5: EAST AFRICA REGION
SECTION 5.1. EAST AFRICA SCOPING STUDY
ACTS - VICTOR ORINDI AND OTHERS

Saleemul Huq and Hannah Reid
Climate Change Group
International Institute for Environment and Development
3 Endsleigh Street, London WC1H 0DD, UK
Tel: (+44 20) 7388 2117
Fax: (+44 20) 7388 2826
Email: saleemul.huq@iied.org hannah.reid@iied.org

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1.1 General Introduction

It is now being recognized that climate change is a key development challenge. Eriksen and Naess, (2003; 1) identified the following broad groups of linkages between climate change and development:

- Climate change may affect the likelihood of success of development projects and programmes, as they have impacts on natural resources and people. A development project designed for one climate regime may not suitable for the other.
- Development projects may affect the vulnerability of societies and ecosystems towards climate change; they make them better prepared to deal with climate change but they may also reduce their ability to adapt to climate change.

People can become vulnerable as a result of climatic events that overwhelm the adaptations they have in place. Vulnerability to climate change occurs due to variation in frequency and duration of those changes or because people are constrained economically, socially or politically from responding adequately to those changes (Galvin et al, 2004).

Diversification of livelihood sources, improved infrastructure, resilient institutions and strengthening of local knowledge would contribute to reduced vulnerability while development that reduce access to natural resources or introduce practices that are incompatible with local customs, traditions or knowledge would increase vulnerability (ibid). The need to mainstream climate changes into development agenda arise from the fact that many measures aimed at adaptation also address poverty reduction (AfDB et al., 2003).

The economies of east African countries (Kenya, Uganda, Tanzania and Sudan) are largely dependent on exploitation of natural resources-which are sensitive to climate variability and climate change. These countries are likely to suffer disproportionately from climate change considering their limited contribution to global warming in terms of fossil fuel consumption. Climate variability is already having a large negative effect on the regions socio-economic development. This is likely to worsen with climate change hence the need to vigorously pursue adaptation to climate change. Climate change is likely to compound the difficulties faced by a region where agricultural yields and per capita food production have been steadily declining and where population growth will double demand for food, water and livestock forage in the next 30 years (Davidson *et al.*, 2003).

1.2 Study Objectives

The objectives of this scoping exercise were:

1 To establish what developing country stakeholders regard as the most urgent research needs in relation to climate change and its implications for poverty reduction and sustainable development.

1.1 To identify what research other funders have supported, or are supporting, as well as where there are gaps.

1.2 To provide a clear definition of researchable problems

1.3 Climatic Trends in east Africa

High variability characterizes the rainfall system in east Africa (Eriksen and Naess, 2003; Galvin et al., 2004). Parts of east Africa will become drier resulting in significant reduction of the length of growing season while others including southern Kenya and Northern Tanzania may become wetter with increases in the length of the growing season (Galvin et al., 2004). Rain-fed agriculture which accounts for approximately 90% of subsistence food production will become more vulnerable with increasing climate variability and long-term climate change. In general, East Africa is expected to receive increased rainfall with climate change (Huq et al., 2004) but surface runoff affected by rainfall and temperatures may reduce due to increased temperatures (Eriksen and Naess, 2003). Extreme climate events including intense droughts and floods are expected to become more common especially those associated with the El-Nino southern phenomenon (ibid). Climate change projections to the year 2030 for Kenya indicate increasing temperatures with doubling of CO_2 levels from baseline scenarios resulting in a decline in precipitation in the semi-arid areas (GoK, 2002) which could lead to reduction in maize yields, shortage of forage for livestock, increased incidences of diseases and breakdown of marketing infrastructure. For Tanzania, the predicted increase in annual temperature over the whole country is between 2.5 to 3^oC in the warmest months of December to February and between 3^oC and 3.9^oC in the coolest months of June to august (URT, 2003). Areas with two rainfall seasons (i.e. north eastern, north western, the Lake Victoria Basin and the northern part of the coastal belt) would experience increase in rainfall for both seasons ranging from 5 to 45% while areas with unimodal rainfall pattern (southern, southwestern, western, central and eastern parts) could experience a decrease in rainfall of between 5 and 15% (ibid).

In recent years, Uganda has experienced frequent and severe droughts in most parts of the country with the incidences being more pronounced in the western and north eastern parts of the country (MLWE, 2002). The predicted increase in temperature using various models is between 2 and 4^oC.The wettest districts include the Lake Victoria basin while the western and northern districts occasionally experience drought. Apart from the central parts, other regions are expected to experience increasingly variable rainfall. A 10-20% increase in runoff is expected for most part of the country except for the semi-arid areas where data is lacking and therefore no conclusive position could be reached (ibid). More than half of Sudan is classified as arid or semi-arid. Change in temperature and rainfall are likely to lead to desertification in some regions while spread of vector-borne diseases is likely in the south (RoS, 2003).

Poor groups remain the most vulnerable to climate variability and long-term climate change because of their high dependence on natural resources. However it should be noted that even vulnerable people generally have a variety of alternatives to decrease their risk in times of stress and shock but new and persistent environmental (e.g. climate variability/change), political and social pressures can undermine peoples ability to deal with such challenges (Gavin et al. 2004).

The following section gives an overview of how current climate variability and long-term climate change affects/may affect different sectors and its implications for poverty reduction and sustainable development in east Africa. This is followed by a summary of on-going and previous research on climate change in the region.

2.1 Climate Change and development in east Africa

East Africa remains one of the poorest regions in the world. Majority of the population is rural and practice rainfed agriculture (UNEP DEWA/PAN-AFRICAN START, 2004).

Table 1: Poverty Levels and contribution of agriculture to GDP in east Africa

Country	**Total Population (in Million)**	**Population in absolute poverty (%)**	**Contribution of agriculture to the GDP (%)**
Kenya	32	57	26
Uganda	26	80	43%
Tanzania	37	48	48%
Sudan	30	-	48%

Sudan, Tanzania and Uganda are classified as Least Developed Countries (LDCs)- a group of 49 of the worlds poorest countries (Huq et al.,2004) while Kenya, though not an LDC also has high poverty levels and not very different from the rest. Unless adequate and timely measures are put in place, climate variability and climate change are likely to worsen the existing poverty situations by creating additional challenges to the already existing problems and diverting resources meant for development to dealing with relief activities. Climate variability is currently a major source of risk to the different livelihood strategies in east Africa and influences hunger, health, access to water just like in other parts of the world.

2.2 Agriculture and food security

Nearly 80% of East Africa's population depends on agriculture for a living, and agriculture contributes 40% of the region's GDP (IFPRI, 2004). The anticipated increase in average temperature could seriously affect both subsistence and commercial agriculture as farmers find it difficult controlling effects of higher temperature and too expensive to irrigate. For Tanzania, the impact will be great for crops such as maize whose yields could reduce by about 33 % for the entire country (or 84%, for central areas) due to increased temperature and reduced rainfall (URT, 2003). Yields of Coffee and Tea which are important cash crop for Kenya, Uganda and Tanzania could also reduce by 20% on average due to increase in temperature and change in precipitation. Gum-Arabic exports from Sudan which accounts for 80% of total gum Arabic supply in the world-market could reduce by between 25 and 30% with climate change (RoS, 2003)..

According to Cooper (2004), the greatest impact on food security in the near future is likely to come from the drastic changes associated with climate variability rather than the gradual long-term change. Climate variability in terms of onset and cessation of rainfall is and will continue being a serious source of vulnerability to farmers in marginal areas of east Africa where agriculture is mostly rainfed. The increasing population pressure in high potential areas is pushing agriculture into the marginal areas where migrants often continue with their traditional farming practices some of which are inappropriate for the newly settled areas. Under conditions of uncertainty about future climate, farmers are often reluctant to invest in agriculture or to adopt some of the improved farming technologies which could improve their returns on investment and facilitate recovery from bad seasons. Examples of improved farming technologies include use of drought resistant and fast maturing varieties, Agroforestry and improved fallowing for soil and water conservation.

Box 1: Agroforestry, By Louise Verchot, ICRAF.
Agroforestry has a dual role to play in the climate change area. Agroforestry has a particular role to play in mitigation of atmospheric accumulation of GHGs according the Intergovernmental Panel on Climate Change (IPCC). Of all the land uses analyzed in the Land-Use, Land-Use Change and Forestry report of the IPCC, Agroforestry offered the highest potential for carbon sequestration in developing countries (Figure 1). Agroforestry is just one of a number of improved farming practices can increase the sustainability of farming systems and contribute to reducing farmers' vulnerability to climate variability while sequestering carbon from the atmosphere. Generally, we have a good idea how these practices affect carbon stocks in the agroecosystem. We have a much poorer understanding of the effects of these improved practices on non-CO_2 greenhouse gases. Thus one key research need is to determine the potential of improved practices, and particularly Agroforestry, to sequester carbon and reduce emissions of other greenhouse gases. This knowledge will open the doors of a number of financial mechanisms aimed at promoting clean development and create opportunities to use these mechanisms to help fund climate change adaptation in the smallholder farming sector.

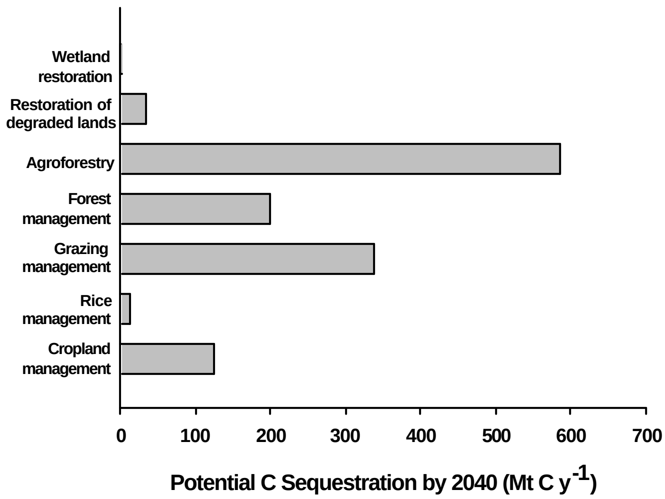

Figure 1. Carbon sequestration potential of different land use and management options (adapted from IPCC Land-Use Land Use Change and Forestry Report, 2000)

While Agroforestry may play a significant role in mitigating the atmospheric accumulation of greenhouse gases (GHG), it also has a role to play in helping smallholder farmers adapt to climate change. While adapting to changes in long-term averages may be feasible through technology and germplasm transfer, increased climate variability with concomitant increased frequencies of extreme events poses a greater challenge, particularly in the semi-arid tropics.

Agroforestry options provide a means for diversifying production systems and increasing the sustainability of smallholder farming systems. The most worrisome component of climate change from the point of view of smallholder farmers is increased inter-annual variability in rainfall and temperature. Tree-based systems have some obvious advantages for maintaining production during wetter and drier years. First, their deep root systems are able to explore a larger soil volume for water and nutrients, which will help during droughts. Second, increased soil porosity, reduced runoff and increased soil cover lead to increased water infiltration and retention in the soil profile which can reduce moisture stress during low rainfall years. Third, tree-based systems have higher evapotranspiration rates than row crops or pastures and can thus maintain aerated soil conditions by pumping excess water out of the soil profile more rapidly than other production systems. Finally, tree-based production systems often produce crops of higher value than row crops. Thus, diversifying the production system to include a significant tree component may buffer against income risks associated with climatic variability.

Research into the contributions of Agroforestry in buffering against climate change and climate variability is not well advanced. Preliminary analyses suggest, for example, that fertilizer tree systems greatly improve maize yields on degraded soils where nitrogen is limiting production, and that

Rainfall variability increases as one move into the dry land areas with a co-efficient of variation as high as 50% having been observed in the region (ASARECA, 2005; RoS, 2003). Poor smallholders are affected most by the high variability as they rely more on rainfed agriculture and other natural resources affected by climate (Jones and Thornton, 2003). The reluctance by farmers to adopt improved farming technologies or use agricultural inputs under conditions of variable climate means that they take longer to recover from" bad" seasons as they are not likely to maximize benefits from the "good" seasons. Sudan with half the country being arid or semi-arid lands already faces the risk of desertification and is likely to experience increased water scarcity and land degradation with climate change which could worsen the food insecurity situation.

Managing climate (especially rainfall) variability will entail improving climate forecasting and provision of such information in a timely and user-friendly manner. In the past, forecasts information has generally been given to government departments (e.g. ministry of agriculture) who are supposed to channel such information to users on the ground. More often, the information reaches only a few people late hence has been of limited use. This needs to change if the information is to help users (e.g. farmers) make investment decisions.

Box 2: Facilitating Investment in Rain-fed Agriculture: Evaluating the implications of current climatic variability and planning for future climate change in Eastern and Southern Africa by Peter J. M. Cooper. ICRISAT, Nairobi, Kenya.

Agricultural practices respond to weather fluctuations at a time scale of individual of daily events. Research required to test these hypotheses is best undertaken using long-term historical daily climatic data. In sub-Saharan Africa such data have been collected by meteorological services for decades, but currently

Irrigation will become increasingly important as some areas get drier. East Africa compared to other regions has the least area under irrigation despite the high potential. Sudan accounts for a large portion of the irrigated area in the region. Some of the irrigation schemes initiated in the past failed due to a number of reasons ranging from inappropriate technology and non-consideration of socio- cultural factors when developing such schemes. Future development of irrigation schemes will need to consider other broad issues including land and water rights, involvement of farmers in the management of such schemes among others to avoid some of the problems experienced in the past and make such investments sustainable.

Rainfall variability also has profound impacts on **pastoral** systems in east Africa (Galvin et al., 2004).In the dry land areas; Pastoralism is sometimes the only activity that may be carried out profitably. For example, the cattle corridor in Uganda contains 60% of the livestock in the country while dry land areas in Sudan contain over 100 million heads of animals (RoS, 2003 MLWE, 2002) and represents the best way through which the rangelands could be used Pastoralist had their own strategies of dealing with the variable climate including moving livestock according to vegetation needs and water availability, keeping mixed herds to take advantage of the heterogeneous nature of the environment and diversifying economic strategies including farming and engaging in wage labour (Galvin et al.,2004). However rising human populations along with many land tenure and land use changes have undermined some of these strategies making it impossible for pastoral groups to rely on livestock as the sole basis of their livelihood in a situation where opportunities for livelihood diversification are decreasing (Galvin et al, 2004; Moyini, 2004).

A number of strategies have been suggested to promote adaptation in the livestock sector including reduction of animal population, improving pastures/ rangeland management and rainwater harvesting. But some of the options for example reduction of animal population seem not to factor in the socio-cultural and political environment in which these livelihood groups operate. Reducing animal population for example may be difficult to implement as it go against cultural practices and do not consider the mobile nature of these communities which sometimes make *how animals are grazed* more important than the *total number of animals* in an area (Moyini,2004). In such a situation, it would be more useful to address the issue of land ownership or access to accommodate the migratory nature of these groups. According to Hesse and Odhiambo (2002), significant resources are being channeled for the development of pastoral areas in east Africa but relatively little attention is being paid to the political and social aspects.

Change in temperature and precipitation could also lead to occurrence of new pests and diseases. For agriculture to remain profitable, the risk of new pests and diseases will have to be addressed through developing pest and disease resistant varieties or appropriate management systems. Livestock and herd animals may be important reservoir or host of disease vectors (Kovats, 2003). Modeling of pest species of plants and livestock may provide useful information for potential effects with future climate conditions.

2.3. Climate change and Health

Vector organisms transmit many important infectious diseases. Climate variability or change will influence the epidemiology of vector-borne diseases because the vector organisms have adapted to different ecosystems. Climate change may alter the distribution of vector species depending on whether conditions are favourable or unfavorable for their breeding places or reproductive cycle (Kovats et al., 2003). Changes in climate that can affect the potential transmission of vector-borne infectious diseases include temperature, humidity, altered rainfall, soil moisture and rising sea level (ibid). Temperatures for example influence the reproduction and maturation rate of the infective agent within the vector organism and survival rate of the vector organism (Kovats et al, 2003). The anticipated increase of 1.0 to 3.5^{o}C in global temperatures by 2100 is likely to increase the likelihood of many vector-borne diseases (Watson et al., 1995) but up to a certain limit because warming above 34^{o}C generally has a negative impact on the survival of vectors and parasites (Githeko et al.,2000). Increasing precipitation would likely increase the number and quality of breeding sites for vectors such as mosquitoes, ticks, and snails while increase in vegetation density could increase the availability of resting sites (ibid). Global warming could cause cholera increases in lake regions (Huq et al., 2004).

Within the tropics, malaria transmission remains a serious health problem and increased climate variability might play a significant role in the disease epidemiology. But the resurgence in malaria cases is not necessarily as a result of climate change (Thomas, 2004: Hay et al., 2004; 2002). Other factors including drug resistance, demography, accessibility of medical services and land use change are also important just like shorter-term climate phenomenon like the El Nino as found out by Hay et al. (2002) to have influenced malaria distribution in southern Uganda through changing vector abundance. Due to uncertainties regarding climate variability and malaria epidemiology, Patz et al. (2002) recommended further monitoring of appropriate climate and disease variables to establish data sets that can support long-term trend analysis of relationship between climate and malaria incidences. It is worth noting that in certain cases, the economic, social and political factors could be more important in explaining resurgence of malaria and other mosquito borne disease (Hay et al., 2002).

High poverty levels mean that budgetary allocation for health is low. This often translates to poor maintenance of health facilities and service provision reducing the capacity to deal with disease outbreak however small it is. High poverty in areas affected by malaria has also encouraged personal treatment where people buy cheap drugs across the counter. Personal treatment has been linked to many problems including treatment failures owing to drug resistance particularly among non-immune populations (Githeko et al., 2000).

The population groups most vulnerable to malaria include the very young, the elderly and pregnant women. Most of the people found in these groups are generally poor, lack income and voice in decision making and cannot afford treatment or protective devices like insect treated bed-nets. Effective control of malaria in the region therefore calls for looking at how such vulnerable groups may be protected which could be achieved through detailed socio-economic assessments. Unfortunately, previous work on malaria only gave limited attention to these. There is need to look at why the existing malaria prevention or control methods are not effective.

According to Githeko et al. (2000), malaria transmission at equatorial latitudes may become more intense at higher altitudes where individuals have low immunity. The low coastal belts and shores of Lake Victoria have the highest transmission of malaria as at now. Kenya, Uganda and Tanzania are already affected by highland malaria as well (ibid). In countries like Tanzania and Sudan, assessment of the impacts of climate change on malaria is constrained by limited resources and lack of reliable epidemiological data as historic records of disease incidence are incomplete making it impossible to create a reliable picture of baseline (non-climate change) prevalence of malaria (URT, 2003;RoS, 2003). Zhou et al. (2004) in their study of association between climate variability and malaria epidemics in east Africa acknowledged the difficulty in assessing the impact of climate on malaria resurgence due to lack of long-term data series on malaria cases from different sites and also because of the high spatial climate variability. For areas that lack epidemiological data for determining the base line conditions, it is necessary that parameters are defined to be more reflective of local conditions to increase the usefulness and accuracy of predictions of climate sensitive diseases.

Most modeling of the effects of climate change on health has focused on malaria and to a lesser extent on dengue fever and some tick borne diseases (Kovats et al., 2003; Githeko et al., 2000). While this is a step forward considering that malaria is the leading killer disease in many parts of Africa; additional work is needed to address areas in which climate variability/change might increase or decrease the risk of transmission of specific diseases. For example, **Dengue fever** transmission can be increased by increased water storage hence should be a priority for areas affected by drought and highly urbanized communities with poorly managed water and solid waste system (Kovats et al., 2003); **Rift Valley Fever** is associated with increased rainfall while **Meningitis** infection is associated with decreased rainfall and dusty conditions which are likely to spread and cover wide areas with climate change (DFID, 2004; Huq et al., 2004).
Assessing impact of climate change on disease distribution requires consideration of not only mean annual temperatures changes but also the extent of temperature and rainfall inter-annual variability (Zhou et al., 2004). Validation of models will help in coming up with more targeted and effective preventive or control methods. Land use changes (e.g. drainage of wetlands) could also have implications for local transmission of climate sensitive diseases.

Disease early warning and detection systems need to be developed in risk areas to reduce or eliminate whenever possible the negative public health and economic impacts of epidemics (Abeku et al., 2004). But some of the health related problems could be effectively addressed through improving water and sanitation coverage in rural and poor urban areas which currently do not have access to such services. The most important adaptive measure is to ensure universal access to clean portable water and sanitation.

Box 3: Summary of Global Change Research Activities in East Africa by S.O.Wandiga

The global change research in East Africa has highlighted the following:

- Vulnerability to extreme weather events exacerbate poverty to the

2.4. Climate change and water resources

Precipitation is one of the climatic variables that will be most affected by climate change and/or climate variability. Large parts of east Africa are arid and semi arid commonly experiencing rainfall of below 500 mm (UNEP-AEO, 2002). Such areas already face problems of water scarcity because most of the countries depend on fresh water resources for domestic, agricultural and hydropower generation (UNEP-DEWA/Pan-African START, 2004). Some areas may get wetter while the dry areas already facing water scarcity may get drier. In Tanzania for example, areas receiving bi-modal rainfall might experience increased rainfall while those with unimodal rainfall patterns are likely to experience reduced precipitation. Two out of the three important rivers are likely to have reduced runoff in their basins accompanied with serious socio-economic consequences. Hydro-electric power generation could be interrupted affecting many other sectors of the economy.

Climate change will affect both the quantity and quality of water. Over extraction of ground water resources, increased competition and conflicts over water may become common in parts of east Africa where per capita water storage is already low. The water storage capacity needs to be improved to store the excess water that often results into floods during the rainy season. In pastoral areas, severe water shortages resulting from drying up of rivers and reservoirs have contributed to death of livestock from hunger, thirst and disease and increased conflicts over grazing belts (UNEP- AEO, 2002; Moyini, 2004).

Degradation of catchment areas has been blamed for the increased cases of flooding where water runoff instead of percolating and being stored in the soil. The excess river flows if harvested and stored could contribute immensely in supporting economic activities for example agriculture outside the rainy season considering that the poor agricultural performance in the region is attributed to high rainfall variability within and between seasons. Heavily silted flow from degraded watersheds/catchments is often directed to by pass existing reservoirs rather than stored to avoid siltation. Soil and water conservation need to be stepped up in farming areas to reduce the rate of soil erosion and improve soil moisture storage. This is one way of strengthening the resilience of farming systems and ensuring they remain productive.

Both mountain glaciers and water bodies (e.g. lakes and rivers) are sensitive to climate change. Ice on Mount Kenya and Kilimanjaro are both likely to recede with global warming. Being sources of some of the most important rivers (e.g. on which hydroelectric dams are located), reduced flows with long-term climate change would mean new challenges not only to the energy sector but to whole economies. The east Africa region also consists of many lakes including Victoria, Kyoga, Albert and Tanganyika among others. Surface waters are sensitive to climate variability and change as seen in the floods of 1962 where water levels in lakes Victoria, Kyoga and Albert rose considerably disrupting economic activities along the shores (MLWE, 2002). This danger still looms. For some countries like Uganda, limited information is available on frequently flooded areas though it is known that flooding of lower valleys and landslides in mountainous areas are common (MLWE, 2002). In Sudan, areas along the Nile and other rivers are affected by floods during the rainy season while in Kenya; three river basins including Nyando, Nzioa and Tana River are the most affected.

It has been acknowledged that ground water storage capacity in many dry land areas is inadequate of meeting peoples need hence other methods of water harvesting and storage needs to explored. There is need to document, strengthen and popularize the traditional water harvesting and storage systems to ensure that available precipitation is effectively used. Ground water resources will become increasingly important in dry areas especially those far from rivers and other surface waters. Ground water storage has not been quantified in Sudan for example despite being an important source of water in dry areas far from river Nile where abstraction of ground water is costly as most of the aquifers are located at depths 40 to 400 M (RoS, 2003).Mapping ground water resources in areas not yet covered would provide important information not only to the relevant government departments concerned with management of water resources but also other organizations or individuals interested in developing ground water resources. Available information on ground water is currently scattered in different government offices and may be lost with time. Such information should be synthesized and kept in a user-friendly format.

Some of the adaptation strategies for the water sector suggested in the initial national communications of the east African countries include interbasin water transfers, construction of reservoirs, increasing irrigation to boost production and encouraging the use of water harvesting technologies. While such strategies could go along way in improving water supply, some of them including construction of reservoirs and interbasin water transfer are expensive and costly and should form part of government's adaptation activities; for households or individuals, the focus should be on low cost technologies (e.g. rainwater harvesting) which could be carried out immediately and with the limited resources available (Orindi and Murray, 2005).

Even though climate and management practice play an important role in determining water availability and access in many areas, policies and socio-economic process remains important in others. In certain areas, people lack access to water not because it is scarce but due to inappropriate policies. The water sector in the east African countries just like in other regions of the world is being reformed, decentralized and liberalized in the hope that this will improve efficiency and delivery of water services (Orindi and Huggins, 2005). It is important that implementation of such wide ranging changes are carried out gradually and in consultation with the users to be affected. Lessons learnt from implementing such changes should be used to inform future management options.

2.5 Climate Related Disasters

The number of hydro-meteorological disasters including landslides, droughts, famines, floods among others has more than doubled since 1996 (IFRCRC, 2002). Eastern Africa has experienced at least one major drought in each decade over the past 30 years (UNEP DEWA and Pan-African START, 2004). Both floods and drought affects large areas of east Africa. In Uganda, the last few decades have seen an increase in the frequency and intensity of extreme weather events with serious socio-economic consequences. The El-Nino rains of 1997 for example resulted in destruction of nearly 10,000 km of rural roads in Uganda (ASARECA, 2005) while the 1999/2000 droughts resulted in water shortages and massive power rationing in Kenya (IRI, 2005; DFID, 2004). Kenya and Sudan have also experienced a number of serious droughts in the recent past. In Sudan, some of the areas affected by the recent droughts include northern Kordofan and Darfur while in Kenya, the North eastern and parts of eastern province have been severely affected.
Meteorological data for Sudan shows that recent droughts cycles are drier, last longer, cover large areas and have shorter non-drought intervals (RoS, 2003). Floods affecting the region are highly unpredictable due to the natural variability of rainfall. Dealing with floods is a priority issue for most of the countries considering the damage to economies and the associated public health problems.

The risk of fire may increase with global warming and may affect grassland areas such as the Serengeti (Huq et al., 2004) - an important wildlife area in east Africa.

2.6 Climate change and energy resources

The energy sector in east Africa is heavily dependent on biomass energy which accounts for up approximately 80% of the energy consumed. Fuel wood is the main source of energy for cooking in many rural and poor urban households. Climate change may increase or decrease availability of biomass sources of energy depending on the suitability of new conditions for plant growth. Apart from biomass, hydroelectric power generation may also be significantly affected by changes in precipitation. Areas which may experience reduced precipitation could experience decreased power generation which could translate to huge economic losses to the national economies. The 1999/2000 drought in Kenya for example led to water shortages and severe cutbacks in power generation , leading to power rationing and blackouts with the total cost to the economy estimated at USD 20 million (IRI, 2005; UNEP-AEO, 2002).

In terms of adaptation especially at the household level, all the countries have recommended promoting use of alternative or renewable sources of energy (e.g. solar) which also happen to have economic, health and environmental benefits. Inspire of the many positive attributes associated with the alternative energy sources (e.g. being non-polluting and efficient), their use among poor households is currently very limited. This could be due to the fact that they are expensive as many poor people who are also not connected to the National grids cannot afford the initial capital required in most cases. Apart from developing environmentally friendly technologies, it is important that the issue of cost and accessibility is addressed if they are to be of use to the poor people.

2.7 Climate change and coastal resources

East Africa has along coastline consisting of diverse ecosystems which may be negatively affected by climate change. Tanzania has an 800 Km long coastline which is vulnerable to increased sea level rise. The initial National Communication of Tanzania highlighted the need for detailed studies of wave, climate and sediment transport in order to estimate erosion, salinity and temperature variations necessary to predict sea level rise and valuation of all vulnerable structures along the coast to determine the best way of protecting them. A sea level rise of 1m is projected to inundate 2117km^2 of Tanzania (IPCC, 1998).

2.8 Climate Change and Biodiversity

The east Africa region by virtue of its location across the equator together with a range of altitude and climatic conditions makes it rich in biodiversity. The regions benefits from biodiversity in terms of tourism, variety of foods and crops, forestry and medicinal plants among others. Anticipated impacts of climate change on biodiversity include shifting of ecosystem boundaries, change in natural habitats and sharp increases in extinction rates for some species (Reid, 2004). Rapid changes are expected in mountainous regions where species have no alternative habitats to which they can migrate in order to survive (ibid). Coral reefs which provide important ecological and economic benefits will also be seriously affected. Change in biodiversity would likely affect the tourism industry which is a major foreign exchange earner for some of the countries like Kenya, Uganda and Tanzania.

Because of the significant role of east Africa species, habitat and ecosystem diversity to the national economies and livelihood strategies, it is important that appropriate measures are put in place to conserve the existing biodiversity as much as possible.

3. Research Themes/Problems

The following is a summary of research issues/problems that came out from the consultation on climate change and development in east Africa region. An attempt was made to arrange the list in order of importance within each sector. Section 3.9 highlights some of the cross-cutting issues that research on climate change need to focus on.

3.1. Pure Climate Research

- Climate change science
- Regional climate change scenario and impacts assessment models
- Assessment of model reality (Validation)
- Climate Forecasting
- Packaging and dissemination of forecast information
- Mainstreaming climate information into national policy
- Mechanisms of extreme climate events

Accompanying these is capacity building (human & equipment)

3.2 Agriculture and Food Security

- Use of long-term daily climatic data to characterize and map the probability of success of agricultural in the context of climatic variability and Climate Change.
- Hydro-climatic zoning (Impact of shifting AEZ on crops/animals)
- Identification/development of appropriate/improved crop varieties together with the risk of pest and diseases
- Risk of land degradation (soil erosion especially areas of increased rainfall, desertification)
- Coping strategies in relation to on-going change i.e. evaluating management options for their ability to facilitate coping
- Policies and institutions that (dis)encourage adaptation strategies
- Potential impacts of high temperatures to dairy industry
- Public-Private partnerships
- Markets and relationship to poverty; identification of small scale income generating options
- Post harvest storage/losses
- Efficient utilization of water for irrigation
- Land-atmosphere interactions
- Social cultural impacts

3.3 Climate and Health

- Development &Validation of predictive models for more targeted and effective control of climate sensitive diseases
- Socio-economic and political factors that are equally important in addressing some of the problems (Most vulnerable groups).
- Role Agroforestry and reforestation in disease vector control/ medicinal value of plants
- Review of health policies
- Links between climate, agriculture and nutrition
- Health infrastructure (personnel and facilities)
- Health Data rescue/ Improving data management for Climate Related Diseases
- Links between Climate change and other diseases e.g. HIV/AIDS

3.4 Water Sector

- Impacts of CC on inland waters; possibility of salvaging (fisheries, land use changes- Lake Jipe, River Lumi)
- Impacts of liberalization on the water sector/ water governance
- Transboundary management of water resources
- Early warning systems –floods
- Hydrological modeling (Inter-basin water transfer, HEP)
- Water harvesting and storage
- Mapping of ground water resources and artificial ground water recharge.
- Improving irrigation performance
- Climate induced land use change and impacts on river basins.
- Impact on aquatic bio-diversity
- Impacts of CC on Indigenous irrigation management systems
- Water quality for drinking

3.5 Climate Related Disasters

- Mapping of both drought and flood risks - (damage to economies and public health problems) followed by costing impacts of floods and droughts
- Disaster preparedness and early warning systems; thresholds for various systems
- Existing coping mechanism of communities
- De-linking climate change and disaster

3.6 Energy Sector

- Hydrological changes, climate forecasting and HEP Generation
- Impacts of land use changes on biomass energy
- Energy policy review & reforms
- Improving access to renewable energy technology.
- Review of engineering codes based on extreme events
- Impacts on hydraulic structures

3.7 Coastal resources

- estimate risk of erosion, salinity and temperature variations to predict sea level rise
- Risk of saline water intrusion in coastal aquifers
- Effect on marine biodiversity
- Somali currents-one of the richest in the east African coast
- Effect of climate induced sea level rise

3.8 Biodiversity

- Impacts on important biodiversity reserves
- Value of agricultural biodiversity in coping with climate variability and potentially Climate Change
- Biodiversity hotspots
- Shift in ecosystem boundaries-ecosystem fragmentation
- Current challenges including human/ wildlife conflicts need to be addressed.
- Sharing of benefits with communities neighboring conservation areas.

3.9 Cross Cutting themes

- Documentation of Indigenous Knowledge and strengthening of coping strategies
- Mapping of Vulnerability
- Policy reviews and strengthening Science-policy/society linkages
- Capacity building
- Land use change
- Decentralization and diversification of livelihood strategies
- Access and sustainability of natural resources management
- Socio-cultural/economic impacts
- Multidisciplinary
- Equity

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