CLIMATE CHANGE AND DEVELOPMENT

CONSULTATION ON KEY RESEARCHABLE ISSUES

SECTION 5: EAST AFRICA REGION
SECTION 5.2. KENYA SCOPING STUDY
ACTS - VICTOR ORINDI AND OTHERS

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Climate Change and development in Kenya

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1.1 General Introduction.

The development agenda of many developing countries are increasingly being affected by climate related disasters including drought, floods and landslides (DWC, 2003) largely because of the increasing climate variability and the risk associated with it. Kenya is no exception. Rain-fed agriculture which accounts for a significant proportion of subsistence food production in Kenya will become more vulnerable with increasing climate variability and long-term climate change. This may increase the risk of food insecurity in the country. Together with other factors including rapidly growing population, poor management of natural resources and limited use of technologies, climate variability or long-term climate change could worsen the poverty situation in Kenya. Because of the many and diverse impacts likely to result from climate change, a combination of approaches including both technical and social strategies will be needed to promote adaptation (Bergkamp et al, 2003) and this is only possible if we take stock of what is being done to address current sources of vulnerability to climate variability and use this to inform long term adaptation strategies.

1. 2. Climatic Trends in Kenya

Because of the past emissions, some climate change is inevitable. Adaptation to climate change provides the most relevant focus for development research that may improve the livelihoods of the poor and the most vulnerable (Cooper, 2004). Climate variability and long-term climate change is a major source of risk to the majority of the Kenyan population because their livelihoods is largely dependent on natural resources, which will be affected. Climate change may affect food production and hunger, health, access to energy, water and therefore poverty in many countries (IRI, 2005).

Climate change projections to the year 2030 indicate increasing temperature with doubling of CO2 levels from baseline scenarios resulting in a decline in precipitation in the semi-arid areas. The impact will be reduction in maize yields, while for livestock would be shortage of forage, increased incidences and breakdown of marketing infrastructure (GoK, 2002) unless appropriate measures are put in place to deal with the anticipated impacts of climate change. Kenya in general might be wetter though.

Despite the variable nature of climate and its potential setback on development if not addressed, only a few African countries use climate information well (IRI, 2005). Reasons for this state of affairs vary from poor climate information which rarely reaches the intended users in time and easily understood format. Dealing with current sources of vulnerability including climate variability may remove some of the problems faced by households and communities, strengthen their livelihood systems and make them more resilient in the face of climate change.

1.3 Study objectives

The scoping exercise on climate change and development in Kenya had the following broad objectives:

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

- To identify what research other funders have supported, or are supporting, as well as where there are gaps.
- To provide a clear definition of researchable problems

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 Kenya. Section three is a summary of interview results and discussions with a number of people from government, non-governmental organizations, research institutes and development organizations working in Kenya while section four gives a prioritized list of research problems.

2.1 Agriculture and food security

Subsistence farming in many parts of Africa is faced with many challenges even without climate variability and long-term climate change. Such challenges include increasing population and subsequent pressure on land, declining soil fertility, increasing indebtness and isolation from markets (IRI, 2005). Increasing population in high-potential areas has contributed to un-economical subdivision and continuous use of land in arable areas and migration to marginal areas. Climate variability especially rainfall is an additional and major constraint to productivity, competitiveness and commercialization of crops and livestock systems in east Africa (ASARECA, 2005), more so because 90% of staple food production currently comes from and will continue to come from rainfed farming systems (Cooper, 2005;Rosegrant et al.,2002). In most cases, it is the temporal variations in rainfall rather than the total amount which bring most problems to rainfed systems. Climate variability and long-term change will therefore affect poor smallholders most as they depend on agriculture which in most cases is rainfed and have few alternatives (Jones and Thornton, 2003). The increasing pressure in the high potential areas has made things worse by pushing subsistence agriculture into the more marginal climatic regions. Migrants often continue with their traditional agricultural practices from the arable areas, some of which are not appropriate for the newly settled regions thereby contributing to their degradation and declining returns on investment. Reliance on rain-fed agriculture and increased use of marginal areas for farming means that food production is becoming more vulnerable to climate variability. Indeed as one moves into the dry areas, both the frequency and magnitude of rainfall variability also increases with coefficient of variation in rainfall being as high as 50% (ASARECA, 2005) (see Box 1 below). In some areas, most of the annual rainfall is received in only a few rainfall events (ibid).

The many risks associated with variable climate in the region have contributed to the limited adoption of improved technology and investment in agriculture more so with the poor groups. This is more so in an area when the soils are inherently low in fertility hence does not allow sustainable farming without external inputs such as fertilizers.

Climate variability and long-term climate change need to be addressed to ensure that poor farmers and pastoralists especially in the marginal areas do not face higher insecurity in food and income (ASARECA, 2005). Factoring in climate issues in national planning will ensure that the environment and natural resources are not degraded further and that productivity is improved; something which is currently lacking in many developing countries in Africa. Potential climate and weather related hazards to agriculture and food security include drought, floods, frost, hailstones, pest and disease outbreaks and disruption of trade among others. In Kenya, the most vulnerable areas are the pastoral, agro-pastoral and marginal agricultural areas where famine and deaths of both human and livestock are frequently reported (Oduor et al., 2002).

Climate variability affects many other important factors (water availability, land degradation and competitiveness especially of rainfed agriculture) that have a direct bearing on food security (ASARECA, 2005). Understanding, adapting to and coping with climate variability is therefore important aspect of natural resource management (NRM) for agriculture in Kenya and east Africa region as a whole. Omenda et al. (1998) argued that a well informed approach to the management of climatic factors influencing maize production is as important as other inputs such as fertilizers, seed quality etc because most of the maize in Kenya is grown under natural climatic conditions. Incorporation of seasonal forecast into decision making could go along way in addressing the risk associated with rainfed agriculture. Farmers for example may plan their activities and make better investment decisions if they have climate forecasts well in advance rather than a few days into the planting season as is the case now. Eradicating poverty in marginal environments for example demands better matching of agricultural activities to seasonal quality and greater food security in the frequently poor years (IRI, 2005). This can be achieved by providing relevant and timely information to the people who need that information including farmers, pastoralists and traders among other users. Rao and Okwach (2005) found that farmers in Machakos, Kenya could obtain an average increase in maize yield of 61% if they accessed climatic outlook information and used such information in adjusting their cropping management strategies. Box 1 below highlights one of the initiatives dealing with climate variability going on in the dry land areas of Kenya.

Box 1: Making the Best of Climate – Adapting agriculture to climate variability
K.P.C. Rao and Louis Verchot (ICRISAT/ICRAF, Nairobi).
The issue: With or without climate change, climate across semi-arid tropics is subjected to pronounced variability (Figure 1). The risk associated with such a variable climate is one of the

Background: The greatest challenge to rain-fed farming is to deal with the variability in rainfall, both within and between seasons. Typically, rainfall during a crop season at many locations in semi-arid tropics varies from about a third to two and half times normal amounts. For example, the long-term rainfall record at Katumani, Kenya shows that average seasonal rainfall during the driest 1/3 years is about 35-40% of that during the wettest 1/3 years.

This big difference in the seasonal rainfall presents different opportunities and challenges for the management to consider in planning field operations. Given the high variation in seasonal rainfall and the need to plan farm operations without knowing the seasonal conditions, farmers favor using low risk conservative management strategies that reduce negative impacts in poor years, but at the expense of reduced productivity and profitability, and inefficient use of resources especially during the seasons with favorable conditions (Figure 2).

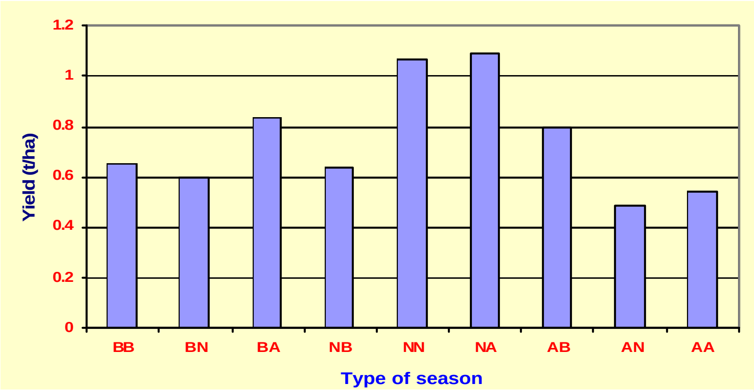

Figure 2: Rainfall conditions during short and long rain seasons and maize yield in Machakos district (B=below normal; N=normal; A=above normal)

This explains why farmer adoption of many technologies like drought tolerant or escaping crops and varieties, *in situ* rain water conservation techniques and *ex situ* water harvesting and small scale irrigation systems is low. Past research has also developed a number of risk management strategies including maintaining storage reserves, insurance, forward selling, futures trading, government subsidies and taxation incentives etc. However, adoption of these interventions requires good institutional and policy support which is limiting in many developing countries in general and in Africa in particular.

Opportunities: Farmers would be able to consider a number of adjustments in the management practices used if they had prior knowledge of what the rainfall conditions are going to be during the forth-coming season. One way of having advance information about the forth coming season is through use of long-term/seasonal climate forecasts made by institutions such as International Research Institute for Climate Prediction (IRI) and ICPAC (IGAD Climate Prediction and Application Centre formerly Drought Monitoring Centre). Growing understanding of interactions between the atmosphere, sea and land surfaces, and advances in modeling the global climate system have contributed significantly in improving the skill and reliability of these long-term forecasts.

While scientists view the present skill in climate forecasting as an important opportunity to reduce risk and improve productivity, the awareness among farmers about the nature and value of these forecasts is limited

Based on their fieldwork in East Africa, both IR I (2005) and ASARECA (2005) identified the following areas for further research:

- Enhancing early warning systems to support appropriate internal response and external assistance
- Empowering vulnerable farming populations to better manage risks through enabling all stakeholders to increase their abilities to use results from prediction, forecasting, modeling of climate variability to make better and strategic decisions with respect to NRM and other investments.
- Preventing large-scale secondary economic shocks through policy or market interventions
- Strengthening institutional capacity and coordination to support generation, communication and application of appropriate climate information.
- Assessment of vulnerability of land resources in relation to climate change and climate variability
- Development and support of the implementation of effective adaptation measures in the context of integrated planning process.

2.2 Climate change and Health

Many vector and water-borne disease are influenced by climate (Nganga et al., 2002). Climate change may increase the prevalence of some vector-borne diseases (e.g. malaria and dengue fever) and vulnerability to water, food or person to person borne diseases (e.g. cholera and dysentery) (AfDB et al.,2003). The anticipated increase of 1.0-3.5^{o}C in average global temperatures by 2100 (Watson et al., 1995) may increase the likelihood of many vector-borne diseases in new areas (Githeko et al., 2000). Climatic anomalies associated with El Nino-Southern Oscillation phenomenon have been linked to outbreaks of malaria in Africa for example (Githeko et al., 2000). Increased frequency and intensity of droughts and floods associated with such climatic anomalies impacts directly on human well-being and health and more so in poor urban and rural areas where health services, water supply and sanitation facilities are inadequate. Climate change will also affect ecological and social systems thereby creating additional challenges (IPCC, 2001).

Climate variability and change have been identified as some of the key drivers in the increased incidence and spread of climate sensitive diseases (e.g. resurgence of Malaria) (Zhou et al.,2004; Githeko and Ndegwa, 2001;Githeko et al.,2000) even though some authors (Hay et al.,2004;2002; Thomas, 2004) feel that other factors including drug resistance, demographic and land use changes could be more important in explaining the recent resurgence in malaria than climate change. Some of the diseases that have been recognized to be climate sensitive include influenza, diarrheal disease, cholera, meningitis, dengue and malaria (IRI, 2005). Malaria and dengue fever remain amongst the most important vector-borne diseases in the tropics and subtropics (Githeko et al., 2000). Malaria is considered to be the most important of the climate-sensitive diseases accounting for the highest number of deaths than any other disease in Kenya (Ref).

Box 2: Influence of meteorological/climatic factors on transmission and incidence of malaria.

- Temperature influences development rates of both the malaria parasite and its mosquito host;
- Increased rainfall increases availability of breeding sites and therefore augments malaria vector populations if temperature is favourable;
- Increased rainfall is associated with increase in air humidity that results in higher adult vector survivorship and therefore greater probability of transmission;
- Higher temperatures shorten the parasite extrinsic incubation period and increase the stability of disease transmission;
- Rainfall much above normal can lead to "flushing out" of mosquito breeding sites and potentially lead to lower malaria incidence.

Source: IRI, 2005 pg 18.

Seasonality of climate is an important factor in determining when and where malaria outbreaks may occur. Climate anomalies have been found to periodically trigger epidemics (IRI, 2005, Zhou et al., 2004). Indeed anomalies in climate variability account for up to 26% of the anomalies in hospital based highland malaria cases in Kenya (Githeko et al., 2000). Despite this relationship, almost nothing is known of the economic burden of malaria epidemics in sub-Saharan Africa (IRI, 2005). Reducing the incidence of climate induced diseases for example will require taking into consideration information on the seasonality of climate and its variability when coming with up control strategy (i.e. routine health campaigns, epidemic preparedness, dealing with outbreaks).

A number of reasons have been given for the recent emergence of certain diseases. In the case of epidemic malaria in the east African highlands, some of the reasons given include increased travel from the malaria-endemic Lake Victoria basin to the highlands, degradation of the health care infrastructure, anti-malarial drug resistance, local malaria transmission in the highlands as a consequence of land use changes and global warming (Zhou et al., 2004; Githeko et al., 2000; Hay et al, 2002). As explained earlier however, the role of climate change in the resurgence of malaria is still controversial and requires further work.

Epidemic malaria in western Kenya for example generally occurs in areas at altitudes of between 1500 to 2200 metres above the sea level , where the annual mean daily temperature varies between 18 and 22^{o}C (Githeko and Ndegwa, 2001). Plateaus which are not well drained compared to valleys can provide suitable mosquito breeding grounds. Kenya is already affected by highland malaria. According to Githeko et al. (2000), malaria transmission at equatorial latitudes may become more intense at higher altitudes where individuals have low immunity. Since 1988, malaria epidemics have spread from 3 to 15 districts in western Kenya with some areas having such outbreaks annually (Githeko and Ndegwa, 2001; World Malaria Situation, 1994). Over the same period, the observed increase in mean monthly maximum temperatures in the region was 2^{o}C (Githeko et al., 2000). According to Githeko and Ndegwa (2001) predicting when and where the outbreaks will occur has so far been a matter of guess work despite the increased frequency of malaria outbreak.

Historically, malaria epidemics in Kenya occurred in the mid 1930s to 40s and then again from 1988 to the present-periods in which increase in mean temperatures were observed in the African region (Githeko and Ndegwa, 2001; Watson et al., 1998). Since 1989, significant change in climate variability has coincided with increased magnitude and frequency of malaria epidemics in the highland areas of east Africa (Zhou et al., 2004). Climate warming as opposed to increased variability has occurred on a small geographical scale in east Africa as shown by the high frequency of extreme climatic events (El-Nino and drought) since the late 1980s (Zhou et al.,2004). Both the frequency of malaria epidemics and number of those affected in an epidemic in east Africa have also significantly increased in 1990s compared to 1980s (Zhou et al.,2004).

Assessment of climate impacts on malaria resurgence is difficult because of high spatial climate variability and lack of long-term data series on malaria cases from different sites (Zhou et al., 2004; Patz et al., 2002). Since both temperature and rainfall may have synergistic effects on malaria transmission, simultaneous analysis of climatic and vector data is needed to show the effects of climate on malaria cases. Despite the fact that association between climate variability and malaria epidemics has not been rigorously examined, Zhou et al.2004 felt that it could be epidemiologically more relevant than the mean temperature increase because outbreak of epidemic malaria is influenced by the climatic extremes/anomalies. It is important to consider not only the mean annual temperature changes but also extent of temperature and rainfall inter-annual variability when assessing impact of climate change on malaria transmission. Other equally important factors that may need to be looked at include change in land use and the role of topography. Land use changes for example may create more mosquito breeding sites, change water chemistry and temperature of mosquito habitats sometimes accelerating development and survival. The fact that vector species are adapted to existing ecosystems means that change in the ecosystems will definitely affect their distribution.

Government policy of quick diagnosis and effective treatment of malaria has been found to assume or ignore such important factors as availability of sufficient man-power, drugs and prompt interventions to prevent a potential epidemic (Githeko and Ndegwa, 2001). This needs to change to predicting when and where epidemics will occur which is currently a problem. Better prediction of when and where the epidemics may occur would help in reducing uncertainties in decision making, better resource and disease management if they eventually occur. There is need to look at other factors like drug resistance, drug access and health infrastructures in controlling disease epidemics.

Because climate variability has the potential to precipitate simultaneously multiple disease epidemics and other types of disasters (Githeko et al., 2000), it is important that research focus not only on malaria but other climate sensitive diseases as well. Occurrence of **Meningitis** is associated with increase in temperature and decrease in humidity, and related to dust. With climate change, arid and dusty conditions may spread to cover wider areas leading to increased risks of the disease outbreak (DFID, 2004). Despite the moderately strong relationship between climate and outbreaks of meningitis, understanding of this relationship is still poor (IRI, 2005).

Human settlement patterns also influence disease trends. In Kenya, majority of the population lives in rural areas where vector control (e.g. removal of larval breeding sites) is often difficult (Githeko et al., 2000). Dengue fever remains largely an urban disease and will become increasingly important in areas with poorly managed water and solid waste systems that is characteristic of many poor urban areas in east Africa.

Pastoralism is central to survival of households in the dry land areas which in Kenya covers 80% of the land area. In some places (e.g. North eastern, parts of eastern Kenya and Rift Valley) it is the only viable mode of production hence the need to address current challenges and those likely to be triggered by climate anomalies or change. **Rift Valley Fever**- a mosquito borne virus is closely associated with heavy rainfall and afflicts people and livestock (IRI, 2005; DFID, 2004). Outbreak of Rift Valley Fever epidemic in 1997/98 as a result of the El-Nino rains killed up to 80% of livestock in Somalia and northern Kenya (DFID, 2004) and led to the banning of livestock imports from suspect countries (IRI, 2005). This resulted in loss of income to pastoralists from the banned countries. To deal with the problem, a model is being developed by IRI and partners that anticipates climate conditions associated with mosquito breeding. This is expected to contribute significantly towards supporting animal health and trade decision making through minimizing future trade stoppages based on assessment of environmental RVF risks.

Box 3: Adaptation to malaria in the Western Kenya Highlands by Andrew Githeko, KEMRI/CDC, Kisumu, Kenya

In the 1990's it became clear that the frequency and intensity of malaria epidemics in the western Kenya highlands were increasing. A number of hypotheses were advanced to explain the cause of the epidemics. These included drug resistance to anti-malarial, migration of infected individuals and

The use of advanced technology such as satellite mapping and Geographic Information System (GIS) has enabled precise spatial and temporal mapping of the distribution of the malaria vectors. We have shown that 75% the malaria mosquitoes in the highlands are confined to 25% of the houses located up to 500 meters

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2.3 Climate Change and Water Resources

Kenya is classified as a water deficient country because it does not have adequate water for the increasing needs within the different sectors (MoA and MoLFD, 2004). The water resource base in Kenya consists of both surface and ground water resources. Surface water resources include rivers, lakes, wetlands, ocean and man-made water storage systems such as reservoirs. It is the surface water resources or systems that are strongly influenced by climatic factors including rainfall and temperatures (Mutua et al., 2002). Ground water resources are also influenced to a smaller extent and with a considerable time lag by rainfall and evaporation (ibid) hence the need for climate information for better management of both surface and ground water resources. Surface water resources are rare in the arid and semi-arid areas which are characterized by high evapotraspiration rates.

Lakes and wetlands are important sources of water for many uses (industrial, agriculture, domestic) and supports fishing, tourism and recreation industries in Kenya which are important sources of foreign exchange earner. But they are potentially more vulnerable to changes in climate parameters than rivers as variation in temperature and precipitation directly causes changes in evaporation, water balance, lake level, hydro-chemical and hydro-biological regimes (Mutua et al., 2002).The fact that they are sensitive to climate necessitates the need for additional information on how they may be affected and possible measures that may be put in place to minimize the adverse effects of climate variability or long-term change.

Even though the Water Management Strategy recognizes water related disasters like floods, droughts and landslides and the potential benefits from better understanding, prediction and use of climate information in water resources planning and management, it has not been effective in dealing with climate related disasters. Flood monitoring for example has been very weak. Climate change issues need to be mainstreamed into the water management policies to ensure that they are fully addressed by the stakeholders.

Replenishment of ground water aquifers is dependent on effective rainfall hence a change in effective rainfall will alter recharge. In Kenya, projections indicate that only the Lake Victoria basin and central highlands east of rift valley will experience increased rainfall (GoK, 2002). The fact that ground water resources are not affected to the same extent as surface waters means that water development need to focus more on this resource to buffer against climate extremes. Coastal aquifers are susceptible to salt-water intrusion which could result from sea level rise with shallow aquifers being particularly at risk.

Surface water resources are and will continue to be most vulnerable to climate variability and change while ground water resources in the coastal regions where they are currently strained will be most vulnerable in future (Mutua et al., 2002).

Even though the frequency and intensity of droughts have increased in parts of Africa, insufficient data analysis on precipitation has not allowed trends in the southern hemisphere to be established to the same extent as the northern hemisphere (Cooper, 2004). That notwithstanding, the basic nature of water to life and the fact that rainfall is one of those climatic variables that may be affected by climate change means that water resources managers and policy makers need information on how the quantity and quality of water resources may be affected by future climate conditions. Some may need to know how future changes in flora and fauna in vulnerable localities will affect regeneration capacity of rivers while others like reservoir managers need reliable indicators of future rainfall quantities to make best use of the limited stored water available. Tana River in Kenya for example has seven hydroelectric dams and contributes most of the electricity used in Kenya. it is estimated that the cost of $20 million resulting from power ration and black out as a result of the 2000 drought could have been worse had the Kenya Electricity Generating Company not used the climate forecast that warned them of the impending drought because they could have released most of the water just in readiness for the rainy season[1]. For smooth operations of reservoirs and also to allow neighboring communities access such water on a regular basis, there is need to have reliable forecasts.

In many areas including the semi-arid lands, there is plenty of rainwater but the problem is that more than 60% of the rainwater often goes back to the atmosphere unutilized for any productive purposes (ASARECA, 2005). This could be attributed to a number of factors ranging from limited use of available technologies to poor laws and policies where the focus has been to control rather than promote efficient water use. This may partly explain the limited extent of irrigation practiced in the region despite its big potential to support agriculture and income generation. Irrigation however remains the largest water consumer in Kenya.

In east Africa just like in other areas of the world, the major challenge of the water sector will be how to meet increased water demand. According to Bergkamp et al.2003, water demand in many areas now exceeds or threatens to outstrip sustainable levels of supply. Current water management strategies may become inadequate more so with climate change. Countries will need appropriate policies, laws, incentives and technical measures to deal with the additional challenge of climate change. According to Olago (2004), non-climatic factors such water policy reforms and management practices would also have significant effects in addition to climate change and variability.

In conformity with global trends, a number of reforms are currently being instituted in the water sector in Kenya. Some of the reforms include the move towards greater involvement of water users and private sector in water management and supply, the creation of new rules and institutions to implement the new water management strategies. However, the many reforms currently being introduced are also creating new challenges and problems including large number of illegal users that the newly created institutions can conveniently do nothing about; organized and more powerful users over-extracting available water at the expense of less powerful groups and marginalization of poor areas which the private sector may not find commercially attractive to invest in (Orindi and Huggins, 2005; Van Koppen et al., 2004). There is also a feeling that the changes focus too narrowly on drinking water, have been too drastic for the ordinary citizen to understand and non-participatory as people on the ground were rarely concerted or adequately informed or sensitized about the new changes (McGranahan and Satterthwaite,2004; Manzungu,2004). More work is needed to address current policy and institutional weaknesses to ensure that the rights of the poor to water for both basic and productive uses are protected.

Conflicts over water and other natural resources have occurred in certain areas due to a number of factors including increased competition over scarce resources, ineffective laws and institutions dealing with water. Conflicts over water are becoming common in many dryland areas. There have been increased cases of violent conflicts between agricultural and pastoral groups over water early this year. Conflict resolution is therefore a priority for the well being of communities found in water stressed environments. This could be achieved through recognizing and integrating informal systems of natural resource management into the new systems for improved management of water resources considering that the formal laws and institutions have only been partially

[1] Samuel Marigi, Senior Meteorologist, Forecasting Division, Kenya Meteorological Department.

effective (Orindi and Huggins, 2005). Even as countries move to implement some of the new management systems, it is important that they take note of and if possible strengthen rather than replace customary resource management systems. The recently held *International Workshop on African water laws* underscored the importance of customary systems in water management. Box 4 below highlights some of the priority areas for research identified during the workshop.

Box 4: Priority areas for research on water governance

- Recording local community-based arrangements with due attention to the vernacular and in such a way that communities are

The need to use water where it most productive and trade to share benefits from such use within basins may become important with decreasing water availability in certain areas (ASARECA, 2005). This may also be due to the fact that the east African countries may not have the financial and technological resources to take water from where it is available to areas where it is needed. Research is needed to determine how best this can be done.

2.4 Climate related Disasters in east Africa.

Disasters refer to disruptions of the functioning of a community or society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community/society to cope using its own resources (UN/ISDR, 2002). Even though disasters (for examples floods, droughts, landslides, dam breaks etc) could be caused by natural factors, human activities have exacerbated their magnitude and extent of destruction (MoA and MoLFD, 2004; Mutua et al.,2002).The anticipated increase in the occurrence of climate related disasters with climate change pose a considerable threat to Kenyan economy and sustainable development. Climate related disasters may result in loss of lives, property and damage to infrastructure. Destruction of existing livelihood systems could trigger conflicts at different scales, which may impoverish affected areas. The fact that disasters often force the redirection of limited resources into dealing with its effects means that other development sectors are given low priority in form of resource allocation. The 1999/2000 droughts resulted in water shortages and massive power rationing in Kenya (IRI, 2005; DFID, 2004). This came before the country could recover fully from the effects of the 1997/98 El-Nino rains which caused serious damage to the various sectors of the economy.

In Kenya just like other developing countries, climate has not been properly factored in disaster preparedness and risk management (Mutua et al., 2002). Capacity for early warning system and disaster preparedness is still weak at the various levels of government. The focus has largely been on dealing with the impacts rather putting in place anticipatory measures that could significantly reduce the extent of damage whenever disasters occur. Strengthening early warning systems is central to communities' resilience in the face of increased frequency of climate related disasters. Weather prediction in Kenya is not very good due to limited monitoring stations in relation to the land area. Currently, there are only very short forecasts covering a few days or weeks though it would be good to have predictions covering longer time periods (for example 3 months to over one year!). This would give people and responsible institutions time to give warnings to areas likely to be affected and also put in place the necessary measures to minimize impacts of such disasters if they eventually occur.

Available forecasts has not been reaching the intended target groups due to a number of reasons including lack of trust on the value of weather forecasting, poor packaging of information and data and use of inappropriate means of mass communication (Mutua et al. 2002). There is need to find better mechanisms of information dissemination to the grass root level if people or areas likely to be affected are to make good use of such information. Such information should be in presented in a simple and easily understood language. Because different sectors require different information, a needs assessment should be carried out so that what is provided is appropriate. Research on climate variability and long-term climate change could provide useful information to governments, non-governmental and donor organization and communities on the ground allowing them to plan and make the best use of available resources. The priority concern is how to deal with climate variability which currently affects large parts of Kenya.

2.5 Climate Change, Forestry, Biodiversity and Tourism

Forests are important for the many roles and products they provide (for example rain catchment, provision of habitats, supply of timber, wood fuel, medicinal products etc). Despite this, forest cover in Kenya stand at less than 2% of the land area. Because forests are long-lived communities, rapidly changing atmospheric CO_2 concentration, temperatures and precipitation could significantly impact them (Omenda et al., 1998). The risk of wildfires may increase with increasing frequency of drought which has been experienced in many parts of the country in the recent parts. Early warning systems and disaster preparedness schemes for dealing with wildfires should be put in place. Current efforts by the government and civil society organizations towards increasing the country forest cover need to be stepped up as well.

Impacts on forest will also affect the wildlife and tourism industry. Tourism industry in Kenya supports many people through direct employment, service provision and is also an important source of revenue to the government. Apart from the effect on forests, climate change could lead to bleaching of coral reefs, damage to infrastructure and other coastal ecosystems. There is need to safeguard the tourism sector through factoring in climate information in development of infrastructure and diversifying tourist attraction to care of some of the impacts on the environment.

2.6 Climate change and energy sector

Kenya's energy demand is met from three broad sources including biomass, petroleum, and electricity. Biomass account for approximately 68% followed by petroleum (22%), electricity (9%) with the rest accounting for 1% (Oludhe et al., 2002). Weather related disasters over the past few years have negatively impacted the energy sector and related industries affecting economic development and lives of many Kenyans. The 2000 drought for example resulted in reduced power generation causing frequent blackouts and power rationing (IRI, 2005; Oludhe et al, 2002).
Excessive rains can also interfere with electrical power supply when uprooted trees fall on power lines and power poles uprooted as well. Because of the important role of energy in both domestic and industrial sector, disaster preparedness for risk and impact reduction is necessary considering the massive investment, network of grid transmission lines and heavy dependence on biomass by majority of the population. Kenya's forest cover stand at less than 2% of the land area meaning that even without climate change, meeting the energy demand would still be a big challenge.

3.0 Knowledge Gaps on Climate change and development in Kenya

This section gives a summary of research problems/issues based on the consultative workshop, literature review and one on one interviews held with a number of stakeholders working in Kenya.

3.1 Agriculture and Food Security

3.1.1 Climate variability: As being seen in East Africa, it is not only the difference in total amounts of rainfall received in a region that matters but also the distribution of the rainfall. Even if the total rainfall received in a year do not deviate much from the average, a two week dry spell within the growing season for example may lead to total crop failure. For areas where rainfed agriculture is practiced, distribution of rainfall is important and more work needs to be done in coming up with country or regional models that could better predict the distribution in future. There is need therefore to characterize and map climate variability implications for investing in rainfed agriculture. This could provide better ways of dealing with current challenges to rainfed agriculture and long-term climate change. There is need for ground truthing of predictions models using available daily climatic data.

The need to address climate variability emanates from the fact that it has contributed to limited uptake of improved farming technologies by poor households and limited investments in resource poor areas. Adoption of improved technologies could boost production in such areas especially during the good seasons. Examples of improved technologies include mulching, terracing, rainwater harvesting, irrigation (e.g. micro-irrigation technologies), use of Agroforestry technologies such as ‘fertilizer trees’ and fertilizer micro-dosing could be used by farmers to improve agricultural production.

Benefits from technologies vary with seasons; reliable forecasts would allow households to invest and benefit from the good seasons. Recovery from bad seasons in marginal areas often depends on how the good seasons are used. Investing in agriculture especially during good seasons could improve returns from investment. However, farmers in the dry land areas have been generally unwilling to put even the necessary inputs after experiencing a bad season for fear of losing again. Under conditions of uncertainty, many people are unwilling to invest in farming hence do not make better use of the good seasons which could facilitate recovery from bad seasons. Good forecasts could also allow the establishment of crop warranties (where farmers form association and raise capital for use during certain periods to allow them keep their produce and only sell when the prices are good).

Currently, climate forecasts are available from the IGAD regional centre and Meteorological department. This information is mostly published in newspapers in terms of probabilities and only accessed by very few people (those with access to electronic and print media) and is of limited use to local farmers who might not understand what is meant by the probabilities. As at now, the information is not used extensively apart from food security predictions (for example the Famine Early Warning Systems-FEWS-Net which is operational in the east Africa region). There are significant benefits farmers may achieve if they base their decisions on climate forecasts. But these can only be achieved if weather information is provided in a user-friendly and timely manner.

Variability is high in semi-arid areas where production systems are already vulnerable. In addition, the population of these areas is also increasing due to in-migration from high potential areas. Many people migrating into these areas carry with them technologies they have been using, some of which are in-appropriate to the new-settled marginal areas (e.g. growing of maize instead of sorghum which is well suited to the marginal areas). The fact that movement and resettlement of peopl e from high potential areas to dry lands seems to be supported by governments (e.g. in Kenyan) means that many people will continue moving and settling in marginal areas. There is need therefore to map and characterize the drier areas for information that could inform the appropriate strategies that may be adopted. People concerned with policy formulation need to understand the probability of drought occurrences for example.

3.1.2 Coping strategies and indigenous knowledge: As explained earlier, there is need for research on and documentation of coping strategies and indigenous knowledge especially in addressing the problem of migrants who tend to continue using practices from their areas of origin, some of which may be inappropriate for newly settled areas. Indigenous knowledge is important in informing the kind of development that may be appropriate for an area. Information on climate variability and coping strategies could help in identifying the most appropriate technology for an area (see Box 6). Experience from semi-arid areas show that available technologies can often take care of variations within seasons which are 10% or less but where it is more than 20%, new technologies may need to be developed or improvements made to take care of such variations[2] in order to have stability in agricultural production. Technologies for short-maturing crops and water harvesting relevant for dry land areas are there but understanding of how the climate is varying would enable both farmers and other stakeholders working in these areas to match them well with the local conditions.

3. 1.3 Indicators of climate variability and change

With uncertainties as to the direction and magnitude of climate change, it is important that clear definitions, perceptions and indicators of climate change and/or variability according to different stakeholders are identified and used in developing models for use in the region. Communities have different indicators which they rely on in determining whether climate has changed or not. While some consider the reduction of river flows, drying of rivers, increasing frequency of drought or disappearance of certain plants to be an indication of changing climate others feel that these are normal events which occur after certain periods. Because of the many and often different indicators people use, it is important that more work is done in defining the indicators which can be reliably used in developing the models and early warning systems. The baseline conditions used when developing models needs to be defined more clearly to improve their accuracy.

Socio-economic factors which have been largely ignored need to be considered when developing the models. Socio-economic changes will definitely influence community's vulnerability, response and adaptations options. Food insecurity for example may at times result from poor market access and distribution networks.

[2] Rao K P C

Box 5: Priority issues for Understanding and buffering against current and future uncertainty in rain-fed agriculture by Peter Cooper, ICRISAT.

An integrated approach to this challenge would include the need to:-

1. Understand **Current Coping Strategies** of farmers / communities with a view to identifying how these strategies can be built on and diversified to deal better with current climatic variability and future climate change, i.e. to become more resilient.
2. Improve, make more accessible and understandable **Seasonal Climate Forecasting** to enable farmers to make rationale investments in farming in any given season which have an acceptable probability of paying off.
3. To characterize and map (using long-term daily climatic records, spatial weather generators, Crop growth simulation models, GIS etc) the **Longer-term Probability of Success of Agriculture and Agricultural Innovations.**
4. Through the combined use of Global Circulation Models and Existing Long-term Climatic Records, **characterize and map the implications of current and future climate change especially as it impacts on the nature of climatic variability.**

The combination of these 4 in an integrated approach provides a science based framework within which better and more accurately targeted decisions and actions (by a broad range of agricultural stakeholders) can take place.

3.1.4 Land degradation is a serious problem in many farming areas and has both on site and off site effects. The onsite effects include the decreased soil fertility and poor physical conditions that limit returns on investment. Off-site effects include sedimentation and reduced water quality in reservoirs. Increased rate of sedimentation of reservoirs not only shorten their life spans but also represents an additional economic burden in their management. Because many rural households depend directly on land for their survival, there is need to focus on the interaction between land degradation, poverty and climate change. Interaction of the three may worsen and make certain livelihood groups more vulnerable to climate variability or change. Conditions in the arid areas for example may be exacerbated by increased temperatures. This added to the problem of land degradation may lead to disasters.

Box 6: Climate Change and Land Transformation: The Impacts on Lake Victoria Ecosystem and Livelihoods by Daniel Olago, University of Nairobi/Pan-Africa START.

Lake Victoria is, by area, the second largest lake in the world and the largest in Africa. The lake has a surface area of 68,800 km^2 and an adjoining catchment area of 184,000 km^2. It is, however, a relatively very shallow Lake, with maximum depth of 80-90 m. The lake is an international water body that offers the riparian communities a large number of extremely important environmental services such as potable water, fisheries, navigation, climate modulation, etc.

The lake has apparently been influenced by the "global warming" trend evident in the high-elevation tropics. The driving mechanism seems to be anomalously high sea-surface temperatures in the tropical ocean persisting for at least 30 years, about the time frame during which Lake Victoria has experienced its most dramatic changes. The lake is now one-half a degree (°C) warmer than in 1960s, in harmony with changes in surface temperature at tropical elevations above 1000 m world-wide, and slackened winds now cause less intense mixing. Within the catchment areas, maximum temperatures have increased, since 1978, by about 1°C for many areas, and more dramatically by 3.4°C in Kericho area. This trend is attributed partly to the global trend of rising temperatures due to greenhouse gas emissions, and also to land transformation (mainly depletion of vegetative cover). Landscape disturbance from the 1930s onwards, and the resulting increase in soil erosion and sedimentation is the dominant cause of the ongoing eutrophication in Lake Victoria.

Over the past three decades or so, the lake has come under increasing and considerable pressure from a variety of interlinked human activities such as: enhanced sedimentation and eutrophication due to land degradation in the catchment and lakeshore areas; overfishing and species introductions in the lake; and, pollution originating from industrial, municipal and rural settlement effluents. Degraded and deforested lands (including wetlands) are becoming increasingly characteristic features in the region as a consequence of a rapidly growing population. More and more of eroded lands are being put under cultivation or for grazing and settlements, leading to rapid depletion of soil nutrients and forest resources. For example, today about 50% of the expansive Nyando River catchment has experienced severe soil physical erosion and degradation, with negative ramifications for food security and increased vulnerability to climate disasters such as floods. The increased demand for fuelwood due to population pressure has exacerbated the deforestation trend. There is increased use of agrochemicals in the lake catchment area, and a huge load of organic wastes originating from domestic, municipal and rural settlement sources is discharged into the lake. Algal blooms have increased since the 1960's, and the filamentous and colonial blue green algae, known for causing hypoxic conditions that occasionally lead to fish kills is now very dominant in Lake Victoria. Consequently, nearly half of the lake floor currently experiences prolonged anoxia for several months of the year, compared to the 1960's when anoxia was localized and sporadic. Enhanced denitrification has lowered the N:P ratio and blue green cyanobacteria have replaced diatoms as the dominant phytoplankton in the lake. These processes negatively impact on the lake ecosystem function, overall diversity, and economic activities and livelihoods associated with the lake resources. For example, the land and water degradation that is taking place, in addition to other factors such as overfishing, places at risk the booming international trade in Nile perch fishery that has a present value of US$270-520 million.

The land use activities, through changes in the type or extent of vegetative cover on the watersheds, are thus changing the microclimate of the region. In addition, land cover change has altered streamflow and has resulted in increased sediment and nutrient loading to rivers and the lake. Problems of soil erosion and deforestation may be exacerbated by climate change effects. Few studies have been carried out on the processes and feedbacks governing land – atmosphere interactions in eastern Africa, but studies in southern Africa show that the depletion of vegetation cover can significantly alter the atmosphere-vegetation moisture exchange budget. For example, there may be increased precipitation in some regions and increased droughts in others, respectively, while shifts in climatic zones may create serious problems in human settlements, agricultural land-use and wildlife management under the existing land tenure systems. Better understanding is required of the long-term interactions between humans, land transformation, and climate variability and change, in order to understand better future climate change impacts on land cover and its knock-on effects on aquatic systems. Climate - land-cover interactions, therefore, require much more investigation, as the impacts of anthropogenically-driven land transformations can, potentially, significantly alter regional climate boundary characteristics in the short-term, and may feedback positively into the global climate system as a whole in the long-term.

Key References:

Odada, E.O., Olago, D.O., Kulindwa, K., Ntiba, M. and Wandiga, S. (2004). Mitigation of environmental problems in Lake Victoria, East Africa: Causal chain and policy option analyses. Ambio, 33 (1-2): 13-23.

Odada, E.O., Olago, D.O., Kulindwa, K.A.A., Bugenyi, F., West, K., Ntiba, M., Wandiga, S. and Karimumuryango, J. (2004). East African Rift Valley Lakes: GIWA Regional Assessment 47. UNEP-GIWA.

Verschuren, D., Johnson, T.C., Kling, H.J., Edgington, D.N. Leavitt, P.R., Brown, E.T., Talbot, M.R. and Hecky, R.E. 2002. History and timing of human impact on Lake Victoria, East Africa. *Proc. Roy. Soc. London B. 269*, 289-294.

3.1.5 Agricultural Policies

How can policies be reformed to support subsistence agricultural improvements? It is generally agreed that government support is necessary for improving access and wider adoption of available technologies. In Kenya for example, the government policy on **subsistence crop improvements** is not adequate hence the limited work being done in this area compared to commercial agriculture.

While agricultural inputs may be available, improved access by the poor will remain important if they are to benefit from available technologies. Many poor farmers often lack access or can not afford inputs hence unable to use them even when forecasts predicts good seasons ahead. There is need for policy reform to encourage individuals, groups and private companies to take advantage of good seasons by creating good and reliable business environment that may improve access to agricultural inputs and technologies. There is need to address factors hindering the wider adoption of available technologies which could be beneficial to poor households to improve their returns on agricultural investment.

Agricultural extension for the purposes of disseminating climate information to users at the local level needs to be improved. Most of the staff in agricultural extension division for example were laid off in the 1990s as part of the Structural Adjustment Programme (SAPs). This weakened dissemination of information from the national level to communities on the ground. The fact the government may not be a position to employ many people in near future to dissemination information means that new and effective ways to address the current weakness needs to be developed. There is need to identify other appropriate channels through which information could be relayed fairly easily to the users on the ground. Groups that may benefit from reliable climate forecasts include:

- Farmers from improved understanding of climate variability and change and ability to make informed decisions
- Banks and Insurance companies: who need case studies to demonstrate benefits to them for example on the need to support (in form of loans) small scale farmers to access inputs at the beginning of the seasons.
- Business people dealing in agricultural inputs and products may also benefit from such kind of information as they will be able to predict the demand and supply.
- Governments, regional bodies and international organizations need this kind of information for ease of coordinating food relief operations. Having this information before hand will allow them plan well and in advance.

3.1.6 More work needs to be in developing improved varieties for the different climatic conditions. Research need to identify varieties that can do well with poor rains but also perform better with good rains (win-win situations). Cultivar based adaptation for example the work done by CIMMYT on maize varieties that combines both attributes needs further research. Improved varieties should be developed in consultation with the intended users and focus should be on working with communities to identifying both food and high value crops that could bring good returns on investment. It would be important to facilitate formation of groups that could prove useful when it comes to marketing of their products. In promoting high value crops (for example legumes, fruit trees in the dry land areas) therefore, it is important that local people or groups involved are enabled to access market information so that they can determine when and where to sell their produce. Market intelligence/information which has been generally inaccessible to such groups need to be made available.

3.1.7 The risk of pest and diseases. Change in temperature and precipitation will likely change the type of pests and diseases. It is important that assessment of the likely impacts of climate change on pest and diseases is carried out. More work need to be done in identifying the risk of crop pests and diseases with increased climate variability and change.

3.1.8 Pastoral Areas have been largely neglected despite the fact that they are the most affected by current climate variability. Pastoralism need to be strengthened by creating the necessary infrastructure and markets more so to take care of drought periods when they are usually expected to sell their animals.

3.1.9 Urban agriculture is becoming increasingly important especially for the poor households. This group often uses waste water to irrigate the cultivated crops despite the many risk associated with the use of such water. Since this trend is likely to continue, it is important that a clear policy is enacted on urban agriculture and use of waste water more so in poor urban area to make it safer for the benefit of farmers as well as consumers of such produce.

Box 7: Agriculture, global change and sustainable development: the issues for agricultural research by Emily Massawa, UNFCCC Focal Point, Kenya.

The new issues

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Agricultural and Climate Change

Agriculture and the carbon cycle

Agriculture generates greenhouse gases: carbon dioxide as a result of ploughing and burning to clear forest or regenerate pasture, or the use of diesel-guzzling machinery;

3.2 Research Priorities in the Water sector

3.2.1 Water monitoring and quality assessments.

Currently, there is limited availability in terms of aquifer recharge information on ground water distribution, storage and capacities. Access to available information remains a problem. There is need to carry out mapping of hydrology and geology in those areas not yet covered to determine where runoff can be usefully directed for storage in the soil. This will ensure that we maximize on the ground water storage capacity to support the increasing water demand in many areas. This kind of information will not only be important for government departments concerned with large scale development and management of water resources but also those who wish to develop ground water especially in dry land areas already facing water scarcity. Detailed river gauging is necessary for use in decisions concerning siting of dams or reservoirs

Monitoring of river flows within the newly created catchment areas under the decentralized water management system need to carried out to provide accurate information for the purpose of licensing water operators. Currently data on water quantity is characterized by discontinuities hence the need to identify the optimum and primary network that could be put in place to provide the necessary information (Mutua et al., 2002).

Flood and drought monitoring should be strengthened to limit the extent of damage/ impacts if they eventually occur. In the past, lack of information on impending floods or drought events has contributed to the huge impacts on the national economy and livelihoods whenever they occur. Existing flood monitoring strategy has not been effectively implemented.

3.2.2 Water Governance

Water access in Kenya is limited more so in poor urban and rural areas not served by the water distribution networks. Such groups have to rely on water sources like rivers, streams, water pans, wells etc for their water needs. Increasing water demand and decreasing water supply together with ineffective laws and institutions have contributed to the increasing conflicts over water resources. in addition, many reforms are being instituted in this sector with an aim of improving water access. research on water governance could therefore usefully address:

- Implications of current reforms e.g. commoditization, involvement of water user associations and private in water management and the implication for water access by the various livelihood groups

- Strengthening informal water management strategies (laws, institutions) which could help in dealing with conflicts over water resources.
- Management of trans-boundary water resources
- Policy on waste water re-use in urban sectors

3.2.3 Strengthening Rain Water Harvesting (RWH) as one of the ways through which current water problems may be addressed and for promoting sustainable development (i.e. addressing hunger, poverty at household level). Rain water harvesting has the potential to improve water access for use in various sectors including domestic, agriculture and industrial sectors. The problem is that RWH is currently not taken seriously by governments and many development partners alike. Governments have instead focused more on the conventional ways of water supply (for example damning rivers, drilling wells and boreholes) which are becoming inadequate. In Kenya for example, per capita water storage has been static for along time standing at less than $500M^3$ per capita far below the recommended level of $1000m^3$. This is a good indicator that the approaches being employed are not effective in harvesting rain water. There is need to change the mindset of stakeholders so that they take rainwater harvesting seriously more so with the many risks associated with climate variability and climate change.

Skills for rainwater harvesting need to be imparted to a large number of people. Currently there is a knowledge gap in rainwater harvesting as it is not part of the curriculum at all education levels. The fact that it is not taught at the various educational levels contributes to the limited technical capacity which has contributed to the limited awareness about available RWH technologies. Capacity building both at institutional and community level for wider adoption of RWH technologies should be apriority for adaptation to climate change initiatives. Even though RWH technologies are associated with many incentives (e.g. low investment and maintenance cost, the decentralized nature of its management) the lack of development and business plans has contributed to their limited adoption. It is important that business and development plans are put in place to promote their adoption.

Concern over quality of rainwater for domestic use has been addressed through development of appropriate filter systems[3]. Rainwater harvesting for agriculture has not been pursued aggressively either despite the fact that rainfall can be harvested in-situ and stored for later use. Storing water in the soil is the most effective way to conserve water for agriculture more so with the additional challenge of climate change. What is needed is the identification of recharge areas so that runoff is directed into the right place to recharge the soil. Already pilot projects are being implemented by RELMA GWP-AP, University of Nairobi and National Museums of Kenya. Scaling-up of such initiatives could lead to many benefits. In Lare Division of Nakuru, the Kenya ministry of agriculture carried out demonstration of how roadside runoff may be harvested. This was later picked by the community. Locals now collect runoff from the roadside and use the water which could have gone to waste for irrigation.

Box 8: Priority Research issues in the water sector by Francis Edalia, Ministry of Water and Irrigation, Kenya.

1. ***Improving irrigation performance*:** **Reason:** Irrigation consumes 70%

AP, Nairobi.

Recollection of knowledge on rainwater harvesting for documentation and wider dissemination is important in informing the development of relevant technologies and strengthening indigenous ways through which communities collected rain water for different uses. RELMA-GWP AP is also currently recollecting knowledge on rainwater harvesting for documentation and later wider dissemination in the region.

3.2.4 Land use change and microclimate.
Land use activities often lead to changes in micro-climate through altering the vegetation cover on a watershed. Land cover change may also alter stream flow and results in increased sediment and nutrient loading to rivers and lakes. Even though it is known that depletion of vegetation cover can significantly alter the atmosphere-vegetation moisture budget, few studies have been done in Kenya on the processes and feedbacks governing land-atmosphere interactions. Further work on the influence of land use on micro-climate and hydrology would provide useful information for the region.

3.3 Climate change and Health

3.3.1 Mapping of risks of disease outbreaks in different areas.
The frequency of climate induced disease outbreaks has become more frequent. Kenya is already experiencing many disease epidemics with very small changes in temperature and precipitation which is likely to worsen with increasing climate variability or long term climate change. Large water bodies and land use changes seems to be modifying factors in the disease outbreaks. Different localities are therefore likely to be affected differently hence the need to carry out risk assessment to determine outcomes for different areas. This could be achieved through developing new models for climate sensitive diseases (like dengue fever, meningitis etc) on which very limited work has been done if any-to improving the existing predictive models like those on malaria, rift valley fever and cholera epidemics.

Vulnerability to the climate induced diseases differs among geographical regions. Areas that have been commonly affected by cholera outbreak in the past include the Lake Victoria basin and Coastal areas and poor urban areas where water and sanitation facilities are inadequate. Areas with sandy soils are particularly at high risk of cholera epidemic. For malaria, focus should be on highland areas where cases of epidemic malaria might increase with climate change. Meningitis on the other hand is associated with arid and dusty conditions.

3.3.2 Poverty and socio-economic factors
High poverty levels in east Africa influences people's response to disease outbreaks. An AIACC study on highland malaria in the Lake Victoria basin of east Africa found that very few people could afford the insect treated bed nets and drugs which are currently used in the fight against malaria. New malaria drugs being introduced costs an average of USD 9 which is too expensive for most people. But poor attitude of health workers in public health facilities has also put off many patients and encouraged self treatment. As a result, people often resort to personal treatment which also leads to other problems including misdiagnosis and drug abuse.

Certain population categories (children, pregnant women and the very old) are more vulnerable to malaria than other groups. Research should focus on how these vulnerable groups may be taken care of in case of epidemics since they are also among the powerless in terms of income and decision making. Inability to pay for treatment/drugs is therefore an important factor in malaria epidemic hence the need for policy change to make drugs and bed nets affordable. There is also need to look for ways through which the negative attitude of health workers and patients (many patients often take half the prescribed dose) may be addressed.

Both cholera and malaria are preventable and curable. A combination of civil works for provision of water and sanitation facilities, poverty eradication efforts and sensitization on disease treatment/prevention could significantly reduce vulnerability of communities to these diseases.

3.3.3 Uptake and use of information. A lot of sensitization is needed to improve uptake and use of information within the government. Currently, uptake and use of new information is very low- it takes many years before change in policy can be carried out based on new information. Change in the use of chloroquine in treating for example took 15 years.

3.3.4 Management of Medical records

Medical records are important source of information for monitoring the epidemiology of the various diseases and coming up with a management strategy. Record keeping in most health facilities is very poor and more so in government facilities. Currently, the east African countries depend on WHO weekly reports which are not very detailed. If good use is to be made of the records, then better ways of managing collected information must be put in place. There is need to rescue health data currently lying in different health facilities before it is lost.

3.3.5. The role of Agroforestry and re-afforestation in the control of malaria need to be evaluated. It has been found that reforestation can drastically reduce the population of malaria vectors. In addition, households also benefit from reforestation in terms of timber and fuel wood supply, improvement in microclimate etc.

Box 9: PRIORITY RESEARCH AND POLICY ISSUES FOR THE MOST VULNERABLE AREAS AND COMMUNITIES IN KENYA By Maggie Opondo, University of Nairobi.

Available data, though scanty indicates that climate change is bound to have a severe impact on the health and well-being of people globally. The African continent will be particularly affected given that the public health systems, which the majority of its people rely on are inadequate, often lacking in capacity (expertise and institutional) to cope with the "normal" disease burden that is not related to climate change. Climate-sensitive diseases which often manifest as epidemics affecting whole regions and thousands of people can hardly be catered for by such inadequate health systems.

Socio-economic change (income disparities/distribution; intra- and inter-household dynamics and displacement) health care (lack of preventative measures and drug resistance)and food production (nutrition) particularly at the household level are among the factors that have been identified as contributing to the emergence and spread of infectious diseases such as malaria and cholera in the face of climate variability and change. This inevitably shifts the focus to the socio-economic aspects of climate induced diseases in which there is a dearth of information. The need to reduce the lacuna between policy and climate-sensitive diseases calls for systematic and detailed research on human health vulnerability and public health adaptability to climate change.

Box 9 continued.
Some of the pertinent issues that need to be addressed include:

- Documentation of the associations between disease outcomes and climate variability and change;
- Risk assessments and management of

3.4 Cross-cutting issues

Strengthening the various livelihood strategies will make communities resilient in the phase of climate change. Some of the areas that more work could be done to improve resilience include provision early warning and use of such information.

3.4.1 Collection, analysis and presentation of Climate information:

There are few monitoring stations (e.g. meteorological stations) across the country and indeed the region as a whole leaving many areas uncovered. Since predictions are based on available information, limited coverage not only affects the quality but also the accuracy and reliability of prediction models. Regional centres like ICPAC which also provides climate forecasts rely on the national meteorology departments for data; their output is therefore affected by the quality of data at national levels.

Information from regional centres (e.g. ICPAC) is mostly published in newspapers in terms of probabilities. This is accessed by very few people who read the newspapers and of limited use to local households who might not understand what is meant by the probabilities. As at now, the information is not used a lot apart from the FEWS-Net on food security predictions. This is so despite the fact that there are significant benefits farmers can achieve if they base their decisions on climate forecasts. It is therefore important that tools are developed that may allow use of climate information for managing risks associated with climate change and variability. Research should focus on how climate data collected may be analyzed and presented in a user friendly manner. As said before, many rural communities do not have access to climate information and rarely use it. The situation is even more challenging for pastoral groups who are mobile in nature. The important question that research should answer is how information collected and analyzed is made more accessible to the different livelihood groups and other users? Appropriate ways of disseminating information need to be identified.

The El-Nino la Nina phenomenon is now becoming more frequent (from 5-6 to 3 years) but very unpredictable. There is need to strengthen meteorological stations to gather enough data and improve on climate modeling with a view of covering both climatic and socio-economic aspects.

Timing of early warning is important. As at now, predictions are given a few days to or sometimes late into the planting season which is of limited use to individuals or communities on the ground. Farmers for example need forecasts of 3 months in advance to make the necessary adjustments. If people could get timely forecasts, then they would be in a position to decide whether to invest more or less in the production depending on how the season ahead looks like. What is important is that they should be told that these are forecasts. But it is worth noting that forecast are only reliable up to a certain point-in most cases not longer than three months.

3.4.2 Empowerment of vulnerable communities to use climate information. Providing information to vulnerable communities is not enough; there is need to empower them to use the information given. While informing communities that they need to plant fast maturing varieties because of poor rains expected is important, it would be more useful to ensure that such seeds are available and accessible. Pastoral groups on the other hand will need markets to dispose of their animals during periods of drought. There is need for policy change to ensure that vulnerable communities are empowered.

Identification of **alternative livelihood strategies** is important especially for pastoral areas that are being faced with many challenges including insecurity, changing land ownership and access to grazing areas. It is important to map what can be done in the different ecological zones and come up with laws and policies supporting this.

3.4.3 National Planning is currently done with limited climate information. This is due to the fact that economic planners still treat climate issues to be outside their mandate. In addition, the form in which the climate information is presented makes it difficult for the planners to incorporate climate information in the economic models used for planning. There is need to develop tools to capture and integrate climate information in economic terms. Going by previous experiences with climate related disasters, governments can not afford to leave climate information out. The El-Nino rains of 1997/98 damaged Kenya's' infrastructure and economy just like other neighboring countries in east Africa. The country also experienced serious droughts immediately thereafter compounding existing problems.

Because policy many makers are concerned with short-term goals which coincide with their duration of tenure, it is often difficult to get long-term considerations like climate change impacts incorporated in plans and given budgetary allocation. It is even more difficult when cost of climate related disasters and that of mitigation has not been carried out. Capacity should be developed to improve the use of climate information in national processes like planning and policy formulation.

4.0 REFERENCES.

AfDB *et al.* 2003. *Poverty and Climate Change: Reducing the vulnerability of the poor through adaptation.* AfDB, ADB, DFID, DGIS, EC, BMZ, OECD, UNDP, UNEP, World Bank.

ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa (2005). Natural Resources Management for Agriculture in Eastern and Central Africa. ASARECA NRM Strategy 2005-2015.

Bergkamp, G., B.Orlando and I. Burton (2003). Change. Adaptation of water resources management to climate change. IUCN, Cambridge. http://www.waterandnature.org/pub/Brochure-UICN-Change.pdf

Cooper, P (2005). Investing in rain-fed farming systems of sub-Saharan Africa: Evaluating the agricultural implications of current climatic variability and planning for future climate change. Concept note, February, 2005).

Cooper, P (2004). Coping with climate variability and adapting to climate change; Rural water management in the dry-land areas. Discussion Paper, IDRC.

DFID. 2004. *Climate Change and Poverty. Making development resilient to climate change.* Department for International Development, London.

DWC (2003). Dialogue on Water and Climate. Learning to better cope with climate variability and change. http://www.waterandclimate.org/News/Documents/Folder_DWC.pdf

Githeko, AK. and Ndegwa, W. 2001. Predicting malaria epidemics in the Kenyan highlands using climate data: a tool for decision makers. *Global Change and Human Health* 2:1.

Githeko, AK., Lindsay, SW., Confalonieri, UE. and Patz, JA. 2000. Climate change and vector-borne diseases: a regional analysis. *Special Theme: Environment and Health, WHO.* Ref No. 00-0737.

GoK (2002). Kenya's First National Communication on Climate Change. Nairobi, Kenya.

Hay, S.I., Shanks, G.D., Stern, D.I., Snow, R.W., Randolph, S.E and Rogers, D.J (2004). Climate variability and malaria epidemics in the highlands of east Africa. *TRENDS in Parasitology*. **Vol 21 No2**. 52-53

Hay, S I; Cox, J,. Rogers, D J., Randolph,S.E., Stern,D.I., Shanks,G.D., Myers, M.F and Snow, R.W (2002). Climate change and the resurgence of malaria in the east africican highlands. *Nature* Vol. **415**; 905-909.

IPCC. 2001. *Climate Change 2001. Impacts, adaptation and vulnerability.* Contribution of Working Group II to the third assessment report of IPCC. Cambridge. Cambridge University Press.

IRI (the International Research Institute for Climate Prediction) (2005). Sustainable development in Africa. Is the climate right? The Earth Institute at Columbia University.

Jones, P.G and Thornton, P.K (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global Environmental Change 13: 51-59

Manzungu, E. (2004) Water for All: Improving Water Resource Governance in Southern Africa. *iied Gatekeeper Series*, No. 113 London.

McGranahan, G and Satterthwaite, D (2004) Improving Access to Water and sanitation: Rethinking the way forward in light of the millennium development goals In: Bigg,T (ed) (2004) *Survival for a Small Planet: The Sustainable Development Agenda*. Earthscan/iied

Mutua, F M., H Oyieke. Gatheru, S.,Kitheka, J U and F.Mwango. *The Water resources sector* in: IGAD/DMCN. Factoring of Weather and climate information and products into disater management policy. A contribution to strategies for disaster reduction in Kenya. UNDP, GoK and WMO

Nganga, J, E. Ayiemba, A, Githeko and K Mutambo (2002). *Human settlement , Health and public safety* in: IGAD/DMCN. Factoring of Weather and climate information and products into disaster management policy. A contribution to strategies for disaster reduction in Kenya. UNDP, GoK and WMO.

Oduor, J E., J.A Mutea and Karanja, F.K (2002). *Agriculture and food security* in: IGAD/DMCN. Factoring of Weather and climate information and products into disaster management policy. A contribution to strategies for disaster reduction in Kenya. UNDP, GoK and WMO

Olago, D.O (2004). Key Climate and climate change issues relevant to Africa. Report to Richard Washington-Contribution to the DfID-DEFRA Africa Climate Report.

Oludhe, C., Theuri, D., Muturi, P and Mutambo, K (2002). Energy, Industry, Transport and Communication Sectors in IGAD/DMCN. Factoring of Weather and climate information and products into disaster management policy. A contribution to strategies for disaster reduction in Kenya. UNDP, GoK and WMO.

Omenda, T.O; Kariuki, J. G and Mbuthi, P.N (1998). Vulnerability and Adaptation to potential impacts of climate change in Kenya. Summary for Policy Makers. Ministry of Research and Technology, Nairobi, Kenya.

Orindi, V and Huggins, C (2005). Review of the dynamics of property rights, water resources management and poverty within Lake Victoria basin. Paper presented at the International Workshop on '*African Water Law: Plural legislative frameworks for rural water management in Africa*. 26-28 January, Johannesburg, South Africa.

Patz, J A., Hulme, M., Rosenzweig, C., Mitchell, T.D., Goldberg, R.A., Githeko, A.K., Lele, S., McMichael, A.J and Le Sueur, D (2002). Climate change (communication arising): Regional warming and malaria resurgence. *Nature* **420**, 627-628.

Rao, K P C and Okwach, G E (2005). Benefits of soil and water conservation under variable climate. Paper prepared for the "The East African Integrated River Basin Management Conference" Morogoro, Tanzania, 7-9, March 2005.

Thomas, C (2004). Malaria. A changed climate in Africa? *Nature* **vol 427**: 690-691.

UN/ISDR (United Nations/International Strategy for Disaster Reduction).2002. *Disaster Reduction and Sustainable Development: Understanding the Links between vulnerability and Risk to disasters related to development and environment*. Background Paper for the world summit on sustainable development (WSSD)) Johannesburg, 26 August -4 September 2002.

Van Koppen B, Sokile C S, Hatibu N, Lankford B A, Mahoo H and Yanda P Z (2004). Formal Water Rights in Rural Tanzania: Deepening the dichotomy? IWMI Working Paper 71

Watson R T et al (eds) (1998). The regional impacts of climate change. An assessment of vulnerability. A special Report of IPCC Working Group II. Cambridge. Cambridge University Press.

Watson R T et al (eds). (1995). Climate Change. Impacts, adaptations and mitigation of climate change: Scientific technical Analysis. Contribution of working group II to the second assessment report of the Intergovernmental Panel on Climate Change. Cambridge. Cambridge University Press.

Zhou .G, Minakawa, N, Githeko, A K and Yan G (2004). Association between climate variability and malaria epidemics in the East African highlands. PNAS vol 101 no 8. 2375-2380.